U.S. Fish & Wildlife Service

Arcata Fisheries Technical Report TR2006-06

Klamath River Salmonid Emigrant Trapping Catch, Mortality, and External Health Indicators - 2004

Charles D. Chamberlain and Samuel C. Williamson

U.S. Fish and Wildlife Service
Arcata Fish and Wildlife Office
1655 Heindon Road
Arcata, CA 95521
(707) 882-7201

With
U.S. Geological Survey
Fort Collins Science Center
2150 Centre Avenue, Bldg. C
Fort Collins, CO 80526-8118
(970) 226-9100

2006

Funding for this study was provided by the U.S. Fish and Wildlife Service Klamath River Basin Fisheries Task Force (Big Bar emigrant trapping); the Service's Klamath River Habitat Assessment (Flow) Study, the Karuk and Yurok Tribal Fishery programs and the U.S. Geological Survey (Chinook and coho salmon fry study); by the Bureau of Reclamation under Agreement Number 03AA204040 (Klamath River coho salmon investigations); and by the National Marine Fisheries Service under Agreement Number SWR-053 (extended trapping seasons and fish health investigations).

Disclaimers

Disclaimer: The mention of trade names or commercial products in this report does not constitute endorsement or recommendation for use by the Federal government.

The Arcata Fish and Wildlife Office Fisheries Program reports study findings through two publication series. The **Arcata Fisheries Data Series** was established to provide timely dissemination of data to local managers and for inclusion in agency and Tribal databases. **Arcata Fisheries Technical Reports** publish scientific findings from single and multi-year studies that have undergone more extensive statistical testing and peer review. Additionally, some study results are published in a variety of professional fisheries journals.

Key words: Klamath River, mortality, salmonid emigration, juvenile fish health

The correct citation for this report is:

Chamberlain, C. D. and S. C. Williamson. 2006. Klamath River salmonid emigrant trapping catch, mortality, and external health indicators - 2004. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata California.

This report and supplemental appendices can be downloaded electronically at: http://www.fws.gov/arcata/ . Red font hereinafter within this report will indicate reference to these supplemental appendices.

Table of Contents

page

List of Tables iv

List of Figures v

List of Appendices vii

Introduction 2

Study Area 4

Methods 7
- Emigrant trapping 7
- External fish health indicators 10
- Coho salmon use of non-natal tributaries 13

Results 14
- Emigrant trap catch 14
- Biological data 23
- External abnormalities 24
- Coho salmon use of non-natal tributaries 40

Discussion 41

Acknowledgments 50

Literature Cited 50

Personal Communications 50

List of Tables

page

Table 1. 2004 Klamath River and tributary trapping locations for this report. 6

Table 2. Klamath River tributaries sampled in 2004 for non-natal coho salmon rearing..... 7

Table 3. Number of coho salmon marked with a calcein-immersion bath and released in Klamath River trapping network 2004..... 13

Table 4. Frame trap mean catch-per-unit effort (catch per day) by month and site for unmarked young-of-year Chinook salmon. Mainstem trap catch was comprised of both hatchery and wild fish after the hatchery release. 16

Table 5. Rotary trap mean catch-per-unit effort (catch per day) by month and site for unmarked young-of-year Chinook salmon. Mainstem trap catch was comprised of both hatchery and wild fish after the hatchery release. 16

Table 6. Frame trap mean catch-per-unit effort (catch per day) by month and site for wild young-of-year coho salmon. 18

Table 7. Rotary trap mean catch-per-unit effort (catch per day) by month and site for wild young-of-year coho salmon. 18

Table 8. Mean trap catch-per-unit effort (catch per day) by month, tributary site, and trap type for young-of-year coho salmon. 19

Table 9. Rotary trap mean catch-per-unit effort (catch per day) by month and site for unmarked yearling coho salmon. 19

Table 10. Mean trap catch-per-unit effort (catch per day) by month, tributary site, and trap type for yearling coho salmon. 20

Table 11. Frame trap mean catch-per-unit effort (catch per day) by month and site for wild young-of-year steelhead. 22

Table 12. Rotary trap mean catch-per-unit effort (catch per day) by month and site for wild young-of-year steelhead. 22

Table 13. Mean trap catch-per-unit effort (catch per day) by month, tributary site, and trap type for young-of-year steelhead..... 23

Table 14. External abnormality rate observed at mainstem trap sites. 25

Table 15. Rate of lamprey wounds observed in fish externally examined at mainstem trap sites. 25

Table 16. Portion of young-of-year Chinook salmon sample with various external symptoms by trap site..... 26

Table 17. Portion of young-of-year coho salmon sample with various external symptoms by trap site..... 26

Table 18. Portion of young-of-year steelhead sample with various external symptoms by trap site..... 26

Table 19. Portion of yearling and older steelhead sample with various external symptoms by trap site. 27

Table 20. Total capture and mortality of young-of-year Chinook salmon. 37

Table 21. Total capture and mortality of young-of-year coho salmon. 38

Table 22. Total capture and mortality of yearling coho salmon. 38

Table 23. Total capture and mortality of young-of-year steelhead 39

Table 24. Total capture and mortality of yearling and older steelhead. 39

Table 25. Capture of coho salmon from tributaries sampled for calcein marked fish. 41

List of Figures

page

Figure 1. Klamath River 2004 mainstem and tributary trap sites of this report operated by Arcata Fish and Wildlife Office and partners. 5

Figure 2. Klamath River 2004 rotary trap at I-5 trap site (river mile 180). 8

Figure 3. Frame trap installations at Horse Creek May 10, 2004 (left), and at Seiad Creek May 28, 2004 (right). 9

Figure 4. Klamath River 2004 mainstem emigrant trapping and external health examination periods by site. 11

Figure 5. Klamath River Chinook salmon exhibiting a swollen abdomen. 11

Figure 6. Klamath River Chinook salmon exhibiting exophthalmia (pop-eye). 12

Figure 7. Klamath River Chinook salmon mortality exhibiting a swollen abdomen and lamprey wound likely inflicted by the species *Entosphenus similes*. 12

Figure 8. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Bogus trap site. 28

Figure 9. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Kinsman trap site. 29

Figure 10. Young-of-year Chinook salmon catch and mortality observed at rotary trap 1 (top) and 2 (bottom) at the Big Bar trap site. 30

Figure 11. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Elk Creek trap site. 31

Figure 12. Young-of-year coho salmon catch and mortality observed in the frame trap at the Bogus trap site. 32

Figure 13. Young-of-year coho salmon catch and mortality observed in the frame trap at the I-5 trap site. 32

Figure 14. Young-of-year coho salmon catch and mortality observed in the frame trap at the Kinsman trap site. 33

Figure 15. Young-of-year coho salmon catch and mortality observed in the rotary trap at the Happy Camp trap site. 33

Figure 16. Young-of-year coho salmon catch and mortality observed in the rotary trap at the Persido Bar trap site. 34

Figure 17. Young-of-year coho salmon catch and mortality observed at rotary trap 1 (top) and 2 (bottom) at the Big Bar trap site. 35

Figure 18. Young-of-year coho salmon catch and mortality observed in the frame trap at the Horse Creek trap site. 36

Figure 19. Incidence of *Parvicapsula minibicornis* (above) and *Ceratomyxa shasta* (below) from samples of juvenile Chinook salmon collected at sites on the Klamath River between Bluff Creek and Persido Bar in 2004. 43

Figure 20. External examination vs. histological infection results from Nichols and Foott (2006). 44

Figure 21. Histological results for *Parvicapsula minibicornis* and *Ceratomyxa shasta* by external symptom type of Chinook salmon that exhibited one or more external abnormalities. 46

Figure 22. *Ceratomyxa shasta* mortality and infection prevalence data from Klamath Basin sentinel exposures conducted June 18 – 21, 2004. 47

Figure 23. Young-of-year Chinook salmon mortality by percent of capture observed at the Big Bar trap site 1997 to 2004. 49

List of Appendices

Appendix A. "Normal" vs. "Abnormal" external exam results by trap site..... 51
Appendix B. Plots of catch-per-unit effort and mortality by trap site..... 58
Appendix C. Condition factor scatter-plots..... 72
Appendix D. Scatter plots of salmonid fork lengths by trap site..... 90

Supplemental Appendices
(available for download as one file at: http://www.fws.gov/arcata/)

Appendix E. Catch-per-unit effort (CPUE) by trap (45 pages)

Appendix F. External symptoms and live vs. mortality tables (91 pages)

Appendix G. Other species captured (2 pages)

blank page

Arcata Fisheries Technical Report TR2006-06

Klamath River salmonid emigrant trapping catch, mortality, and external health indicators - 2004

Charles D. Chamberlain and Samuel C. Williamson

U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office
1655 Heindon Road, Arcata, CA 95521
charles_chamberlain@fws.gov

U.S. Geological Survey, Fort Collins Science Center
2150 Centre Avenue, Bldg. C, Fort Collins, CO 80526-8118
sam_williamson@usgs.gov

Abstract Several field investigations conducted in spring and early summer of 2004 resulted in concurrent operation of young-of-year and age 1+ salmonid emigrant traps at six mainstem and three Klamath River tributary sites. Mortality sharply increased starting April 29 at the Bogus, I-5, and Kinsman frame trap sites. By early May, mortality approached 50% for wild young-of-year Chinook salmon captured at Kinsman, Happy Camp, and Persido Bar. From June 2 to June 18, mortality observed in daily catches of Chinook salmon at Kinsman ranged between 51% and 88%. Overall mortality of young-of-year Chinook salmon observed at lower mainstem trap sites (Persido Bar and Big Bar, 6% each) were paltry compared with those observed at Kinsman and Happy Camp (34% and 25%, respectively). In mid-May, a systematic external examination was incorporated into fish sampling as more than half of the live fish captured at Kinsman and Happy Camp exhibited external signs of disease and/or stress. High and low incidence of pale gills and other external abnormalities coincided with sites and time periods having high and low mortality. Based on external examinations, Kinsman was a "hotspot" of symptomatic young-of-year Chinook salmon (at 82%), declining downstream to Happy Camp (56%), Persido Bar (40%), and Big Bar (14%). Common external abnormalities noted in examinations of Chinook salmon included pale gills (pink or grey in color rather than a healthy red appearance), distended abdomen, gill rot, and lamprey wounds. Abnormality rates were highest at Kinsman and Happy Camp for all salmon species and age classes. Mortality was low at tributary traps operated at Horse Creek, Seiad Creek, and Elk Creek and captured fish were healthy in appearance. This agrees well with previous fish health investigations and two studies conducted on the Klamath River in 2004. In one of those studies, sentinel fish held in the mainstem became infected with *Ceratomyxa shasta* and *Parvicapsula minibicornis*, but sentinel fish held in tributaries were not. The timing of peak catch of young-of-year coho salmon and steelhead at various sites indicated no consistent downstream movement, but rather that both species were rearing and moving in the mainstem. Rotary traps at the three upper mainstem sites were inefficient compared to frame traps for catching young-of-year Chinook salmon and ineffective for catching young-of-year coho salmon and steelhead.

Introduction

The U.S. Fish and Wildlife Service Arcata Fish and Wildlife Office (AFWO) has conducted salmonid outmigration trapping in the Klamath River at the Big Bar River Access since 1988, at I-5 since 2000, and at Bogus and Kinsman since 2002. In 2004, because of several coincidentally concurrent projects, an unprecedented array of traps was fished in the Klamath River mainstem and tributaries by AFWO and Karuk and Yurok tribal partners, at sites dispersed over a large portion of the river from near Iron Gate Dam 193 river miles (RM) from the Pacific Ocean to Big Bar, 51 RM from the Pacific Ocean.

Data from multiple investigations contributed to this report. This however is NOT a comprehensive report of ALL trapping efforts in the basin and the following major sampling efforts are not summarized in this report: California Department of Fish and Game operated traps at the Shasta and Scott Rivers; the Karuk Tribe of California operated traps at Indian Creek and partnered with the Salmon River Restoration Council to operate a trap site on the Salmon River; and traps were operated in the Trinity River Basin by AFWO, the Yurok Tribe, and the Hoopa Valley Tribe. This report is intended to present one year's intensive sampling results and not present the extensive (but much less intensive) results from other years. Those other sampling results include: Big Bar rotary trap data for 1988 to 2006; Bogus, I-5 and Kinsman rotary and frame trap data for 2001 to 2006; mark-recapture production estimates from those sites and years; and temperature and flow data for those years. With data for one year, it is not reasonable to attribute causation beyond noting major differences between sampling locales, which in our data did not adequately correspond to observed small differences in flows and water temperatures.

To quantify production and estimate successful emigrants of wild Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*), March to May operation of mainstem trap sites at Bogus, I-5, and Kinsman was funded by the Klamath River Basin Fisheries Task Force and the U.S. Geological Survey. Data collected from this portion of the 2004 trapping network is intended for use in development and refinement of a

salmonid production model SALMOD, which is a component of the Klamath River-based Systems Impact Assessment Model (Bartholow et al. 2003).

The Bureau of Reclamation funded study of coho salmon in 2004 to develop information regarding coho salmon production, habitat use, and survival in the mainstem Klamath River. Trapping efforts in the mainstem Klamath River at Kinsman, Happy Camp, Persido Bar, and Big Bar, and at tributary sites at Horse Creek, Seiad Creek, and Elk Creek were conducted. Marking operations at two mainstem and three tributary trapping sites occurred along with recapture attempts at ten alternate tributary sites to investigate potential use of tributaries by coho salmon for non-natal rearing.

The Arcata Fish and Wildlife Office and partners have operated emigrant traps at Big Bar on the Klamath River since 1988. In 2004, Big Bar trap operation was partially funded by the Klamath River Basin Fisheries Task Force for continued monitoring of downstream movement of juvenile Chinook salmon, coho salmon, and steelhead (*O. mykiss*) during the spring and into June.

In early May 2004, before the first Iron Gate Hatchery (IGH) release of Chinook salmon occurred, crews operating Klamath River traps at the Kinsman site (RM 146) noted a marked increase in mortality and occurrence of unhealthy wild fish in the traps. The U.S. Fish and Wildlife Service California-Nevada Fish Health Center diagnosed some of these fish with myxosporean parasites *Ceratomyxa shasta* and *Parvicapsula minibicornis*. Due to large numbers and percentages of unhealthy, dying, and dead fish reported from portions of the 2004 trapping network, especially at the Kinsman trapping site, the National Marine Fisheries Service funded supplemental trapping efforts to extend the trapping period and characterize fish health at certain locales.

Other 2004 Klamath River fish health studies

Other fish health related studies that occurred in the Klamath River in 2004 included a health monitoring investigation of Klamath River young-of-year Chinook salmon conducted by California-Nevada Fish Health Center (Nichols and Foott 2006). A study conducted by Oregon State University's Center for Fish Disease Research utilized sentinel rainbow trout (*O. mykiss*) and Chinook salmon held at various locations in the

Klamath River and tributaries to test for presence and virulence of *C. shasta* (Stocking et al. in press).

Study Area

The collective geographic area of projects that contributed data to this report spans the Klamath River mainstem and lower reaches of several tributaries located between Iron Gate Dam at RM 193 and the Big Bar River Access at RM 51, 12 km upstream of the Klamath River's confluence with the Trinity River (Figure 1). Emigrant trapping sites are given in Table 1. Tributaries sampled to detect non-natal coho salmon rearing are given in Table 2.

