KLAMATH RIVER FISHERIES ASSESSMENT PROGRAM

JUVENILE SALMONID MONITORING ON THE MAINSTEM KLAMATH RIVER AT BIG BAR AND MAINSTEM TRINITY RIVER AT WILLOW CREEK
1996

Department of the Interior
U.S. Fish and Wildlife Service
Arcata Fish and Wildlife Office
Arcata, California

Annual Report FY 1996

June 1999

ANNUAL REPORT

KLAMATH RIVER FISHERIES ASSESSMENT PROGRAM

JUVENILE SALMONID MONITORING ON THE MAINSTEM KLAMATH RIVER AT BIG BAR AND MAINSTEM TRINITY RIVER AT WILLOW CREEK
1996

U.S. Fish and Wildlife Service
Arcata Fish and Wildlife Office
Arcata, CA

Rod McLeod
Jim Craig
Michael Prall
John Williamson

Funded in part by:

Trinity River Task Force
Klamath River Basin Fisheries Task Force
Bureau of Reclamation
Arcata Fish and Wildlife Office

June 1999

Preferred Citation:

USFWS. 1999. Juvenile salmonid monitoring on the mainstem Klamath River at Big Bar and mainstem Trinity River at Willow Creek, 1996. Annual report of the Klamath River Fisheries Assessment Program. Arcata Fish and Wildlife Office, Arcata, CA.

Disclaimer

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIXES

ACKNOWLEDGMENTS

The U.S. Fish and Wildlife Service acknowledges the following persons integral to the efforts of this project:

Bruce Halstead (Project Leader).

Tom Kisanuki (Assistant Project Leader).

Joseph Polos, for supervision and editing.

Jim L. Craig, for supervision and editing.

Bob Rohde, for supervising Karuk Tribal Fisheries staff.

We also appreciate the contributions of the following individuals who worked as crew members on this project:

Charlie Chamberlin	John Lang	Robert Knight
Vic Sundberg	Mike Marshall	Mark Catalano
Rick Quihillalt	Dan Nehler	Cory Anderson
Ann Gray	Mark Magneson	
Markus Medak	Bruce Oppenheim	

This project was done in cooperation with the following individuals of the Karuk Tribal Fisheries Office located in Orleans, CA:

Luana Hillman	Troy Myers
Bill Tripp	Paul Kuska
Stephanie Myers	

We would also like to commend Vic Sundberg for all his help with trap repairs and modifications.

Appreciation is also extended to the following volunteer staff who helped with various aspects of this report:

Tracy McCulloch
Mike Hastings

Special thanks to Al Andreoli, for allowing access through his property at the Trinity River trap site.

ABSTRACT

Monitoring of juvenile salmonid emigration on the mainstem Klamath and Trinity rivers has been conducted by the Arcata Fish and Wildlife Office since 1988. Rotary screw traps have been utilized as monitoring devices on these rivers since 1989. This report describes monitoring conducted in 1996. Catch data were used to calculate abundance indices for juvenile chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*) and steelhead (*O. mykiss*). The age of outmigrants, length frequency distributions, development stages, migration rates, and hatchery contributions were also determined. River discharge and temperature data are also presented. Non-target species abundance and biological data are presented for sculpin (*Cottus sp.*), speckled dace (*Rhinichthys osculus*), Klamath smallscale sucker (*Catostomus rimiculus*), Pacific lamprey (*Lampetra tridentata*), American shad (*Alosa sapidissima*), green sturgeon (*Acipenser medirostris*), and threespine stickleback (*Gasterosteus aculeatus*). Catch data is also presented for less abundant species.

Klamath River monitoring in 1996 was conducted from March 21 to July 30. The 1996 Klamath River chinook abundance index was 1,420,307 and was comprised of 41% hatchery fish. Age one-plus chinook were captured in small numbers from the start of trapping through May. Klamath River natural and hatchery young-of-year (YOY) chinook emigration peaked during Julian weeks (JWs) 24 and 26, respectively.

The majority of coho captured on the Klamath River were natural YOY fry and parr. The 1996 Klamath River coho abundance index was 7,106 and was comprised of 14% hatchery fish. Klamath River coho emigration peaked during JW 20.

Klamath River steelhead were captured throughout the 1996 trapping period. The 1996 Klamath River steelhead abundance index was 20,906. The hatchery contribution to the 1996 abundance index is not known because Iron Gate Hatchery steelhead were not marked. Klamath River fry, parr, and smolt steelhead emigration peaked during JWs 29, 17, and 20, respectively.

Trinity River monitoring in 1996 was divided into spring and fall monitoring periods. Spring monitoring was conducted from March 15 to September 30, and fall monitoring was conducted from October 1 to December 3. The 1996 Trinity River chinook spring abundance index was 662,430, and was comprised of 26% hatchery fish. The 1996 Trinity River chinook fall abundance index was 109,115, and was comprised of 82% hatchery fish. Emigration of Trinity River natural and hatchery YOY chinook peaked during JW 24 in the spring, and during JW 40 in the fall.

The 1996 Trinity River coho spring abundance index was 10,086 and was comprised of 66% hatchery fish. The 1996 Trinity River coho fall abundance index was 925 and was comprised of 100% natural fish. Trinity River natural YOY and hatchery 1+ coho abundance peaked during JW 20 in the spring. Trinity River natural YOY coho abundance peaked during JW 47 in the fall. No TRH coho were captured during the fall monitoring period.

The 1996 Trinity River steelhead abundance index was 75,076 in the spring and 6,744 in the fall. The hatchery contribution to the 1996 abundance index is not known because Trinity River Hatchery steelhead were not marked. Spring emigration of fry, parr and smolt steelhead peaked during JWs 28, 23, and 20, respectively. Fall emigration of fry and parr peaked during JW 47, while smolt emigration peaked during JW 48.

INTRODUCTION

The Klamath River system is the second largest river system in California, draining an area of approximately 26,000 square kilometers (km^2) in California, and 14,400 km^2 in Oregon. The Trinity River is the largest tributary to the Klamath River, draining approximately 7,690 km^2 in California. Iron Gate Dam on the Klamath River and Lewiston Dam on the Trinity River are the upper limits of anadromous fish migration in the Klamath River Basin. Two fish hatcheries, Iron Gate Hatchery (IGH) on the Klamath River and Trinity River Hatchery (TRH), were constructed to mitigate for losses of anadromous fish habitat upstream of Iron Gate and Lewiston dams.

The Klamath and Trinity rivers once supported large runs of chinook salmon (Oncorhynchus tshawytscha), coho salmon (O. kisutch) and steelhead trout (O. mykiss) which supported tribal, ocean troll and recreational fisheries. Declines in the Klamath River Basin anadromous fish populations, due to floods, water and land management and fish harvest management (Klamath River Basin Fisheries Task Force, 1991), led Congress to enact the Trinity River Basin Fish and Wildlife Restoration Act (PL 98-541) in 1984, and the Klamath River Basin Conservation Area Fishery Restoration Program (PL 99-552) in 1986. Both of these Acts directed the Secretary of the Interior to take actions necessary to restore the fishery resource of the Klamath River Basin, primarily by addressing restoration of the freshwater habitat.

Prior to 1981, fishery investigations in the Klamath River Basin (conducted primarily by the California Department of Fish and Game (CDFG)) focused on adult returns. This was due primarily to harvest allocation and escapement concerns. The Arcata Fish and Wildlife Office (AFWO) has conducted intermittent juvenile salmonid investigations in the Klamath River Basin since 1981 (U.S. Fish and Wildlife Service, 1982). In 1988, a substantial monitoring effort was initiated in the mainstem of the Klamath and Trinity rivers utilizing frame nets. In 1989 the utilization of rotary screw traps began. The purpose of the screw trap project was to monitor juvenile emigration and determine the abundance, timing, hatchery contribution, and biological parameters of anadromous salmonids in the mainstem Klamath and Trinity rivers. The advantage of monitoring outmigrating juvenile salmonids is that it allows managers to focus on the effects that in-river conditions have on production success. This, in turn, should allow managers to make better decisions concerning the fishery resource.

METHODS

Trapping Sites

In 1996, Klamath River trapping was again conducted at the Big Bar river access, located at river kilometer (rkm) 80 (16 rkms downstream of Orleans CA, and 10 rkm above the Trinity River confluence). The Big Bar trapping site was originally chosen in 1988. The site was selected because it allowed sampling of fish outmigrating from virtually the entire Klamath River Basin upstream of the Trinity River confluence, and the year to year channel configuration appeared to be consistent. The Big Bar site also allowed ready access by boat or vehicle and was not visible from Highway 96. In 1996, Trinity River trapping was again conducted at the Riverdale Campground (rkm 34) near Willow Creek (Figure 1). This location has been used since 1991 because the channel configuration is fairly consistent, it has private access, and the trap is not visible from Highway 96.

Trap Design and Operation

Rotary screw traps with 2.44 m diameter cones were used (Figure 2). Traps were anchored with 0.64 cm diameter aircraft cable to large trees or a series of steel fence stakes upstream. One or two 0.1 x 0.15 x 6.0 m (4"x6"x10') beams were used to push the trap out from the bank and to compensate for changes in river stage and velocity. Cone revolutions were used to determine where and when the trap could be operated without inducing unnecessary risk to the trap. River conditions ultimately dictated when traps were deployed. An effort was made to place rotary traps in the river prior to the emigration of young-of-year (YOY) chinook so that emigration patterns and the relative abundance of natural and hatchery chinook within all life history stages could be evaluated. The traps were fished on the edge of the thalweg during high river discharge, and incrementally moved back into the thalweg as river discharge decreased. When deployed, the bottom of the cone was generally <1 m from the stream bottom. A sampling day was defined as the time period between the setting of the trap one day, and removal of captured fish approximately 24 hours later. This period encompassed all night hours, when the majority of juvenile salmonids emigrate. Trap checks usually occurred during late morning or early afternoon. During peak emigration periods, fish were removed from traps several times during the sampling period (the frequency dictated by water temperatures, fish numbers, and mortality rates).

Daily trap data were summarized by Julian week (JW)(Appendix A), with the first day of JW 1 commencing on the first day of the year.

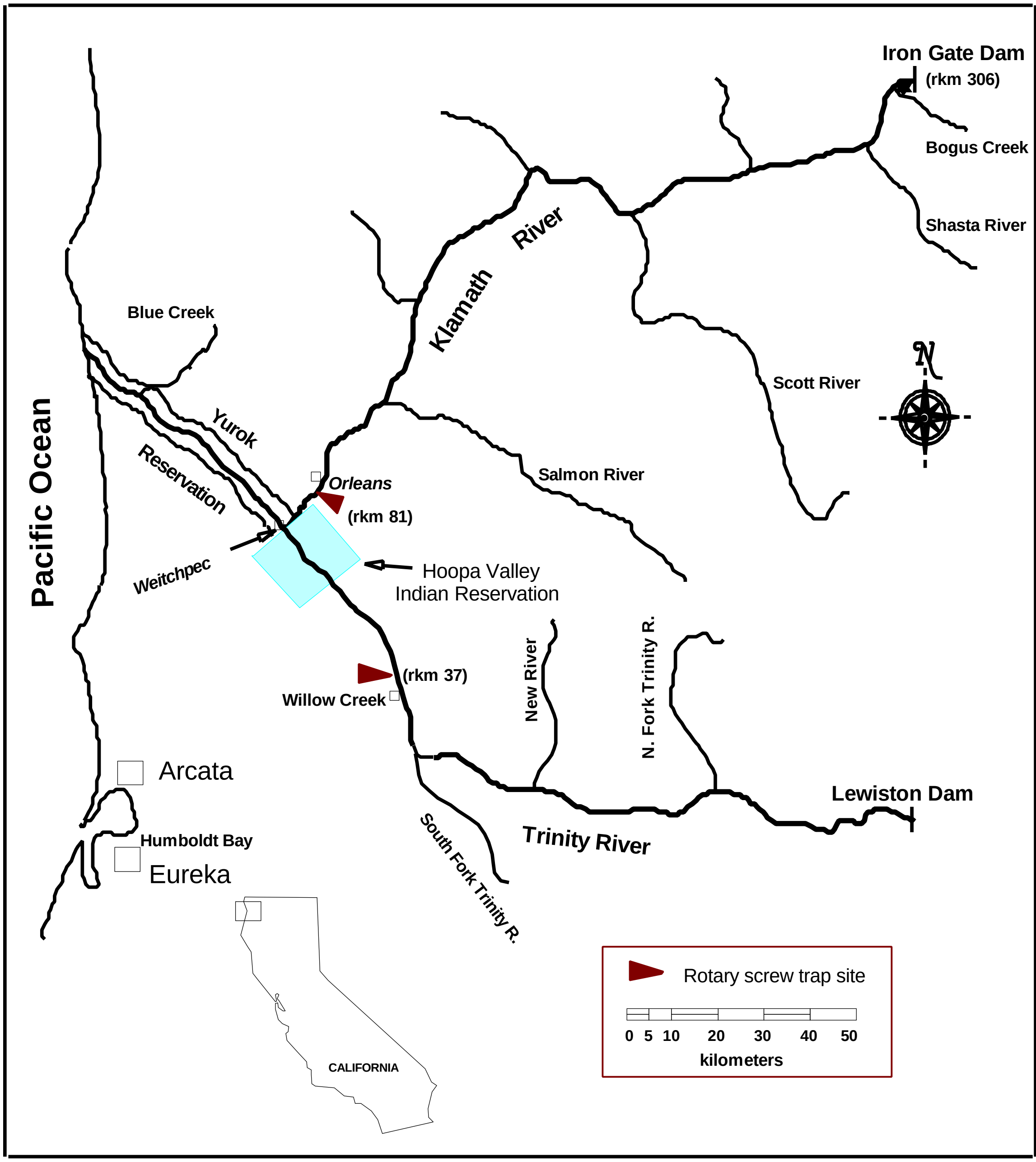


Figure 1. Location of rotary screw trap sites on the Klamath and Trinity rivers in Northwestern California.

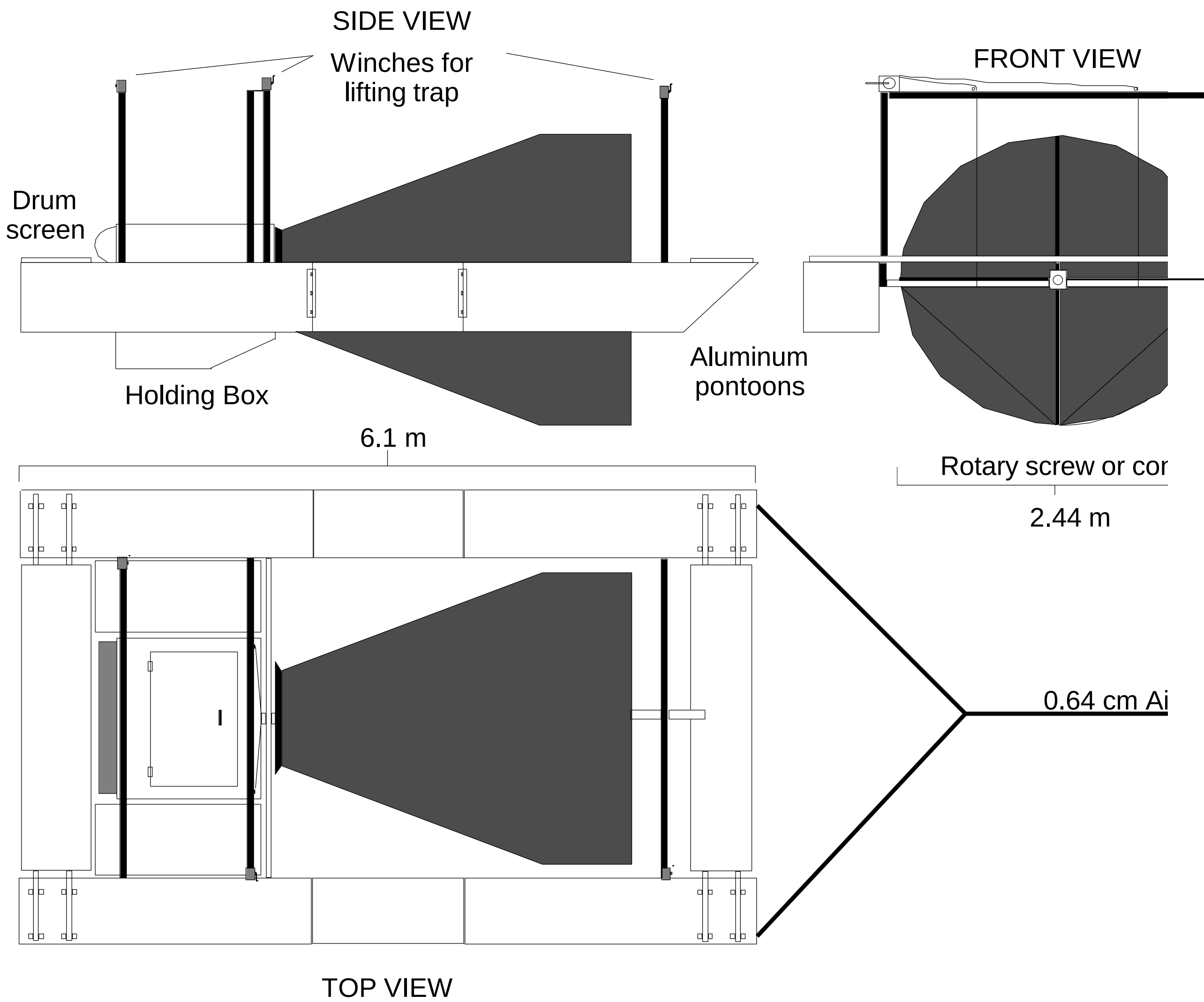


Figure 2. Rotary screw trap design depicting key components and di

All JWs are seven days in length except the last JW of the year and the 9th JW during leap years, which are both eight days in length.

Water Flow and Temperature Measurements

Normal cone operating depth was 1.07 m. Daily velocity measurements were taken directly in front of the cone as follows: the submerged portion of the cone was divided into three cells (right, center, left); within each cell, velocity was measured at 0.2 and 0.8 of the cone operating depth for 60 seconds using a General Oceanics digital flowmeter (Model 2030) (General Oceanics, Inc. 1983). A mean water velocity was calculated for each cell. Each cell area (m^2) was calculated, then multiplied by its corresponding mean water velocity (m/s). The values for each cell were summed, yielding an estimate of volume of river discharge sampled (Q_s) in cubic meters per second (m^3/s). Discharge data from U.S. Geological Survey Water Resource gauge stations at Orleans (#11-523000 at rkm 95.2) on the Klamath River and at Hoopa (#11-530000 at rkm 19.9) on the Trinity River were used as surrogate measures of mean daily river discharge (Q) at the trap sites. It was assumed that there was no significant difference between river discharge at these gauging stations and the respective trap locations.

Water temperature data were collected using a Ryan TempMentor thermograph attached to the outside bottom edge of each traps live box. Temperature was recorded every two hours for the entire sampling season. Mean daily river temperatures were calculated by averaging over 24-hour periods.

Biological Sampling Procedures

All fish captured were anesthetized with tricaine methanesulfonate (MS-222) prior to processing. Up to 30 individuals of each species and developmental stage (fry, parr, smolt, etc.) were randomly subsampled (biosampled) from the daily catch. Biosampled salmonids were measured to the nearest mm fork length (FL), weighed by volumetric displacement, and examined for developmental stage, fin clips, and physical irregularities. All captured salmonids that were not biosampled were tallied by species, development stage and/or age and examined for fin clips.

Fish other than chinook, coho, or steelhead were considered non-target species. Non-target fishes captured were identified to species (or genus in some cases), enumerated, and up to 30 specimens were measured to FL. Total length (TL) was measured on species without a forked caudal fin.
All anesthetized fish not retained were allowed to resuscitate in buckets of ambient river water before being released downstream of

the trap. NovAqua® water conditioner was added to recovery buckets to help protect fish during handling, minimize infection, reduce stress and aid in recovery. Adult salmonids were not anesthetized. Fork lengths of adult salmonids were approximated before release. Any salmonid mortality in the live box was checked for a fin clip and, if included in the subsample, measured (FL). If a salmonid escaped during netting or handling before it could be identified to species or checked for a hatchery mark (i.e. fin or maxillary clip), it was counted in the sample tally as an "unknown". Based on the probability of occurrence, unknown fish were redistributed into the most likely marked or unmarked species categories.

When present, daily subsamples of marked hatchery chinook were collected. A missing adipose fin (Ad-clip) was the external marker depicting fish with a coded wire tag (CWT) embedded in the snout. Ad-clipped fish were sacrificed for subsequent CWT retrieval. If the Ad-clip component of the catch was large and the possibility of multiple CWT codes existed, a subsample of up to 20 Ad-clipped fish was collected. Otherwise a subsample consisted of up to 10 Ad-clipped fish. Collected fish were stored in a freezer until time of dissection. Occasionally, Ad-clipped fish were also collected for disease sampling, after which the CWT’s were removed. This resulted in a total subsample of up to 30 or 40 Ad-clipped fish for some days.

Juvenile chinook were classified as YOY or 1+, based on size and date of capture. Coho were classified as either YOY or 1+; the latter of which were much larger in size, silvery, and lacked distinct parr marks. Steelhead were classified as fry (<=65 mm), parr, or smolts. Again, delineation of parr and smolts was subjective and based primarily on the degree of silvery coloration and distinctness of parr marks. Occasionally, steelhead <65 mm were classified as parr if captured very early in the season. Scale samples were collected from a subsample of chinook, coho, and steelhead for age analysis. Fish were assigned an age based on the number of annuli (overwinter period) present. A fish with one annuli was classified as a 1+, two annuli designated a 2+, etc.

Young-of-year chinook and coho captured in 1996 were produced from adult spawners in 1995 and were therefore considered 1995 brood year (BY), while one-plus (1+) chinook and coho were BY 1994 fish. Young-of-year steelhead captured in 1996 were considered BY 1996, while 1+ and 2+ steelhead were considered BY 1995 and BY 1994 respectively.

Hatchery and Natural Stocks Estimate

Captured chinook and coho were later categorized as being either of hatchery or natural origin, based on hatchery marks and hatchery release data provided by TRH and IGH. The California Department of Fish and Game coded wire tagged and Ad-clipped natural chinook from the upper Trinity River as part of their natural stocks assessment program. Natural fish are defined as the progeny of river or tributary spawning adults regardless of parental genetics. Hatchery release strategies for chinook consist of fingerling releases in the spring and "yearling" releases in the fall. These two distinct release periods prompted the division of the trapping season into spring and fall monitoring periods. Hatchery coho and steelhead were released as 1+ fish in the spring.

Chinook

All Ad-clipped fish collected were passed through a magnetic field detector manufactured by Northwest Marine Technology to determine the presence or absence of a CWT. The snout of each fish that registered positive for a tag was dissected until the CWT was recovered. Each fish registering negative for a tag had its head dissolved in a solution of potassium hydroxide. A magnet was then stirred through the resultant slurry. If the tag was not recovered, the fish was considered an Ad-clipped fish that had shed its tag (No-Tag). Recovered tags were decoded using a dissection microscope. CWT recoveries were summed by specific CWT code for each JW. The number of CWT fish captured for each code was estimated by multiplying the number of CWT's recovered by an expansion factor (E) which accounted for subsampling of Ad-clipped fish, CWT's that were lost during dissection, and unreadable tags. The expansion factor (E) was calculated using the formula:

$$E = (C/MS)(Ad/H)(T/TR)$$

Where,
- C = Total # of chinook captured,
- MS= Number of fish examined for Ad-clips,
- Ad= Number of Ad-clipped fish observed,
- H = Number of Ad-clipped fish collected,
- T = Number of collected Ad-clipped fish containing a CWT,
- TR= Total number of CWT's recovered and decoded after processing.

To account for unmarked hatchery fish over a JW, the expanded estimates for each CWT code were multiplied by a production multiplier (PM) specific to each CWT code. Each PM was calculated from hatchery release data (Pacific States Marine Fisheries Commission, 1997) using the following formula:

$$PM = \frac{\#\ Tagged + \#\ Poor\ Tagged + \#\ Unmarked}{\#\ Tagged}$$

Where:

Tagged = The actual number of Ad-clipped fish released with a CWT,

Poor Tagged = The number of Ad-clipped fish that were tagged and shed the tag (No-Tags),

Unmarked = The number of unmarked fish in a release group.

The estimated contribution of hatchery fish attributable to a specific CWT code for a given JW, was calculated by the following formula:

$$\#\ Hatchery_{code\ i} = (\#\ recovered_{code\ i}) * (E_{code\ i}) * (PM_{code\ i})$$

The total weekly estimated hatchery contribution to the catch was the sum of all estimated hatchery fish attributable to CWT codes.

The weekly contribution of naturally produced chinook to the catch was estimated by subtracting the estimated hatchery contribution from the total weekly catch. Occasionally, the daily estimated hatchery contribution exceeded the total daily catch. In such instances the estimated hatchery contribution was limited to the actual daily catch.

Towards the end of each emigration period, due to relatively few fish passing by the trap, it is possible that we captured juveniles of hatchery origin not represented by Ad-clipped fish. If no hatchery fish captured within a given time period were marked, the hatchery contribution for that period could not be differentiated from the natural component. Thus, all fish captured during that period were considered of natural origin. The hatchery and natural stock estimates assume no differential mortality between tagged and untagged fish of the same release group, equal vulnerability to capture and accurate estimates of the numbers of marked, unmarked and poor tagged fish released from the hatchery. The estimate does not account for Ad-clipped or non-Ad-clipped hatchery fish removed from the river upstream.

Coho

All hatchery coho released in 1996 were marked with a maxillary clip (TRH coho received a right maxillary clip and IGH coho received a left maxillary clip). The weekly contribution of naturally produced coho to the catch was estimated by subtracting the actual hatchery contribution (marked fish) from the total weekly catch.

Steelhead

Hatchery steelhead released in 1996 were not marked. Therefore, due to the uncertainty of determining the origin of steelhead smolts, no attempt was made to separate hatchery from natural smolts. Analysis of scale samples taken over the sampling season provided FL to age relationships.

Abundance Index

Catch effort data were collected and evaluated for each sample day. Trends in emigration were analyzed on a JW basis using daily abundance indexes, adjusting for any days not sampled (occasionally woody debris or an accumulation of aquatic vegetation would cause the cone to cease rotating). Daily abundance indexes ($Index_d$) for each species and development stage were calculated by the following equation:

$$Index_d = Catch_d /(Q_s/Q).$$

Where: $Catch_d$ = daily catch of a species
Q_s = volume of water sampled (cfs)
Q = mean daily river discharge (cfs)

Weekly abundance indexes were calculated for each JW using the following equation:

$$Index_{JWi} = \Sigma Index_d \text{ (\# days in } JW_i\text{*/\# days sampled during } JW_i)$$

*JW 9, 1996, was an 8 day JW.

Abundance indices were also calculated for the more abundant non-target species in the same manner as for salmonids.

The usefulness of this index as an estimator of abundance is contingent upon the assumptions that catch rates are directly proportional to the percentage of river flow sampled and that individuals from a given species are equally susceptible to capture. Assuming similar trapping effort and efficiency, the abundance index allows for comparison of relative abundance between years. The abundance index is not intended to represent a population estimate. This index is also used to describe relative abundance between weeks during the trapping season and between trapping seasons.

Migration Rate

Initial migration rates for hatchery chinook and coho were estimated by dividing the distance (rkm) traveled by the number of days elapsed between the initial release date and initial capture date for specific CWT codes or marked fish. Mean migration rates were calculated for each CWT group throughout the trapping period. Because IGH released chinook over a 3-day period (June 3-5) during the spring of 1996, the median date of June 4 was used as the initial release date when calculating mean migration rates. Due to a prolonged release period (March 18 to March 31), mean migration rates were not calculated for TRH chinook. Also, because naturally produced chinook tagged by CDFG on the Trinity River were tagged in early spring before initiation of migration, migration rates for these CWT groups were not calculated.

Daily migration rates were weighted by the proportion of river flow sampled to reflect the magnitude of the fish passing through the sampling area. A mean migration rate per CWT code or marked fish was calculated by the following formula with the first 10% and last 10% of each group excluded.

$$Rate_{mean} = \frac{\Sigma\left(\# \times \frac{rkm}{d} \times \frac{Q}{Q_s}\right)}{\Sigma\left(\# \times \frac{Q}{Q_s}\right)}$$

Where # = Daily expanded CWT_i code or fin clip counts,
rkm/d = distance traveled divided by number of days taken to reach trap after initial release.

The 10 through 90 percent capture dates were used to calculate the migration rate of the majority of each specific CWT or mark group. When less than ten tags of any specific release group were recovered all tags were used. Ad-clipped chinook not collected (i.e.; released at time of capture) were included in migration rate calculations using tag allocation procedures previously described in the hatchery and natural stocks estimation section of this report.

Trap Efficiency

Past experience has shown that successful efficiency tests on the Trinity River require a marked release group of about 1000 fish. Water temperatures should also be relatively low (<18^{o}C) to avoid mortality during the marking process. These conditions were rarely met in 1996, thus no trap efficiency tests were performed on the Trinity River during the 1996 trapping season. Conducting efficiency tests on the Klamath River is even more difficult due to higher flows, warmer temperatures and generally poorer health condition of the captured chinook. Thus, we made no attempt to conduct efficiency tests on the Klamath River during the 1996 trapping season.

RESULTS AND DISCUSSION

Mainstem Klamath River at Big Bar

Klamath River trapping commenced on March 21 1996, before any significant natural chinook YOY emigration was believed to have occurred. The Klamath River Big Bar trap (BBT) was operated for a total of 130 (98%) of 133 possible trap days during the spring monitoring period (March 21-July 30). Trapping data were not obtained for two days in April and one day in July due to logs that disabled the trap. Maximum daily river temperatures began to reach "stressful" levels (>20.0 ^{o}C, Bell 1973) by June 30. Mean daily water temperatures exceeded 20.0 ^{o}C on July 1 and increased to a high of 24.5 ^{o}C on July 26 (Figure 3). The maximum recorded water temperature was 25.8 ^{o}C, recorded on July 30. Due to the high water temperatures and associated stress on fish, low catch numbers, and the increasing difficulty in keeping the cone clear of algae, trapping was terminated on July 31.

In 1996, IGH released 5.6 million fingerling chinook on June 3-5. Iron Gate Hatchery also released 407,177 yearling chinook on November 12. Since trapping was terminated on July 31 no data are presented for this fall release.

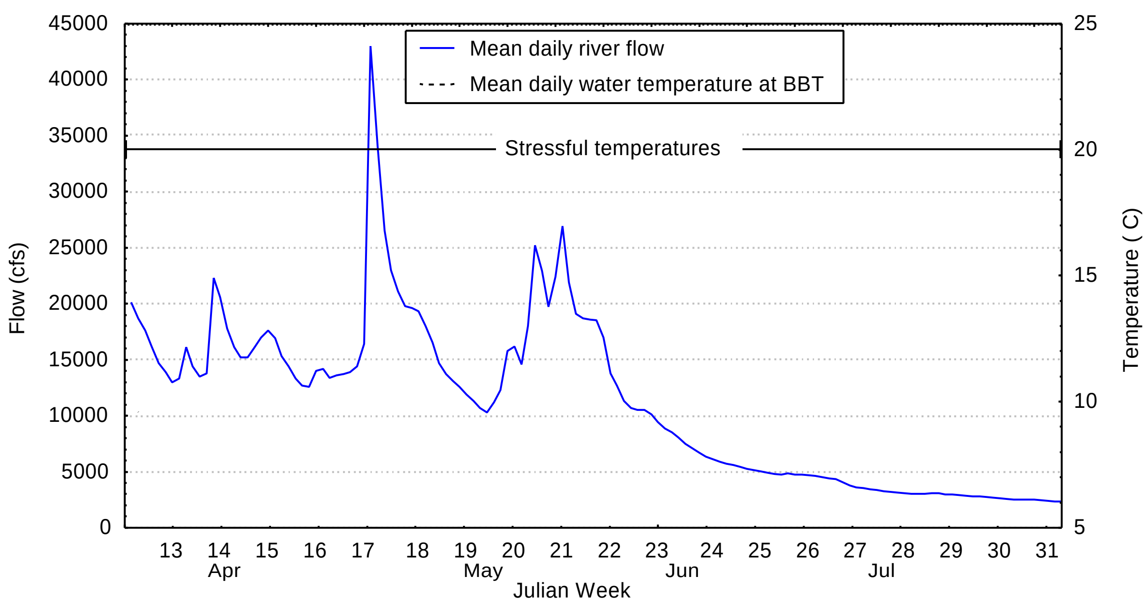


Figure 3. Mean daily Klamath River flow at Orleans and mean daily river temperature at the BBT, 1996.

Chinook

A total of 26,121 chinook were captured at the BBT during the spring monitoring period. Of these, 14,532 (56%) were attributed to natural YOY, 11,538 (44%) were hatchery YOY (including 393 Ad-clipped fish), and 50 (0.2%) were 1+ fish (Table 1). Although no Ad-clipped 1+ fish were captured, some of the 1+ fish may have been released in the fall of 1995 and overwintered in the upper Klamath River. Ad-clipped fall release chinook have been captured during the subsequent spring monitoring in some years (1989, 1990, 1991, and 1993).

Abundance Index and Hatchery Contributions

For the first 10 weeks of the trapping season (JWs 12-21) weekly index values were relatively low (1,467-9,646) and were comprised of 85% natural YOY and 15% 1+ fish of unknown origin (Table 1). By the end of JW 21 the total cumulative YOY index was only 35,276, 4.2% of the season total natural YOY index and 2.5% of the season total YOY index (Table 1). Ninety percent of the total 1+ chinook index occurred from JWs 18 to 22 (Table 1).

Natural YOY chinook emigration began to increase dramatically around June 1 (JW 22)(Figure 4). Eighty-six percent of the season total natural YOY index occurred from JWs 23 to 27, and 94% of the season total natural YOY index had occurred by the end of JW 27 (July 8) (Table 1). Natural chinook YOY represented 59% of the season total YOY index (Table 1). Thirty percent of the total YOY index occurred prior to the arrival of IGH fish at the BBT.

From June 3-5 IGH released 5.6 million fall-run fingerling chinook, 3.4% of which were Ad-clipped (Table 2). The Ad-clipped fish were from four different lots, each designated with a unique CWT. Approximately one third of the Ad-clipped fish were released each of the three days of the release period. The first Ad-clipped chinook was captured at the BBT on June 14 (JW 24); thus it is likely that some unmarked chinook captured during JW 24 were of hatchery origin. To help account for this, the hatchery percentage based on Ad-clips caught during the last four days of JW 24 (3%) was ascribed to that whole JW. Succeeding weekly hatchery contributions were 58%, 66%, 40%, 26%, 18%, and 14% respectively, for JWs 25 to 30 (Table 1). The YOY index total for the spring monitoring period was 1,413,909 of which 41% was attributed to IGH releases.

Table 1. Weekly chinook catches, abundance indices and hatchery contribution
Klamath River, 1996.

			WEEKLY CHINOOK CATCH						WEEKLY CHINOOK INDE				
	Mean												
	River				Hatchery		Natural				Hatchery		Na
Julian	Flow	Trap	1+ [a]		YOY[b]		YOY[b]	Catch	1+ [a]		YOY[b]		Y
Week	(cfs)	Days	NC[c]	Ad[d]	NC[c]	Ad[d]		Totals	NC[c]	Ad[d]	NC[c]	Ad[d]	
12	17,471	5	0	0	0	0	22	22	0	0	0	0	
13	15,200	6	1	0	0	0	13	14	152	0	0	0	
14	17,000	7	2	0	0	0	6	8	409	0	0	0	
15	14,686	7	0	0	0	0	24	24	0	0	0	0	
16	13,886	7	1	0	0	0	31	32	134	0	0	0	
17	26,271	6	0	0	0	0	8	8	0	0	0	0	
18	16,414	7	8	0	0	0	5	13	1,232	0	0	0	
19	11,471	7	25	0	0	0	11	36	2,550	0	0	0	
20	18,914	7	11	0	0	0	30	41	1,569	0	0	0	
21	20,871	7	2	0	0	0	47	49	351	0	0	0	
22	12,357	7	0	0	0	0	241	241	0	0	0	0	2
23	8,510	7	0	0	0	0	1,505	1,505	0	0	0	0	11
24	5,983	7	0	0	85	3	2,604	2,692	0	0	5,641	199	17
25	4,967	7	0	0	3,859	136	2,898	6,894	0	0	210,811	7,440	15
26	4,571	7	0	0	4,590	162	2,433	7,185	0	0	232,021	8,188	12
27	3,566	7	0	0	2,186	77	3,364	5,627	0	0	96,108	3,392	14
28	3,079	7	0	0	371	13	960	1,344	0	0	13,305	470	3
29	2,919	6	0	0	25	1	122	148	0	0	1,017	41	
30	2,600	7	0	0	28	1	182	211	0	0	926	33	
31	2,399	2	0	0	0	0	27	27	0	0	0	0	
Spring Total		130	50	0	11,145	393	14,532	26,121	6,398	0	559,829	19,762	83
Fall Total		0	0	0	0	0	0	0	0	0	0	0	
Season Total		130	50	0	11,145	393	14,532	26,121	6,398	0	559,829	19,762	83

[a]1+ = fish that have overwintered in the river.

[b]YOY = Young-of-year.

[c]NC = no adipose fin clip.

[d]Ad = adipose fin clip.

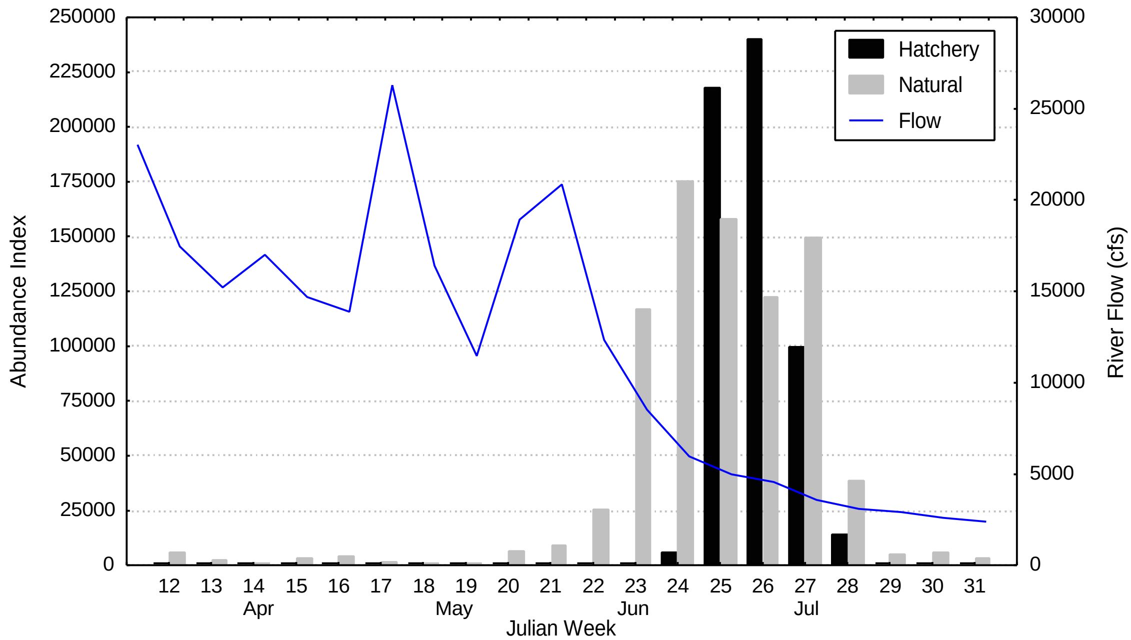


Figure 4. Mean weekly Klamath River flow at Orleans and weekly hatchery and natural chinook YOY abundance indices at the BBT, 1996.

Table 2. Iron Gate Hatchery releases, spring, 1996.

Releases							Tagging rates				
Tag code or mark	Race	Brood year	Type	Size @ Release (fish/lb)	Release site (rkm)	Release dates (1996)	No. correctly tagged	No. shed tags	No. not tagged	Production Multiplier	Total Release
6-1-2-2-2	fall chin	'95	f	84	IGH	6/03 - 6/05	49,886	1,998	1,411,538	29.3	1,463,422
6-1-2-2-3	fall chin	'95	f	84	IGH	6/03 - 6/05	59,158	2,369	1,673,892	29.3	1,735,419
6-1-2-2-4	fall chin	'95	f	84	IGH	6/03 - 6/05	28,995	1,161	820,421	29.3	850,577
6-1-2-2-5	fall chin	'95	f	84	IGH	6/03 - 6/05	53,760	2,153	1,521,154	29.3	1,577,067
Left max	coho	'94	y	10	IGH	4/11	74,250	0	0	1.0	74,250
No mark	steelhead	'95	y	8	IGH	4/26	0	0	163,000	N/A	163,000

Fork Length

A total of 50 1+ chinook with a mean (0) FL of 142 mm were captured from late March through early June (Table 3). Mean weekly FLs of 1+ chinook were not significantly different throughout the period they were captured (Table 3). Chinook YOY FL's were the smallest during the first JW of trapping (0=38 mm, s=4.78, sample size (n)=21) (Table 3, Figure 5). Although mean YOY FL increased only slightly by JW 16, the range of FLs generally increased during this period.

Table 3. Sample size (n), mean (0), minimum (min), maximum (max), and standar
weekly FLs (mm) of YOY and 1+ chinook captured at the BBT, Klamath R

	YOY					1+		
Julian week	n	0	min	max	s	n	0	min
12	21	38	32	55	4.78	0	---	--
13	13	41	35	51	5.78	1	113	11
14	6	46	37	57	7.58	2	155	14
15	23	42	34	67	9.27	0	---	--
16	31	46	34	73	9.98	1	180	18
17	8	41	35	53	5.85	0	---	--
18	5	51	39	56	7.19	8	149	13
19	10	61	37	78	12.40	25	142	10
20	24	64	38	105	20.58	11	140	11
21	45	61	43	98	14.73	2	122	11
22	163	84	44	119	18.60	0	---	--
23	210	92	45	116	12.65	0	---	--
24	210	89	47	110	9.93	0	---	--
25	210	87	74	118	6.51	0	---	--
26	210	92	69	115	8.46	0	---	--
27	210	92	68	113	7.75	0	---	--
28	206	89	67	110	7.23	0	---	--
29	50	89	60	115	11.61	0	---	--
30	171	92	65	110	6.36	0	---	--
31	24	93	75	101	6.30	0	---	--
Spring Total	1850	86	32	119	16.09	50	142	10
Fall Total	0	---	---	---	---	0	---	--
Season Total	1850	86	32	119	16.09	50	142	10

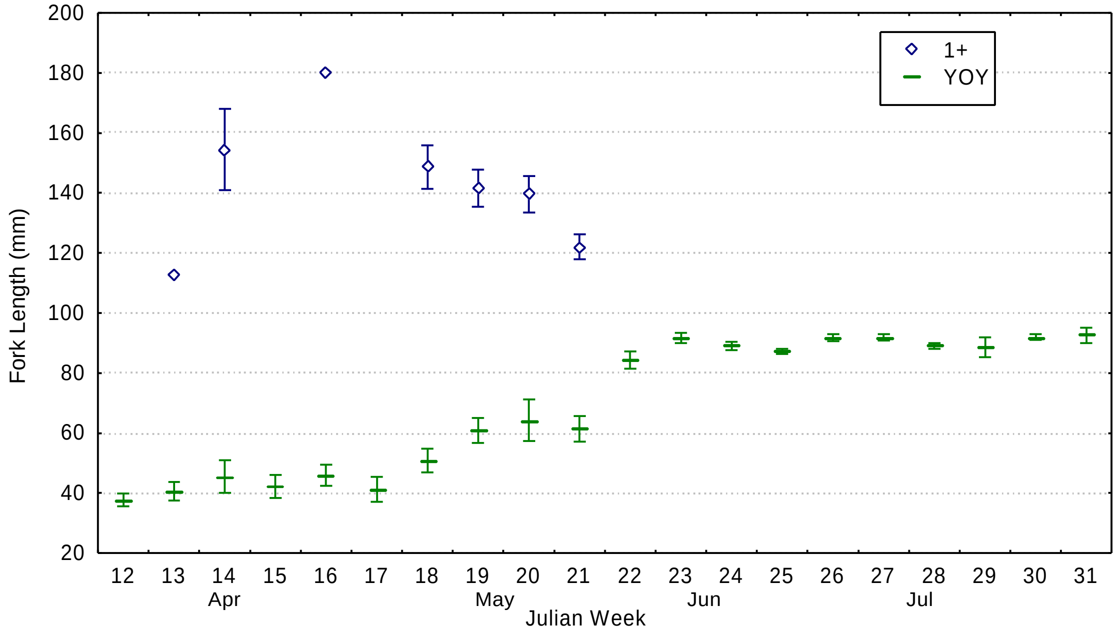


Figure 5. Chinook 1+ and YOY mean weekly FLs (+/- 2 standard errors), BBT, Klamath River, 1996.

This trend probably reflects the range of hatch dates and variable growth conditions in the river system. Smaller, newly emerged fry were continually being caught along with larger fish that emerged earlier in the season. By JW 18, mean weekly FL began to increase more rapidly and fewer newly emerged fish were present in the catch. The most dramatic increase in mean FL occurred from JW 21 (0=61 mm, s=14.73, n=45) to JW 22 (0=84 mm, s=18.60, n=163) (Figure 5). This period was about one JW prior to the arrival of IGH fingerlings at the trap.

YOY chinook catch began to significantly increase as mean FL approached the 60 to 80 mm range (Table 3, Figure 5). This pattern is similar to that found for previous trap years, and suggests that for these years, 60-80 mm was the size range at which chinook were physiologically ready to begin emigration. Some of this catch increase could also be due to chinook moving out from edge water to deeper habitats at this size range, thus becoming more vulnerable to capture.

Migration Rates

Rates at which IGH fingerlings emigrate through the upper mainstem have been calculated since 1989. Prior to 1992, excess hatchery chinook were released early in the season (April-May) as pre-smolts. This resulted in fingerlings released at a size of 122/lb to 269/lb.

These pre-smolt fish were not captured at the BBT until June. It is likely that these fish reared in the upper river following release until they reached the appropriate size and development for outmigrating. This release strategy probably increased the potential for competition between hatchery and natural fish. Beginning in 1992 IGH has made an attempt to reduce hatchery/natural competition by delaying the fingerling release time until a size of 90/lb is reached or until water temperatures of the Klamath River are a concern.

Size of chinook and degree of smoltification, along with other variables such as photoperiod, stream flows, water temperatures, and density-dependent factors, may influence juvenile salmon migratory behavior. Correlation analysis of eight years of migration data revealed that rate of migration of hatchery chinook is most influenced by fish size at the time of release (Figure 6).

Between June 3 and June 5 IGH released four lots of fall-run chinook. Each lot was marked with a unique CWT (Table 4) and represented four different spawning periods. Average fish size was not recorded for lots individually, but the average for all lots combined was 84 fish/lb. As a group, CWT fish migrated to the BBT

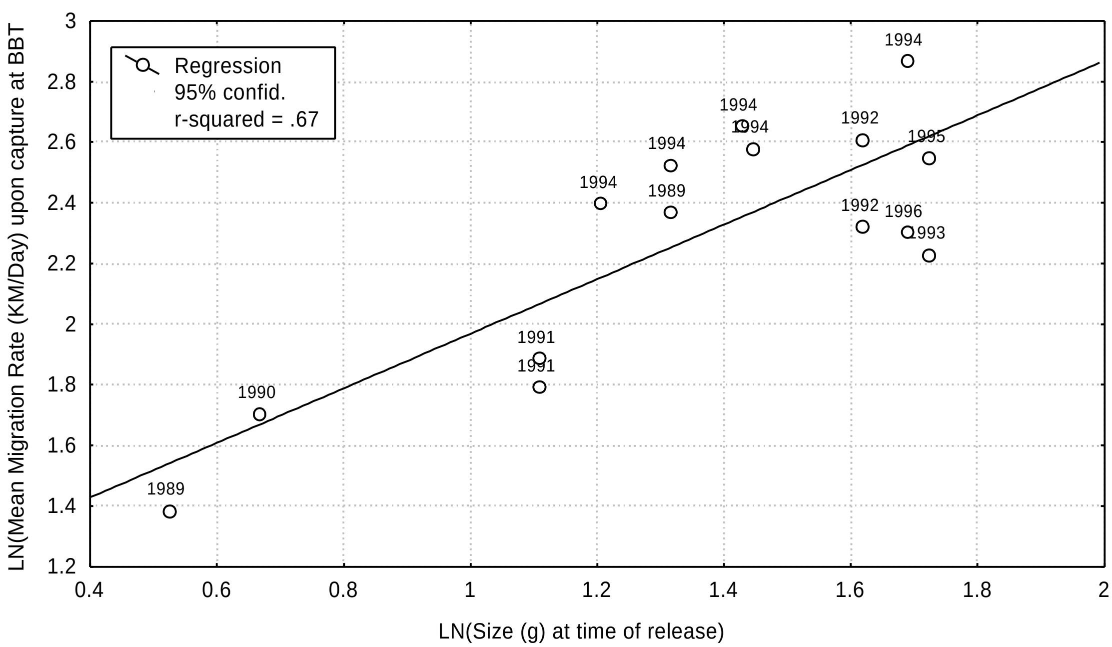


Figure 6. Relationship between mean migration rate and size at release of IGH fingerling chinook, 1989-1996.

Table 4. Iron Gate Hatchery releases and recoveries at the BBT 1996.

Releases				Recoveries at trapsite			Migration rates	
Tag code or mark	Race	Release site (rkm)	Release dates	Date of first capture	Days after release	Number Captured	Initial Rate (rkm/day)	Mean Rate (km/d)
6-1-2-2-2	fall chin	IGH	06/03- 06/05/96	06/14/96	11	79	20.45	11.59
6-1-2-2-3	fall chin	IGH	06/03- 06/05/96	06/16/96	13	66	17.31	10.89
6-1-2-2-4	fall chin	IGH	06/03- 06/05/96	06/21/96	18	43	12.50	9.04
6-1-2-2-5	fall chin	IGH	06/03- 06/05/96	06/19/96	16	43	14.06	8.29
All tags						231		9.60
Left max	coho	IGH	04/11/96	05/07/96	26	8	8.65	6.99
No mark	steelhead	IGH	04/26/96	N/A	N/A	N/A	N/A	N/A

at a mean rate of 9.6 rkm/day (Table 4). Mean migration rates appear to differ among the CWT groups (F=17.5, P<0.001) (Figure 7).

Although the lots were of slightly different ages (2-3 weeks between each lot), there was no significant difference among mean FLs of CWT fish we captured from each lot.

Coho

As in previous years, coho catches at the BBT in 1996 were very low. A total of 52 natural YOY (BY95) coho were captured from mid-March to mid-July, and one apparently natural coho smolt (BY94) was captured in mid-May, though this may have been an unmarked IGH fish because it was captured during the peak of the hatchery coho smolt migration (Table 5).

Abundance Index and Hatchery Contributions

For the first six weeks of trapping (JWs 12-17) all coho captured at the BBT were natural YOY (Table 5, Figure 8). On April 11 (JW 15), 74,250 BY94 1+ coho smolts were released from IGH, all of which were marked with a left maxillary clip (Table 2). These fish first appeared in the catch during JW 18, peaked during JW 19 (index=302), and were not captured after JW 23 (Table 5, Figure 8).

The natural YOY weekly index peaked during the same general period as the hatchery smolt weekly index (JWs 17-21) (Table 5, Figure 8). Eight of nine (89%) 1+ coho captured at BBT were of hatchery origin (Table 5). Peak YOY and 1+ coho emigration coincided with peak flow events in April and May, following IGH releases (Figure 8).