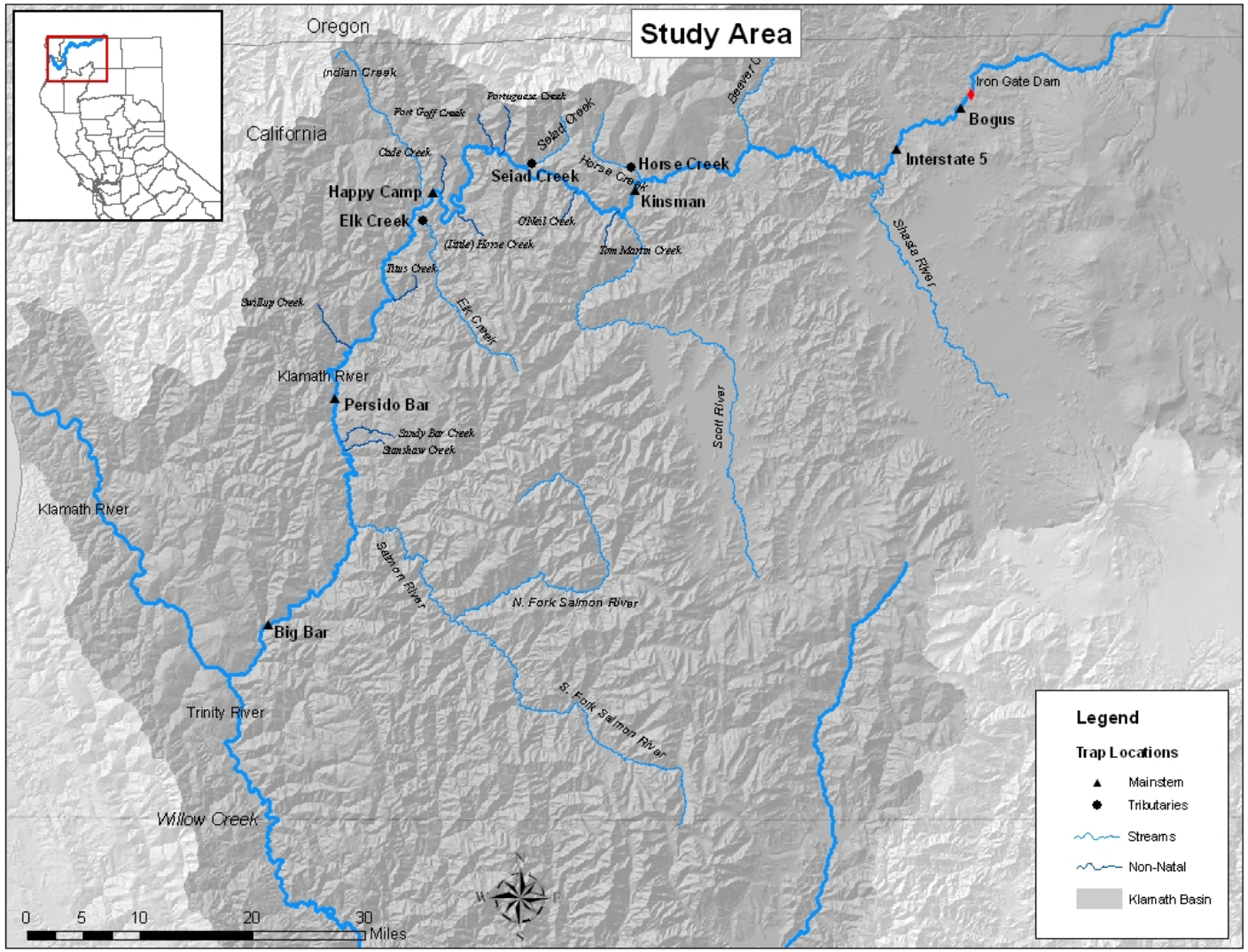

Figure 1. Klamath River 2004 mainstem and tributary trap sites of this report operated by Arcata Fish and Wildlife Office and partners. "Non-Natal" refers to tributaries sampled for the presence of marked coho salmon from elsewhere in the study area.

Table 1. 2004 Klamath River and tributary trapping locations for this report.

Mainstem location	Approximate river mile		Trap type	Start date	End date
Bogus	189		10 ft Frame	10-Mar	13-May
			8 ft Rotary	10-Mar	05-May
Interstate 5 (I-5) (near Carson Creek)	180		10 ft Frame	11-Mar	06-May
			8 ft Rotary	10-Mar	21-Apr
Kinsman	146		10 ft Frame	10-Mar	28-Jun
			8 ft Rotary	10-Mar	03-Jul
Happy Camp	108		10 ft Frame	30-Mar	09-Jul
			8 ft Rotary	05-Mar	14-Jun
Persido Bar	82		10 ft Frame	07-Mar	23-Jun
			8 ft Rotary	03-Mar	19-Jul
Big Bar	51		10 ft Frame	15-Apr	26-Apr
			8 ft Rotary$_1$	23-Mar	23-Jun
			8 ft Rotary$_2$	08-Apr	30-July
Tributary location	**Klamath river mile at mouth**	**Tributary mile**			
Horse Creek	149	1.6	10 ft Frame	26-Feb	16-Apr
			5 ft Frame	21-Apr	03-Jul
			5 ft Frame	27-May	27-Jun
Seiad Creek	132	0.1	10 ft Frame	03-Mar	19-Mar
			5 ft Frame	23-Mar	27-May
			5 ft Frame	20-Apr	03-Jul
Elk Creek	106	0.1	5 ft Rotary	31-Mar	03-Jun
		1.0	5 ft Frame	29-May	25-Jul

Table 2. Klamath River tributaries sampled in 2004 for non-natal coho salmon rearing.

Tributary sampled	Klamath river mile at tributary mouth	Date sampled
Tom Martin Creek	144.2	08-Nov
O'Neil Creek	138.8	08-Nov
Portuguese Creek	129.0	08-Nov
Fort Goff Creek	128.0	08-Nov
* *Little* Horse Creek	118.1	27-Oct
Cade Creek	110.6	08-Nov
Titus Creek	96.7	29-Oct
Swillup Creek	89.7	02-Nov
Sandy Bar Creek	77.6	02-Nov
Stanshaw Creek	76.9	02-Nov

*"*Little*" added to the name of this Horse Creek by the investigators to differentiate it from another tributary of the same name mentioned elsewhere in this report.

Methods

Emigrant trapping

At each trapping site, frame traps, rotary traps, or a combination of the two were used to capture emigrating salmonids. Methods described below were employed consistently throughout the trapping network.

Rotary traps

Rotary traps (Figure 2) of either 8 feet or 5 feet diameter were fished in mainstem and tributary locations (Table 1). These traps are designed to be fished in relatively fast (>2.5 feet per second) moving water with a depth at least 1 ft greater than the radius of the cone. Flowing water hydraulically turns the "screw" (preferably at least five turns per minute) and pushes captured fish into a live-box at the rear of the trap. Generally, a drum screen is mounted at the rear of the live-box to entrain and expel floating debris that otherwise would accumulate in the live-box. The vanes of the screw physically inhibit escape through the front of the trap.

Figure 2. Klamath River 2004 rotary trap at I-5 trap site (river mile 180).

Frame traps

Frame traps (Figure 3) were also fished at mainstem and tributary locations, sometimes adjacent to rotary traps (Table 1). A frame trap has a wide-mouthed net anchored to a rectangular frame. The wide opening is faced upstream and the net tapers down to a live-box on the downstream end. Generally, two or more live-boxes are mounted in tandem to increase live-box volume and reduce live-box water velocities and stress on captured fishes. These traps were fished in shallower water closer to the stream margin than rotary traps where smaller young-of-year fish are more likely to be captured by virtue of their preference for edge habitats (Hardin et al. 2005). Frame traps are fished in shallower water (greater than 3 ft but less than 4.5 ft at the deeper edge) than the rotary traps, but they also rely on sufficient water velocity (>1.5 feet per second) to prevent fish escape. Site selection for the best combination of depth, velocity, and proximity to the thalweg and woody cover are important factors that contribute to effectiveness of both rotary and frame traps.

Figure 3. Frame trap installations at Horse Creek May 10, 2004 (left), and at Seiad Creek May 28, 2004 (right).

Catch-per-unit effort

All traps were set on one day, fished overnight, and checked the following day. This overnight fishing effort defined the basic unit for catch-per-unit effort purposes. Catch-per-unit effort (CPUE) is reported for each trap and site for all trap dates where a valid trap set occurred, and is simply number of fish captured overnight by species, age class, and mark (a portion of the fish released from Iron Gate Hatchery were marked). Effort for a trap in this report is referenced to the day the trap was checked, not the day it was set. If mechanical problems such as a log lodged in the cone of a rotary trap or a torn net influenced CPUE, then the set was considered "flawed" and recorded as such, and catch was not reported as CPUE. Biological data (discussed below) were recorded on all days, including those with a flawed set when there was capture of fish.

Biological data

Biological data from a random subsample of fish captured were reported for each trap and site by day and were collected whenever fish were captured, even when flawed sets occurred. Live biologically sampled fish were anesthetized with tricaine methanesulfonate (MS-222) prior to processing. Biological data collected included species, fork length in millimeters (mm), and presence and nature of any applied external marks such as fin clips, dyes, etc. For some sites and dates, weight in grams (g) of live fish was also recorded and was used for calculating Fulton's condition factor.

External fish health indicators

For the period March through mid-May, external condition (gill color, skin condition, etc.) of biologically sampled fish was recorded only when abnormalities such as lamprey wounds or bloating were noticed. By mid-May however, it became apparent that a significant portion of fish captured at certain locales were experiencing mortality or exhibiting clinical signs of disease or injury. A physical examination was incorporated into the biological data collection process whereby live fish randomly selected for the biological sample were also examined for a suite of external characteristics. Mainstem traps at the Bogus and I-5 sites were removed for the season before this external examination was initiated, but the examination was added to biological data sampling procedures at Kinsman (beginning 5/13), Happy Camp (5/17), Persido Bar (5/27), and Big Bar (5/24; Figure 4). Once initiated, all fish sampled for external characteristics were given subjective scores based on gill color (normal or pale), condition of the abdomen (normal appearance or swollen; Figure 5), and presence or absence of gill rot, hemorrhaging anal vent, lamprey wounds, and exophthalmia (pop-eye; Figure 6). External characteristics not portrayed by these categories were noted in comments when encountered. Since lamprey wounds are recognizable and don't change appearance after death of an individual, presence of lamprey wounds (Figure 7) was noted for those dead fish that were part of the biological sample.

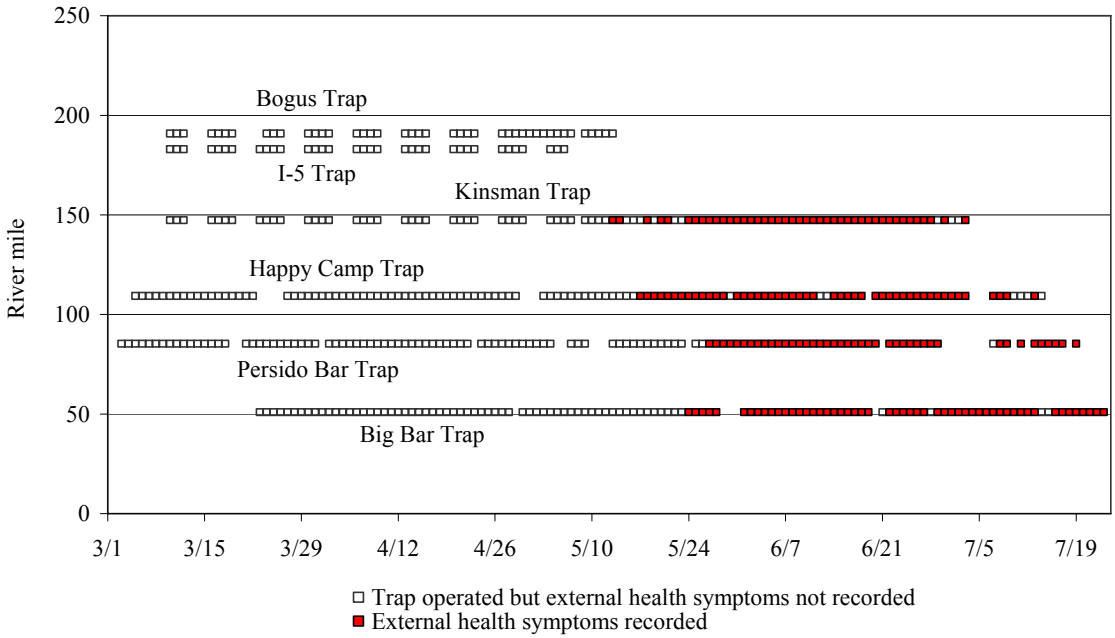

Figure 4. Klamath River 2004 mainstem emigrant trapping and external health examination periods by site. River mile 0 is the mouth of the Klamath River at the Pacific Ocean, and Iron Gate Dam is at river mile 193.

Figure 5. Klamath River Chinook salmon exhibiting a swollen abdomen.

Figure 6. Klamath River Chinook salmon exhibiting exophthalmia (pop-eye).

Figure 7. Klamath River Chinook salmon mortality exhibiting a swollen abdomen and lamprey wound likely inflicted by the species *Entosphenus similes*.

Mortality

Dead fish were identified to species and age class, checked for hatchery and other marks, and then enumerated. "Handling" mortality that occurred during processing and before return of "recovered" fish to the river was also recorded. Mortality in terms of percent of daily capture by species and age class were determined for each trap site.

Condition factor

Length and weight data from portions of the biologically sampled fish were processed to calculate Fulton's condition factor (Equation 1).

$$Condition\ \ factor\ K = \frac{W}{L^3}(10^5)$$

Where: $W = weight\ in\ g$ Equation 1

$L = \ fork\ length\ in\ mm$

Coho salmon use of non-natal tributaries

Young-of-year coho salmon were marked to determine if they leave the mainstem and seek thermal refugia in tributaries when mainstem water temperatures become too warm. Juvenile coho salmon from two mainstem and three tributary traps (Table 3) were opportunistically marked at various trap network locations using an immersion bath of calcein dye, and were released just downstream from their capture location. Calcein is a compound that binds with calcified fish tissues (scales, otoliths, and fin rays) and can be later detected when a marked fish is examined under blue light of about 500 nm wavelength.

Table 3. Number of coho salmon marked with a calcein-immersion bath and released in Klamath River trapping network 2004.

Trap site	Klamath river mile at trap site or tributary mouth	Total marked
Klamath at Bogus	189	722
Horse Creek	149	490
Klamath at Kinsman	146	18
Seiad Creek	132	233
Elk Creek	106	56
Total		1,519

Pools near the mouths of ten Klamath River tributaries (Table 2) were seined in late October and early November 2004. No marking of coho salmon occurred in these ten tributaries. Each coho salmon captured was inspected for calcein marks to determine if it was marked elsewhere in the trapping network.

Results

Emigrant trap catch

Highest young-of-year Chinook salmon CPUE occurred in the frame trap at the Bogus trap site with 4,976 fish/day caught on March 24 (Appendix B). Only 288 young-of-year Chinook salmon were captured on the same date by the rotary trap at this site. Daily CPUE for young-of-year Chinook salmon at the Bogus rotary trap peaked at 476 fish/day on April 13 when CPUE at the frame trap was 1,070. Frame trap mean CPUE by month for Chinook and coho salmon in the upper river (Bogus to Kinsman) was always higher than rotary trap mean CPUE with one exception and one tie (Table 4 and Table 5). Rotary trap mean CPUE by month for Chinook salmon in the lower river (Happy Camp to Big Bar) was always higher than frame trap mean CPUE with one exception. Frame traps were much more effective and efficient than rotary traps for catching recently emerged fish.