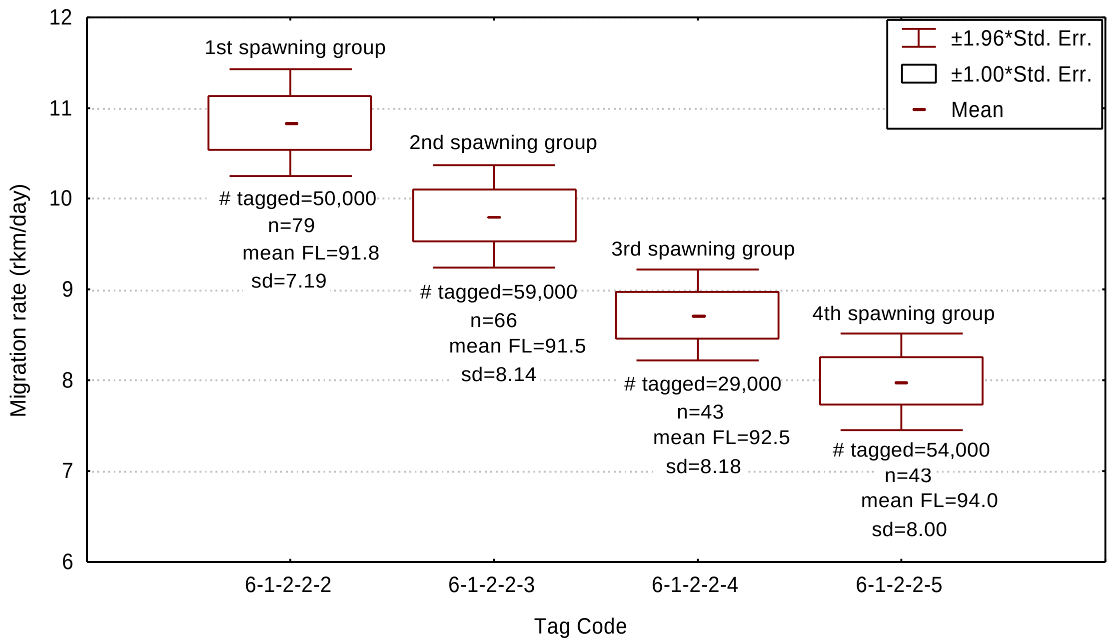


Figure 7. Mean migration rates of four CWT chinook groups released from IGH, June 3-5, 1996. All fish were reportedly released at a mean size of 84 fish/lb. Data collected at time of recovery at the BBT.

Fork Length

Captured hatchery coho 1+ smolts ranged from 151 to 198 mm ($\bar{x}$=173 mm, s=17.50, n=9). The single unmarked smolt was 152 mm and may have been a hatchery fish that escaped the marking process. Coho YOY ranged from 34 to 103 mm ($\bar{x}$=68 mm, s=18.81, n=50) (Table 6, Figure 9). In general, mean weekly FL of YOY coho increased from 35 mm on JW 13 to 83 mm on JW 29.

Migration Rates

The mean migration rate for the eight IGH coho captured at BBT was 7.0 rkm/day (Table 4). This was about two rkm/day slower than the mean migration rate of IGH fingerling chinook.

Steelhead

A total of 166 juvenile steelhead were captured in the BBT in 1996 (Table 7). Smolts composed 47% of the total catch, parr and fry composed 34% and 19% of the total catch, respectively. All but 3 steelhead (1 parr and 2 smolt) were measured to FL.

Table 5. Weekly coho catch, abundance indices, and hatchery contributions at
River, 1996.

			Coho Catch				Coho index		
	Mean								
Julian	river	Trap	Hatchery	Natural		Catch	Hatchery	Natural	
JW	flow	days	1+	1+	YOY	total	1+	1+	YOY
12	17,471	5	0	0	1	1	0	0	220
13	15,200	6	0	0	2	2	0	0	356
14	17,000	7	0	0	0	0	0	0	0
15	14,686	7	0	0	1	1	0	0	121
16	13,886	7	0	0	0	0	0	0	0
17	26,271	6	0	0	4	4	0	0	1,503
18	16,414	7	1	0	0	1	180	0	0
19	11,471	7	3	0	3	6	302	0	312
20	18,914	7	2	1	6	9	274	137	1,254
21	20,871	7	1	0	3	4	176	0	528
22	12,357	7	0	0	1	1	0	0	101
23	8,510	7	1	0	3	4	82	0	231
24	5,983	7	0	0	2	2	0	0	130
25	4,967	7	0	0	4	4	0	0	201
26	4,571	7	0	0	9	9	0	0	448
27	3,566	7	0	0	8	8	0	0	350
28	3,079	7	0	0	3	3	0	0	118
29	2,919	6	0	0	2	2	0	0	81
30	2,600	7	0	0	0	0	0	0	0
31	2,399	2	0	0	0	0	0	0	0
Spring Subtotal		130	8	1	52	61	1,014	137	5,955
Fall Subtotal		0	0	0	0	0	0	0	0
Total		130	8	1	52	61	1,014	137	5,955

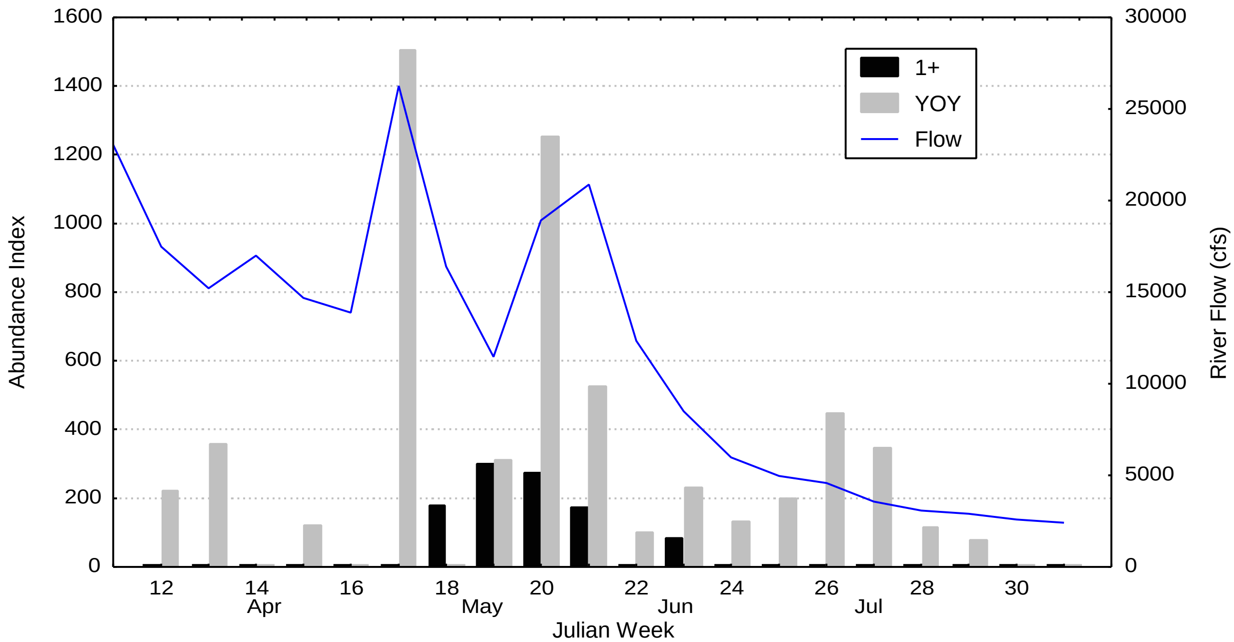


Figure 8. Mean weekly Klamath River flow at Orleans and weekly 1+ and YOY coho abundance indices at the BBT, 1996.

Since parr were not thought to represent fish actively emigrating, the parr index may only represent dispersal from less favorable rearing habitat. Some parr also showed signs of initial smoltification, thus a pre-smolt classification, may be warranted in the future.

Scale samples were collected from 70 steelhead for age analysis, 63 (90%) from smolt and 7 (10%) from parr (Table 8, Appendix B). Scales were taken only from steelhead believed to be natural fish (e.g. no eroded fins), however, it is possible that some hatchery fish were mistaken for natural.

Ages were assigned to most steelhead captured by plotting FLs by JW and comparing scale-aged fish to unscaled fish (Figure 10). For each JW, unscaled fish of similar size to scale-aged fish were assigned the same age as the scale-aged fish (Appendices C and D). Fork lengths of scale-aged 1+ and 2+ fish greater than 140 mm showed considerable overlap (Figure 10), thus ages were not assigned to unscaled fish over 140 mm. Using this method, all 56 parr were assigned an age of 1+ (7 scale-aged) (Appendix C). Of the 63 scale-aged smolt, 51 were assigned an age of 2+, and 12 were assigned an age of 1+ (Appendix D). Two of the 11 unscaled smolts were less than 100 mm FL and were most likely 0+ fish (Figure 10). The other

Table 6. Sample size (n), mean (0), minimum (min), maximum (max), and standa
weekly FLs (mm) of YOY and 1+ coho salmon captured at the BBT, Klama

	YOY					Smolt (1		
Julian week	n	0	min	max	s	n	0	min
12	1	37	37	37	0	0	---	--
13	2	35	34	36	1.41	0	---	--
14	0	---	---	---	---	0	---	--
15	1	45	45	45	0.00	0	---	--
16	0	---	---	---	---	0	---	--
17	4	44	40	48	4.35	0	---	--
18	0	---	---	---	---	1	164	16
19	3	59	54	67	7.23	3	180	16
20	6	65	57	72	5.01	3	169	15
21	3	63	50	73	11.68	1	151	15
22	1	63	63	63	0.00	0	---	--
23	3	83	68	98	15.00	1	180	18
24	2	78	73	82	6.36	0	---	--
25	4	65	52	75	9.97	0	---	--
26	8	79	35	103	24.31	0	---	--
27	7	85	72	93	6.85	0	---	--
28	3	63	40	80	20.82	0	---	--
29	2	83	77	88	7.78	0	---	--
30	0	---	---	---	---	0	---	--
31	0	---	---	---	---	0	---	--
Spring Total	50	68	34	103	18.81	9	171	15
Fall Total	0	0	0	0	0.00	0	0	[illegible]
Season Total	50	68	34	103	18.81	9	171	15

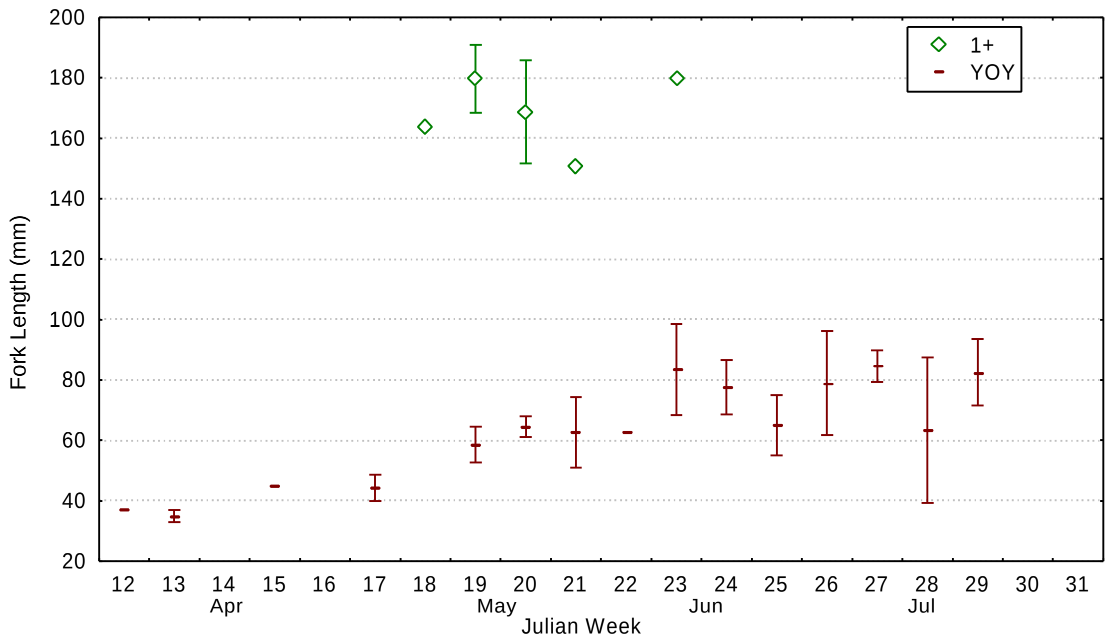


Figure 9. Coho 1+ and YOY mean weekly FLs (+/- 2 standard errors) by JW, BBT, Klamath River, 1996.

nine smolts were greater than 140 mm FL and were not aged (Appendix D). All 32 fish classified as fry were considered to be 0+ (YOY) (Figure 10, Appendix C).

Scale-aged 1+ parr had a mean FL of 98.0 mm (range=87-119, s=10.94). Scale-aged 1+ smolts had a mean FL of 171.5 mm (range=150-185 mm, s=12.60). Scale-aged 2+ smolts had a mean FL of 198 mm (FL=148-245 mm, s=20.97) (Table 8).

Abundance Index and Hatchery Contributions

The total (fry, parr, smolt) steelhead abundance index for 1996 was 20,906 (Table 7). Of this, 52% (10,735) was attributed to smolts, 40% (8,459) was attributed to parr, and 8% (1,619) was attributed to fry (Table 7).

On April 26 IGH released 163,000 unmarked 1+ steelhead smolts (Table 2). Because these fish lacked hatchery marks, we did not attempt to distinguish hatchery from natural fish at the BBT (other than for scale sampling purposes). However, because the steelhead smolt catch increased significantly about two weeks after the hatchery release and dropped again five weeks later it is suspected that at least some of the smolts captured during this period were of hatchery origin. During this five-JW period (JWs 19-23), 79% of the total

Table 7. Weekly steelhead catch and abundance indices by development stage at the BBT, Klamath River, 1996.

Julian Week	Mean River Flow	Trap Days	STEELHEAD CATCH Fry	Parr	Smolt	Catch Total	STEELHEAD INDEX Fry	Parr	Smolt	Index Totals
12	17,471	5	0	2	1	3	0	519	274	794
13	15,200	6	0	4	0	4	0	614	0	614
14	17,000	7	1	3	0	4	260	597	0	857
15	14,686	7	1	2	0	3	145	277	0	422
16	13,886	7	0	10	1	11	0	1,344	134	1,479
17	26,271	6	0	7	4	11	0	1,965	970	2,935
18	16,414	7	1	3	3	7	118	537	481	1,136
19	11,471	7	0	12	17	29	0	1,214	1,717	2,931
20	18,914	7	0	4	14	18	0	705	2,781	3,486
21	20,871	7	0	1	11	12	0	223	2,305	2,529
22	12,357	7	0	0	6	7	0	0	768	862
23	8,510	7	0	1	12	13	0	83	936	1,019
24	5,983	7	1	0	2	3	65	0	130	195
25	4,967	7	1	0	1	2	49	0	53	103
26	4,571	7	0	0	1	1	0	0	49	49
27	3,566	7	2	0	1	3	83	0	45	128
28	3,079	7	9	3	1	13	328	122	51	501
29	2,919	6	9	3	1	13	353	118	39	509
30	2,600	7	7	1	0	8	218	30	0	247
31	2,399	2	0	1	0	1	0	111	0	111
Spring Subtotal		130	32	57	76	166	1,619	8,459	10,735	20,906
Fall Subtotal		0	0	0	0	0	0	0	0	0
Total		130	32	57	76	166	1,619	8,459	10,735	20,906

steelhead smolt index occurred (Table 7). Sixty five percent of total steelhead fry index occurred during July, the last month of trapping (Table 7). Ninety five percent of the total steelhead parr index occurred during the first 10 weeks of trapping. Parr and smolt abundance at the BBT peaked during high flow events from JWs 16 to 23 (Figure 11).

Fork Length

Mean weekly FLs of fry, parr and smolt, respectively, did not change significantly throughout the 1996 trapping season (Table 9). This may reflect the wide range in the dates of emergence and differences in growth due to variable rearing conditions in the system. Newly emerged steelhead fry were present in the catch from early April through most of July in 1996 (Table 9).

Migration Rates

Because hatchery steelhead were not marked in 1996, we were unable to distinguish hatchery from wild fish. Thus, migration rates could not be calculated for steelhead in 1996 (Figure 11, Table 9).

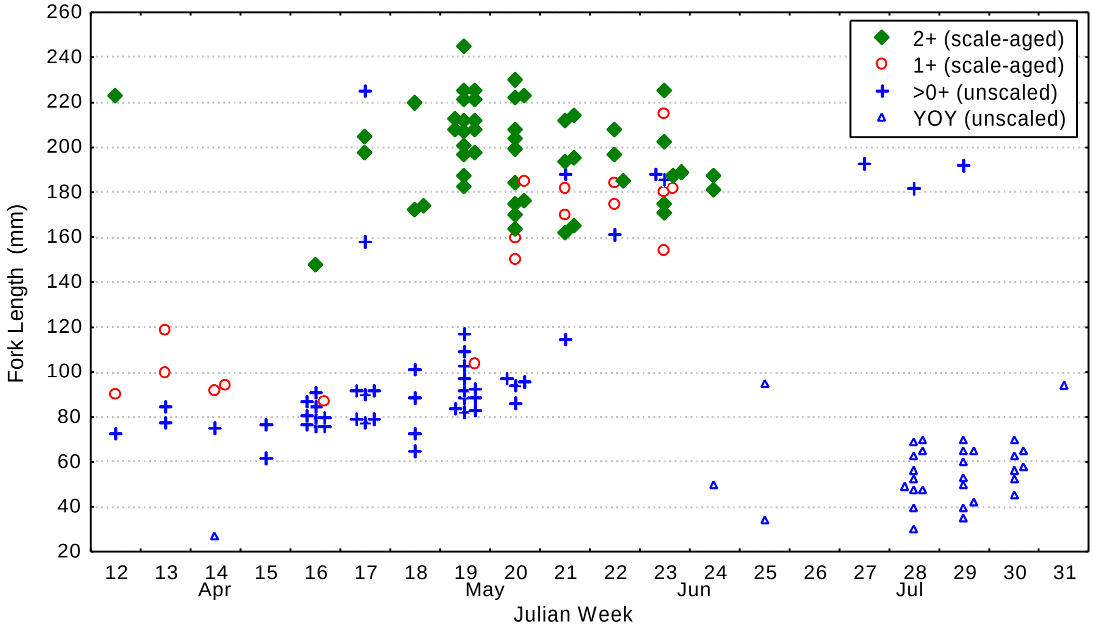


Figure 10. Fork lengths of all scale-aged and unscaled steelhead captured at the BBT, Klamath River, 1996.

Table 8. Development stage, age, and length of scale-aged steelhead captured at the BBT, Klamath River, 1996.

Aging summary				Length (mm)		
Development stage	Age	No. of fish	% of development stage	Range	Average	s
Parr	1+	7	100	87-119	98.0	10.94
Smolt	1+	11	17.0	150-185	171.5	12.60
Smolt	2+	52	83.0	148-245	198.5	20.97
Total		70	--------	87-245	184.2	35.94

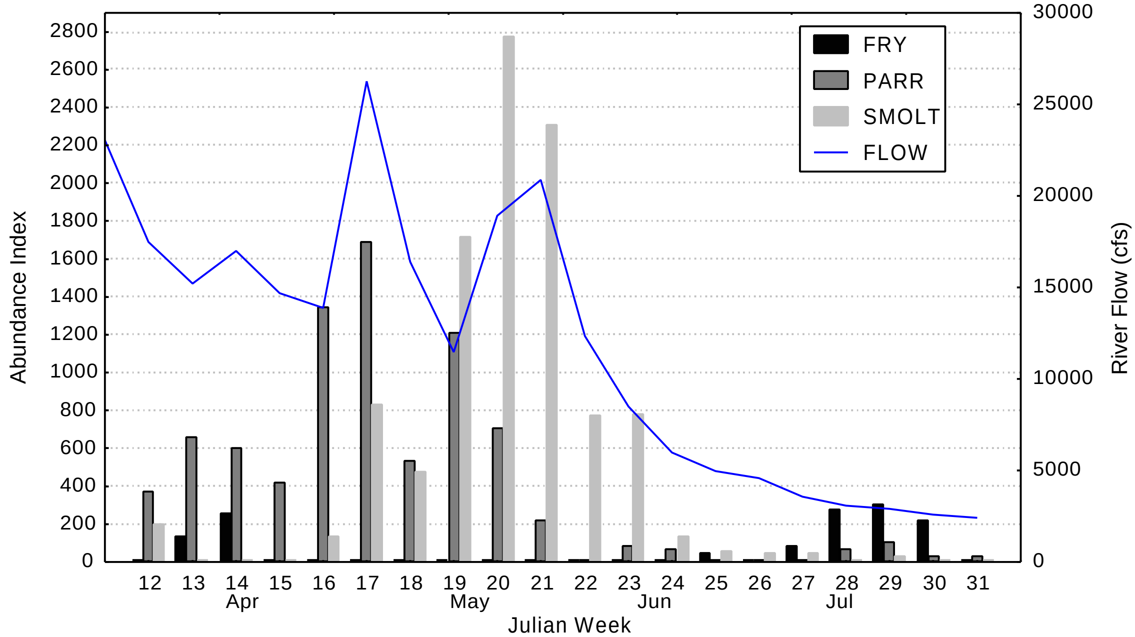


Figure 11. Mean weekly Klamath River flow at Orleans and weekly steelhead abundance indices at the BBT, 1996.

Table 9. Sample size (n), mean (0), minimum (min), maximum (max), and standar weekly FLs (mm) of fry, parr and smolt steelhead captured at the BB 1996.

Julian week	Fry n	Fry 0	Fry min	Fry max	Fry s	Parr n	Parr 0	Parr min	Parr max	Parr s	n	0
12	0	---	---	---	---	2	82	73	90	12.02	1	223
13	0	---	---	---	---	4	96	78	119	18.16	0	---
14	1	27	27	27	0.00	3	87	75	94	10.44	0	---
15	1	62	62	62	0.00	1	77	77	77	0.00	0	---
16	0	---	---	---	---	10	82	76	91	5.23	1	148
17	0	---	---	---	---	6	85	78	92	6.99	4	197
18	1	65	65	65	0.00	3	88	73	101	14.05	3	189
19	0	---	---	---	---	12	95	82	117	11.07	17	209
20	0	---	---	---	---	4	93	86	97	4.99	14	189
21	0	---	---	---	---	1	115	115	115	0.00	10	185
22	0	---	---	---	---	0	---	---	---	---	6	185
23	0	---	---	---	---	0	---	---	---	---	12	188
24	1	50	50	50	0.00	0	---	---	---	---	2	184
25	1	34	34	34	0.00	0	---	---	---	---	1	95
26	0	---	---	---	---	0	---	---	---	---	0	---
27	0	---	---	---	---	0	---	---	---	---	1	193
28	9	50	30	65	10.86	2	70	69	70	0.71	1	182
29	8	51	35	65	11.56	1	70	70	70	0.00	0	---
30	6	57	45	65	7.34	1	70	70	70	0.00	0	---
31	0	---	---	---	---	1	94	94	94	0.00	0	---
Spring Total	28	51	27	65	11.41	51	88	69	119	12.11	73	191
Fall Total	0	---	---	---	---	0	---	---	---	---	0	---
Season Total	28	51	27	65	11.41	51	88	69	119	12.11	73	191

Mainstem Trinity River (below Willow Creek)

Because TRH conducts both spring (fingerling) and fall (yearling) releases, trapping at WCT was divided into spring and fall monitoring periods. Spring monitoring began on March 15 (JW 11) and ended on September 30 (JW 39), 1996. Trapping was not conducted for a total of eight days during the spring due to technical difficulties. Thus a total of 191 (96%) of 199 days possible were trapped during the spring monitoring period. River temperatures began to reach "stressful" levels (>20.0°C, Bell 1973) by late July (JW 30) (Figure 12). TRH released both spring-run and fall-run chinook fingerlings in early June.

Fall monitoring began on October 1 (JW 40), the first day of TRH's seven-day volitional chinook yearling release. Fall trapping ceased on December 3 (JW 49) due to low catch numbers and the beginning of winter storms. During this period the trap operated 59 (94%) of 63 days possible.

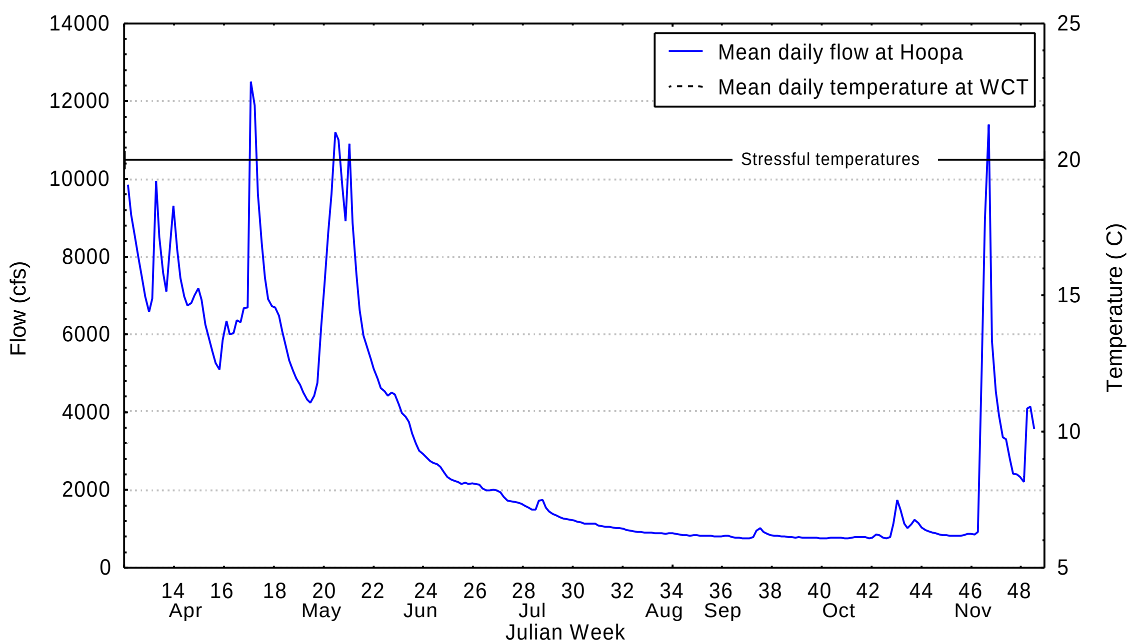


Figure 12. Mean daily Trinity River flow at Hoopa and mean daily water temperature at the WCT, 1996.

Chinook

Spring Catch

Just over 24,000 chinook were captured in the WCT during the spring monitoring period (Table 10). Initial catches consisted primarily of natural fry and occasional 1+ chinook (Table 10).

Trinity River Hatchery conducted a volitional release of fingerling chinook from June 3 to June 13, 1996. The release consisted of 3,095,538 fish (34% spring-run, 66% fall-run), 13% of which were Ad-clipped (Table 11). Representative Ad-clipped fish were captured beginning June 10 (Table 12). Twenty seven percent of the spring catch was attributed to TRH fingerling releases and 73% to natural stocks. Although the TRH fingerling release consisted of 34% spring-run and 66% fall-run fish, recovery of TRH fish at the trap consisted of 45% spring-run and 55% fall-run.

Age one-plus chinook accounted for only one tenth of one percent of the total springtime chinook catch. One-percent (200) of the natural chinook captured at the WCT represented fish tagged by CDFG during their Trinity River Project (TRP) natural chinook tagging program (Table 11). These 200 fish represent just two tenths of one percent of the 123,610 chinook tagged in 1996 by the TRP.

Fall Catch

A total of 11,324 chinook were captured in the WCT during the fall monitoring period (Table 10). Trinity River Hatchery conducted a volitional release of yearling chinook from October 1 to October 7, 1996. The release consisted of 1,315,518 fish (31% spring-run, 69% fall-run), 16% of which were Ad-clipped (Table 11). Representative Ad-clipped fish were captured beginning October 4 (Table 12). Eighty two percent of the fall catch was attributed to TRH releases and 18% to natural stocks. Recovery of TRH chinook at the trap consisted of 58% fall-release fall-run, 39% fall-release spring-run, and 3% spring-release fall-run fish. Trinity River Hatchery spring-run and fall-run fish released in the fall were captured in exactly the same proportion as they were released. Seven of the natural chinook captured during the fall monitoring period had been tagged by the TRP (Table 10).

Table 10. Weekly chinook catches, abundance indices and hatchery contribution
Trinity River, 1996.

			CHINOOK CATCH							CHINOOK INDEX				
	Mean River Flow		1+ [a]		Hatchery YOY[b]		Natural YOY[b]		Catch	1+ [a]		Hatchery YOY[b]		Natura YOY[b]
Julian Week	(cfs)	Trap Days	NC[c]	Ad[d]	NC[c]	Ad[d]	NC[c]	Ad[d]	Totals	NC[c]	Ad[d]	NC[c]	Ad[d]	NC[c]
12	8,640	7	6	0	0	0	293	0	299	650	0	0	0	29,796
13	7,856	7	1	0	0	0	314	0	315	84	0	0	0	27,919
14	7,497	7	1	0	0	0	206	0	207	79	0	0	0	17,989
15	6,024	7	0	0	0	0	55	0	55	0	0	0	0	4,254
16	6,229	7	0	0	0	0	67	0	67	0	0	0	0	5,057
17	9,063	7	1	0	0	0	76	5	82	97	0	0	0	7,084
18	6,009	6	1	0	0	0	38	0	39	97	0	0	0	3,524
19	4,549	7	4	0	0	0	28	1	33	230	0	0	0	1,584
20	9,103	7	4	0	0	0	19	0	23	470	0	0	0	2,339
21	7,791	7	13	0	0	0	123	3	139	1,297	0	0	0	10,374
22	4,779	7	0	0	0	0	137	6	143	0	0	0	0	7,556
23	3,844	7	0	0	34	8	526	17	584	0	0	1,527	348	26,580
24	2,784	7	0	0	923	190	1,499	21	2,637	0	0	37,688	7,774	61,503
25	2,260	7	0	0	602	100	908	4	1,615	0	0	22,334	3,734	34,097
26	2,089	7	0	0	434	67	549	6	1,057	0	0	15,195	2,340	19,383
27	1,843	6	0	0	284	40	702	7	1,036	0	0	8,851	1,251	22,372
28	1,597	7	0	0	575	78	1,445	25	2,125	0	0	15,928	2,160	40,362
29	1,429	7	0	0	671	93	1,137	9	1,911	0	0	16,542	2,306	27,609
30	1,187	4	0	0	262	36	1,298	11	1,606	0	0	8,281	1,139	41,345
31	1,080	7	0	0	325	44	1,122	12	1,504	0	0	5,130	687	17,424
32	974	7	0	0	476	63	1,931	30	2,505	0	0	5,892	778	23,846
33	896	7	0	0	327	41	1,297	8	1,673	0	0	3,715	468	14,849
34	863	7	0	0	320	41	1,346	12	1,723	0	0	3,122	402	13,282
35	822	7	0	0	152	19	931	13	1,117	0	0	1,466	179	9,038
36	800	7	0	0	98	13	774	8	893	0	0	943	126	7,486
37	827	7	0	0	72	9	349	1	431	0	0	671	84	3,259
38	837	7	0	0	21	3	139	1	164	0	0	207	29	1,314
39	777	7	0	0	0	0	86	0	86	0	0	0	0	790
40	765	7	0	0	3,647	740	607	2	5,003	0	0	34,078	6,839	5,343
41	772	7	0	0	2,927	510	315	0	3,779	0	0	26,707	4,648	2,907
42	795	7	0	0	799	163	466	4	1,445	0	0	7,691	1,570	4,591
43	1,156	6	0	0	382	58	181	0	621	0	0	4,690	730	2,205
44	1,049	7	0	0	86	14	171	0	271	0	0	1,279	213	2,502
45	837	7	0	0	41	6	110	1	159	0	0	471	70	1,261
46	1,471	7	0	0	6	1	38	0	45	0	0	73	12	625
47	5,901	4	0	0	0	0	1	0	1	0	0	0	0	92
48	2,914	7	0	0	0	0	0	0	0	0	0	0	0	0
Spring Subtotal		191	31	0	5,576	845	17,392	200	24,069	3,005	0	147,493	23,805	482,012
Fall Subtotal		59	0	0	7,888	1,492	1,889	7	11,324	0	0	74,988	14,083	19,525
Total		250	31	0	13,464	2,337	19,281	207	35,393	3,005	0	222,481	37,889	501,537

[a]1+ = fish that have overwintered in the river.
[b]YOY = Young-of-Year.
[c]NC = no adipose fin clip.
[d]Ad = adipose fin clip.
[e] No tags = adipose fin clipped fish in which r

Table 11. Trinity River Hatchery and Trinity River Project's Natural Stocks Assessment Program releases, 1996.

Releases							Tagging rates				
Tag code or mark	Race	Brood year	Type	Size at release fish/lb	Release site (rkm)	Release dates (1996)	No. correctly tagged	No. shed tags	No. not tagged	Production multiplier	Total release
6-1-8-1-15[a]	chinook	'95	f	N/A	131.0	4/09-4/23	23,248	N/A	N/A	N/A	23,248
6-1-8-2-1[a]	chinook	'95	f	N/A	131.0	4/15-4/24	27,057	N/A	N/A	N/A	27,057
6-1-8-2-2[a]	chinook	'95	f	N/A	131.0	4/22-4/30	29,007	N/A	N/A	N/A	29,007
6-1-8-2-6[a]	chinook	'95	f	N/A	131.0	4/30-5/09	27,945	N/A	N/A	N/A	27,945
6-1-8-2-7[a]	chinook	'95	f	N/A	131.0	5/09-5/11	16,353	N/A	N/A	N/A	16,353
6-52-23[b]	spr chin	'95	f	54-65	TRH	6/03-6/13	196,211	1,974	858,892	5.4	1,057,077
6-52-24[b]	fall chin	'95	f	71-89	TRH	6/03-6/13	216,051	702	1,821,708	9.4	2,038,461
6-52-25[b]	spr chin	'95	y	12	TRH	10/01-10/07	101,934	204	303,092	4.0	405,230
6-52-26[b]	fall chin	'95	y	16-17	TRH	10/01-10/07	110,327	666	799,295	8.3	910,288
Right max[b]	coho	'94	y	9.7	TRH	04/02	71,675	0	0	1.0	71,675
No mark[b]	steelhead	'95	y	5.2	TRH	3/18-3/31	0	0	312,998	N/A	312,998
No mark[b]	steelhead	'95	y	7.7	TRH	3/18-3/31	0	0	301,840	N/A	301,840

[a] – Trinity River Project wild fish release. f = fingerling release
[b] – Trinity River Hatchery release y = yearling release

Table 12. Trinity River Hatchery and CDFGs Trinity River Project releases and recoveries at the WCT, 1996.

Releases				Recoveries at trapsite			Migration rates	
Tag code or mark	Race	Release site (rkm)	Release dates	Date of first capture	Days after release	No. Captured	Initial Rate (rkm/day)	Mean Rate[c] (km/d)
6-1-8-1-15[a]	chinook	131.0	04/09-04/23/96	06/01/96	53	38	N/A	N/A
6-1-8-2-1[a]	chinook	131.0	04/15-04/24/96	06/12/96	58	22	N/A	N/A
6-1-8-2-2[a]	chinook	131.0	04/22-04/30/96	06/05/96	44	52	N/A	N/A
6-1-8-2-6[a]	chinook	131.0	04/30-05/09/96	06/04/96	35	65	N/A	N/A
6-1-8-2-7[a]	chinook	131.0	05/09-05/11/96	06/13/96	35	30	N/A	N/A
6-52-23[b]	spr chin	TRH	06/03-06/13/96	06/10/96	7	283	N/A	N/A
6-52-24[b]	fall chin	TRH	06/03-06/13/96	06/11/96	8	432	N/A	N/A
6-52-25[b]	spr chin	TRH	10/01-10/07/96	10/04/96	3	90	N/A	N/A
6-52-26[b]	spr chin	TRH	10/01-10/07/96	10/04/96	3	199	N/A	N/A
Right max[b]	coho	TRH	04/02/96	04/06/96	4	65	36.0	3.1
No mark[b]	steelhead	TRH	03/18-03/31/96	N/A	N/A	N/A	N/A	N/A
No mark[b]	steelhead	TRH	03/18-03/31/96	N/A	N/A	N/A	N/A	N/A

[a] – Trinity River Project wild fish release.
[b] – Trinity River Hatchery release.
[c] – Mean migration rate calculated only for the 10-90th percentile.

Abundance Index and Hatchery Contributions

Spring

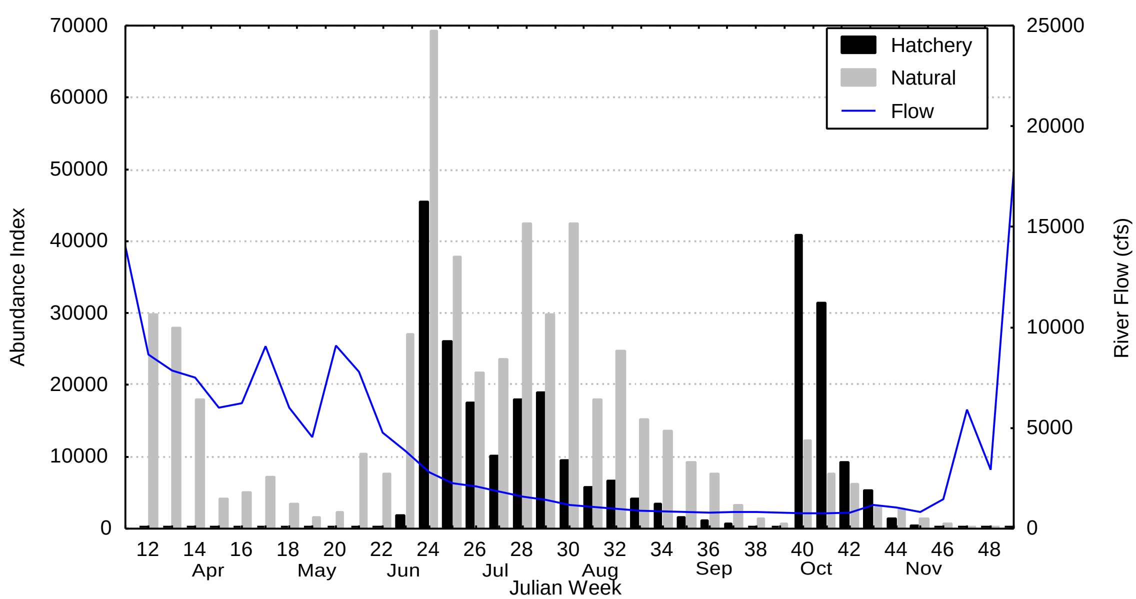
The chinook YOY weekly index started off moderately high (18,000-30,000) during the first three weeks of trapping (JWs 12-14) then decreased to relatively low levels (1,500-7,000) until a few weeks before the arrival of TRH fish (Table 10, Figure 13). Upon the arrival of TRH fish during JW 23, the natural YOY index increased dramatically (>60,000) then gradually decreased to about 800 by the end of the spring monitoring period (Table 10, Figure 13). During the entire spring sampling season the weekly natural chinook index was higher than the corresponding weekly hatchery chinook index (Figure 13). Age one-plus chinook made a very small contribution to the total natural chinook spring index through the first 12 weeks of trapping (Table 10).

Hatchery Ad-clipped fish first appeared in the catch on June 10 (JW 23), and the highest weekly hatchery index of the year (37,688) occurred on JW 24 (Table 10, Figure 13). The weekly hatchery index steadily declined for the remainder of the spring sampling period. Forty three percent of the spring hatchery index was obtained within the first two weeks of their appearance in the catch. No marked

Figure 13. Mean weekly Trinity River flow and weekly hatchery and natural chinook YOY abundance indices at the WCT, 1996.

hatchery fish were captured during the last JW of the spring monitoring period (JW 39)(Table 10).

Fall



As in the spring, the natural chinook index increased with the arrival of hatchery fish in the fall (Table 10, Figure 13).

However, unlike the spring monitoring period, the natural chinook index was less than that of the hatchery chinook during the first four weeks of fall monitoring (Table 10, Figure 13). For those first four weeks natural fish composed only 12%, 8%, 33%, and 27% of the total weekly indices, respectively. Low percentages of natural fish have been observed during all previous fall monitoring. From JWs 44 to 46, natural fish composed 63%, 70%, and 88% of the weekly indices, respectively, although this was due more to decline in hatchery fish than to any increase in natural fish (Table 10). The concomitant increase in natural and hatchery fish during both spring and fall monitoring periods has been noted for other years and may indicate that hatchery fish displace natural chinook downstream (U.S. Fish and Wildlife Service, 1991, 1992, 1994, 1998).

The Ad-clip rate of captured fish increased dramatically the three days following the first arrival of fall-released fish (Figure 13). Thirty eight percent of the total fall hatchery index was obtained during those first three days. Over 80% of the fall hatchery index had been obtained by the end of the second JW of fall monitoring, and 100% had been obtained by the seventh JW of fall monitoring (Table 10).

Fork Length

A total of 5,446 (15.4% of the catch) chinook were measured during the entire 1996 trapping season. Fork lengths of YOY generally increased throughout the trapping period, ranging from 28 to 174 mm (Table 13, Figure 14). Fork lengths of 1+ chinook captured in the spring decreased overall, ranging from 93 to 164 mm (0=117 mm s=14.82, n=30)(Figure 14).

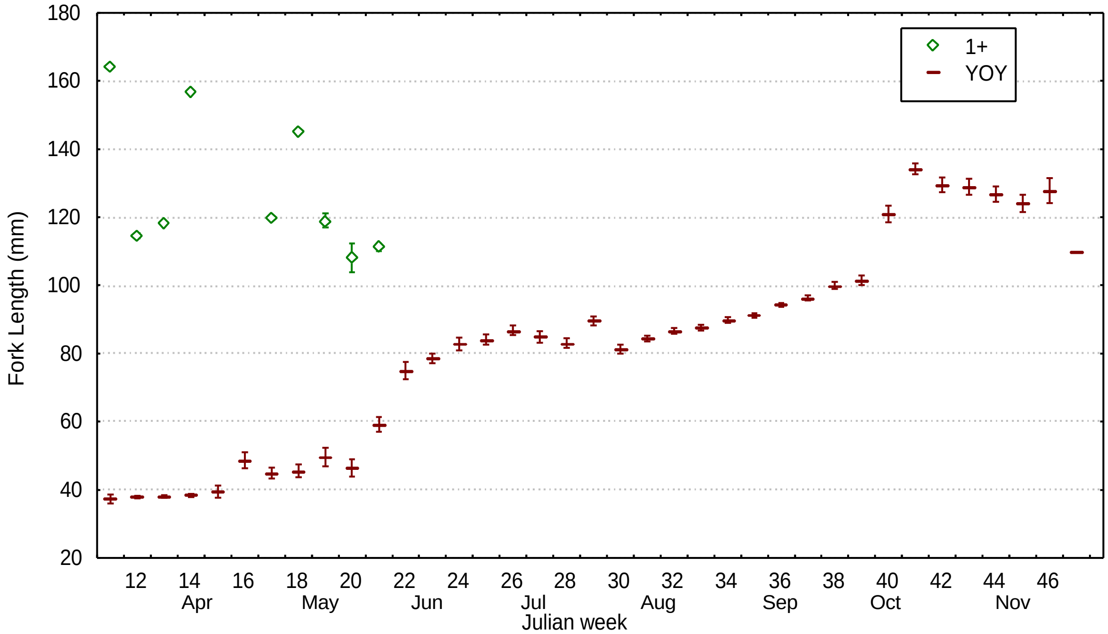
Early season catches of chinook consisted of YOY <40 mm FL and occasional 1+ fish >100 mm (Table 12, Figure 13). Young-of-year smolt began to appear in the catch by JW 16 at a size of about 70 mm (Table 13, Figure 14). Hatchery fingerlings began arriving during JW 23 at an average size of about 80 mm (Table 13, Figure 14). Because some hatchery fingerlings were as large as small 1+ fish, we did not attempt to separate these two life stages after JW 23.

Table 13. Sample size (n), mean (0), minimum (min), maximum (max), and standard deviation (s) of weekly FLs (mm) of YOY and 1+ chinook captured at the WCT, Trinity River, 1996.

	YOY					1+				
Julian week	n	0	min	max	s	n	0	min	max	s
11	30	37	28	46	3.65	1	164	164	164	0.00
12	174	38	31	50	2.74	4	114	109	120	4.65

13	190	38	32	54	2.62	1	118	118	118	0.00
14	168	38	33	53	3.05	1	157	157	157	0.00
15	55	39	31	64	6.40	0	----	----	----	----
16	67	49	35	74	9.79	0	----	----	----	----
17	81	45	29	67	7.54	1	120	120	120	0.00
18	38	46	36	59	5.82	1	145	145	145	0.00
19	29	50	36	68	7.92	4	119	114	125	5.83
20	19	46	36	55	6.18	4	108	93	116	10.23
21	123	59	41	94	12.09	13	111	103	125	6.32
22	127	75	44	103	14.29	0	----	----	----	----
23	211	79	45	118	10.71	0	----	----	----	----
24	210	83	46	111	13.63	0	----	----	----	----
25	210	84	50	110	11.28	0	----	----	----	----
26	210	87	47	109	10.01	0	----	----	----	----
27	150	85	56	111	10.55	0	----	----	----	----
28	210	83	55	105	9.92	0	----	----	----	----
29	180	90	69	110	8.45	0	----	----	----	----
30	120	81	67	103	7.54	0	----	----	----	----
31	210	84	67	112	6.49	0	----	----	----	----
32	210	87	71	109	6.04	0	----	----	----	----
33	210	88	76	112	5.91	0	----	----	----	----
34	210	90	75	128	6.00	0	----	----	----	----
35	210	91	81	106	4.46	0	----	----	----	----
36	210	94	83	108	4.37	0	----	----	----	----
37	187	96	84	113	5.59	0	----	----	----	----
38	130	100	88	130	6.09	0	----	----	----	----
39	80	101	86	116	6.50	0	----	----	----	----
40	198	121	92	161	17.40	0	----	----	----	----
41	210	134	95	165	11.94	0	----	----	----	----
42	210	130	93	170	15.58	0	----	----	----	----
43	167	129	83	174	15.53	0	----	----	----	----
44	184	127	82	162	15.24	0	----	----	----	----
45	142	124	95	174	15.53	0	----	----	----	----
46	45	128	100	152	12.17	0	----	----	----	----
47	1	110	110	110	0.00	0	----	----	----	----
48	0	----	----	----	----	0	----	----	----	----
Spring Total	4259	77	28	130	21.32	30	117	93	164	14.82
Fall Total	1157	128	82	174	15.69	0	----	----	----	----
Season Total	5416	88	28	174	28.97	30	117	93	164	14.82

Figure 14. Chinook 1+ and YOY mean weekly FLs (+/- 2 standard errors), WCT, Trinity River, 1996.



Mean weekly FL of YOY chinook gradually increased to 101 mm (s=6.50, n=80) by JW 39 (Table 13). Commencing with the arrival of fall released yearlings during JW 40, average FL increased significantly (0=121 mm, s=17.40, n=198)(Table 13, Figure 14). The following JW showed another jump in mean FL to 134 mm (s=11.94, n=210). For the remainder of the season mean weekly FL remained virtually unchanged, reflecting the influence of hatchery yearlings in catches. Smaller sized fish (92 to 110 mm FL) were also captured during fall monitoring and may represent late emigrating fish of natural origin (Table 13, Figure 14).

Migration Rates

As in past years, we have calculated migration rates only for CWT groups that are released over a time period of three days or less. All 1996 TRH release groups were volitional, extending from seven to fourteen days (Table 11). Natural chinook tagged by TRP were captured, tagged, and released over a prolonged time period (Table 11). Also, TRP fish were not of typical migrating size when they were released. Therefore, we do not present migration rates for any 1996 Trinity River chinook.

Coho

A total of 150 coho were captured at WCT during the 1996 sampling season (Table 14). Of this total, 54% of the catch consisted of natural YOY fry and parr, 43% were hatchery 1+ smolts, and 3% were natural 1+ smolts (Table 14). For the first two weeks of trapping (JWs 12-13) catches consisted entirely of natural fry and parr.

On April 2 (JW 14) TRH released 71,675 1+ coho smolts (BY 1994) (Table 11). All TRH coho were marked with a right maxillary clip (Table 11). Hatchery coho began appearing in the catch on April 6 (JW 14) (Table 12). However, catches of hatchery coho were low until JW 20. The majority (83%) of the 65 hatchery coho captured during the season were obtained during JWs 20 and 21 (Table 14).

Abundance Index and Hatchery Contributions

The weekly coho indices were less than 600 for the entire 1996 sampling season with the exception of JWs 20 and 21 when the indices were 4,368 and 2,133, respectively (Table 14). Hatchery fish made up 88% and 100% of the catch during these two weeks, respectively (Table 14). Spring and fall peak abundance's corresponded with increases in flow (Figure 15).

Fork Length

Fork lengths of 1+ coho smolts ranged from 124 to 197 mm (Table 15, Figure 16). Mean weekly FL during peak smolt emigration in May (JW 20) was 162 mm (s=11.67, n=33) (Table 15). Based on previous year's observations, natural smolts are generally smaller than their hatchery counterparts. However, the FLs of the four natural smolts captured in 1996 were similar to those of the hatchery smolts ($\bar{x}$=156 mm, range = 124-180, s=28.47). It is possible that some of these smolts were actually hatchery fish that escaped the marking process.

Fork lengths of coho YOY ranged from 31 to 110 mm (Table 15, Figure 16). The smallest fish were captured early in the season and mean weekly FL slowly increased from 36 mm (n=4, s=3.11) on JW 12 to 103 mm (n=1) on JW 39 (Table 15, Figure 16). As with previous years, catches of YOY during the fall monitoring period primarily occurred in November (JWs 47-48) (Table 15).

Migration rates

The first TRH coho was captured on April 6, just four days after its release from the hatchery. This fish traveled an average of 36.0

Table 14. Weekly coho catch, abundance indices, and hatchery contributions at the WCT, Trinity River, 1996.