Young-of-year Chinook salmon mean CPUE by month peaked in the upper river in March with high catches at the Bogus and I-5 frame traps and the I-5 rotary trap. In April, the highest CPUEs for Chinook salmon were observed at the Bogus and I-5 frame and rotary traps. The large numbers of young-of-year Chinook salmon observed at the Bogus and I-5 traps never were observed further downstream at the Kinsman traps (Table 4 and Table 5). In May, the highest CPUE was at the Happy Camp rotary trap, albeit much less than CPUEs for previous months at upstream trap sites. Iron Gate Hatchery released 5,182,000 young-of-year Chinook salmon between May 13 and June 3 (Mark Hampton, personal communication). In June after the hatchery release, the highest CPUE was at Big Bar rotary trap 2. Increased CPUE in June coincided with the hatchery release of Chinook salmon, 95% of which were unmarked, and is clearly visible in rotary trap data from all mainstem sites still fishing after mid-May. A few yearling Chinook

salmon (three or less) were caught in each of the mainstem traps with exceptions of the Happy Camp rotary trap (with 32 fish) and the Persido Bar rotary trap (with 17 fish).

No young-of-year Chinook salmon were caught in the Horse Creek frame trap and only 23 were caught in the Seiad Creek frame trap. Emigration from Elk Creek (with a total catch of 2,807) peaked on June 6 (54). No yearling Chinook salmon were caught in tributary traps of this study.

Table 4. Frame trap mean catch-per-unit effort (catch per day) by month and site for unmarked young-of-year Chinook salmon. Mainstem trap catch was comprised of both hatchery and wild fish after the hatchery release.

	Bogus	I-5	Kinsman	Happy Camp	Persido Bar	Big Bar
March	2,395 12 days	1,128 12 days	175 13 days	8.5 2 days	0.0 days	0.0 days
April	833 18 days	526 18 days	53.2 18 days	5.7 29 days	0.75 4 days	42.3 6 days
May	30.2 12 days	5.0 3 days	90.2 24 days	9.3 27 days	4.5 19 days	0.0 days
June	0.0 days	0.0 days	54.0 23 days	9.0 17 days	6.2 16 days	0.0 days
July	0.0 days	0.0 days	0.0 days	0.33 6 days	0.0 days	0.0 days
Season total	1,050 42 days	698 33 days	85.2 78 days	7.3 81 days	4.8 39 days	42.3 6 days

Table 5. Rotary trap mean catch-per-unit effort (catch per day) by month and site for unmarked young-of-year Chinook salmon. Mainstem trap catch was comprised of both hatchery and wild fish after the hatchery release.

	Bogus	I-5	Kinsman	Happy Camp	Persido Bar	Big Bar Rotary 1	Big Bar Rotary 2
March	81.8 12 days	861 7 days	17.6 11 days	12.9 23 days	0.70 27 days	44.1 7 days	0.0 days
April	246 11 days	1,276 11 days	9.9 9 days	17.7 24 days	5.3 26 days	38.3 29 days	124 23 days
May	29.5 2 days	0.0 days	13.2 26 days	75.6 29 days	20.1 24 days	16.0 27 days	24.2 28 days
June	0.0 days	0.0 days	54.0 30 days	168 28 days	218 28 days	96.3 21 days	978 27 days
July	0.0 days	0.0 days	1.0 3 days	9.9 11 days	25.6 8 days	0.0 days	127 30 days
Season total	150 25 days	1,114 18 days	28.4 79 days	67.3 115 days	61.5 113 days	46.1 84 days	312 108 days

The highest mean CPUE by month for coho salmon was observed at the frame traps: Bogus in March, April, and May; I-5 in March and April; and Kinsman in March, April, and May (Table 6 and Table 7). Peak catch of coho salmon occurred on April 27 (155) at the Bogus frame trap; March 30 (59) at the I-5 frame trap; April 15 (31) at the Kinsman frame trap; May 21 (8) at the Happy Camp rotary trap; May 13 (7) at the Persido Bar rotary trap; and June 10 (10) at the Big Bar rotary trap 2. Unlike young-of-year Chinook salmon, no consistent downstream pattern in movement was observed in the timing of peak catches of coho salmon (Figure B-9 to Figure B-17) and size of fish at capture (Figure D-9 to Figure D-17) at tributary and mainstem sites. Young-of-year coho salmon were exiting the tributaries and both moving and rearing within the mainstem. For example, 636 coho salmon were caught at the Bogus frame trap from April 20 to May 6, but only 23 were caught in the I-5 frame trap in the same period (Supplemental Appendix E). Rotary traps in the upper mainstem (but not in the lower mainstem) were inefficient and ineffective compared to frame traps for catching recently emerged young-of-year coho salmon (Table 6 and Table 7).

Maximum tributary CPUE for young-of-year coho salmon occurred later than in the mainstem (Table 8). No hatchery marked Chinook or coho salmon or steelhead were expected or encountered in tributaries.

Unmarked IGH yearling age class coho salmon in the mainstem were not differentiable from wild fish, and roughly 10% of coho salmon released at IGH in 2004 were unmarked (Mark Hampton, personal communication). Very few fish of this age class were captured in mainstem frame traps (Table 9). Tributary yearling coho salmon were not numerous, but CPUE peaked in March at Horse Creek and Seiad Creek (Table 10).

Table 6. Frame trap mean catch-per-unit effort (catch per day) by month and site for wild young-of-year coho salmon.

	Bogus	I-5	Kinsman	Happy Camp	Persido Bar	Big Bar
March	15.3 12 days	9.3 12 days	5.4 13 days	0.0 2 days	0.0 days	0.0 days
April	43.7 18 days	12.2 18 days	7.8 18 days	0.28 29 days	0.25 4 days	2.3 6 days
May	25.6 12 days	0.0 3 days	4.0 24 days	0.0 27 days	0.0 19 days	0.0 days
June	0.0 days	0.0 days	0.43 23 days	0.06 17 days	0.0 16 days	0.0 days
July	0.0 days	0.0 days	0.0 days	0.0 6 days	0.0 days	0.0 days
Season total	30.4 42 days	10.0 33 days	4.1 78 days	0.11 81 days	0.03 39 days	2.3 6 days

Table 7. Rotary trap mean catch-per-unit effort (catch per day) by month and site for wild young-of-year coho salmon.

	Bogus	I-5	Kinsman	Happy Camp	Persido Bar	Big Bar Rotary 1	Big Bar Rotary 2
March	0.08 12 days	0.86 7 days	0.0 11 days	0.0 23 days	0.0 27 days	0.29 7 days	0.0 days
April	0.73 11 days	1.1 11 days	0.0 9 days	0.04 24 days	0.54 26 days	1.3 29 days	0.87 23 days
May	0.50 2 days	0.0 days	0.0 26 days	0.72 29 days	1.8 24 days	2.0 27 days	1.1 28 days
June	0.0 days	0.0 days	0.0 30 days	0.36 28 days	0.18 28 days	0.33 21 days	1.9 27 days
July	0.0 days	0.0 days	0.0 3 days	0.18 11 days	0.0 8 days	0.0 days	0.07 30 days
Season total	0.40 25 days	1.0 18 days	0.0 79 days	0.30 115 days	0.56 113 days	1.2 84 days	0.96 108 days

Table 8. Mean trap catch-per-unit effort (catch per day) by month, tributary site, and trap type for young-of-year coho salmon.

	Horse Creek frame trap	Seiad Creek frame trap	Elk Creek frame trap	Elk Creek rotary trap
February	0.0 1 day	0.0 days	0.0 days	0.0 days
March	4.3 16 days	0.0 12 days	0.0 days	0.0 1 days
April	3.5 26 days	0.93 28 days	0.0 days	4.2 26 days
May	12.1 30 days	4.3 31 days	0.0 3 days	0.37 27 days
June	10.3 29 days	8.4 30 days	0.57 30 days	0.0 3 days
July	5.3 3 days	2.0 3 days	0.86 22 days	0.0 days
Season total	8.0 105 days	4.0 104 days	0.65 55 days	2.1 57 days

Table 9. Rotary trap mean catch-per-unit effort (catch per day) by month and site for unmarked yearling coho salmon.

	Bogus	I-5	Kinsman	Happy Camp	Persido Bar	Big Bar Rotary 1	Big Bar Rotary 2
March	2.1 12 days	0.0 7 days	0.0 11 days	0.43 23 days	0.04 27 days	0.0 7 days	0.0 days
April	0.55 11 days	0.27 11 days	0.11 9 days	0.0 24 days	0.0 26 days	0.03 29 days	0.04 23 days
May	0.0 2 days	0.0 days	0.15 26 days	0.24 29 days	0.08 24 days	0.19 27 days	0.29 28 days
June	0.0 days	0.0 days	0.0 30 days	0.0 28 days	0.0 28 days	0.0 21 days	0.04 27 days
July	0.0 days	0.0 days	0.0 3 days	0.0 11 days	0.0 8 days	0.0 days	0.0 30 days
Season total	1.2 25 days	0.17 18 days	0.06 79 days	0.15 115 days	0.03 113 days	0.07 84 days	0.09 108 days

Table 10. Mean trap catch-per-unit effort (catch per day) by month, tributary site, and trap type for yearling coho salmon.

	Horse Creek frame trap	Seiad Creek frame trap	Elk Creek frame trap	Elk Creek rotary trap
February	0.0 1 day	0.0 days	0.0 days	0.0 days
March	2.2 16 days	2.8 12 days	0.0 days	0.0 1 days
April	0.96 26 days	0.82 28 days	0.0 days	0.04 26 days
May	0.27 30 days	0.16 31 days	0.0 3 days	0.04 27 days
June	0.03 29 days	0.0 30 days	0.0 30 days	0.0 3 days
July	0.0 3 days	0.0 3 days	0.0 22 days	0.0 days
Season total	0.66 105 days	0.60 104 days	0.0 55 days	0.04 57 days

Peak young-of-year steelhead numbers occurred on May 10 (108) at the Bogus frame trap; April 13 and 22 (13) at the I-5 frame trap; April 21 (10) at the I-5 rotary trap; May 28 (45) at the Kinsman frame trap; June 13 and 20 (22) at the Happy Camp rotary trap; May 21 (21) at the Persido Bar frame trap; and May 19 (89) at the Big Bar rotary trap 2 (Supplemental Appendix E). Timing of peaks indicated no consistent pattern in downstream movement as observed for Chinook salmon. For young-of-year steelhead in the upper river (Bogus to Kinsman), frame trap mean CPUE by month was always higher (the Bogus frame trap in May was the highest) than rotary trap CPUE with one exception (Table 11 and Table 12). For young-of-year steelhead in the lower river (Happy Camp to Big Bar), mean CPUE by month did not show a clear difference in effectiveness between trap types, although the CPUE for the Big Bar rotary trap 2 in May, June, and July was consistently the highest.

Tributary CPUE for young-of-year steelhead occurred later and peaks were higher than for traps in the mainstem (Table 13). At the Horse Creek frame trap, young-of-year steelhead were first caught on May 1. Catch peaked on June 5 (1,083) and was still high

at 373 on July 3, the last day of trapping (Supplemental Appendix E). The Seiad Creek frame trap had two distinct peaks of young-of-year steelhead CPUE, one on May 15 (387) and one on June 21 (543). The Elk Creek young-of-year steelhead CPUE peaked on June 7 (171) at the frame trap and on May 22 (376) at the rotary trap.

Yearling steelhead CPUEs for all tributary traps were much larger than for mainstem traps (Appendix D). Iron Gate Hatchery yearling steelhead were not encountered or expected in the tributaries. Yearling steelhead CPUE peaked on: March 30 (87) at the Horse Creek frame trap; May 9 (11) at the Seiad Creek frame trap; and April 27 (23) at the Elk Creek rotary trap (Supplemental Appendix E).

Table 11. Frame trap mean catch-per-unit effort (catch per day) by month and site for wild young-of-year steelhead.

	Bogus	I-5	Kinsman	Happy Camp	Persido Bar	Big Bar
March	0.0 12 days	0.0 12 days	0.08 13 days	0.0 2 days	0.0 days	0.0 days
April	7.6 18 days	4.6 18 days	0.83 18 days	0.07 29 days	0.0 4 days	2.3 6 days
May	39.3 12 days	2.0 3 days	12.5 24 days	0.15 27 days	5.0 19 days	0.0 days
June	0.0 days	0.0 days	6.9 23 days	1.1 17 days	1.7 16 days	0.0 days
July	0.0 days	0.0 days	0.0 days	0.83 6 days	0.0 days	0.0 days
Season total	14.5 42 days	2.7 33 days	6.1 78 days	0.36 81 days	3.1 39 days	2.3 6 days

Table 12. Rotary trap mean catch-per-unit effort (catch per day) by month and site for wild young-of-year steelhead.

	Bogus	I-5	Kinsman	Happy Camp	Persido Bar	Big Bar Rotary 1	Big Bar Rotary 2
March	0.0 12 days	0.43 7 days	0.0 11 days	0.0 23 days	0.0 27 days	0.14 7 days	0.0 days
April	0.82 11 days	2.1 11 days	0.0 9 days	0.0 24 days	0.0 26 days	0.38 29 days	2.5 23 days
May	0.0 2 days	0.0 days	0.42 26 days	1.8 29 days	0.25 24 days	6.1 27 days	28.3 28 days
June	0.0 days	0.0 days	0.57 30 days	8.2 28 days	2.8 28 days	5.0 21 days	36.5 27 days
July	0.0 days	0.0 days	0.67 3 days	3.2 11 days	6.1 8 days	0.0 days	18.4 30 days
Season total	0.36 25 days	1.4 18 days	0.38 79 days	2.8 115 days	1.2 113 days	3.4 84 days	22.1 108 days

Table 13. Mean trap catch-per-unit effort (catch per day) by month, tributary site, and trap type for young-of-year steelhead.

	Horse Creek frame trap	Seiad Creek frame trap	Elk Creek frame trap	Elk Creek rotary trap
February	0.0 1 days	0.0 days	0.0 days	0.0 days
March	0.0 16 days	0.0 12 days	0.0 days	0.0 1 days
April	0.0 26 days	0.32 28 days	0.0 days	0.23 26 days
May	247 30 days	125 31 days	46.3 3 days	104 27 days
June	655 29 days	119 30 days	77.2 30 days	117 3 days
July	255 3 days	57.7 3 days	24.9 22 days	0.0 days
Season total	259 105 days	73.2 104 days	54.6 55 days	55.6 57 days

Biological data

For all salmon species, scatter plots of fork length reflect a generally distinct separation of wild young-of-year age classes from older individuals (Appendix D). Distinct clustering by age-class is not apparent for steelhead in some fork-length scatter plots (Figure D-21 to Figure D-23).

Unlike IGH Chinook salmon, 100% of steelhead released from IGH were adipose-clipped and therefore were distinguishable from wild fish. Normally, all coho salmon are marked as well, but about 10% of the coho salmon released from IGH were not marked in 2004. Unmarked IGH origin young-of-year coho salmon were indistinguishable in size from wild yearling fish (see examples Figure D-9, Figure D-11). Chinook salmon at IGH were marked at rates of 5% and hatchery marked Chinook salmon released in mid-May were virtually the same size as their wild counterparts (Figure D-5, Figure D-6). Because unmarked hatchery Chinook salmon were indistinguishable in the field from wild fish, the Bogus and I-5 traps were removed prior to hatchery release of Chinook salmon.

External abnormalities

External examination codes were systematically recorded after about mid-May when traps had already been removed from the Bogus and I-5 trap sites (Supplemental Appendix F). Plots by species of number of "normal" vs. "abnormal" appearing individuals sampled at the remaining mainstem sites are given in Appendix A. Highest incidences of external abnormalities and lamprey wounds for Chinook and coho salmon and steelhead were observed at the Kinsman trap site (Table 14 and Table 15). Pale gills were the most frequently observed external abnormality in all three species (Table 16 to Table 19). As with mortality, the highest overall mean abnormality rate occurred at Kinsman and decreased downstream for young-of-year Chinook salmon (82% to 14%), young-of-year coho salmon (83% to 0%), young-of-year steelhead (71% to 10%), and yearling and older steelhead (79% to 6%; Table 14).