			COHO CATCH				COHO INDEX				
Julian Week	Mean River Flow	Trap Days	Hatchery Smolts	Natural Smolts	Natural Fry/parr	Catch Totals	Hatchery Smolts	Natural Smolts	Natural Fry/parr	Index Totals	(%) Hat
12	8,640	7	0	0	4	4	0	0	382	382	0%
13	7,856	7	0	0	2	2	0	0	165	165	0%
14	7,497	7	1	0	0	1	79	0	0	79	100%
15	6,024	7	1	0	1	2	71	0	71	142	50%
16	6,229	7	0	0	2	2	0	0	156	156	0%
17	9,063	7	1	3	1	5	91	243	91	425	21%
18	6,009	6	2	0	1	3	189	0	98	287	66%
19	4,549	7	1	0	1	2	54	0	56	110	49%
20	9,103	7	32	1	3	36	3,835	131	402	4,368	88%
21	7,791	7	22	0	0	22	2,133	0	0	2,133	100%
22	4,779	7	2	0	2	4	121	0	110	231	52%
23	3,844	7	1	0	9	10	45	0	491	536	8%
24	2,784	7	2	0	5	7	85	0	209	294	29%
25	2,260	7	0	0	3	3	0	0	121	121	0%
26	2,089	7	0	0	1	1	0	0	34	34	0%
27	1,843	6	0	0	2	2	0	0	79	79	0%
28	1,597	7	0	0	1	1	0	0	26	26	0%
29	1,429	7	0	0	12	12	0	0	299	299	0%
30	1,187	4	0	0	1	1	0	0	29	29	0%
31	1,080	7	0	0	5	5	0	0	76	76	0%
32	974	7	0	0	5	5	0	0	62	62	0%
33	896	7	0	0	3	3	0	0	35	35	0%
34	863	7	0	0	0	0	0	0	0	0	0%
35	822	7	0	0	1	1	0	0	10	10	0%
36	800	7	0	0	0	0	0	0	0	0	0%
37	827	7	0	0	0	0	0	0	0	0	0%
38	837	7	0	0	0	0	0	0	0	0	0%
39	777	7	0	0	1	1	0	0	10	10	0%
40	765	7	0	0	0	0	0	0	0	0	0%
41	772	7	0	0	1	1	0	0	9	9	0%
42	795	7	0	0	0	0	0	0	0	0	0%
43	1,156	6	0	0	0	0	0	0	0	0	0%
44	1,049	7	0	0	2	2	0	0	35	35	0%
45	837	7	0	0	0	0	0	0	0	0	0%
46	1,471	7	0	0	0	0	0	0	0	0	0%
47	5,901	4	0	0	6	6	0	0	565	565	0%
48	2,914	7	0	0	6	6	0	0	316	316	0%
Spring Subtotal		191	65	4	66	135	6,703	373	3,009	10,086	66.46%
Fall Subtotal		59	0	0	15	15	0	0	925	925	0.00%
Total		250	65	4	81	150	6,703	373	3,935	11,012	60.88%

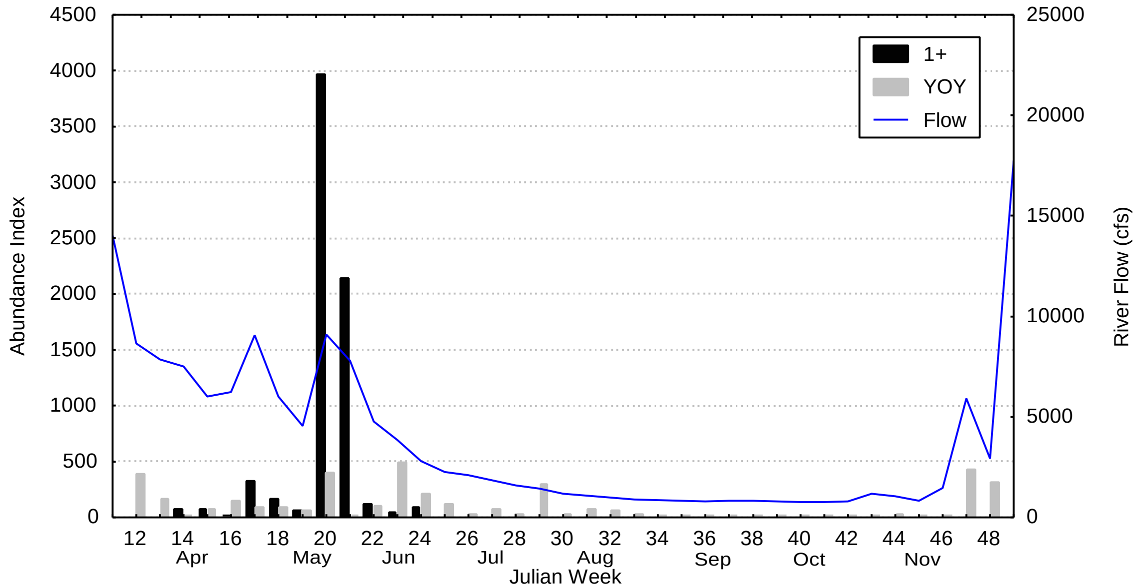


Figure 15. Mean weekly Trinity River flow at Hoopa and weekly 1+ and YOY coho abundance indices at the WCT, 1996.

km/day (Table 12). The mean migration rate for all TRH coho captured was only 3.1 km/day (Table 12).

Steelhead

Trinity River Hatchery began releasing 614,838 unmarked steelhead smolts the day before trapping commenced (Table 11), thus the trap was operating prior to the time the hatchery fish arrived at the trap site. Although the hatchery fish were unmarked, many of the smolts captured appeared to be of hatchery origin (e.g. eroded fins). However, distinguishing hatchery fish based on this feature alone was unreliable. Therefore, we did not attempt to make such a distinction.

A total of 1,427 juvenile steelhead were captured in the WCT in 1996 (Table 16). Of this, 1,169 (82%) were captured during the spring sampling period. Catch composition for the spring sampling period was as follows: 67% smolts, 21% parr, and 12% fry (Table 16).

Scale samples were collected from 666 steelhead for age analysis, 645 (97%) from smolt and 21 (3%) from parr (Table 17). As with the BBT data, an age was assigned to most fish by plotting FLs by JW and comparing scale-aged fish to unscaled fish (Figure 17). For each JW, unscaled fish of similar size to scale-aged fish were assigned the same age as the scale-aged fish (Appendix E). YOY and small

Table 15. Sample size (n), mean (0), minimum (min), maximum (max), and standard deviation (s) of weekly FLs (mm) of YOY and 1+ coho salmon captured at the WCT, Trinity River, 1996.

	YOY					1+				
Julian week	n	0	min	max	s	n	0	min	max	s
12	4	36	31	38	3.11	0	----	----	----	----
13	2	34	32	36	2.83	0	----	----	----	----
14	0	----	----	----	----	1	148	148	148	----
15	1	33	33	33	0.00	1	153	153	153	----
16	2	45	40	50	7.07	0	----	----	----	----
17	1	39	39	39	0.00	4	168	140	180	19.04
18	1	48	48	48	0.00	1	172	172	172	----
19	1	65	65	65	0.00	1	197	197	197	----
20	3	59	50	65	8.14	33	162	124	190	11.67
21	0	----	----	----	----	22	167	151	182	8.99
22	2	56	55	57	1.41	2	187	186	188	1.41
23	9	59	48	71	7.60	1	159	159	159	----
24	5	64	58	74	6.12	2	161	159	162	2.12
25	3	64	58	70	6.03	0	----	----	----	----
26	1	61	61	61	0.00	0	----	----	----	----
27	2	83	81	84	2.12	0	----	----	----	----
28	1	75	75	75	0.00	0	----	----	----	----
29	12	75	65	94	8.11	0	----	----	----	----
30	1	92	92	92	0.00	0	----	----	----	----
31	5	94	82	100	7.16	0	----	----	----	----
32	5	97	92	107	5.83	0	----	----	----	----
33	3	91	66	110	22.61	0	----	----	----	----
34	0	----	----	----	----	0	----	----	----	----
35	1	97	97	97	----	0	----	----	----	----
36	0	----	----	----	----	0	----	----	----	----
37	0	----	----	----	----	0	----	----	----	----
38	0	----	----	----	----	0	----	----	----	----
39	1	103	103	103	0.00	0	----	----	----	----
40	0	----	----	----	----	0	----	----	----	----
41	1	94	94	94	0.00	0	----	----	----	----
42	0	----	----	----	----	0	----	----	----	----
43	0	----	----	----	----	0	----	----	----	----
44	2	83	82	84	1.41	0	----	----	----	----
45	0	----	----	----	----	0	----	----	----	----
46	0	----	----	----	----	0	----	----	----	----
47	6	88	76	98	8.06	0	----	----	----	----
48	6	90	76	105	10.13	0	----	----	----	----
Spring Total	66	69	31	110	20.52	68	165	124	197	12.28
Fall Total	15	88	76	105	8.19	0	----	----	----	----
Season Total	81	72	31	110	20.31	68	165	124	197	12.28

wild 1+ parr were fairly distinguishable, but there were many large 1+ (possibly hatchery) mixed in with 2+ (probably wild) that prevented assignment of ages to some unscaled fish with any degree of confidence (Figure 17, Appendix E). Thus, here we simply present the percentage of aged scale samples from each developmental stage.

During the first 14 weeks of trapping (JWs 12-25), catches were predominantly composed of smolts, with parr and fry representing

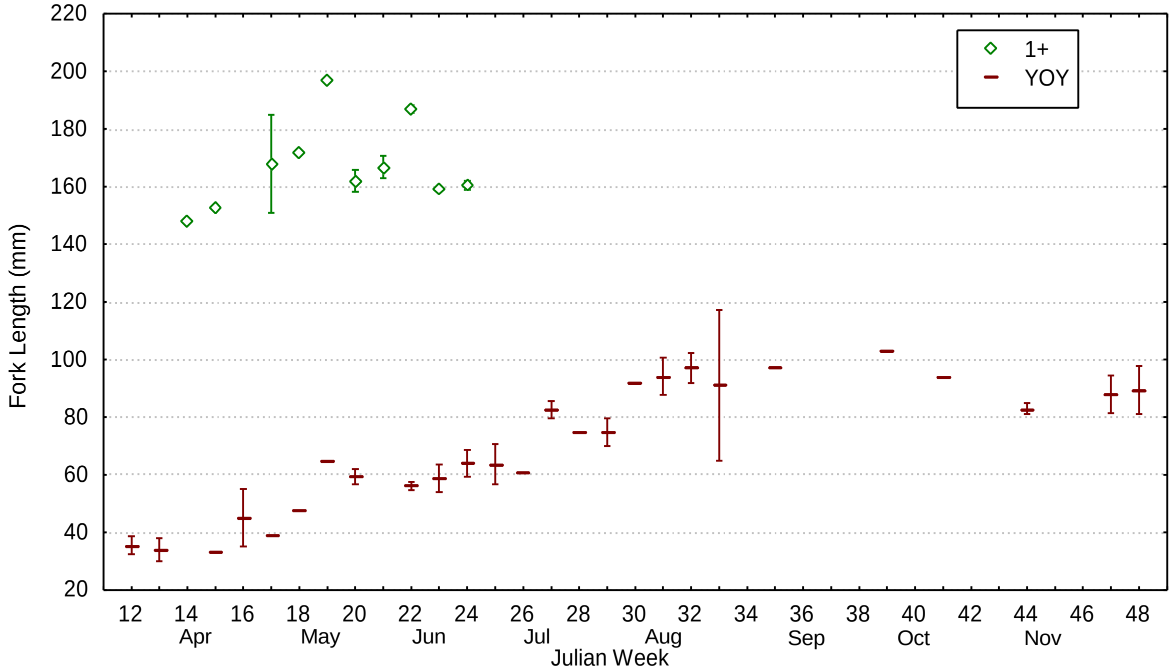


Figure 16. Coho 1+ and YOY mean FLs (+/- 2 standard errors) by JW, WCT, Trinity River, 1996.

only 9% and 4% of the catch during that period, respectively (Table 16). Scales were collected from 13 parr and 575 smolts during this period (Appendix E). All of the parr were aged as 1+ fish (FL=95-120 mm, 0=108.0, s=7.46). Seventy one percent of the smolts were aged as 1+ fish (FL=136-239 mm, 0=181.8, s=20.75), 28% as 2+ fish (FL=152-272 mm, 0=190.7, s=24.00), and 1% as 3+ fish (FL=175-260 mm, 0=229.7, s=31.27) (Table 18).

Beginning in JW 26, smolt catches dropped considerably as catches of parr and fry steelhead increased (Table 16). All scale samples collected during JWs 26 through 31 were subsequently lost and not available for age analysis. However, fry and parr were aged using length frequency distributions for each JW. Due to the mixing of wild and hatchery smolts, no attempt was made to age smolts captured during this time period. From JWs 26 to 31, the catch composition was 52% fry (all YOY), 33% parr (50% YOY, 50% 1+), and 14% smolts (unknown mix of wild and hatchery fish) (Table 16).

During the remainder of the spring sampling period (JWs 32-39) parr became the most frequently caught developmental stage (64% of the catch) with smolts and fry contributing 18% each to the catch (Table 16). All fry were considered 0+ (FL=38-65 mm, 0=57.7, s=6.68)(Table 18). Length frequency distributions indicated that 89% of parr

Table 16. Weekly steelhead catch and abundance indices by development stage at the WCT, Trinity River, 1996.

Julian Week	Mean River Flow	Trap Days	STEELHEAD CATCH Fry	Parr	Smolt	Catch Total	STEELHEAD INDEX Fry	Parr	Smolt	Index Totals
12	8,640	7	0	1	27	28	0	90	2,820	2,910
13	7,856	7	0	4	29	33	0	339	2,868	3,207
14	7,497	7	1	6	40	47	79	483	3,495	4,057
15	6,024	7	0	6	18	24	0	453	1,312	1,765
16	6,229	7	2	4	41	47	147	292	3,106	3,545
17	9,063	7	3	4	91	98	417	350	10,158	10,925
18	6,009	6	0	4	24	28	0	364	2,193	2,557
19	4,549	7	1	6	49	56	56	327	2,746	3,129
20	9,103	7	4	3	126	133	551	242	14,853	15,646
21	7,791	7	2	6	128	136	157	478	11,676	12,310
22	4,779	7	1	4	38	43	52	212	2,225	2,489
23	3,844	7	6	10	29	45	303	511	1,418	2,232
24	2,784	7	6	12	61	79	255	497	2,535	3,287
25	2,260	7	6	6	21	33	218	227	802	1,246
26	2,089	7	7	4	1	12	242	140	34	415
27	1,843	6	12	5	1	18	358	163	33	554
28	1,597	7	30	14	5	49	811	384	129	1,323
29	1,429	7	11	8	6	25	301	199	157	657
30	1,187	4	2	5	3	10	63	153	89	304
31	1,080	7	14	12	5	31	232	187	78	496
32	974	7	7	16	6	29	84	194	74	353
33	896	7	7	19	9	35	80	218	102	399
34	863	7	3	11	5	19	30	108	49	186
35	822	7	1	20	3	24	9	193	29	231
36	800	7	6	15	5	26	58	146	48	251
37	827	7	6	13	3	22	65	129	27	220
38	837	7	6	21	3	30	60	205	30	295
39	777	7	0	9	0	9	0	83	0	83
40	765	7	0	9	5	14	0	82	44	127
41	772	7	1	6	1	8	9	55	9	74
42	795	7	0	55	11	68	0	536	109	644
43	1,156	6	3	49	4	56	70	953	43	1,066
44	1,049	7	4	20	6	28	65	322	81	467
45	837	7	0	8	22	30	0	92	252	344
46	1,471	7	0	0	6	6	0	0	125	125
47	5,901	4	3	26	2	31	282	2,517	194	2,993
48	2,914	7	0	12	5	17	0	636	267	903
Spring Total		191	144	248	777	1,169	4,627	7,364	63,085	75,076
Fall Total		59	11	185	62	258	427	5,194	1,123	6,744
Season Total		250	155	433	839	1,427	5,054	12,558	64,208	81,820

Table 17. Development stage, age, and length of scale-aged natural steelhead captured at the WCT, Trinity River, 1996.

Aging summary				Length (mm)		
Development stage	Age	No. of fish	% of development stage	Range	Average	s
Parr	0+	5	23.8%	97 - 102	99.2	2.17
Parr	1+	16	76.2%	95 - 170	112.3	16.96
Smolt	0+	2	0.3%	102 - 115	108.5	9.19
Smolt	1+	464	71.9%	122 - 239	179.4	22.14
Smolt	2+	173	26.8%	152 - 272	192.3	24.38
Smolt	3+	6	0.9%	175 - 260	229.7	31.27
Total		666	--------	95 - 272	141.0	27.30

collected during this period were 0+ (FL=66-109 mm, 0=83.6, s=11.29), and 11% were 1+ (FL=115-133 mm, 0= 122.8, s=4.82) fish (Appendix E, Table 18). Of 25 smolt scale samples taken during this period 24 (96%) were aged as 1+ (FL=122-194 mm, 0=151.6, s=18.32) and one was aged as a 0+ fish (FL=102 mm) (Appendix E, Table 18).

During the fall sampling period the catch consisted of 71% parr, 25% smolts, and 4% fry (Table 16). Of eight parr scale samples taken during the fall monitoring period, five (62%) were aged as 0+ fish (FL=97-102 mm, 0=99.2, s=2.17) and three (38%) as 1+ fish (FL=105-170 mm, 0=130.7, s=34.59)(Appendix E, Table 18). Of 45 smolt scale samples taken during the fall monitoring period, 32 (71%) were aged as 1+ fish (FL=123-225 mm, 0=169.5, s=25.30), 12 (27%) as 2+ fish (FL=190-247 mm, 0=214.5, s=18.95) and 1 (2%) as a 0+ fish (FL=115 mm)(Appendix E, Table 18).

Abundance Index and Hatchery Contributions

The weekly steelhead abundance index appeared to be closely tied to flow patterns throughout the season (Figure 18). The weekly steelhead abundance index was 2,000-11,000 for the first eight weeks of sampling before peaking near 16,000 on JW 20 (Table 16, Figure 18). The weekly index rapidly decreased during the next few weeks and remained at 500 or less from JWs 30 to 39 (Table 16, Figure 18).

The beginning of the fall monitoring period saw some of the lowest flows and lowest weekly steelhead indices of the year (Figure 18). Flows began to increase during the seventh JW of the fall season (JW 46), and the steelhead index increased slightly during the final two weeks of the fall monitoring period (Table 16, Figure 18).

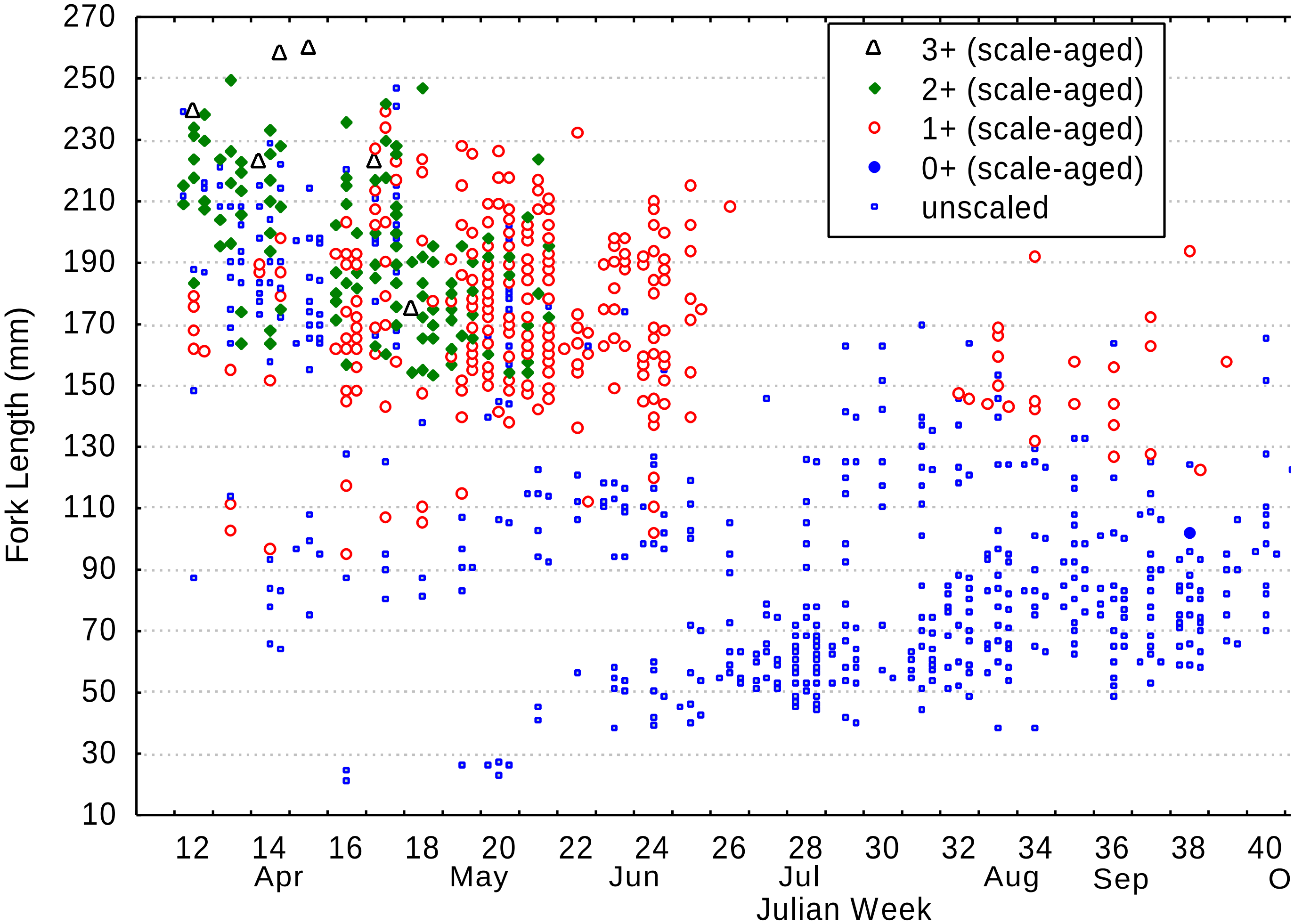


Figure 17. Fork lengths of all scale-aged and unscaled natural steelhead captu
Trinity River, 1996.

Table 18. Sample size (n), mean (0), minimum (min), maximum (max), and standard deviation (s) of weekly FLs (mm) of fry, parr and smolt steelhead captured at the WCT, Trinity River, 1996.

	Fry					Parr					Smolt				
Julian week	n	0	min	max	s	n	0	min	max	s	n	0	min	max	s
12	0	----	----	----	----	1	87	87	87	0.00	26	206	148	249	27.96
13	0	----	----	----	----	3	109	103	114	5.69	28	200	155	272	24.60
14	0	----	----	----	----	7	81	64	97	12.49	40	198	152	260	24.69
15	0	----	----	----	----	5	95	75	108	12.13	18	182	155	220	18.51
16	2	23	21	25	2.83	4	107	87	128	19.02	41	182	145	239	21.49
17	0	----	----	----	----	4	93	80	107	11.22	78	196	125	247	24.69
18	0	----	----	----	----	4	96	81	110	13.94	24	179	138	228	23.65
19	1	26	26	26	----	6	97	83	115	11.76	49	179	140	226	20.41
20	4	26	23	27	1.73	2	106	105	106	0.71	120	178	138	224	18.44
21	2	43	41	45	2.83	6	106	92	115	10.71	127	183	122	232	20.98
22	1	56	56	56	----	4	113	106	121	6.18	35	178	136	233	17.82
23	6	51	38	58	6.99	10	109	94	118	8.73	28	184	149	210	15.54
24	6	50	39	60	8.17	12	109	97	127	10.46	60	177	137	215	18.59
25	6	47	40	56	6.31	6	96	70	119	20.35	21	187	140	232	22.39
26	7	58	53	63	4.03	4	91	73	105	13.40	1	146	146	146	0.00
27	12	58	51	63	4.40	5	78	66	98	11.93	1	176	176	176	0.00
28	30	56	44	65	6.12	14	82	66	126	19.24	5	156	117	193	34.02
29	11	55	40	65	8.27	8	91	67	125	23.43	6	141	115	165	20.87
30	2	56	55	57	1.41	5	119	72	152	31.27	3	160	125	186	31.63
31	12	58	44	65	6.02	12	101	69	135	25.18	4	155	137	198	28.74
32	7	55	49	60	4.32	16	83	67	123	15.94	6	147	121	166	16.89
33	7	56	38	64	8.90	19	87	66	124	17.12	9	155	140	192	16.51
34	3	55	38	65	15.04	11	97	75	129	20.13	5	140	124	158	12.97
35	1	62	62	62	----	20	92	66	133	17.50	3	147	133	164	15.72
36	6	58	49	65	6.74	15	85	68	120	14.35	5	145	127	163	14.43
37	6	60	53	65	3.95	13	94	68	125	17.08	3	145	128	172	23.86
38	6	61	58	65	2.81	21	83	66	124	12.72	3	128	105	158	27.06
39	0	----	----	----	----	9	87	66	108	15.38	0	----	----	----	----
40	0	----	----	----	----	9	91	70	110	13.38	3	148	128	165	18.77
41	0	----	----	----	----	7	112	89	123	12.24	0	----	----	----	----
42	0	----	----	----	----	55	106	80	142	11.57	11	161	145	189	14.46
43	3	59	52	63	5.86	62	97	67	151	18.26	4	144	139	157	8.68
44	4	53	45	59	5.89	20	87	67	120	19.68	6	167	140	195	22.32
45	0	----	----	----	----	8	115	67	111	29.20	22	204	123	247	26.75
46	0	----	----	----	----	0	----	----	----	----	6	196	164	231	23.81
47	3	60	56	63	3.51	25	90	66	121	15.90	2	151	132	169	26.16
48	0	----	----	----	----	12	85	69	112	13.84	5	155	132	173	18.58
Spring Total	138	54	21	65	9.56	246	93	64	152	18.55	749	182	105	272	24.41
Fall Total	10	57	45	63	5.68	198	98	66	167	18.17	59	178	123	247	31.42
Season Total	148	54	21	65	9.35	444	95	64	167	18.52	808	182	105	272	24.98

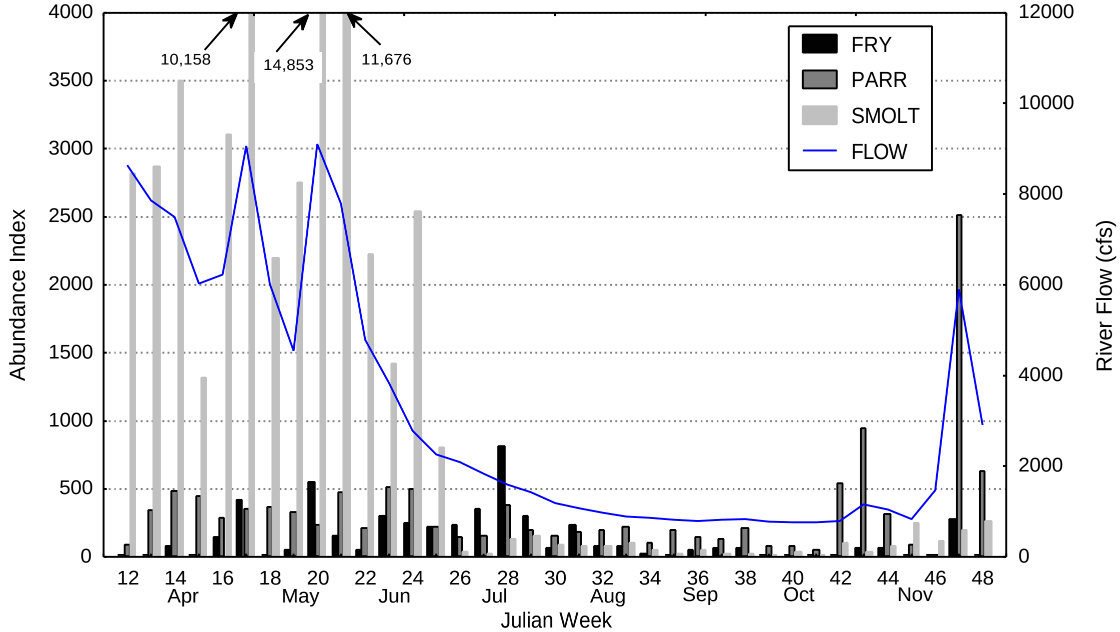


Figure 18. Mean weekly Trinity River flow at Hoopa and weekly steelhead abundance indices at the WCT, 1996.

Fork Length

As with the Klamath River trap catches, mean weekly FLs of Trinity River steelhead fry, parr and smolt did not change significantly throughout the 1996 trapping season (Table 18, Figure 19). Again, this reflects differences in spawn timing, emergence timing, and growth of steelhead in the Trinity Basin. This results in almost continual recruitment of fish into the three developmental stages. Steelhead fry were captured from JW 16 through JW 47, and fish as small as 38 mm were captured into JW 34 (Table 18). As with the Klamath River trap catches, most fry were captured in July (JWs 27-31) and most smolts were captured before mid-June (before JW 25) (Table 16).

Cross Channel Bottom Profile and Trap Placement

The 1996 trap location was 20-50m downstream of the 1992-1995 location. The bottom profile and substrate of the Trinity River was measured just behind the WCT on May 31, 1996 (Figure 20). In general, the river bottom (looking downstream) gradually sloped from a cobble/boulder dominated left bank, leveled off mid-channel and became gravel dominated at about 1.3 meters depth, then became a sand/boulder dominated slope for the last 12m. The 1996 bottom profile is similar to those measured in 1993 and 1995 (U.S. Fish and

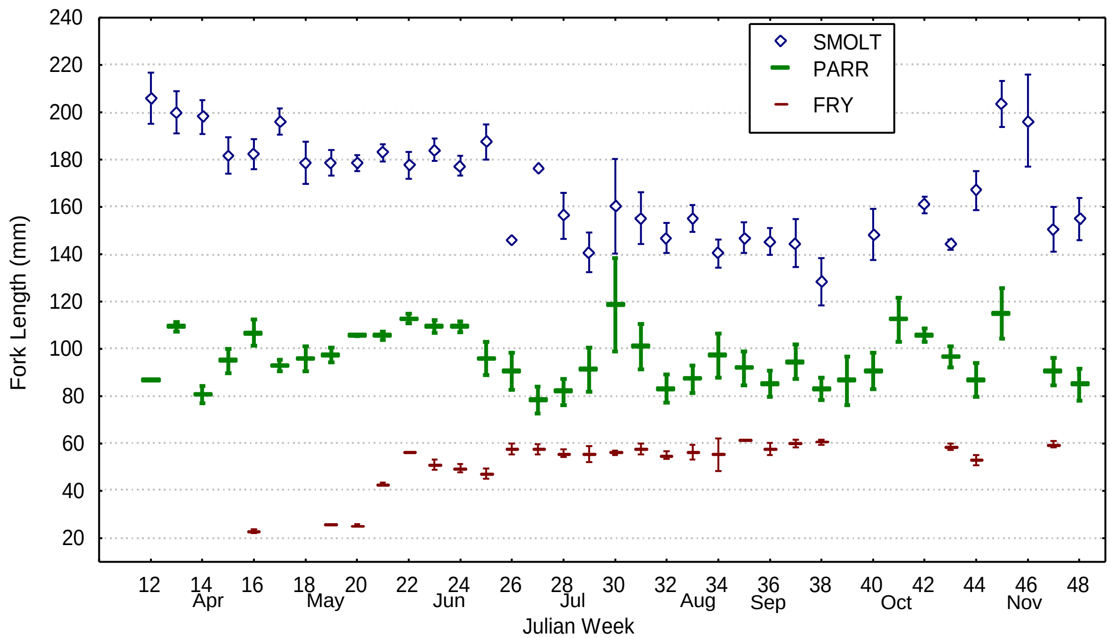


Figure 19. Mean weekly FLs (+/- 2 standard errors) of scale-aged steelhead captured at WCT, Trinity River, 1996.

Wildlife Service, 1998). Although the profiles were taken in slightly different locations each year, they do show that relative to their respective bottom profiles, the WCT was fishing a similar portion of the stream during these years.

Trinity River Salmonid Health Assessment

In cooperation with the AFWO, the USFWS California - Nevada Fish Health Center (FHC) evaluated both natural and hatchery-origin chinook smolts captured at WCT. Samples were collected during two periods corresponding to TRH's June (fingerling) and October (yearling) releases. The first sample period ran from May 28 to July 2 while the second collection period ran from September 30 to October 22. In addition, in cooperation with CDFG, hatchery fish were examined at TRH prior to their releases. Natural chinook were examined during May and early June at the WCT. There were ten total sample collections. Histological examination was done on tissues from over two hundred fish. Other assays were performed to determine: % body moisture, gill ATPase, leukocrit, Enzyme Linked Immunosorbent Assay (ELISA) for *R. salmoninarum*, bacterial culture, plasma protein electrophoresis, metacercaria counts in kidney; total protein, triglyceride, glucose and sodium concentration of plasma; hepatosomatic index, and liver polysaccharide content. The most significant findings were:

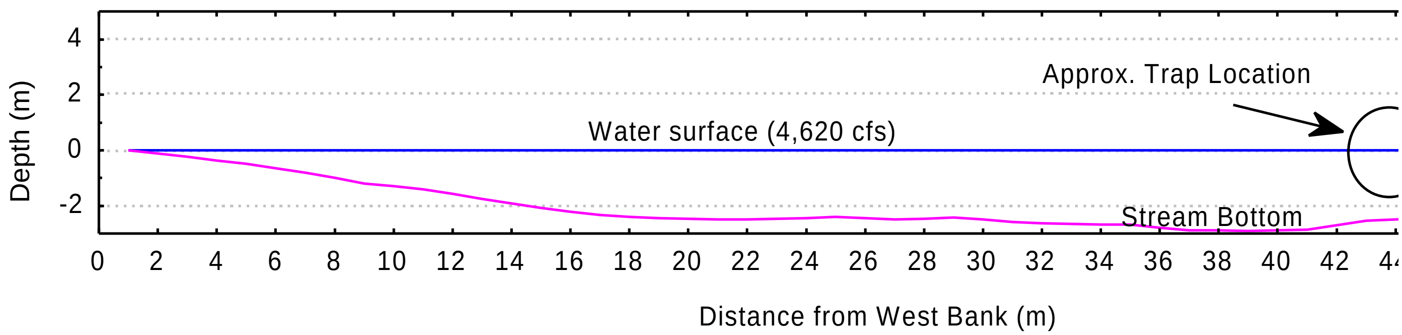


Figure 20. Cross sectional profile of the Trinity River at the WCT trap locati
Flow measured at Hoopa.

1) High incidence (60-100%) of metacercaria trematode infection in kidneys of all but one (October 21) of the sample groups. October sample groups had higher rates of infection than May and June sample groups. It is uncertain how these infections affect the survival of these fish. In a separate FHC vibrio bacteria challenge experiment (unpublished report), trematode infected and non-infected chinook were challenged with vibrio bacteria. No significant difference in survival was found between trematode infected and non-infected controls. Infected fish were able to withstand a bacterial infection as well as the control group even though trematode infections were twice that seen in nature (as high as 10,000 parasites/ gram kidney). In a second laboratory experiment, saltwater challenged trematode infected chinook did show decreased osmoregulatory ability compared to uninfected saltwater challenged chinook. These results indicate that osmoregulatory abilities may be compromised by trematode infections.

2) High concentrations of *R. salmoninarum* antigens (as indicated by ELISA) were detected in 25% of natural chinook and there was significantly greater incidence of infection in natural chinook compared to TRH chinook samples ($P<0.05$). Seventy-one percent of natural origin chinook had moderate to high levels of infection indicative of early subclinical infection. There were no clinical symptoms and it is unclear whether survival was impaired.

3) Twenty-five to thirty percent of the first three October sample groups had cloudy eyes and symptoms of gas bubble disease.

4) Condition factor, FL, and weight of chinook sampled at TRH were greater than samples taken from the WCT. This suggests that larger fish migrate out of the Trinity River while other smaller sized chinook remain to rear in the river. Similarly, energy levels of TRH chinook were higher (VFAT, TG, LG, %Body lipid) than later WCT sample groups. This could be a result of segregation based on energy level after release from TRH. Energetically prepared fish apparently migrate first while less prepared fish remain in the upper river to rear.

Non-target Species

A total of 3,850 non-target species were captured in the WCT. These were comprised of 13 species from 10 families. Total catch for the BBT was 3,729 fish comprised of 13 species from 9 families. The WCT and BBT were not fished for the same number of days; therefore season totals are not comparable (we report totals together for convenience). Six introduced and six endemic species were captured at both the BBT and WCT. The BBT and WCT had four of the six introduced species in common (Table 19).

Table 19. Season catch totals of non-target fish species captured at the BBT (Klamath River) and the WCT (Trinity River), 1996. N = native; O = occasional; A = anadromous; I = introduced.

Scientific Name	Common Name	Status	Number of Specimens Captured: WCT	Number of Specimens Captured: BBT
Catostomus rimiculus	Klamath smallscale sucker	N	1641	187
Rhinichthys osculus	speckled dace	N	675	236
Gasterosteus aculeatus	threespine stickleback	N	203	9
Lampetra tridentata	ammocete	NA	901	2346
Lampetra tridentata	eyed juvenile	NA	117	0
Lampetra tridentata	adult lamprey	NA	15	25
Acipenser medirostris	green sturgeon	NA	43	679
Cottus sp.	sculpin	N	83	49
Alosa sapidissima	American shad	IA	138	1
Notemigonus crysoleucas	golden shiner	I	1	124
Pimephales promelas	fathead minnow	I	0	34
Ameirus sp.	bullhead	I	1	32
Salmo trutta	brown trout	I	11	0
Oncorhynchus nerka	sockeye salmon	OA	11	0
Lepomis cyanellus	green sunfish	I	7	3
Micropterus salmoides	largemouth bass	I	1	1
Pomoxis sp.	crappie	I	0	3
	Days Sampled		250	130
	Season Totals		2206	3538

Cottidae

Four cottid species are known from the Trinity and lower Klamath Rivers (Moyle 1976). Prickly sculpin (*Cottus asper*) is the most likely to be caught in both rivers, the coastrange sculpin (*C. aleuticus*) is probably also present in both rivers, but is seldom as abundant as the prickly sculpin when they occur together (Moyle

1976). Marbled sculpin (*C. klamathensis*) is reportedly widely distributed in the Klamath River, and the reticulate sculpin (*C. perplexus*) may occasionally be found in the lower Klamath (Moyle 1976). Identification to species was inconsistent thus we report all sculpin catches together.

Sculpin were the sixth most abundant species at each trap. Total sculpin catches were 83 at the WCT and 49 at the BBT (Table 19). Sculpin weekly indices at the WCT were sporadic early in the season (JWs 12-25), consistent from JWs 30 to 37, and highest indices occurred during JW 12 (Figure 21a). Total length for sculpin ranged from 60 to 200 mm at the WCT. Sculpin under 80 mm TL were uncommon except from JWs 30 to 38 (Figure 22a.). Weekly indices at the BBT were highest from JWs 14 to 18 (Figure 21b). Total lengths for sculpin captured at the BBT were usually greater than 100 mm and many were greater than 150 mm (Figure 22b).

Life history and distribution may differ between sculpin species making it difficult to interpret the trends reported above. Prickly

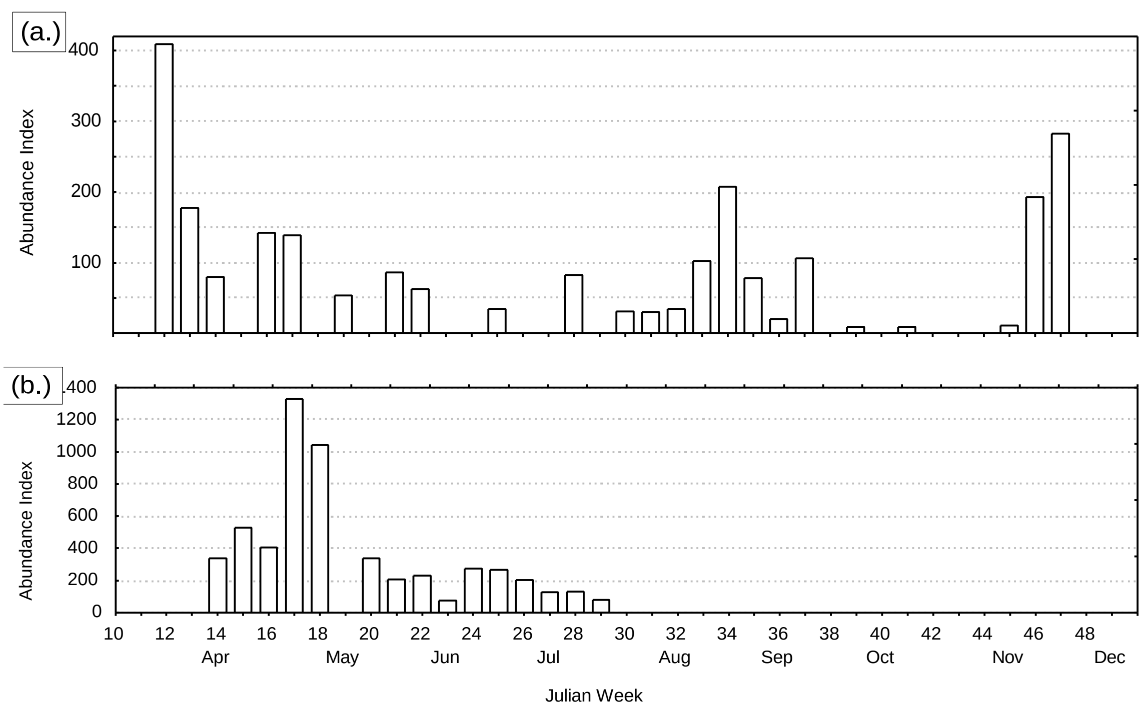


Figure 21. Weekly sculpin (Cottus sp.) indices at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

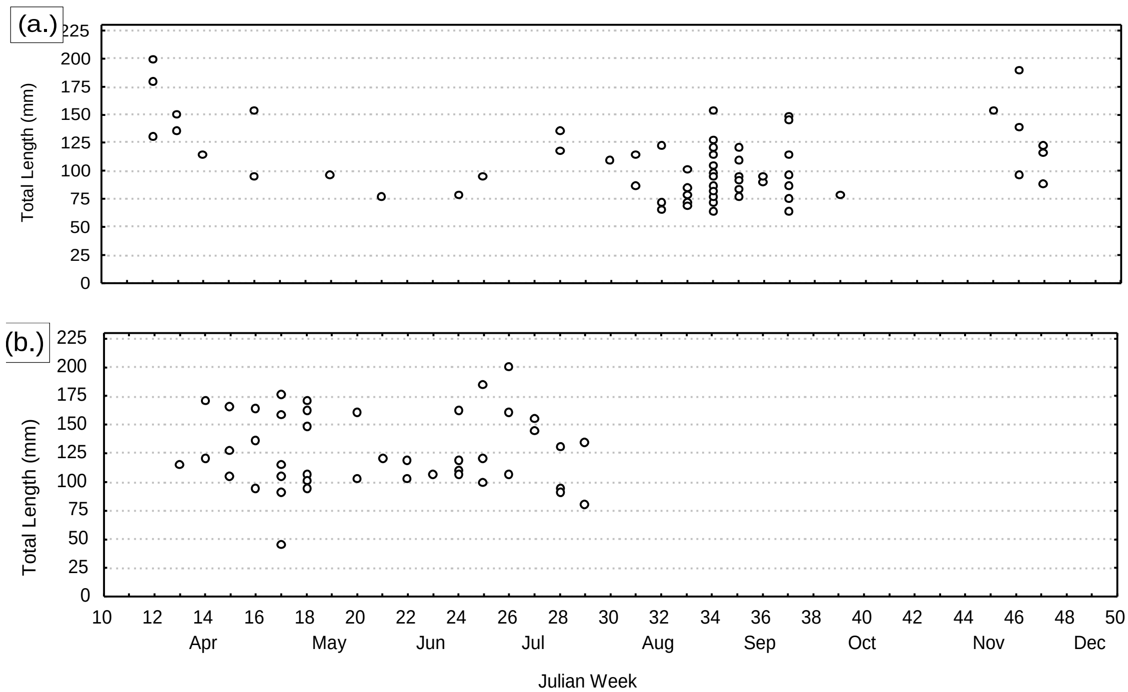


Figure 22. Sculpin TL by JW at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

sculpin and coastrange sculpin typically migrate downstream to spawning areas between January and March and may spawn between February and June (Moyle 1976). Spawning behavior of the marbled sculpin is not known. It is likely that sculpin migrating downstream to spawn would be more susceptible to capture by rotary traps. Field crews have observed gravid female sculpin from both traps.

Cyprinidae

At the BBT, 236 speckled dace (*Rhinichthys osculus*), 124 golden shiner (*Notemigonus crysoleucas*), and 34 fathead minnow (*Pimephales promelas*) were captured. At the WCT, 143 speckled dace and one golden shiner were captured. Speckled dace is common throughout the Klamath River Basin, and is the only native cyprinid of the three species captured in both traps.

At the WCT, the speckled dace weekly index was highest on JW 12, but a prolonged period of moderate indices occurred from JWs 22 to 44 with a mode at JW 31 (Figure 23a). Speckled dace ranged in size from 20 to 105 mm FL but most were between 30 and 90 mm. A distinct period of YOY recruitment (20-30 mm FL) was evident beginning on JW

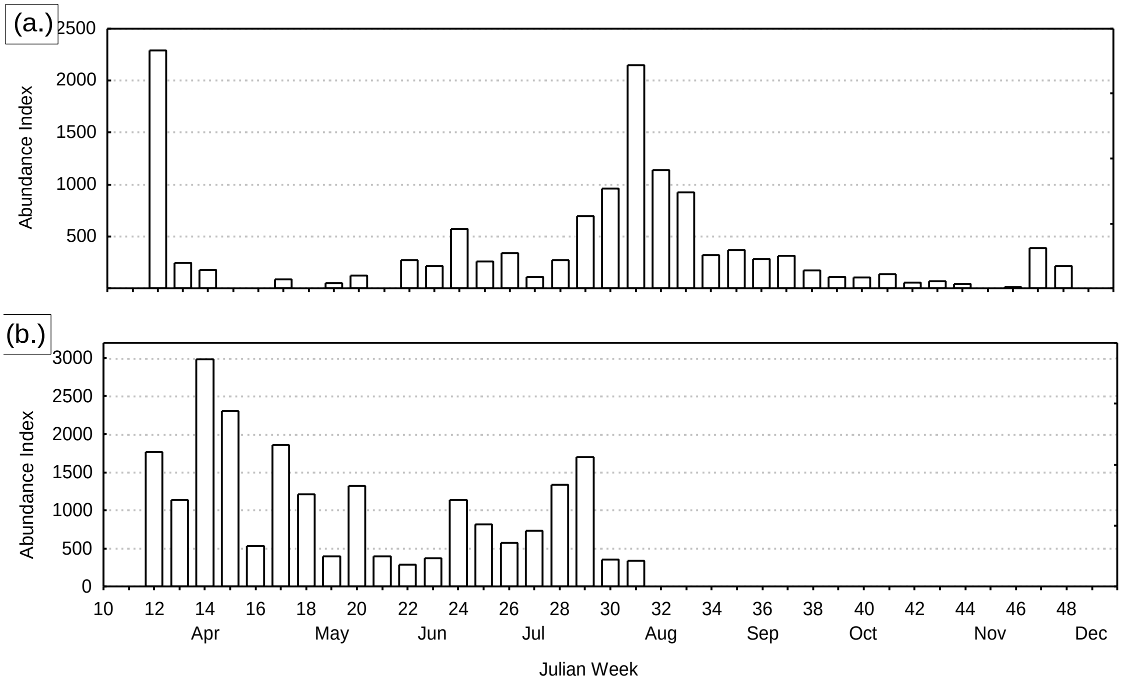


Figure 23. Weekly speckled dace indices at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

32 (Figure 24a). These recruits were distinguishable from larger fish until they reached about 50 mm FL around JW 40 (Figure 24a).

Speckled dace were captured in small numbers throughout the sampling season at the BBT. The weekly index was highest on JW 14 (Figure 23b). A recruitment of YOY sized fish, similar to the WCT, was observed at the BBT. Dace FLs less than 30 mm were first observed at the BBT during JW 27 (Figure 24b), however due to the earlier termination of sampling at the BBT the lengths of this cohort could not be tracked past JW 31.

Catostomidae

Of the four species of sucker found in the Klamath drainage, Klamath smallscale sucker (*Catostomus rimiculus*), Klamath largescale sucker (*C. snyderi*), Lost River sucker (*C. luxatus*), and shortnose sucker (*Chasmistes brevirostris*), the Klamath smallscale sucker was the only species captured at the WCT and BBT traps in 1996. It was the most frequently captured non-target species at the WCT and fourth most abundant at the BBT (Table 19). Highest weekly indices at the WCT occurred from JWs 29 to 34 with lesser peaks from JWs 20 to 23 and JWs 47 to 48 (Figure 25a). Similar periods of abundance

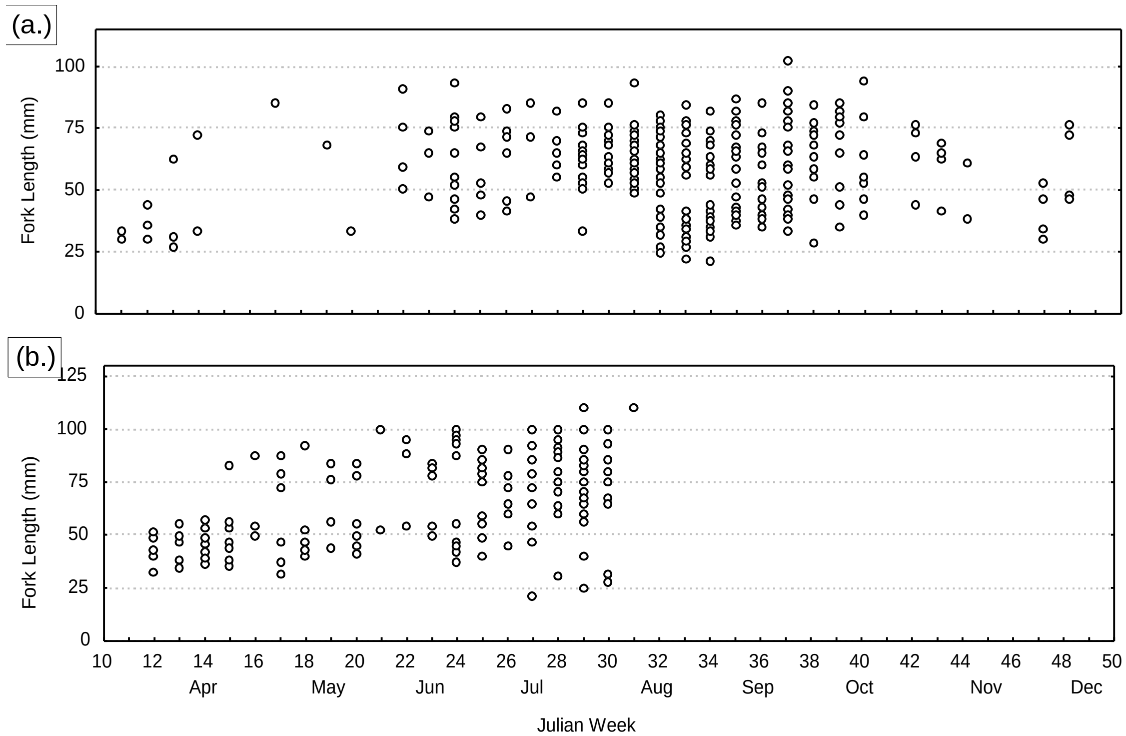


Figure 24. Specled dace FLs by JW at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

occurred at the BBT with peak indices from JWs 28 to 30 and an earlier smaller peak during JWs 20 and 21 (Figure 25b).

Most Klamath smallscale sucker captured at the WCT were less than 200 mm FL. The majority of adult sucker over 200 mm were captured from JWs 29 to 37. Young-of-year sucker less than 30 mm appeared during JW 29 and this cohort remained distinct from older fish until JW 38 (Figure 26a). The size distribution of sucker at the BBT trap was more uniformly spread across the range of FLs recorded. During JW 27, YOY fish less than 30 mm appeared at the BBT and were distinguishable until the end of trapping on July 30 (JW 31) (Figure 26b). Selectivity of our trap mesh size (1/4inch) may have minimized entrainment of fish less than about 25 mm.