For yearling and older steelhead, there was very high mortality (46%; n=559) and incidence of lamprey wounds (88%; n=138) at the Kinsman site (Table 15). Capture of eyed lamprey less than 300 mm total length was highest at this site (Supplemental Appendix G). Adults of two Klamath Basin endemic freshwater and parasitic lamprey species, Klamath River lamprey (*Entosphenus similes*: common) and Miller Lake lamprey (*E. minimus*: rare), in this size range have been noted from independent collections at this site. Fish greater than about 80 mm fork length are more susceptible to *E. similes* because of its mouth size (Damon Goodman, personal communication). Adults of these two freshwater lamprey species are similar in size to the non-parasitic macropthalmia of Pacific lamprey (*E. tridentata*) and the three species were indistinguishable in our data.

Table 14. External abnormality rate observed at mainstem trap sites. External indicators of stress/disease examined include: pale gills, gill rot, swollen abdomen, hemorrhaging anal vent, or pop-eye. "NA" = none inspected.

Age class	External abnormality rate observed at mainstem trap site: Kinsman 5/13 to 7/3	Happy Camp 5/17 to 7/9	Persido Bar 5/27 to 7/19	Big Bar 5/24 to 7/30
Young-of-year Chinook salmon	82% n = 1,030	56% n = 1,398	40% n = 865	14% n = 2,470
Yearling Chinook salmon	NA	NA	0% n = 2	NA
Young-of-year coho salmon	83% n = 35	0% n = 16	20% n = 5	0% n = 63
Yearling coho salmon	NA	14% n = 7	NA	20% n = 5
Young-of-year steelhead	71% n = 14	16% n = 55	8% n = 99	10% n = 82
Yearling and older steelhead	79% n = 138	42% n = 183	12% n = 120	6% n = 49

Table 15. Rate of lamprey wounds observed in fish externally examined at mainstem trap sites. "NA" = none inspected.

Age class	Lamprey wound rate observed at mainstem trap site: Kinsman 5/13 to 7/3	Happy Camp 5/17 to 7/9	Persido Bar 5/27 to 7/19	Big Bar 5/24 to 7/30
Young-of-year Chinook salmon	5% n = 1,030	1% n = 1,398	0% n = 865	0% n = 2,470
Yearling Chinook salmon	NA	NA	0% n = 2	NA
Young-of-year coho salmon	0% n = 35	0% n = 16	0% n = 5	0% n = 63
Yearling coho salmon	NA	0% n = 7	NA	0% n = 5
Young-of-year steelhead	0% n = 14	0% n = 55	0% n = 99	0% n = 82
Yearling and older steelhead	88% n = 138	2% n = 183	4% n = 120	0% n = 49

Table 16. Portion of young-of-year Chinook salmon sample with various external symptoms by trap site.

Trap site	Gills pale (no rot)	Gill rot	Pale gill and rot	Swollen abdomen	Exophthalmia (pop-eye)	Lamprey wound	Sample size
Kinsman	43%	29%	10%	22%	2%	5%	1,030
Happy Camp	40%	14%	1%	6%	0.4%	0.6%	1,398
Persido Bar	32%	7%	1%	0.5%	0.6%	0%	865
Big Bar	12%	2%	0.4%	0%	0%	0%	2,470

Table 17. Portion of young-of-year coho salmon sample with various external symptoms by trap site.

Trap site	Gills pale (no rot)	Gill rot	Pale gill and rot	Swollen abdomen	Exophthalmia (pop-eye)	Lamprey wound	Sample size
Kinsman	71%	9%	3%	0%	0%	0%	35
Happy Camp	0%	0%	0%	0%	0%	0%	16
Persido Bar	0%	20%	0%	0%	0%	0%	5
Big Bar	0%	0%	0%	0%	0%	0%	63

Table 18. Portion of young-of-year steelhead sample with various external symptoms by trap site.

Trap site	Gills pale (no rot)	Gill rot	Pale gill and rot	Swollen abdomen	Exophthalmia (pop-eye)	Lamprey wound	Sample size
Kinsman	43%	29%	0%	7%	0%	0%	14
Happy Camp	13%	4%	0%	4%	0%	0%	55
Persido Bar	7%	1%	0%	0%	0%	0%	99
Big Bar	5%	1%	0%	4%	0%	0%	82

Table 19. Portion of yearling and older steelhead sample with various external symptoms by trap site.

Trap site	Gills pale (no rot)	Gill rot	Pale gill and rot	Swollen abdomen	Exophthalmia (pop-eye)	Lamprey wound	Sample size
Kinsman	60%	10%	9%	0%	0%	88%	138
Happy Camp	37%	4%	0%	3%	0%	2%	183
Persido Bar	8%	3%	0.8%	0%	0%	4%	120
Big Bar	6%	0%	0%	0%	0%	0%	49

Mortality

Mortality of young-of-year Chinook salmon in the most effective mainstem traps increased dramatically after April 28 and with progression downstream: Bogus frame trap on April 28; I-5 frame trap on April 28; Kinsman frame trap on April 29; Happy Camp rotary and frame trap on May 6; Persido Bar frame trap on May 11; and Big Bar rotary trap 1 on May 13 (Figure 8 to Figure 10; Appendix B). These mortality increases for young-of-year Chinook salmon in the mainstem did not occur in the tributaries (Figure 11; Appendix B), nor for young-of-year coho salmon (Figure 12 to Figure 17). We associated this increased mortality in young-of-year Chinook salmon and first appearance of external abnormalities (other than lamprey wounds) with stress from disease and disease itself. Our systematic sampling for external abnormalities began in mid-May.

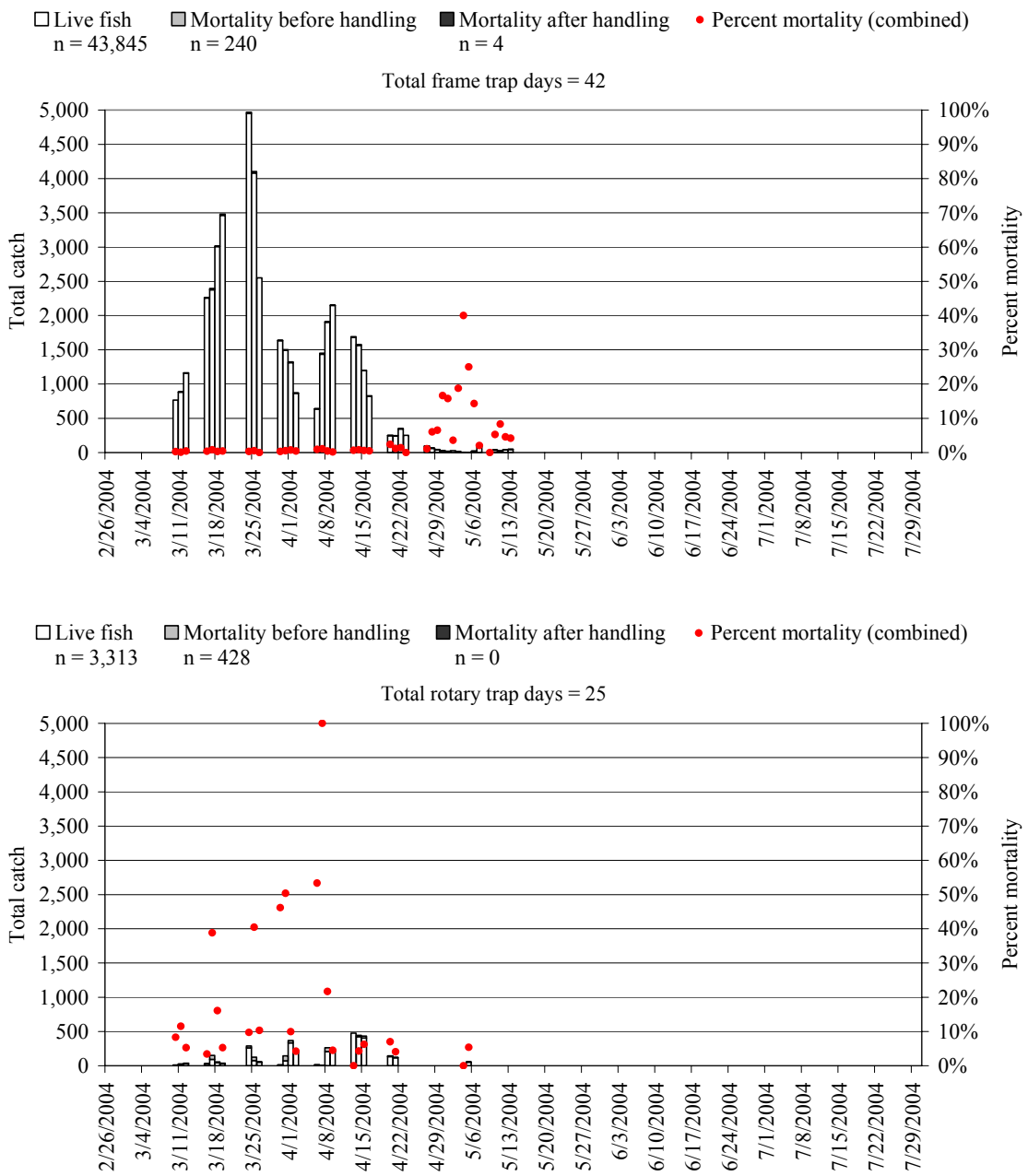

Figure 8. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Bogus trap site.

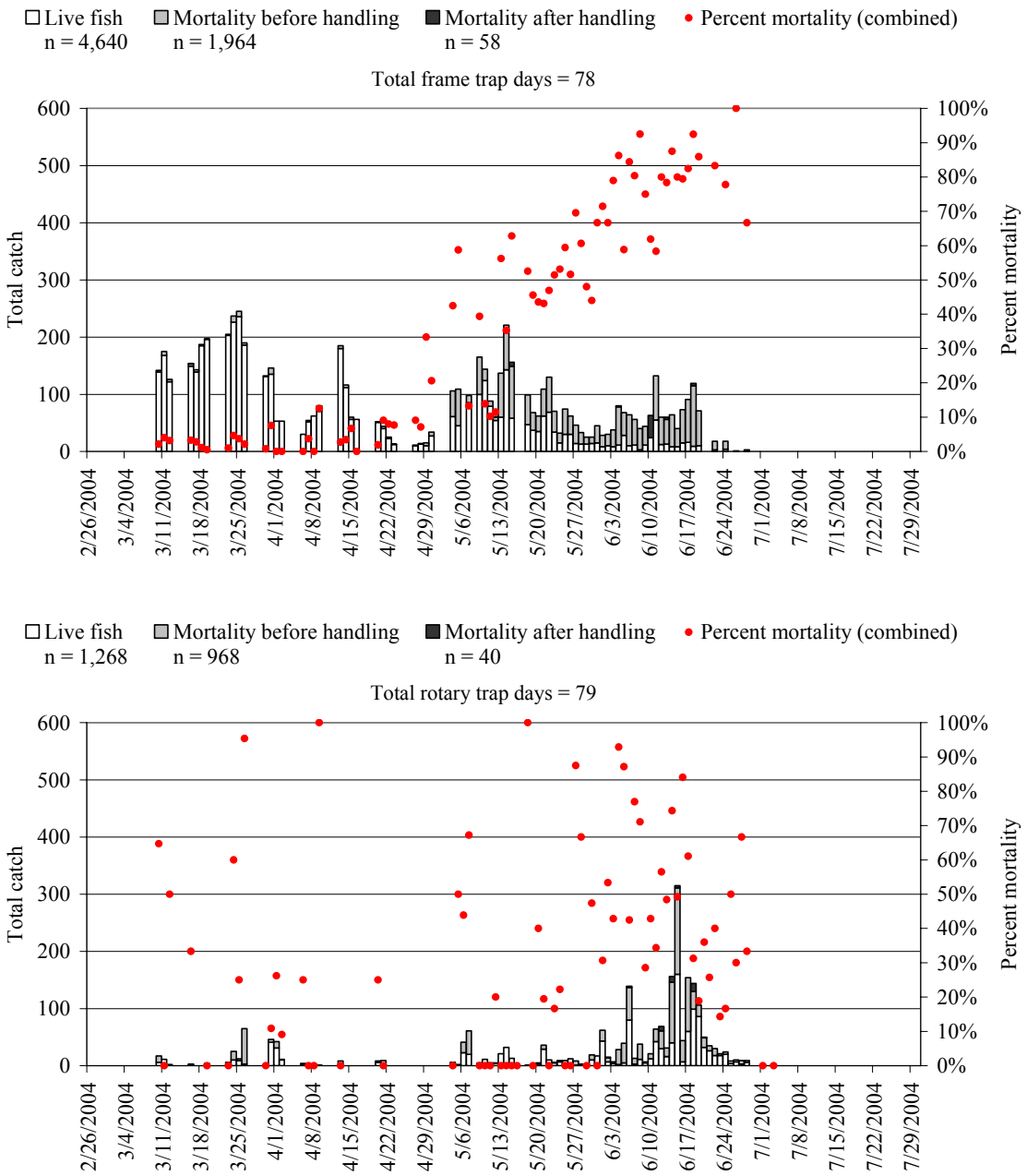

Figure 9. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Kinsman trap site.

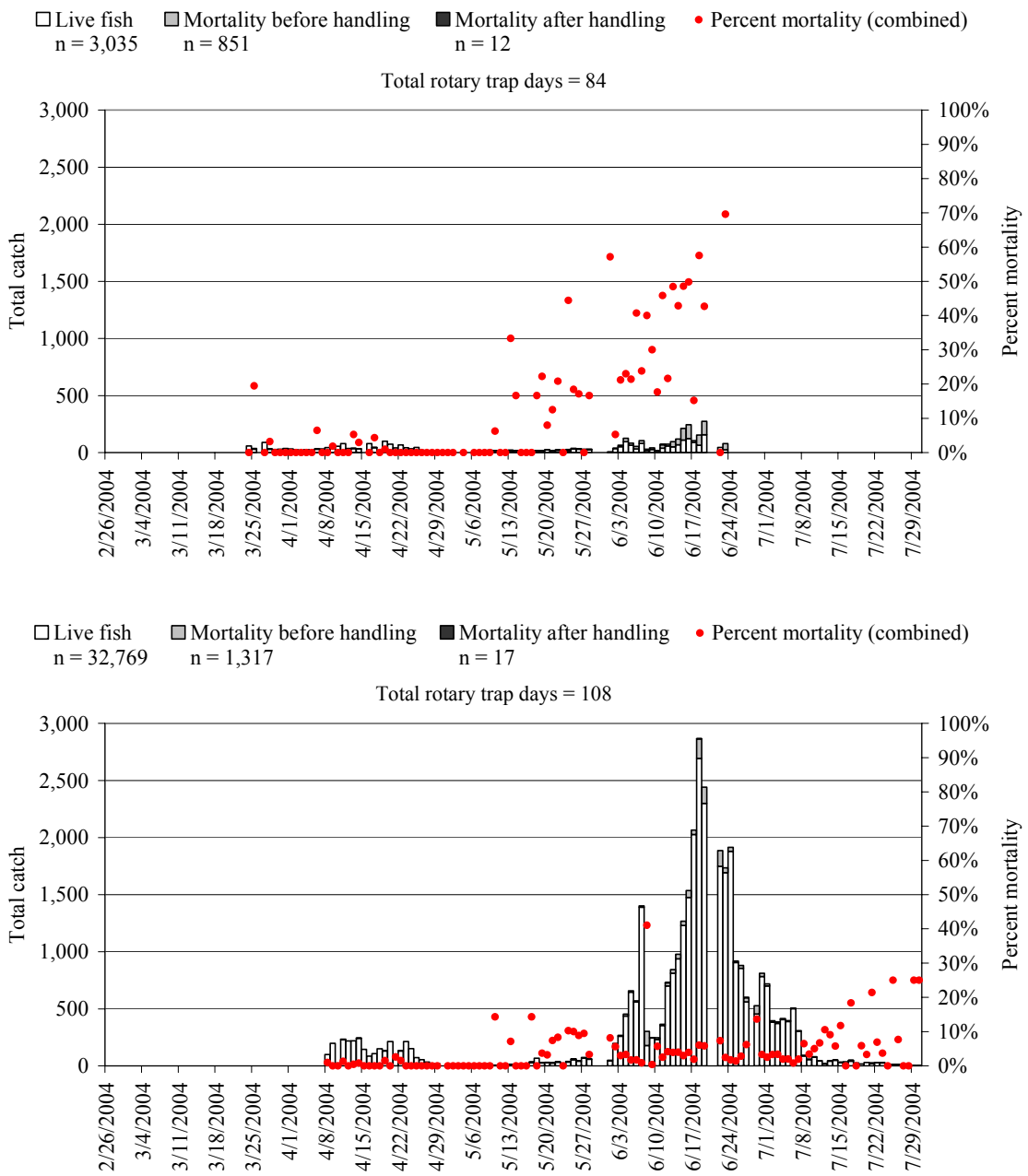

Figure 10. Young-of-year Chinook salmon catch and mortality observed at rotary trap 1 (top) and 2 (bottom) at the Big Bar trap site.

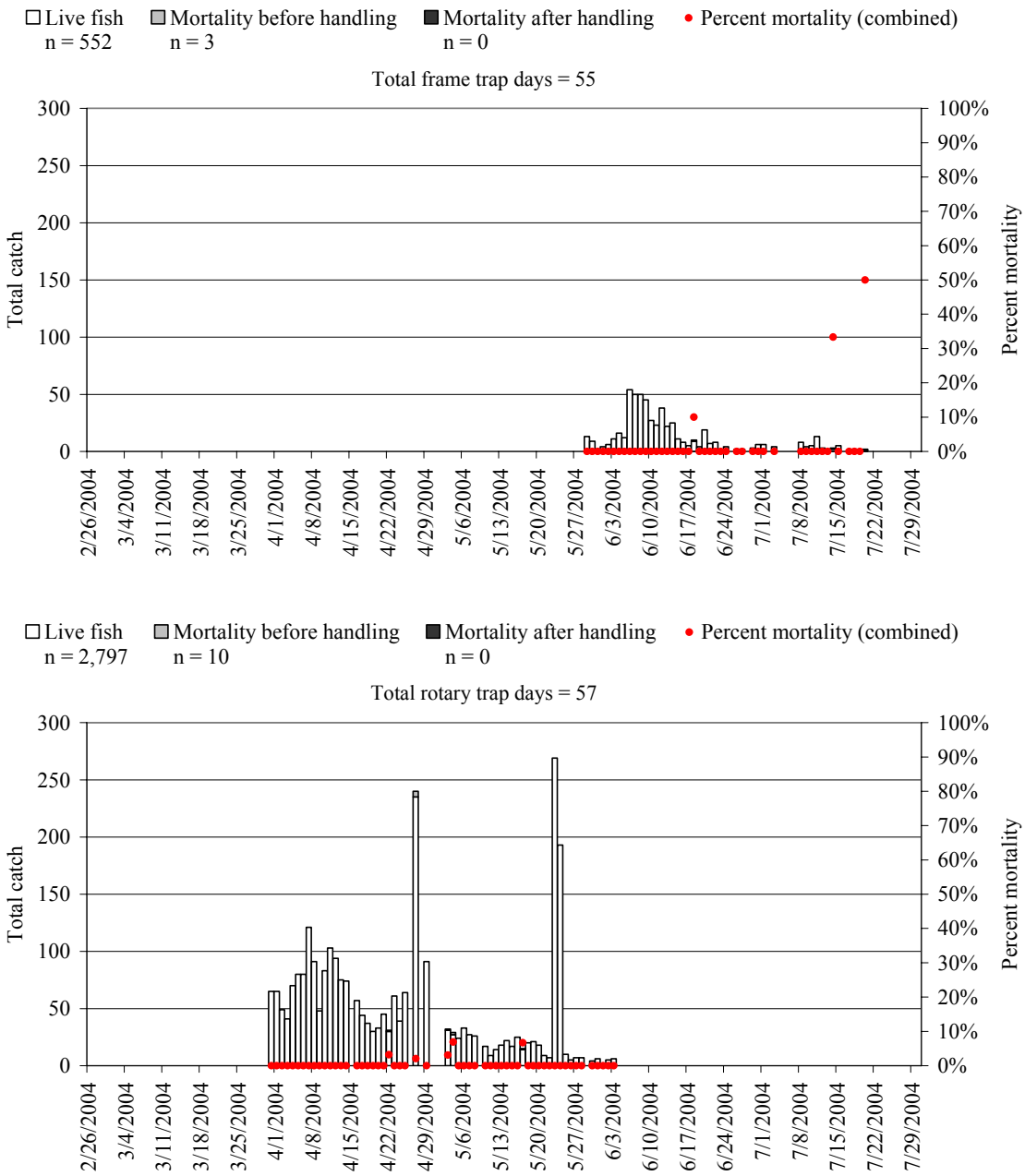

Figure 11. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Elk Creek trap site.

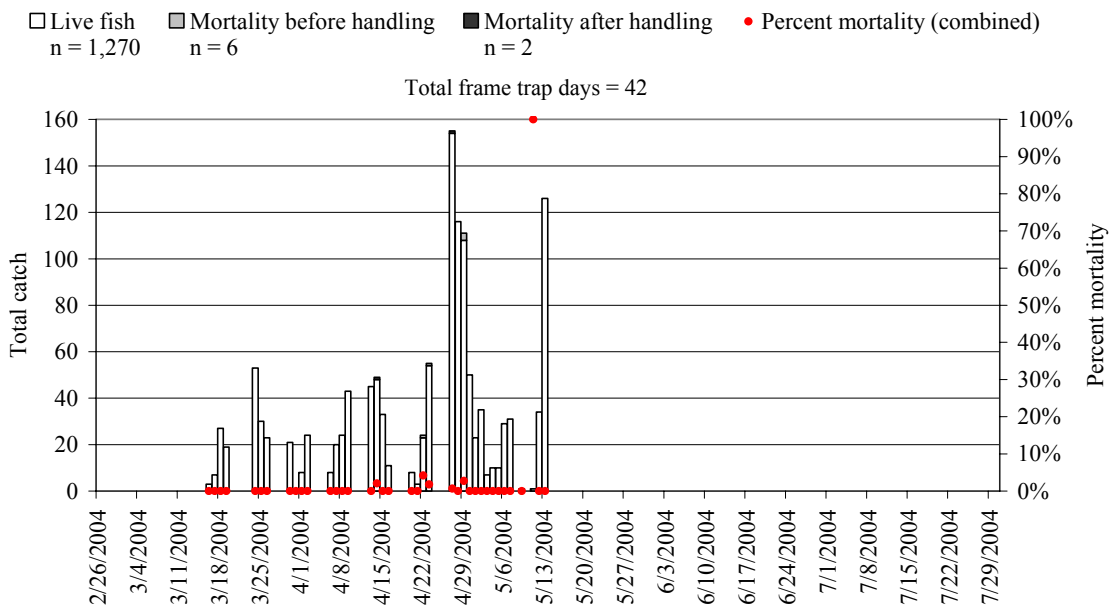

Figure 12. Young-of-year coho salmon catch and mortality observed in the frame trap at the Bogus trap site. Ten live coho salmon were captured in the rotary trap at this site with no mortality (data not shown).

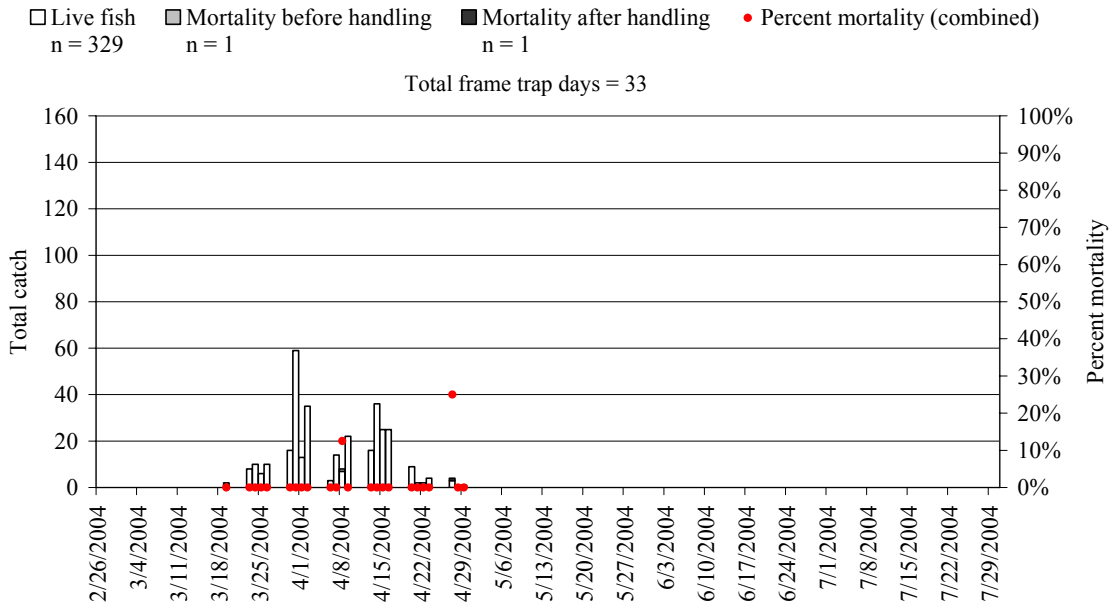

Figure 13. Young-of-year coho salmon catch and mortality observed in the frame trap at the I-5 trap site. Seventeen live young-of-year coho salmon and one mortality (before handling) were captured in the rotary trap at this site (data not shown).

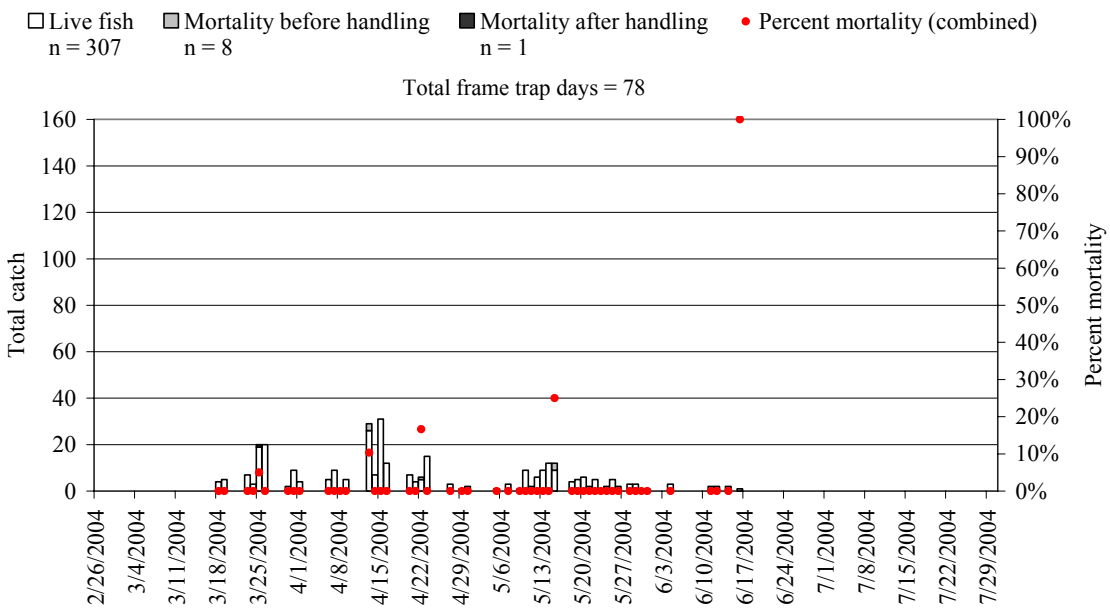

Figure 14. Young-of-year coho salmon catch and mortality observed in the frame trap at the Kinsman trap site. No young-of-year coho salmon were captured in the rotary trap at this site.

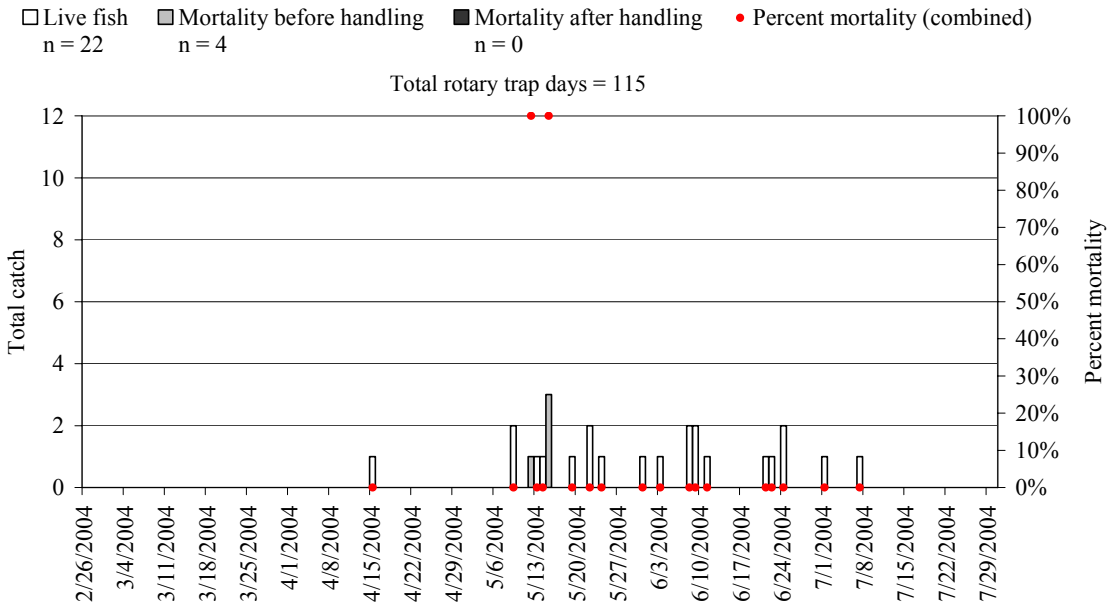

Figure 15. Young-of-year coho salmon catch and mortality observed in the rotary trap at the Happy Camp trap site. Nine live young-of-year coho salmon and no mortalities were captured in the frame trap at this site (data not shown).