<u>Petromyzontidae</u>

Three life history stages of lamprey were captured: ammocete larvae, eyed juveniles, and adults. Pacific lamprey (*Lampetra tridentata*) ammocete larvae are a non-parasitic life stage categorized by the lack of developed eyes and mouthparts. Ammocetes are normally found in fine sediments in shallow backwater areas (Beamish and Levings,

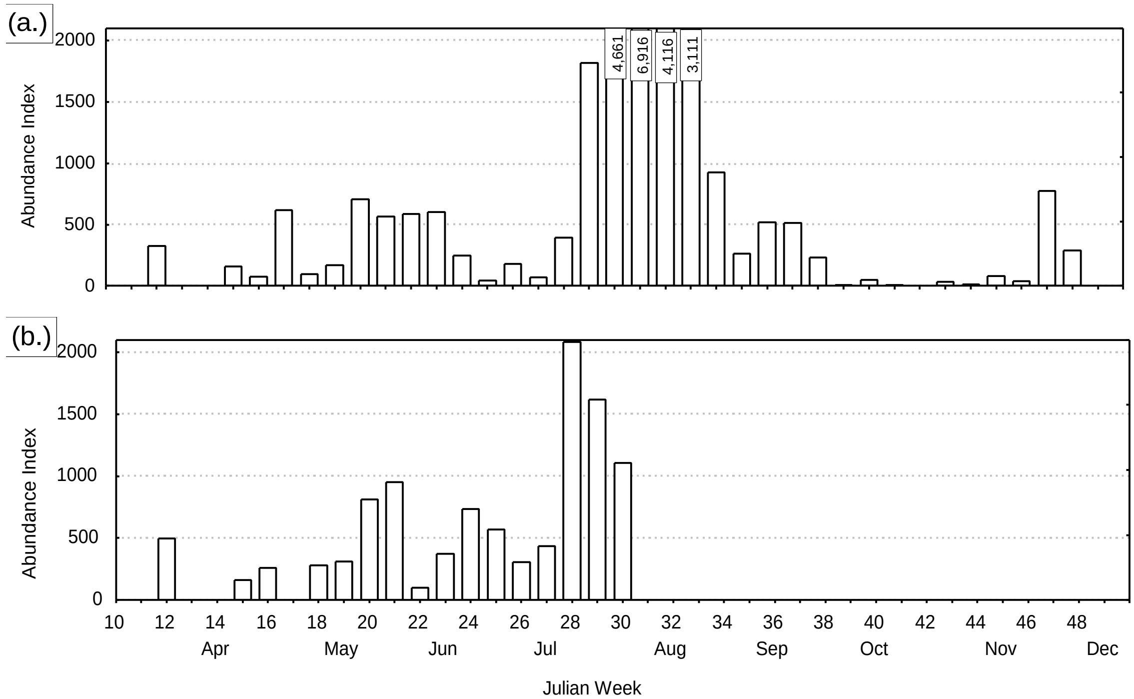


Figure 25. Weekly Klamath smallscale sucker indices at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

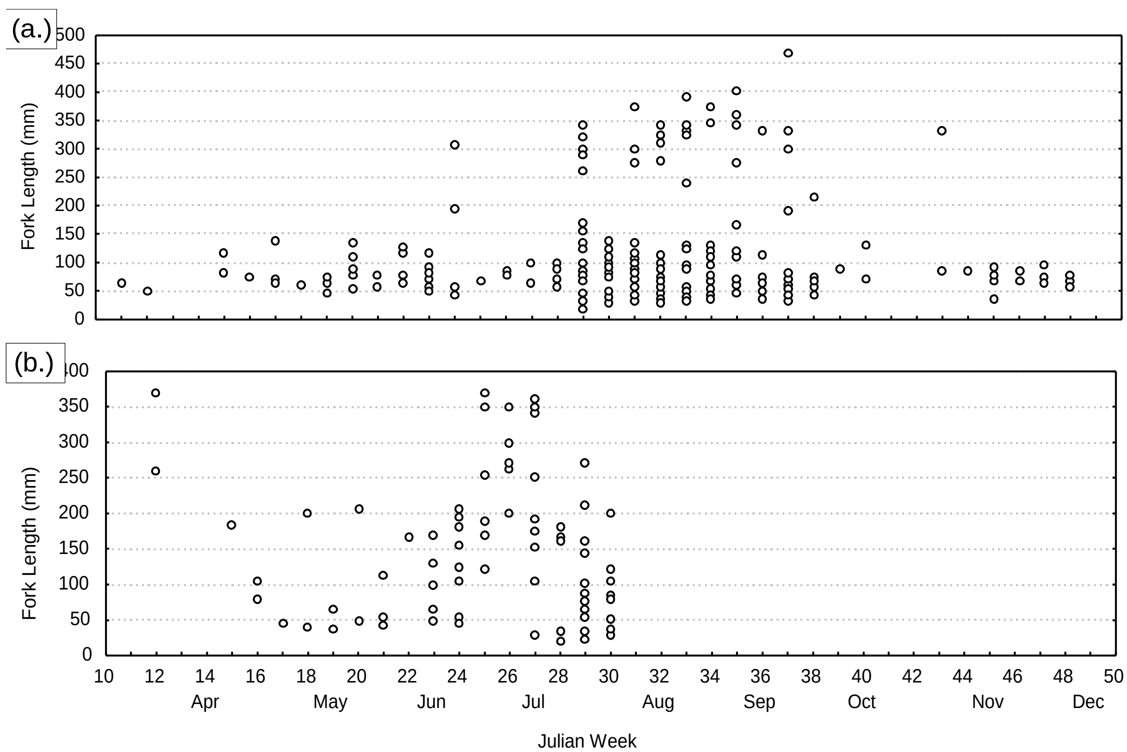


Figure 26. Klamath smallscale sucker FLs by JW at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

1991). Well-defined eyes and mouthparts characterize completely metamorphosed juvenile lampreys (Youson and Potter, 1979). During metamorphosis the ammocete mouth changes from a small thin hood to a large sucking disk armed with horny teeth and a rasping tongue (Richards and Beamish, 1981). Morphological, behavioral and presumably, physiological changes occur to ready juvenile Pacific lamprey for migration to the marine environment and parasitic feeding on the fluids of teleosts and elasmobranchs (Richards and Beamish, 1981).

Ammocetes and juvenile lamprey captured showed little variation in external morphology. Trap field crews have occasionally observed smaller adult lamprey that may not be Pacific lamprey, but none were collected or positively identified in 1996. For analysis, it was assumed that all ammocete and juvenile lamprey captured at the BBT and WCT were Pacific Lamprey. If other species of lamprey were present in significant numbers and were unidentified, this analysis may be affected.

Ammocete larvae ranked second most abundant by total catch at the WCT (Table 19). Ammocete weekly indices were greatest early in the spring from JW 12 (start of trapping at WCT) to JW 22 (Figure 27a). Very few ammocetes were captured during summer months, but a sharp increase in the ammocete catch began in the late fall during JW 47 (Figure 27a). Index peaks appear to correspond with peaks in river discharge (Figure 27a). Daily catch per unit effort plotted vs. average daily river discharge indicates that there was a positive correlation between ammocete density in the water column and river discharge at both traps (Figures 28a and 28b.). This supports the findings of other studies where migrations of ammocetes have been correlated with discharge (Manion and McLain 1971; Manion and Smith 1978; Beamish and Levings 1991).

Total lengths of ammocetes captured at the WCT and BBT were evenly distributed across a range of 20 mm to 150 mm at both traps (Figure 29a, b) during periods of high ammocete abundance (Figure 27a, b). During periods of lower abundance the size range for ammocetes decreased to approximately 60 to 120 mm at the WCT and 40 to 120 mm at the BBT (Figure 29a, b). Juvenile metamorphosed lamprey were captured periodically at the WCT from JWs 20 to 48, while none were captured at the BBT in 1996 (Figure 29a, b). Juvenile metamorphosed lamprey ranged in size from 93 to 175 mm (Figure 29a).

Total lengths of transformed juveniles were approximately the same size as the upper size limit of ammocetes captured earlier in the season (Figure 29a.). Furthermore, during the period of highest abundance of transformed juveniles, very few ammocetes were captured

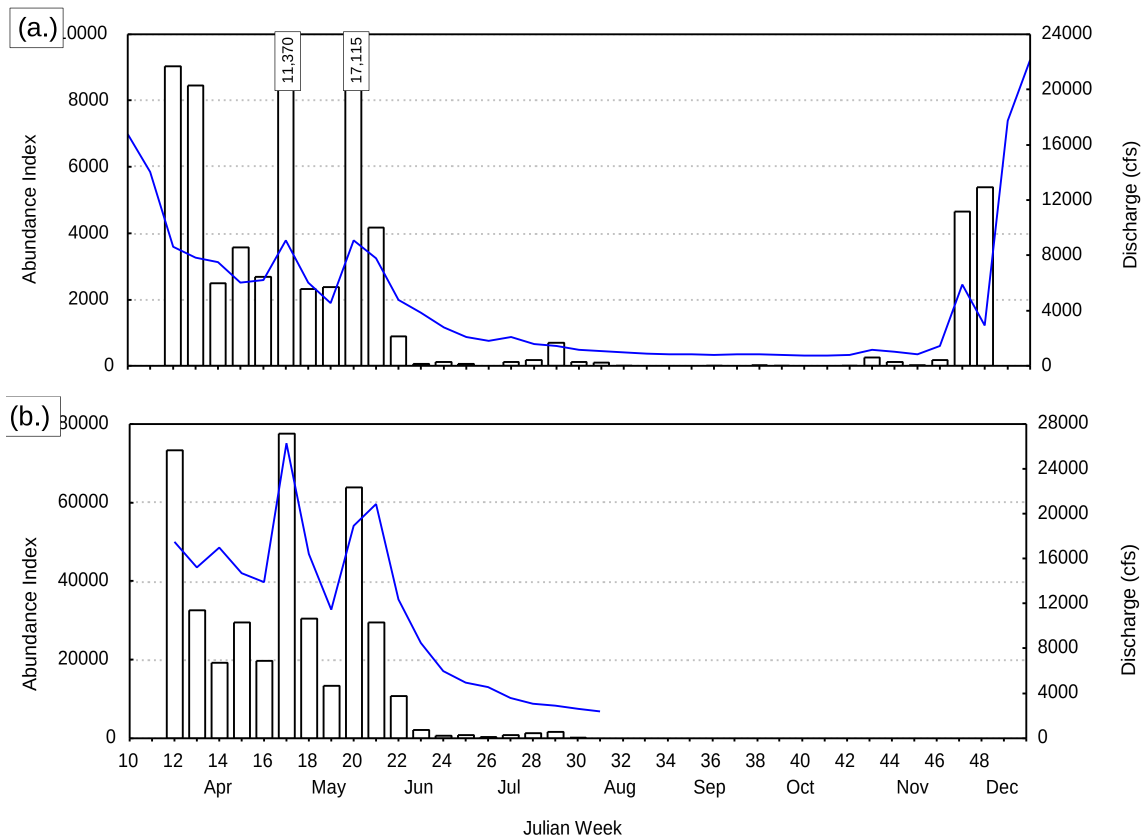


Figure 27. a) Weekly lamprey ammocete index at WCT and mean daily Trinity River flow at Hoopa. b) Weekly lamprey ammocete index at BBT and mean daily Klamath River flow at Orleans, 1996.

of the same size range. This may provide a possible explanation of the observed migration behavior of larger ammocetes.

Transforming ammocetes are known to seek out coarser sediments with higher current velocities as changes in their respiratory apparatus and haemoglobins necessitate higher dissolved oxygen levels (Richards and Beamish, 1981). Smaller ammocetes that are not preparing for transformation may be physically displaced as fine sediments are scoured or they may make a directed migration to disperse and colonize more favorable habitat as indicated by other studies (Beamish and Levings, 1991). The absence of smaller sized (<60 mm TL) ammocetes from JWs 22 to 47 at the WCT corresponds with reduced river discharge and lower abundance indices (Figure 27a). Ammocetes are known to feed primarily on diatoms (Moore and Beamish, 1973). It is possible that these younger ammocetes have found suitable habitat and are actively feeding on diatoms that would be abundant during the summer and fall.

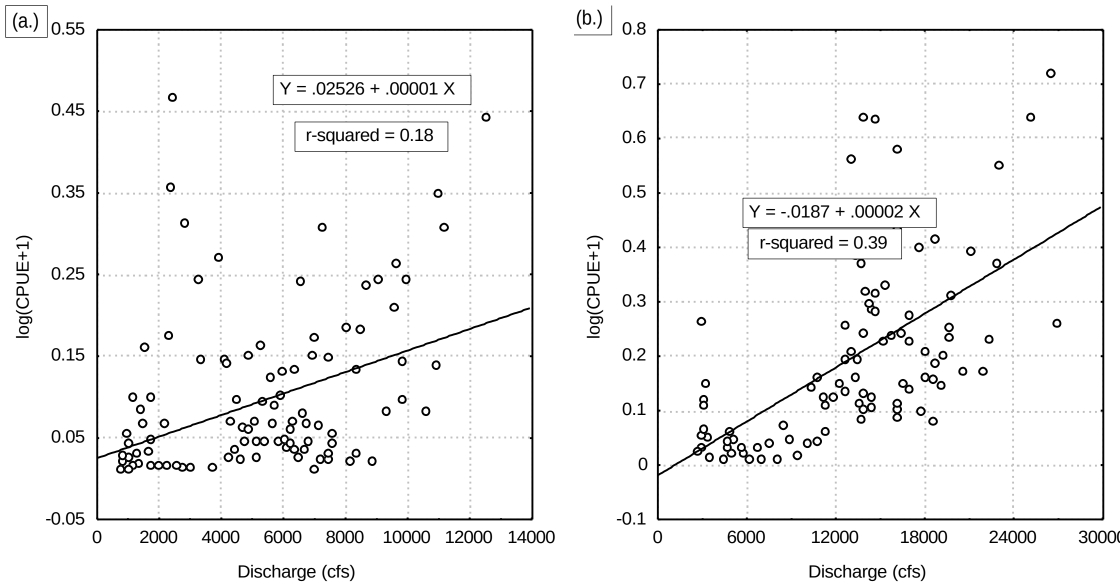


Figure 28. Transformed (log(x+1)) lamprey ammocete daily catch per unit effort (CPUE) vs. mean daily river flow at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

Clupeidae

American shad (*Alosa sapidissima*), an introduced anadromous species, spawn in the Trinity and Klamath Rivers annually. Adults are rarely captured in the rotary traps but are commonly observed by crews in the late spring/early summer. At the BBT, a single 23 mm FL specimen was captured on July 15. A total of 138 juvenile American shad were captured at the WCT. Shad were caught in small numbers during JWs 29 and 30. From JW 36 through JW 44 shad were more abundant with peak abundance during JW 42 (Figure 30). Juvenile shad ranged in length from 30 mm to 99 mm FL. Two adult shad were caught at 370 mm and 390 mm FL.

Acipenseridae

Juvenile green sturgeon (*Acipenser medirostris*) were the second most abundant non-target species captured at the BBT and the eighth most abundant at the WCT (Table 19). Total catch was 679 at the BBT, and 43 at the WCT. These captures occurred within a narrow period of time at both traps. Willow Creek Trap catches of juvenile green sturgeon began during JW 29, ended during JW 33, and the weekly index peaked on JW 29 (Figure 31a). Big Bar Trap catches of juvenile green sturgeon began during JW 24, ended during JW 31, and the weekly index peaked on JW 29 (Figure 31b).

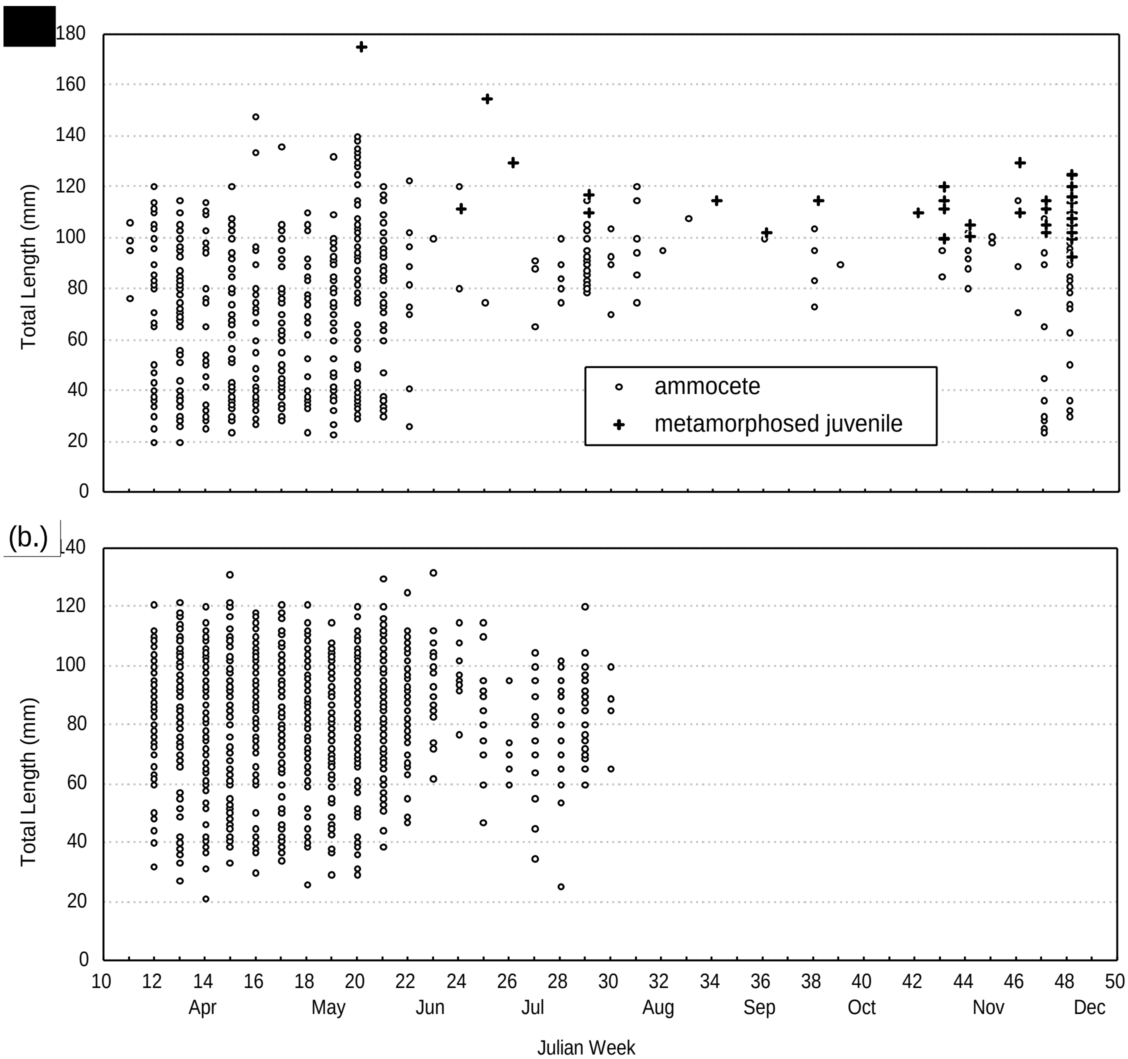


Figure 29. Ammocete and metamorphosed juvenile lamprey TL by JW for at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

Sturgeon sizes ranged from 23 mm to 150 mm TL at the WCT and 24 mm to 120 mm TL at the BBT. Individuals of these size ranges are most likely YOY spawned in the spring. Since little is known about sub-yearling green sturgeon, this assumption is based on the following: (1) age data from the white sturgeon (*Acipenser transmontanus*) which can grow to 180 to 300 mm FL by the end of the first year (Moyle, 1976); (2) data gathered from the Klamath River estuary where age 1-4 green sturgeon ranged in size from 320-660 mm TL (U.S. Fish and Wildlife Service, 1995). Total length plotted against time (Figure 32) shows substantial increase in lengths of sturgeon captured during the June to August period of capture at both traps.

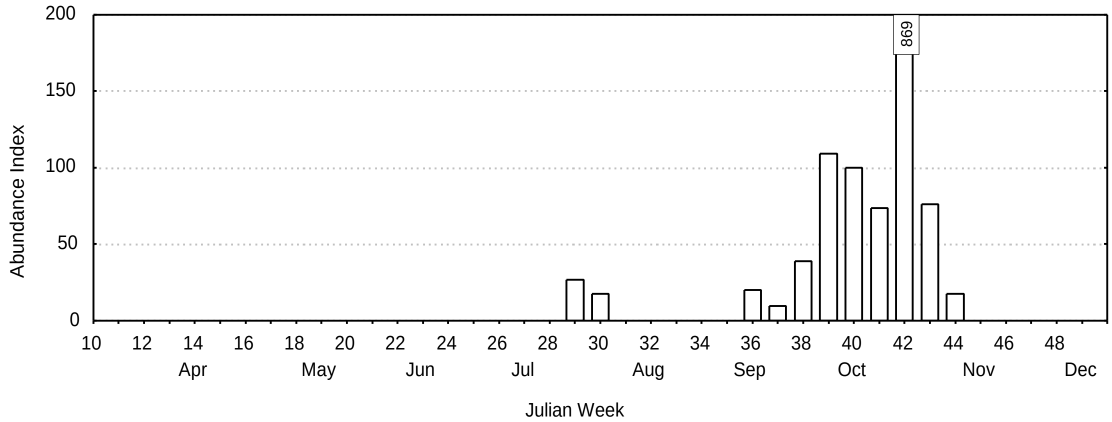


Figure 30. Weekly American shad indices at the WCT (Trinity River), 1996.

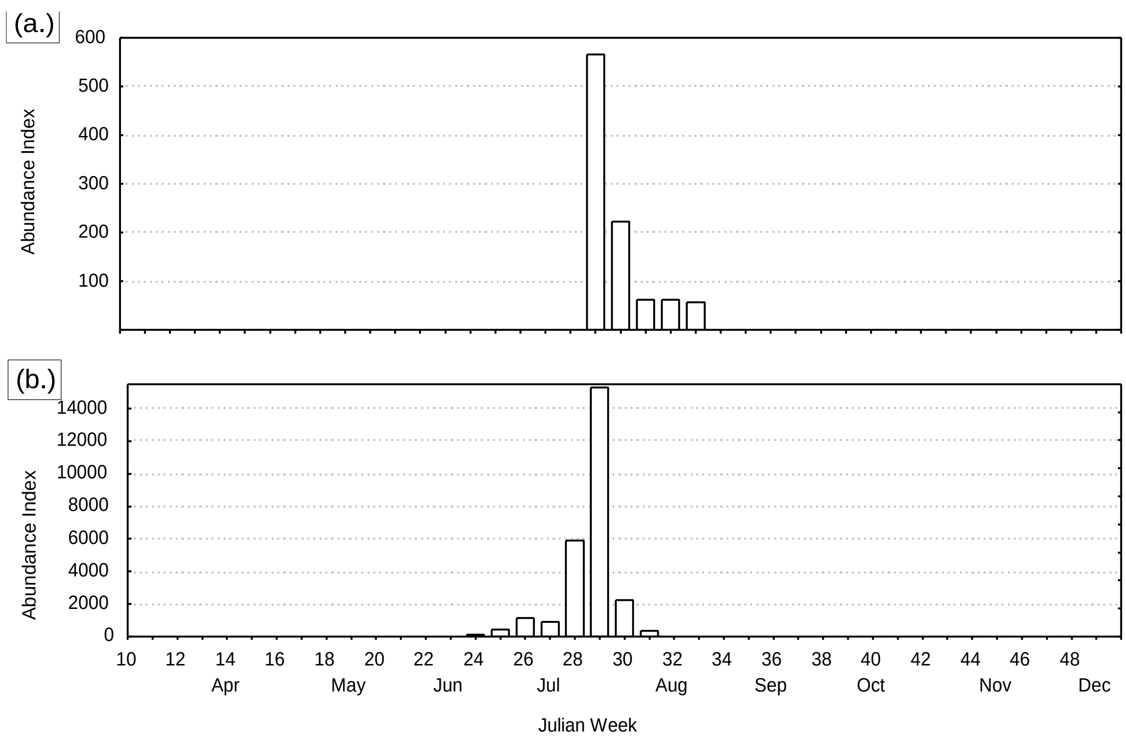


Figure 31. Weekly green sturgeon indices at (a.) the WCT (Trinity River) and (b.) the BBT (Klamath River), 1996.

Centrarchidae

At least three centrarchid species were captured in small numbers at the BBT; *Pomoxis sp.* (unidentified crappie), *Lepomis sp.*

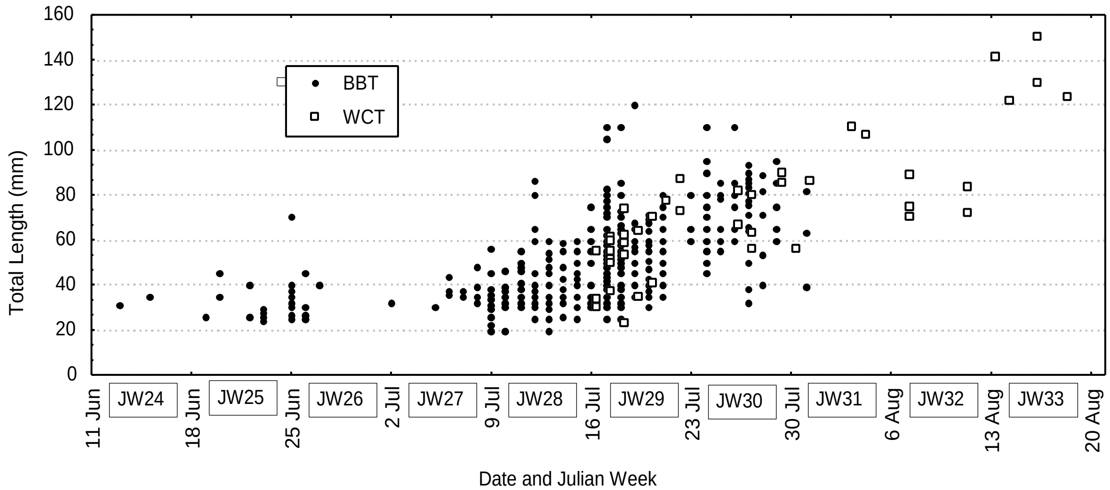


Figure 32. Green sturgeon TL by date and JW at the BBT (Klamath River), and the WCT (Trinity River), 1996.

(unidentified sunfish) and largemouth bass (*Micropterus salmoides*). Largemouth bass and *Lepomis sp.* were also captured at the WCT. Seven juvenile *Lepomis sp.* were captured at the WCT and 3 were captured at the BBT. One juvenile largemouth bass was captured at each trap (132 mm FL at the WCT and 27 mm FL at the BBT) and three crappie (95 mm, 105 mm and 160 mm FL) were captured at the BBT.

Gasterosteidae

Threespine stickleback (*Gasterosteus aculeatus*) was the fourth most abundant species at the WCT, while only 9 specimens were captured at the BBT. Stickleback were present throughout the 1996 WCT sampling period in small numbers. A period of increased abundance occurred from JWs 29 to 38 with and peaked on JW 35 (Figure 33). Fork length of stickleback early in the sampling season (JWs 12-27) ranged from 40 mm to 65 mm, but during JW 29 a smaller cohort appeared and was discernable for the rest of the sampling period (Figure 34). Threespine stickleback complete their life cycle in one year (Moyle, 1976). The observed trends in Figure 34 could be explained by the recruitment of a YOY cohort that appeared in our trap during JW 29. The larger fish captured earlier in the year were part of an older cohort.

Ictaluridae

Thirty-two bullhead (*Ameirus sp.*) were captured at the BBT ranging

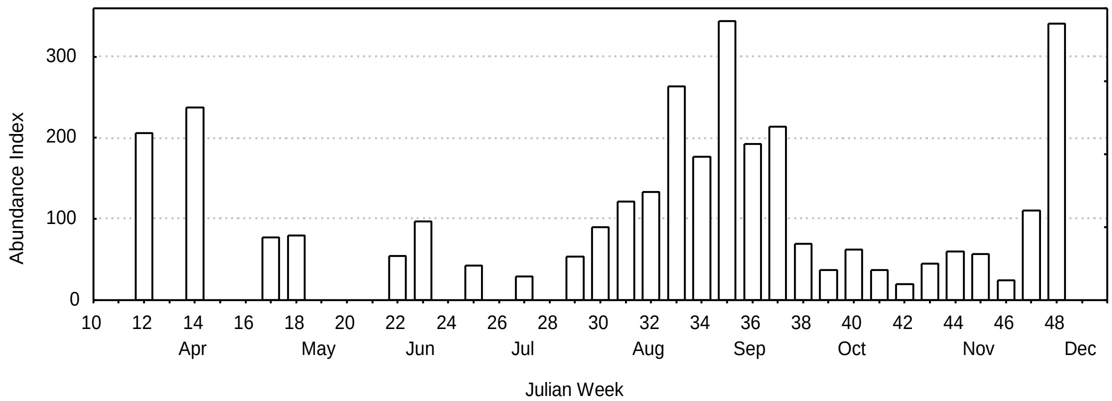


Figure 33. Weekly threespine stickleback indices at the WCT, Trinity River, 1996.

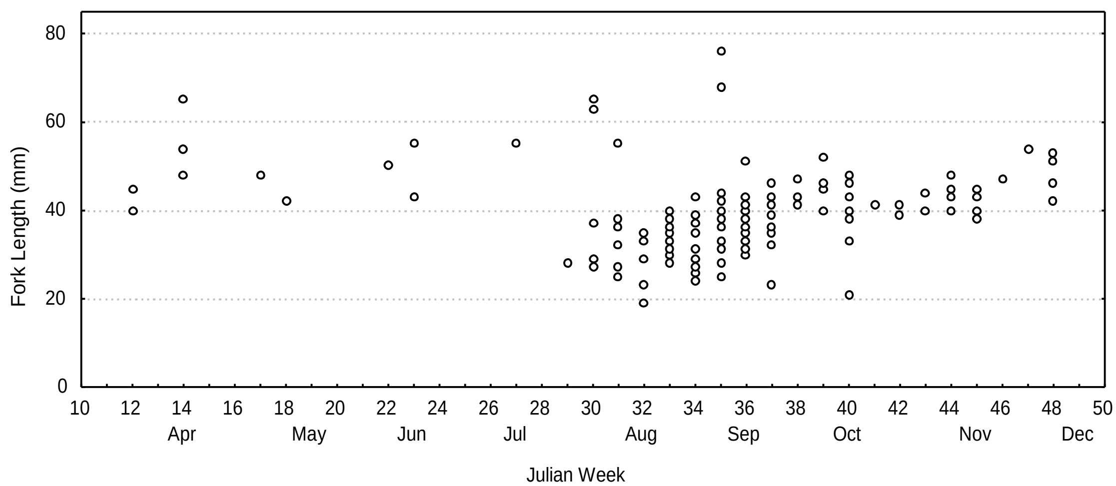


Figure 34. Threespine stickleback FLs by JW at the WCT, Trinity River, 1996.

in size from 12 mm TL to 210 mm TL. One 222 mm TL bullhead was captured at the WCT.

Salmonidae

Three brown trout (*Salmo trutta*) (30 mm FL, July 17; 107 mm FL, April 4; 152 mm FL, March 19) were captured at the WCT. Eleven juvenile sockeye salmon (*Oncorhynchus nerka*), identified by gill raker counts, were captured at the WCT. Fork length increased over time from the first specimen (40 mm FL) captured on August 7, 1996 to the largest (78 mm FL) on November 10, 1996. Adult sockeye have not been observed in the Trinity River below Lewiston Dam at CDFG’s weir at Willow Creek or during spawning surveys. It is likely that the sockeye salmon parr caught at the WCT came from a kokanee salmon (land locked sockeye salmon) population in Trinity Lake. It is also possible that occasional sockeye salmon spawn somewhere in the Trinity River watershed in the late spring or early summer.

INTRA BASIN COMPARISON

Flows on the Klamath River were significantly higher than on the Trinity River during the entire period both traps were operating. Mean daily water temperatures (MDT) were slightly lower on the Klamath River for most of the period both traps were operating (Figure 35). The MDT of both rivers exceeded "stressful conditions" (>20^{o}C) by the beginning of July (JW 27), and increased to around 24^{o}C twice during that month (Figure 35). Klamath River temperature data are not available after July 31 (JW 31), but we assume Klamath River MDTs closely followed those of the Trinity River, which dropped below 20^{o}C by September 4 (JW 36).

On both rivers, the bulk of the 1996 natural YOY chinook emigration corresponded with periods of rapidly increasing water temperatures. Most chinook had migrated past the traps before MDTs reached stressful levels. The peak of the Klamath River natural YOY chinook emigration (JWs 23-27) was more pronounced and significantly larger in magnitude than on the Trinity River. However, YOY emigration tapered off faster on the Klamath River than on the Trinity River.

RECOMMENDATIONS

Rotary screw traps have proven to be an effective tool in assessing juvenile salmonid downstream migration. Traps can sample a large volume of water 24 hours a day, and can handle large amounts of debris. However, on large rivers such as the Klamath and Trinity, only a very small portion of the total river flow can be effectively sampled. Thus, an unknown portion of downstream migrants pass the traps unsampled, making it difficult to estimate the true population. Currently AFWO uses the trapping data to develop an abundance index that is used to compare relative abundance of fish caught at a particular site over time. The index method must be used because river flows, and thus the proportion of the flow sampled, vary daily. One assumption of the index is that the catch at the trapping site is directly proportional to the proportion of flow sampled. It is not known to what degree this assumption may be

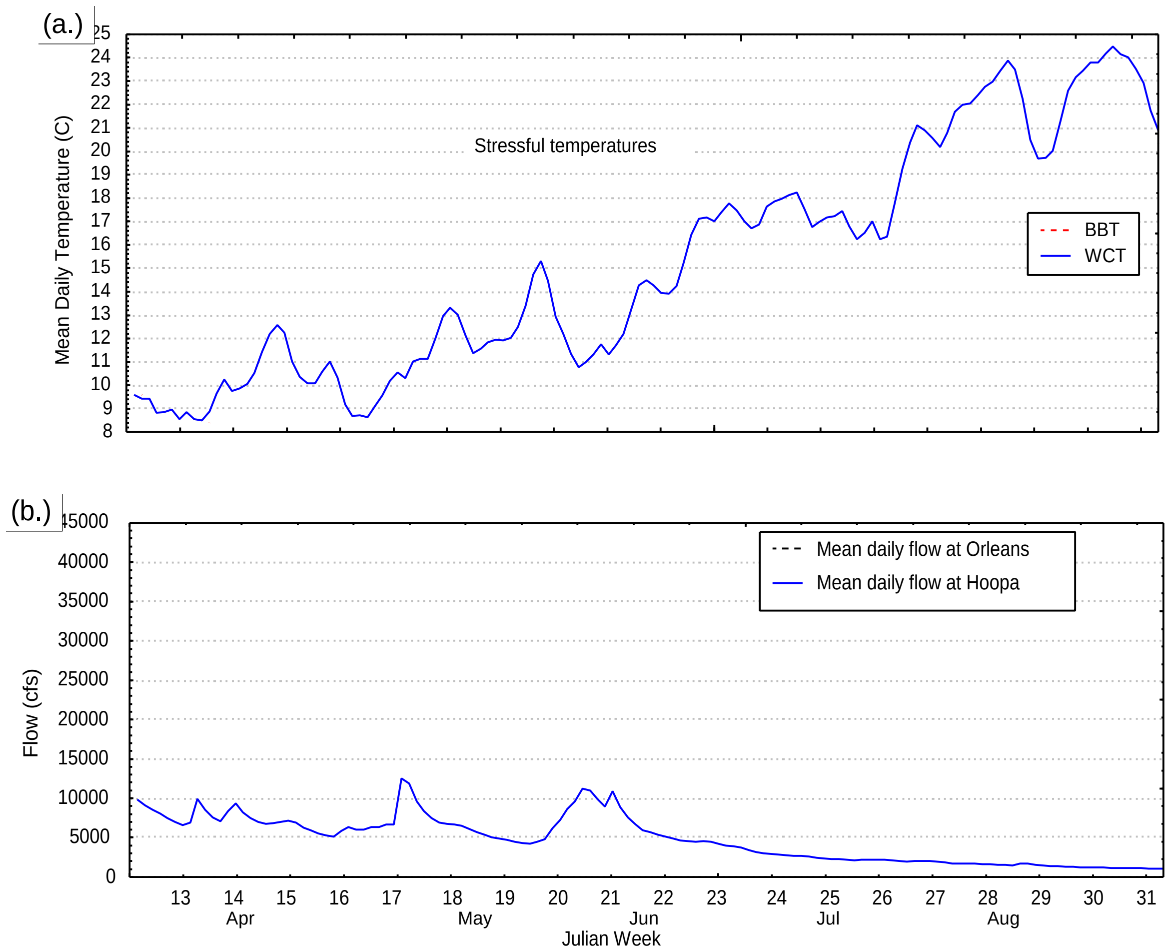


Figure 35. a) Mean daily temperatures of the Klamath and Trinity Rivers at the BBT and WCT trap sites during the period that both traps were in operation, 1996; b) Klamath River (at Orleans) and Trinity River (at Hoopa) flows during the period that both traps were in operation, 1996.

violated, but it likely depends on the trapping site. Currently, the abundance index does not account for other factors that may affect emigration and trapping efficiency, such as moon phase, temperature, turbidity, etc.

Changes in flow, moon phase, temperature, turbidity, etc. would not be an issue and, in fact, an actual population estimate could be attained, if known numbers of marked fish were released an appropriate distance above a trap each day the trap was operating. The proportion of marked fish caught would then provide an estimate of trap efficiency for that particular day which could then be applied to the catch of unmarked fish to estimate the number of unmarked fish that passed the trap unsampled. The proportion of marked fish captured each day may vary according to a myriad of factors, but what those factors are and how much each one affects the catch does not need to be known to calculate the population estimate.

The AFWO has conducted varying numbers of efficiency tests each year at the WCT since 1989 (U.S. Fish and Wildlife Service 1991, 1992, 1994, 1998). Calculated efficiencies have ranged from 0% to 17.6% (O=3.61%). Several attempts to conduct efficiency tests on the Klamath River were aborted due to low catches, poor fish health and associated high mortalities (U.S. Fish and Wildlife Service 1991, 1992,).

A major obstacle to conducting valid efficiency tests on both rivers is lack of adequate fish capture in one day for a single marking event (U.S. Fish and Wildlife Service 1991, 1992, 1994, 1998). One or two day marking events have been desirable because of the extra manpower and equipment required to mark, transport, hold and release fish upstream, in addition to the regular trapping duties. Fish marked at the trap must be transported a sufficient distance upstream to allow random mixing with unmarked fish prior to their arrival at the trap. Also, the fish must be held in pens at the release site until dark.

One way to avoid many of the above problems would be to run two screw traps in the same river a relatively short distance apart. Fish captured at the upstream trap would be measured and marked (using a different mark each JW), then released. Captures of marked fish at the downstream trap would be used to calculate trap efficiency. This method was used successfully by Dempson and Stansbury (1991). The distance between the traps should be great enough to allow for random mixing of marked and unmarked fish, but close enough so that between trap mortality is negligible. It would also be desirable to have the traps far enough apart so that fish released in the morning or afternoon could not arrive at the trap before nightfall. One possibility would be to mark fish at the current WCT location and recapture somewhere downstream in the Hoopa Valley.

The AFWO recommends the continuation of annual rotary trapping programs to collect data used to assess: hatchery and natural contributions, salmonid abundance indexes, size and emigration rate relationships and emigration duration. The traps also provide fish for health and disease assessment. Collecting abundance data on non-target species may also provide additional insight on the health of the Klamath River Basin.

The continuance of juvenile salmon monitoring may enable fisheries biologists a means of relating natural juvenile abundance indices and adult escapement estimates. Monitoring also provides information regarding the effects of water resource management policies on juvenile salmonid emigration. Such data are necessary for effectively implementing an "adaptive management" approach that will best meet the water needs of the fishery and various interests.

REFERENCES

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. Can. J. Fish. Aquat. Sci. 48:1250-1263.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, Portland, Oregon. Contract No. DACW57-68-C-0086. 425 PP.

Dempson, J. B. and D. E. Stansbury 1991. Using partial counting fences and a two-sample stratified design for mark-recapture estimation of an Atlantic salmon smolt population. N. Amer. J. Fish. Manage. 11:27-37.

General Oceanics, Inc. 1983. Digital flowmeter manual. General Oceanics, Inc. Miami, FL. 13pp.

Klamath River Basin Fisheries Task Force. 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program. USFWS. Yreka, CA.

Manion, P.J., and A.L. McLain. 1971. Biology of larval sea lampreys (*Petromyzon marinus*) of the 1960 year-class, isolated in the Big Garlic River, Michigan, 1960-65. Great Lakes Fish. Comm. Tech. Rep. 16: 35pp.

Manion, P.J., and B.R. Smith. 1978. Biology of larval and metamorphosing sea lampreys, *Petromyzon marinus*, of the 1960 year-class, in the Big Garlic River, Michigan. Part II, 1966-72. Great Lakes Fish. Comm. Tech. Rep. 30: 35pp.

Moore, J.W., and F.W.H. Beamish. 1973. Food of the larval sea lamprey (*Petromyzon marinus*) and American brook lamprey (*Lampetra lamottei*). J. Fish. Res. Bd. Can. 30:7-15.

Moyle, P.B. 1976. Inland Fishes of California. University of California Press, Berkeley, Los Angeles, London. 405pp.

Pacific States Marine Fisheries Commission. 1997. Pacific salmonid coded wire tag releases, 1990-1997. Regional Mark Processing Center, PSFMC. Gladstone, OR. 176 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.

U.S. Fish and Wildlife Service. 1982. Annual Report of the Klamath River Fisheries Investigation Program, 1981. Fisheries Assistance Office. Arcata, CA. 131 pp.

U.S. Fish and Wildlife Service. 1991. Klamath River Basin Juvenile Salmonid Fisheries Investigation. Annual Report of the Klamath River Fisheries Assessment Program, 1989. Coastal California Fishery Resource Office. Arcata, CA. 81 pp.

U.S. Fish and Wildlife Service. 1992. Juvenile Salmonid Trapping on the Mainstem Trinity River at Willow Creek and the Klamath River at Big Bar. Annual Report of the Klamath River Fisheries Assessment Program, 1990. Coastal California Fishery Resource Office. Arcata, CA. 50 pp.

U.S. Fish and Wildlife Service. 1994. Juvenile Salmonid Trapping on the Trinity and Klamath Rivers. Annual Report of the Klamath River Fisheries Assessment Program, 1991. Coastal California Fishery Resource Office. Arcata, CA. 58 pp.

U.S. Fish and Wildlife Service. 1995. Age and growth of Klamath River green sturgeon (*Acipenser medirostris*). Klamath River Fishery Resource Office, Yreka, California. 20pp.

U.S. Fish and Wildlife Service. 1998. Juvenile salmonid monitoring on the mainstem Klamath River at Big Bar and mainstem Trinity River at Willow Creek, 1992-1995. Annual Report of the Klamath River Fisheries Assessment Program, 1992-95. Coastal California Fish and Wildlife Office. Arcata, CA. 97 pp.

Youson, J.H., and I.C. Potter. 1979. A description of the stages of metamorphosis of the anadromous sea lamprey, *Petromyzon marinus* L. Can. J. Zool. 57:1808-1817.

Submitted by:

Roderick F. McLeod ________________________
Fishery Biologist

Approved by:

Bruce G. Halstead ________________________
Project Leader

APPENDIX

Appendix A. Julian Weeks and calendar dates.

Julian week	Calendar date		Julian week	Calendar date	
	Start	End		Start	End
1	Jan 01	Jan 07	27	Jul 02	Jul 08
2	Jan 08	Jan 14	28	Jul 09	Jul 15
3	Jan 15	Jan 21	29	Jul 16	Jul 22
4	Jan 22	Jan 28	30	Jul 23	Jul 29
5	Jan 29	Feb 04	31	Jul 30	Aug 05
6	Feb 05	Feb 11	32	Aug 06	Aug 12
7	Feb 12	Feb 18	33	Aug 13	Aug 19
8	Feb 19	Feb 25	34	Aug 20	Aug 26
9[a]	Feb 26	Mar 04	35	Aug 27	Sep 02
10	Mar 05	Mar 11	36	Sep 03	Sep 09
11	Mar 12	Mar 18	37	Sep 10	Sep 16
12	Mar 19	Mar 25	38	Sep 17	Sep 23
13	Mar 26	Apr 01	39	Sep 24	Sep 30
14	Apr 02	Apr 08	40	Oct 01	Oct 07
15	Apr 09	Apr 15	41	Oct 08	Oct 14
16	Apr 16	Apr 22	42	Oct 15	Oct 21
17	Apr 23	Apr 29	43	Oct 22	Oct 28
18	Apr 30	May 06	44	Oct 29	Nov 04
19	May 07	May 13	45	Nov 05	Nov 11
20	May 14	May 20	46	Nov 12	Nov 18
21	May 21	May 27	47	Nov 19	Nov 25
22	May 28	Jun 03	48	Nov 26	Dec 02
23	Jun 04	Jun 10	49	Dec 03	Dec 09
24	Jun 11	Jun 17	50	Dec 10	Dec 16
25	Jun 18	Jun 24	51	Dec 17	Dec 23
26	Jun 25	Jul 01	52[b]	Dec 24	Dec 31

[a]JW9 is an eight day JW on leap years.
[b]JW52 is always an eight day JW.

Appendix B. Age class of scaled steelhead by development stage and Julian Week, BBT, Klamath River, 1996.

Julian week	Parr Age class 1+	Smolt Age class 1+	Smolt Age class 2+	Total
12	1	0	1	2
13	2	0	0	2
14	2	0	0	2
15	0	0	0	0
16	1	0	1	2
17	0	0	2	2
18	0	0	3	3
19	1	0	16	17
20	0	3	11	14
21	0	3	6	9
22	0	2	3	5
23	0	3	7	10
24	0	0	2	2
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
Total	7	12	51	70

Appendix C. Fry and Parr steelhead age distribution based on scale-aged fish, BBT, Klamath River, 1996.

Fry					Parr				
JW	Dev.	FL	Scale	Age	JW	Dev.	FL	Scale	Age
14	2	27	N	0	12	3	73	N	1
24	2	50	N	0	12	3	90	Y	1
25	2	34	N	0	13	3	78	N	1
28	2	30	N	0	13	3	85	N	1
28	2	40	N	0	13	3	100	Y	1
28	2	48	N	0	13	3	119	Y	1
28	2	48	N	0	14	3	75	N	1
28	2	49	N	0	14	3	92	Y	1
28	2	52	N	0	14	3	94	Y	1
28	2	56	N	0	15	3	77	N	1
28	2	63	N	0	16	3	76	N	1
29	2	35	N	0	16	3	76	N	1
29	2	40	N	0	16	3	77	N	1
29	2	42	N	0	16	3	80	N	1
29	2	50	N	0	16	3	80	N	1
29	2	60	N	0	16	3	81	N	1
30	2	45	N	0	16	3	85	N	1
30	2	52	N	0	16	3	87	Y	1
30	2	56	N	0	16	3	87	N	1
30	2	58	N	0	16	3	91	N	1
30	2	63	N	0	17	3	78	N	1
30	2	65	N	0	17	3	79	N	1
15	2	62	N	0	17	3	79	N	1
18	2	65	N	0	17	3	90	N	1
28	2	65	N	0	17	3	92	N	1
28	2	69	N	0	17	3	92	N	1
28	2	70	N	0	18	3	73	N	1
29	2	53	N	0	18	3	89	N	1
29	2	65	N	0	18	3	101	N	1
29	2	65	N	0	19	3	82	N	1
29	2	70	N	0	19	3	83	N	1
30	2	70	N	0	19	3	84	N	1
					19	3	89	N	1
					19	3	89	N	1
					19	3	92	N	1
					19	3	93	N	1
					19	3	97	N	1
					19	3	103	N	1
					19	3	104	Y	1
					19	3	109	N	1
					19	3	117	N	1
					20	3	86	N	1
					20	3	94	N	1
					20	3	96	N	1
					20	3	97	N	1
					21	3	115	N	1

Appendix D. Steelhead smolt age distribution based on scale-aged fish, BBT, Klamath River, 1996.

JW	Dev.	FL	Scale	Age	JW	Dev.	FL	Scale	Age
17	4	158	N	ND	19	4	221	Y	2
20	4	150	Y	1	19	4	221	Y	2
20	4	160	Y	1	19	4	225	Y	2
20	4	185	Y	1	19	4	225	Y	2
21	4	165	Y	1	19	4	245	Y	2
21	4	170	Y	1	20	4	164	Y	2
21	4	182	Y	1	20	4	170	Y	2
22	4	161	N	ND	20	4	175	Y	2
22	4	175	Y	1	20	4	176	Y	2
22	4	184	Y	1	20	4	184	Y	2
23	4	154	Y	1	20	4	199	Y	2
23	4	180	Y	1	20	4	204	Y	2
23	4	182	Y	1	20	4	208	Y	2
23	4	215	Y	1	20	4	222	Y	2
25	4	95	N	1	20	4	223	Y	2
28	4	182	N	ND	20	4	230	Y	2
29	4	192	N	ND	21	4	162	Y	2
31	4	94	N	1	21	4	165	Y	2
12	4	223	Y	2	21	4	188	N	ND
16	4	148	Y	2	21	4	194	Y	2
17	4	198	Y	2	21	4	195	Y	2
17	4	205	Y	2	21	4	212	Y	2
17	4	225	N	ND	21	4	214	Y	2
18	4	172	Y	2	22	4	185	Y	2
18	4	174	Y	2	22	4	197	Y	2
18	4	220	Y	2	22	4	208	Y	2
19	4	183	Y	2	23	4	171	Y	2
19	4	187	Y	2	23	4	175	Y	2
19	4	197	Y	2	23	4	186	N	ND
19	4	198	Y	2	23	4	187	Y	2
19	4	201	Y	2	23	4	188	N	ND
19	4	207	Y	2	23	4	189	Y	2
19	4	208	Y	2	23	4	202	Y	2
19	4	208	Y	2	23	4	225	Y	2
19	4	212	Y	2	24	4	181	Y	2
19	4	212	Y	2	24	4	187	Y	2
19	4	213	Y	2	27	4	193	N	ND

ND - age not determined

Appendix E. Age class of scaled steelhead by development stage and Julian Week, WCT, Trinity River, 1996.

Julian	Parr Age class		Smolt Age class				
JW	0+	1+	0+	1+	2+	3+	Total
12	0	0	0	5	13	1	19
13	0	2	0	1	13	0	16
14	0	1	0	8	11	3	23
15	0	0	0	0	0	0	0
16	0	2	0	24	17	0	43
17	0	1	0	21	35	1	58
18	0	2	0	7	15	1	25
19	0	1	0	32	17	0	50
20	0	0	0	71	20	0	91
21	0	0	0	106	19	0	125
22	0	1	0	33	0	0	34
23	0	0	0	23	0	0	23
24	0	3	0	58	1	0	62
25	0	0	0	19	0	0	19
26	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0
32	0	0	0	3	0	0	3
33	0	0	0	6	0	0	6
34	0	0	0	4	0	0	4
35	0	0	0	1	0	0	1
36	0	0	0	5	0	0	5
37	0	0	0	3	0	0	3
38	0	0	1	2	0	0	3
39	0	0	0	0	0	0	0
40	0	1	0	0	0	0	1
41	0	0	0	0	0	0	0
42	5	2	0	10	0	0	17
43	0	0	0	4	0	0	4
44	0	0	0	5	1	0	6
45	0	0	1	11	10	0	22
46	0	0	0	2	1	0	3
47	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0
Total	5	16	2	464	173	6	666