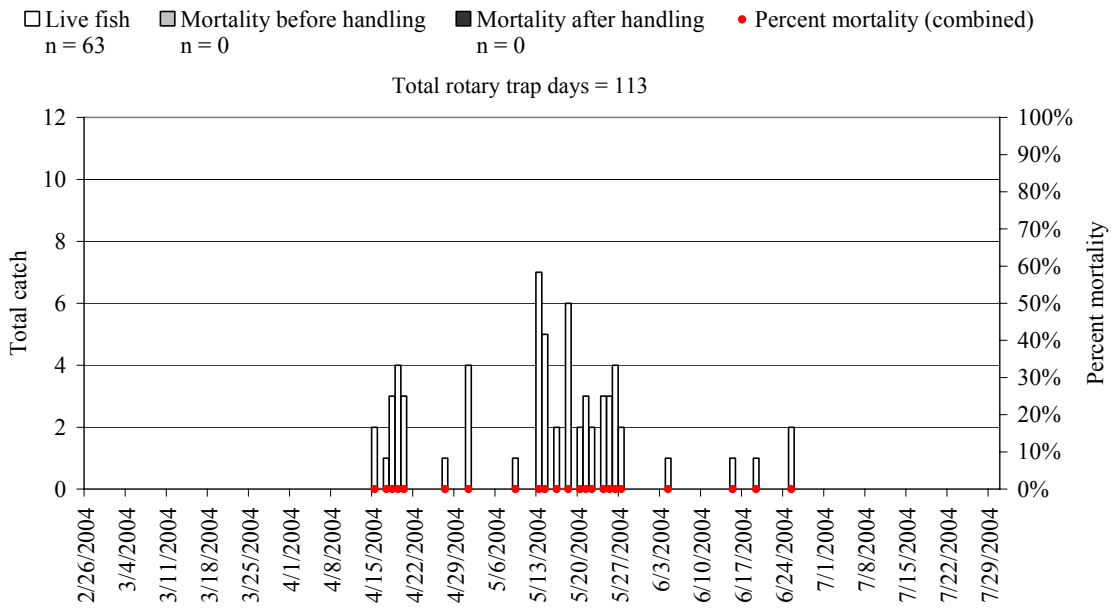

Figure 16. Young-of-year coho salmon catch and mortality observed in the rotary trap at the Persido Bar trap site. One live young-of-year coho salmon was captured in the frame trap at this site (data not shown).

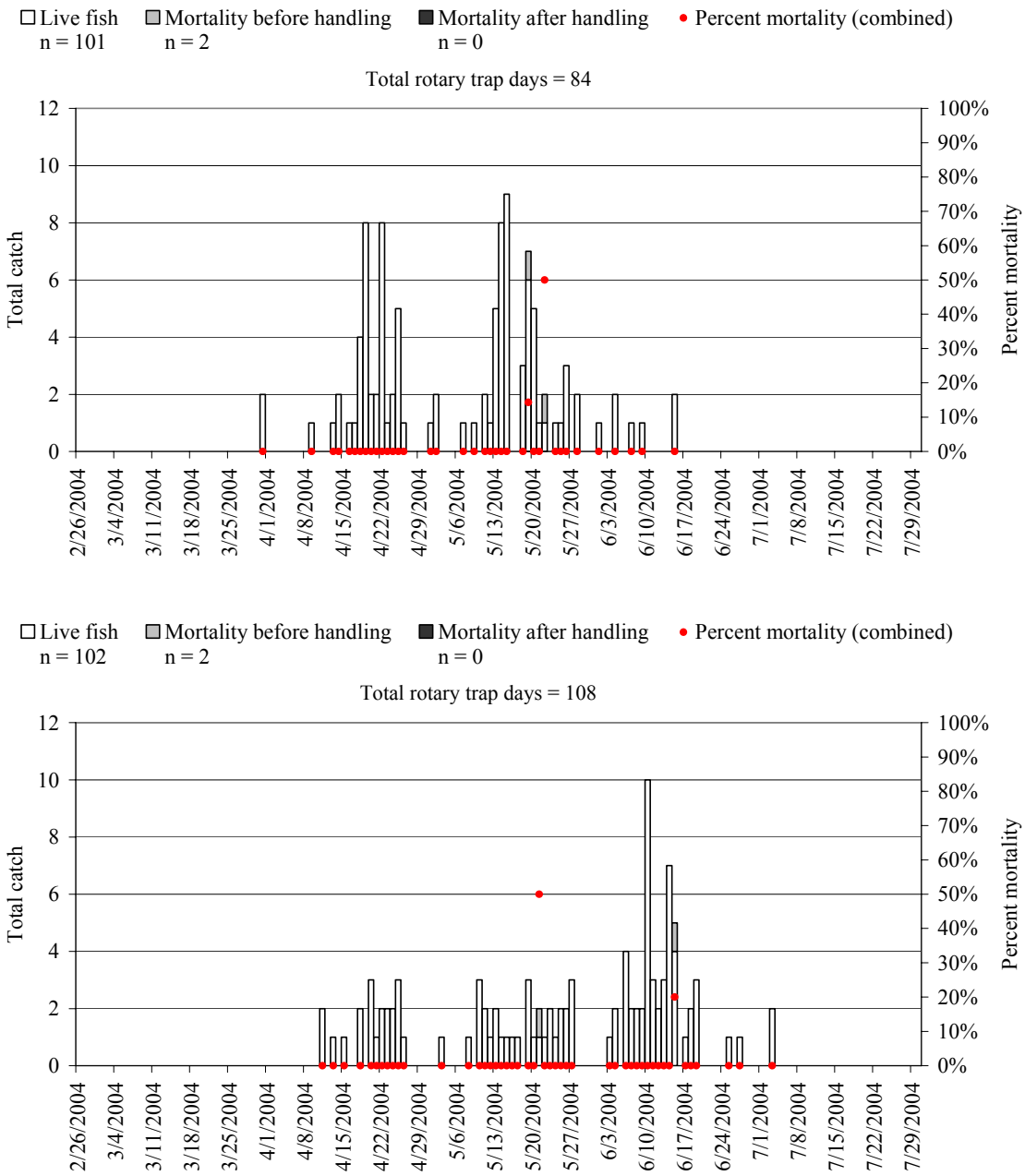

Figure 17. Young-of-year coho salmon catch and mortality observed at rotary trap 1 (top) and 2 (bottom) at the Big Bar trap site.

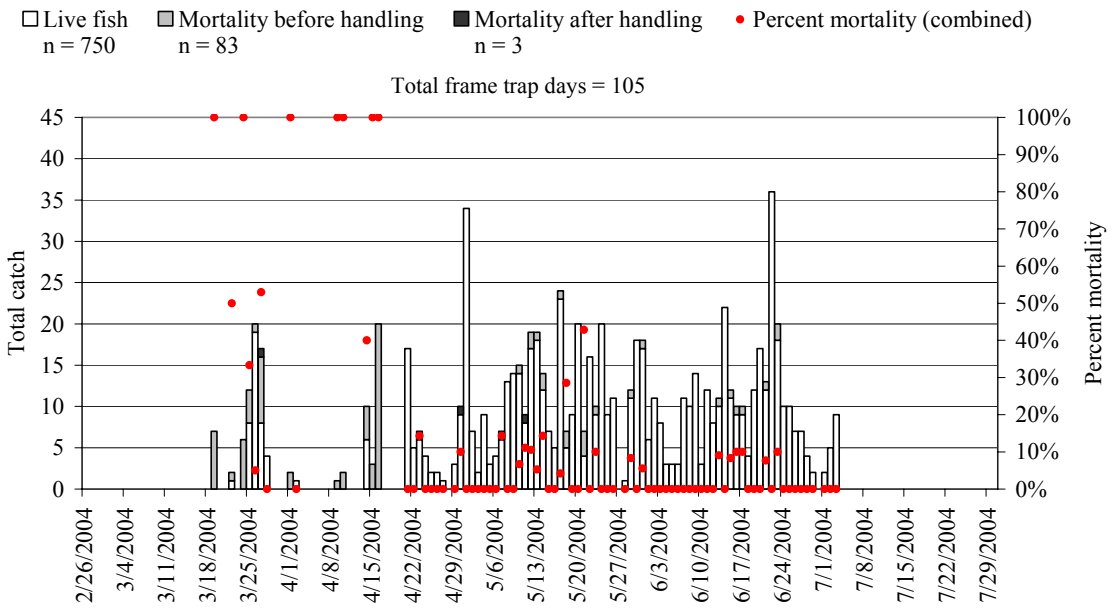

Figure 18. Young-of-year coho salmon catch and mortality observed in the frame trap at the Horse Creek trap site. No young-of-year coho salmon were captured in the rotary trap at this site.

As detailed earlier, external abnormality rate for young-of-year Chinook salmon was highest at the Kinsman trap site (82%, n=1030; Table 14 and Table 16). Mortality of young-of-year Chinook salmon was also highest at the Kinsman trap site at 34% and declined to 6% at the Persido Bar and Big Bar traps located further downstream (Table 20). The Bogus and I-5 traps upstream of Kinsman were removed in mid-May before severe Chinook salmon mortality was observed. Rotary traps at and above Happy Camp had higher mortality than frame traps early in the trapping season due to fish becoming entrapped in aquatic macrophytes in the live-boxes. Clogging the live-box with vegetation was a particular problem with the I-5 rotary trap, so much so that we could not keep it running without checking it several times per night. Frame trap live-boxes in upper mainstem traps early in the season did not have this mortality problem. No Chinook salmon were captured at the Horse Creek trap site, and mortality was very low at the other tributary trap sites.

Table 20. Total capture and mortality of young-of-year Chinook salmon. Mainstem trap capture included both hatchery and wild fish after the hatchery release.

Site	Captured	Dead in live-box	Expired during handling	Total mortality
Bogus*	47,996	675	4	1%
I-5*	43,279	3,715	4	9%
Kinsman	9,030	2,953	98	34%
Happy Camp	8,513	2,044	48	25%
Persido Bar	7,306	392	29	6%
Big Bar	38,356	2,172	29	6%
Horse Creek	0	NA	NA	NA
Seiad Creek	33	1	0	3%
Elk Creek	3,529	51	0	1%

* Bogus and I-5 traps were removed prior to hatchery release of Chinook salmon

The highest observed mortality of young-of-year coho salmon (28%; n = 43) occurred at the Happy Camp traps. Less than 3% mortality for young-of-year coho salmon was observed at other mainstem traps. With the exception of the Happy Camp site, mortality of young-of-year coho salmon was higher in tributary traps (but always 10% or lower) than in the mainstem (Table 21).

All Iron Gate Hatchery origin coho salmon were released as yearlings. Most yearling coho salmon caught in this study were of IGH origin (Appendix D; Figure D-9 through Figure D-14) and were primarily encountered at the Bogus and I-5 traps (941 of 1,164). At the Bogus, I-5, and Kinsman sites, most yearling coho salmon captured had been reared and marked at IGH. At traps further downstream, natural-reared yearling coho salmon outnumbered IGH-reared fish. Mortality was low at Bogus (1.4%; n = 712) and increased downstream to Kinsman (69%; n = 16). Mortality of yearling coho salmon in mainstem traps was higher than in the tributaries, except at Bogus (Table 22).

Table 21. Total capture and mortality of young-of-year coho salmon. All young-of-year coho salmon were natural-reared.

Site	Captured	Dead in live-box	Expired during handling	Total mortality
Bogus	1,288	6	2	0.6%
I-5	349	2	1	0.9%
Kinsman	316	8	1	3%
Happy Camp	43	12	0	28%
Persido Bar	64	0	0	0.0%
Big Bar	221	4	0	2%
Horse Creek	836	83	3	10%
Seiad Creek	416	28	0	7%
Elk Creek	163	9	0	6%

Table 22. Total capture and mortality of yearling coho salmon. Mainstem trap capture was comprised of both hatchery and wild fish after the hatchery release.

Site	Captured	Dead in live-box	Expired during handling	Total mortality
Bogus	712	10	0	1%
I-5	229	22	0	10%
Kinsman	16	11	0	69%
Happy Camp	27	6	0	22%
Persido Bar	3	0	0	NA
Big Bar	22	3	0	14%
Horse Creek	88	9	0	10%
Seiad Creek	65	4	1	7%
Elk Creek	2	0	0	NA

Total season young-of-year steelhead mortality was highest in the mainstem at the Kinsman and Happy Camp sites (10% and 7%, respectively; Table 23). Total season yearling and older steelhead mortality also peaked at the Kinsman and Happy Camp sites (46% and 38%, respectively; Table 24). After systematic sampling began in mid-May, abnormality rates for both young-of-year and yearling and older steelhead were highest at Kinsman (71% and 79%; Table 14) and then at Happy Camp (16% and 42%). At Horse Creek, young-of year and yearling coho salmon both experienced about 10% mortality (Table 21 and Table 22), although mortality of steelhead was low (0.7% for young-of-

year and 3.2% for yearling and older steelhead; Table 24). At Seiad Creek, we observed 7% mortality for young-of year and yearling coho salmon and young-of-year steelhead, with somewhat higher (9%) mortality for yearling and older steelhead. At Elk Creek, mortalities were much lower at 0.2% for young-of-year and 2% for yearling and older steelhead.

Table 23. Total capture and mortality of young-of-year steelhead

Site	Captured	Dead in live-box	Expired during handling	Total mortality
Bogus	616	4	0	0.6%
I-5	114	1	1	2%
Kinsman	508	51	0	10%
Happy Camp	143	10	0	7%
Persido Bar	210	2	1	1%
Big Bar	2,684	160	8	6%
Horse Creek	27,163	195	0	0.7%
Seiad Creek	7,614	534	1	7%
Elk Creek	6,185	11	0	0.2%

Table 24. Total capture and mortality of yearling and older steelhead. Mainstem trap capture comprised of both hatchery and wild fish.

Site	Captured	Dead in live-box	Expired during handling	Total mortality
Bogus	449	14	1	3%
I-5	68	10	1	16%
Kinsman	559	255	2	46%
Happy Camp	684	257	1	38%
Persido Bar	374	46	1	13%
Big Bar	224	11	0	5%
Horse Creek	1,634	53	0	3%
Seiad Creek	658	58	0	9%
Elk Creek	224	4	0	2%

Condition factor

Condition factor for most trap sites and species/life stages increased over the course of the trapping season (Appendix C). Distributions of young-of-year Chinook salmon

condition factors at Bogus, I-5, and Kinsman trap sites were very similar with a mean of 0.82 to 0.91. By the end of June at Persido Bar, however, nearly 2/3 of Chinook salmon examined exhibited abnormalities, and condition factors became highly variable with many over 2.0. When high mortality was observed at the Kinsman site in mid-May, weighing of fish at this site was dropped to reduce handling stress. We caution against interpretation of high condition factor to indicate better condition for Klamath River salmonids or when incidence of disease can be high.

Condition factor of salmonids by species, age class, and trap site were plotted in Appendix C. Plots include three categories of fish: those with no external abnormalities noted from the systematic external examination, those with one or more abnormality, and those that were not included in the systematic external examination. Systematic external examination procedures were not initiated until mid-season (after the Bogus and I-5 traps were removed). Fish with external abnormalities were specifically avoided for length and weight measurements at Bogus, I-5, and Kinsman sites.

Coho salmon use of non-natal tributaries

To explore emigration into and rearing within non-natal Klamath River tributaries, 1,519 juvenile coho salmon from two mainstem and three tributary trapping sites (Table 3) were marked with a calcein dye. Seining was conducted near the mouths of ten Klamath River tributaries to search for calcein marked coho salmon, but not until October 27 to November 8, 2004 because of staff shortages and logistical difficulties (Table 25). Of 154 wild coho salmon captured and inspected from these samples, no calcein marked coho salmon were detected. In late October and early November, mean daily water temperatures in the Klamath River were about 12º C (Toz Soto, personal communication). Potential non-natal use of lower reaches of cool-water tributaries is likely higher when mainstem temperatures are more stressful.

Table 25. Capture of coho salmon from tributaries sampled for calcein marked fish. A total of 1,519 coho salmon were marked at two mainstem and three tributary sites (none of those below) to investigate non-natal rearing. No calcein marked coho salmon were recaptured in these non-natal tributaries.

Stream Name	Date	Total coho salmon captured and inspected for calcein
Tom Martin Creek	8-Nov	None captured
O'Neil Creek	8-Nov	None captured
Portuguese Creek	8-Nov	6
Fort Goff Creek	8-Nov	21
**Little* Horse Creek	27-Oct	27
Cade Creek	8-Nov	None captured
Titus/ Tinkham Creek	29-Oct	53
Swillup Creek	2-Nov	None captured
Sandy Bar Creek	2-Nov	40
Stanshaw Creek	2-Nov	7
Total		154

*"*Little*" added to the name of this Horse Creek by the investigators to differentiate it from a separate tributary of the same name mentioned elsewhere in this report

Discussion

Capture efficiency

Mark-recapture trap efficiencies of one to two percent per trap (either rotary or frame trap) for young-of-year Chinook salmon at sites in the Klamath River were common because of the river's large size and the low proportion of total discharge sampled. The traps' efficiency at capturing dead, unhealthy, or dying fish compared to healthy fish is unknown. Rotary traps at three upper mainstream sites were highly inefficient compared with frame traps for catching young-of-year Chinook and coho salmon and steelhead. Frame traps can be used to sample the slower and shallower adjacent-to-shore water preferred by newly emerged salmonids (Hardin et al. 2005). Mark-recapture efficiency estimates were conducted for traps at Bogus (three times with natural-reared fish), I-5 (three times with natural-reared fish), Kinsman (twice with natural-reared fish), Persido Bar (twice with hatchery-reared fish), and Big Bar (five times with hatchery-reared fish). These data along with those from other years will be analyzed and reported separately. We intend to explore trap efficiencies with hatchery-reared as well as natural-reared fish when we again have sufficient natural-reared fish to make such comparisons.

External abnormalities

The external abnormalities recorded in this study are not precise diagnostics for *C. shasta* or *P. minibicornis*, but may be symptoms of organ dysfunction or failure. Presence of these external symptoms does not confirm and absence does not belie infection by these pathogens (Nichols and Foott 2006). The clinical signs of disease they tracked (pale gills, swollen abdomen, and swollen kidney) demonstrated only marginal utility in identifying the presence of these particular pathogens. However, from a fish biology perspective, pale gills, swollen abdomen, or swollen kidney indicate anemic and compromised conditions of fish that exhibit these symptoms (Nichols and Foott 2006). Observations of external symptoms recorded in this study do indicate presence of fish with compromised condition, but accurate disease diagnoses requires concomitant pathogen and physiological assays. Separate, designed studies were conducted in 2004 and continue to be conducted to diagnose and quantify effects of disease in the mainstem Klamath River.

In a separate study with which we cooperated by providing fish, the California-Nevada Fish Health Center (CA-NV FHC) conducted weekly pathogen monitoring on the Klamath River from May 11 through July 27, 2004 (Figure 19). Monitoring sites included the same trapping sites at Big Bar (RM 51) and Persido Bar (RM 81) and a roving beach seine conducted between Bluff Creek (RM 50) and Persido Bar. At Big Bar, incidence of *P. minibicornis* ranged from 39% to 96% and incidence of *C. shasta* infection ranged from 19% to 69%. From capture of 737 juvenile Chinook salmon at these sites, four external characteristics (gill color, presence/absence of gill lesions, presence/absence of skin lesions, and presence/absence of a distended abdomen) were recorded and compared to histological results for *P. minibicornis* and *C. shasta*; other pathogens were noted as encountered. Of those fish, 24% had no infection of the above pathogens, 42% had *P. minibicornis* only, 0.7% had *C. shasta* only, and 34% had a dual infection of these pathogens (preliminary data, CA-NV FHC) (Figure 20).

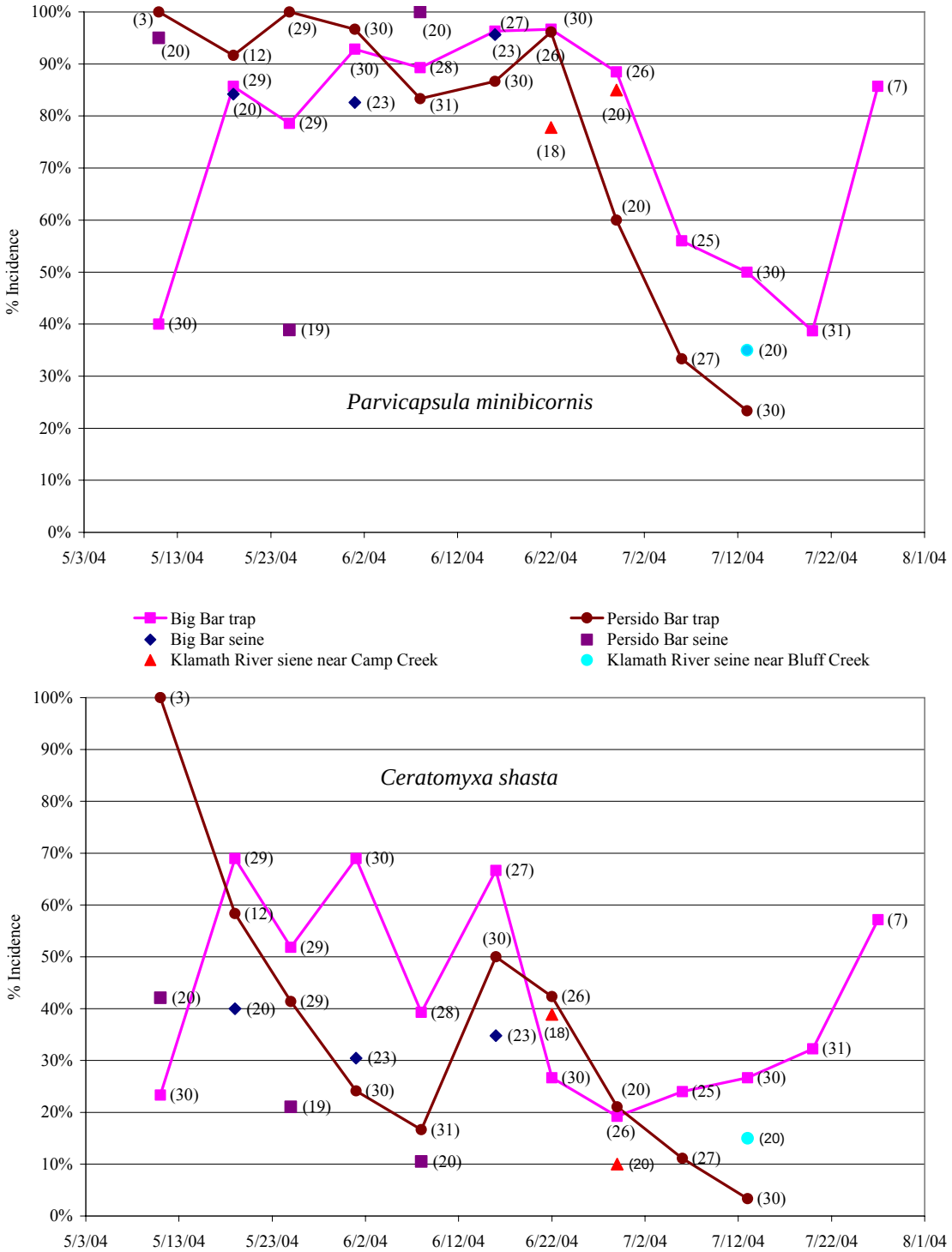

Figure 19. Incidence of *Parvicapsula minibicornis* (above) and *Ceratomyxa shasta* (below) from samples of juvenile Chinook salmon collected at sites on the Klamath River between Bluff Creek and Persido Bar in 2004. Sample size shown in parenthesis. Our analysis of preliminary data provided by U.S. Fish and Wildlife Service California-Nevada Fish Health Center.

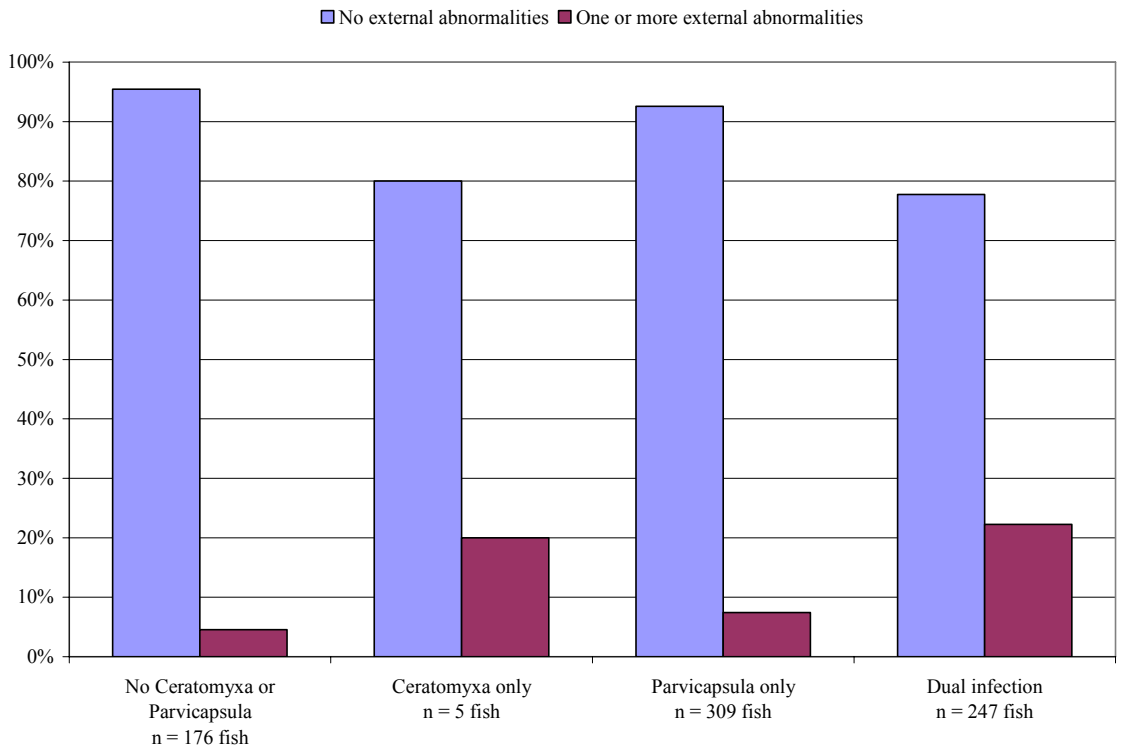

Figure 20. External examination vs. histological infection results from Nichols and Foott (2006). Fish were collected in the Klamath River in 2004 at the Big Bar trap site (n = 318), Persido Bar trap site (n = 237), and from nearby seine sites (n = 182). Our analysis of preliminary data provided by U.S. Fish and Wildlife Service California-Nevada Fish Health Center.

Nineteen fish (2.5%) had one or more visible lesions on the gills. Gill imprints were collected from 18 of 19 fish with gill lesions and *Flavobacterium columnaris* (columnaris) was positively identified on 15 (83%). If samples from all fish had been cultured for *F. columnaris*, it is likely that some fish with no visible gill lesion (rot) would have tested positive. Presence of the pathogen does not necessarily result in a visibly diseased condition. Nonetheless, incidence of columnaris appeared to be low (Nichols and Foott 2006).

While the rate of abnormalities observed was high among infected fish, the majority of infected fish still appeared "healthy" from an inspection of external characteristics (Figure 20). Based on this data, absence of external symptoms was a poor indicator of absence of these pathogens, especially if infection severity was low or the fish was in

early stages of infection. However, presence of external symptoms was a good indicator of presence of some of these pathogens. At Big Bar and Persido Bar it was highly unlikely for a fish to have grey, white, or tan gills (as the only disease symptom) without a *P. minibicornis*, *C. shasta,* or dual infection (40:3; Figure 21). With very high prevalence of *P. minibicornis*, it was unlikely for most fish with an abnormality to be uninfected. The Bogus and I-5 traps were not fished as long as traps located downstream, but mortalities observed in the lower and upper mainstem trap sites were much lower than those observed at Kinsman and Happy Camp (34%, n=9,030 and 25%, n=8,513, respectively) (Table 20). Severe infections of *C. shasta* are fatal to Chinook salmon, and the eventual fate of many of the fish we released alive was likely the same as fish observed dead in the live-box (Nichols and Foott 2006).

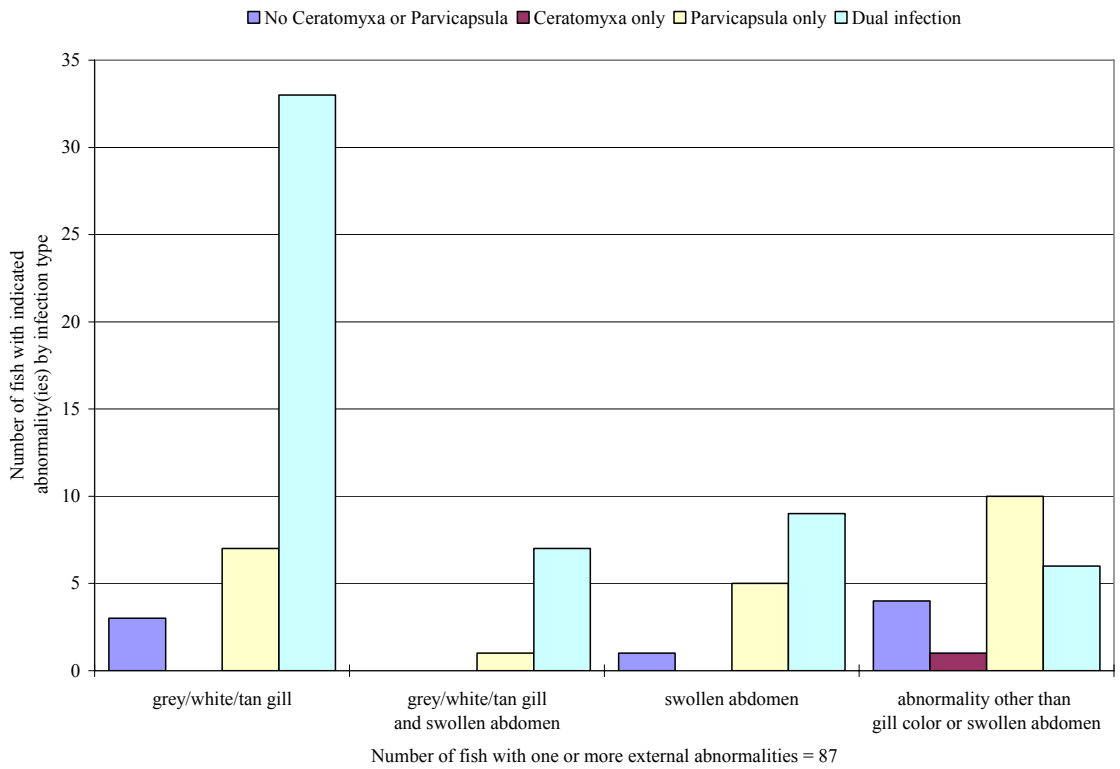

Figure 21. Histological results for *Parvicapsula minibicornis* and *Ceratomyxa shasta* by external symptom type of Chinook salmon that exhibited one or more external abnormalities. Fish were collected in the Klamath River in 2004 at the Big Bar trap site (n = 41), Persido Bar trap site (n = 24), and from nearby seine sites (n = 22). Our preliminary analysis of data provided by U.S. Fish and Wildlife Service California-Nevada Fish Health Center.

Sentinel fish study of Ceratomyxa shasta in the Klamath River

In June 2004, Stocking et al. (in press) conducted a sentinel study with fish known to be susceptible to *C. shasta*. A Cape Cod strain of rainbow trout (*O. mykiss*) from Roaring River and Oak Springs hatcheries in Oregon were held in live-cages and exposed for 4 days to ambient water at 18 locations throughout the length of the Klamath River and various tributaries to test for differences in severity of ceratomyxosis. The fish were subsequently reared in a laboratory and monitored for 100 days post-exposure. Stocking et al. documented the resulting percent mortalities and prevalence of *C. shasta* in these fish (Figure 22). From four exposure locations downstream of Iron Gate Dam (RM 195), 98 to 100% of those trout exposed exhibited *C. shasta* and mortality. This far surpassed mortality of fish from eight sites upstream of Iron Gate Dam (0.0 to 4.3% mortality). None of 280 sentinel fish exposed to four tributary waters upstream or downstream of

Iron Gate Dam were infected with *C. shasta*. Of 70 IGH Chinook salmon exposed for four days at Beaver Creek in the lower Klamath River (Figure 1), 49% succumbed to *C. shasta* infection.

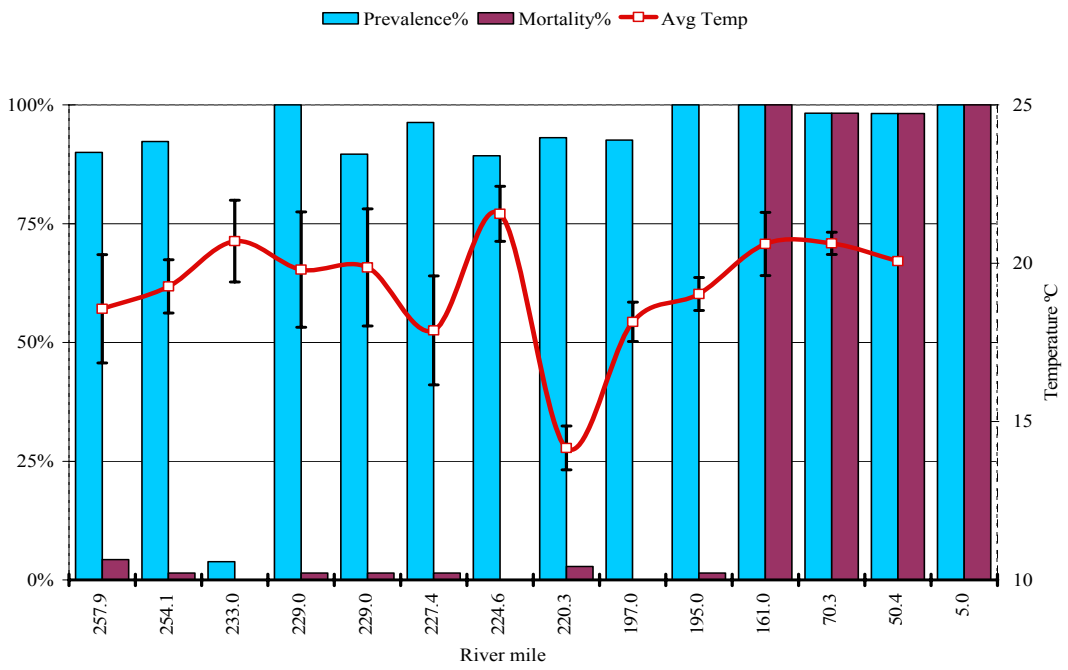

Figure 22. *Ceratomyxa shasta* mortality and infection prevalence data from Klamath Basin sentinel exposures conducted June 18 – 21, 2004. Seventy susceptible rainbow trout (Oregon Cape Cod strain) were exposed at each location and monitored for 100 days post exposure. Figure adapted from Stocking et al. (in press).

We associated the increased mortality and first appearance of external abnormalities in late April / early May with stress from disease and disease itself. Stocking et al. (in press) found *C. shasta* infection prevalence for sentinel young-of-year Chinook salmon was considerably lower (and mortality near zero) in April than in June, July, September, or November. They found support for the concept of water temperatures of 10˚C as a critical threshold for production and release of the *C. shasta* infectious stage.

Estimating successful emigrants and mortality loss

The Klamath Fish Health Advisory Team (KFHAT) has identified a need for indicators to use for assessing fish-kill risk in the Klamath Basin (KFHAT 2005). Because of the availability of long-term data from the Big Bar trap site (Figure 23), percent mortality observed at this site has been suggested to serve as an estimate successful emigrant

numbers and mortality. However, the Big Bar site (nor any other one or two sites) by itself would not suffice to estimate overall mortality or show where in the mainstem a particular mortality problem is greatest. While the highest mortality and rates of external symptoms of disease for Chinook and coho salmon and steelhead were observed at Kinsman and Happy Camp in 2004, rates observed at Big Bar (none higher than 14%) were much lower (Table 14 to Table 24). Nichols and Foott (2006) concluded that young-of-year Chinook salmon experienced high mortality below their sample reach (Persido Bar to Big Bar) prior to migration to the ocean. For young-of-year Chinook salmon that were released from IGH or emerged from the major spawning gravel sites in Bogus Creek or the mainstem Klamath River upstream of the I-5 site, the high mortality in the Nichols and Foott study reach would be cumulative with the higher season-long mortality at the Kinsman and Happy Camp sites (Table 20) and higher external abnormality rate (indicative of anemic and compromised conditions) from mid-May to early July (Table 14). In 2004, only emigrant fish that moved through the entire study area early (by the end of April; viz., some natural-reared fish) or quickly (viz., some large hatchery-reared fish) would likely survive.

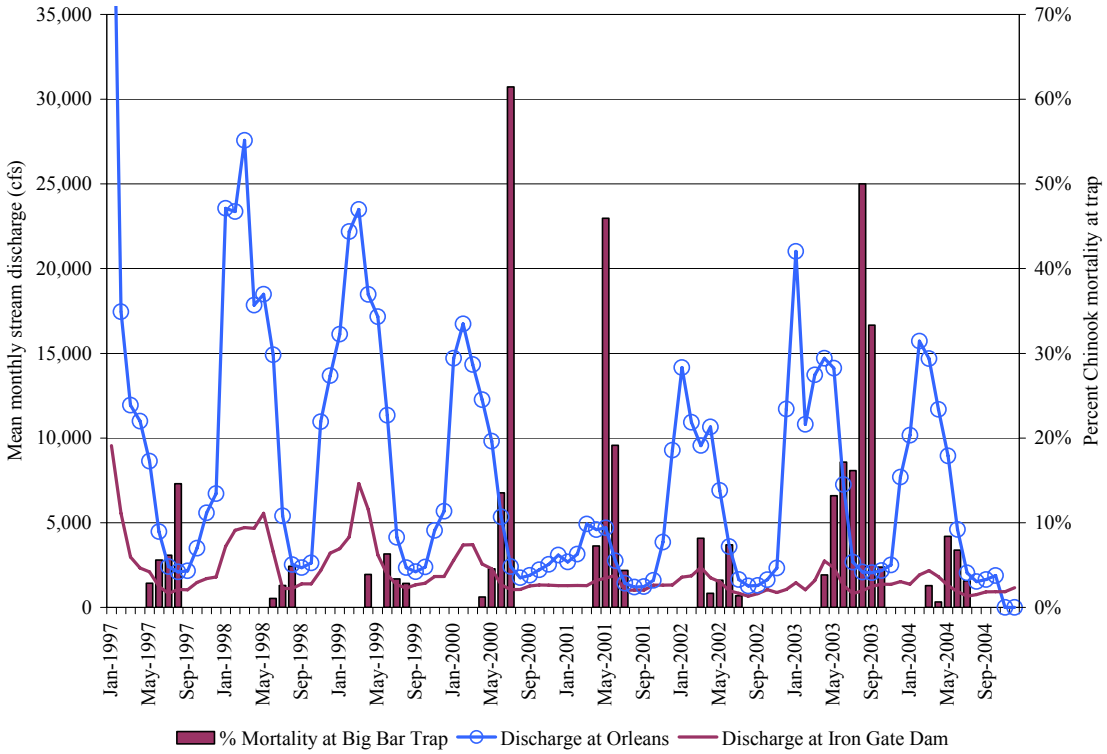

Figure 23. Young-of-year Chinook salmon mortality by percent of capture observed at the Big Bar trap site 1997 to 2004.

With data for one year, it is not reasonable to attribute causation beyond noting major differences between sampling locales. Observed small differences water temperatures did not adequately correspond with noted major differences in mortality and external abnormality rates between locals. Our data indicate an alarming 34% mortality (not infection) rate for fish passing the Kinsman trap site followed by 25% mortality for fish passing the Happy Camp site. These high levels of cumulative site-specific mortalities explain the sharp drop in CPUE for successfully migrating young-of-year Chinook salmon between the I-5 and Happy Camp trap sites (Table 4 and Table 5). Klamath River managers and researchers wishing to successfully quantify young-of-year Chinook salmon production by source, mainstem habitat use by coho salmon, and mainstem mortality for coho and Chinook salmon and steelhead need a variety of indicators, sampling techniques and sampling locations. In 2004, the high level of effort expended through multiple efforts helped us better understand and quantify the effects of fish disease and environmental factors.

Acknowledgments

The U.S. Fish and Wildlife Service and the authors acknowledge valuable field and technical assistance by Arcata Fish and Wildlife Office personnel: Mark Magneson, Isaac Sanders, Dennis Therry, Michael Mettee, Jason Ogawa, Forrest Cottrell, Pat McNeil, Wendy Mellberg, Michael Cunanan, Joe Polos, Schuyler Grove, and Tina Freeman. Field and technical assistance was provided by the Natural Resources Department of the Karuk Tribe of California (Toz Soto, Mike Polmateer, Ken Brinks, and Alex Corum), the Yurok Tribal Fisheries Program (Scott Turo, Frankie Myers, Jamie Holt, and Barry McCovey), and the California Department of Fish and Game (Bill Chesney). Mark Magneson and Isaac Sanders coordinated large number of projects over a large geographic area. Mike Cunanan organized and standardized the data. We are grateful for the thoughtful reviews provided by Ken Nichols, Scott Foott, Cindy Williams, Jerri Bartholomew, and Roxanna Hinzman.

Literature Cited

Bartholow, J., J. Heasley, B. Hanna, J. Sandelin, M. Flug, S. Campbell, J. Henriksen, and A. Douglas. 2003. Evaluating water management strategies with the systems impact assessment model: SIAM version 3. Fort Collins, CO: U.S. Geological Survey. USGS Open File Report 03-82. Fort Collins, Colorado. March 2003. Available: http://www.mesc.usgs.gov/ (April 2005).

Hardin, T. S., R. T. Grost, M. B. Ward, and G. E. Smith. 2005. Habitat suitability criteria for anadromous salmonids in the Klamath River, Iron Gate Dam to Scott River, California. An investigation for the U.S. Fish and Wildlife Service and California Department of Fish and Game. California Department of Fish and Game Stream Evaluation Report 05-1

Klamath Fish Health Assessment Team (KFHAT). 2005. End of Year Report, 2004. Available: http://ncncr-isb.dfg.ca.gov/KFP/DesktopDefault.aspx (March 2005)

Nichols, K. and J. S. Foott. 2006. FY2004 investigation report: Health monitoring of juvenile Klamath River Chinook salmon. U.S. Fish and Wildlife Service, California-Nevada Fish Health Center. Anderson, CA.

Stocking, R. W., R. A. Holt, J. S. Foott, and J. L. Bartholomew. In press. Spatial and temporal occurrence of the salmonid parasite *Ceratomyxa shasta* in the Oregon-California Klamath River Basin. Journal of Aquatic Animal Health.

Personal Communications

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

Hampton, Mark. California Department of Fish and Game. Yreka, CA.

Soto, Toz. Karuk Tribe of California Natural Resources Department. Orleans, CA.

Appendix A. "Normal" vs. "Abnormal" external exam results by trap site.

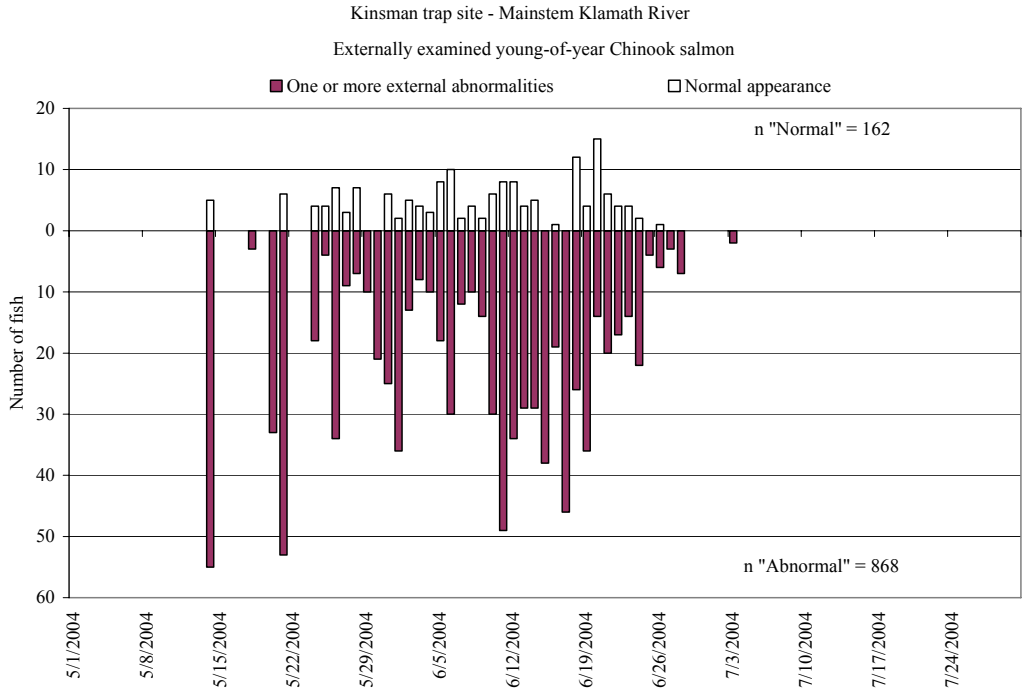

Figure A-1. Young-of-year Chinook salmon external examination results at Kinsman.

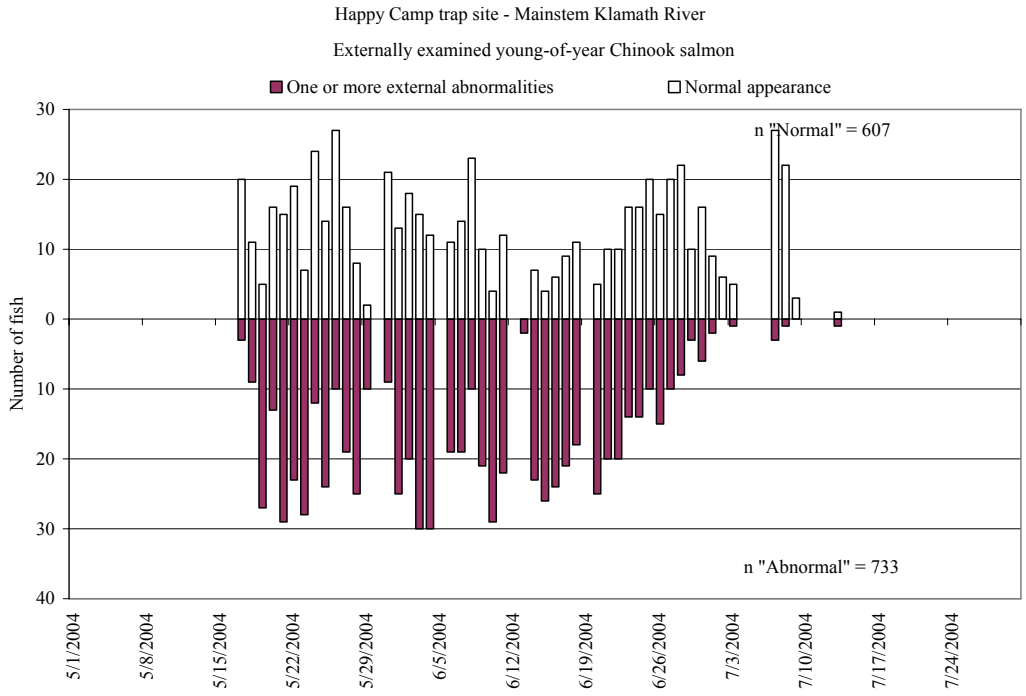

Figure A-2. Young-of-year Chinook salmon external examination results at Happy Camp.

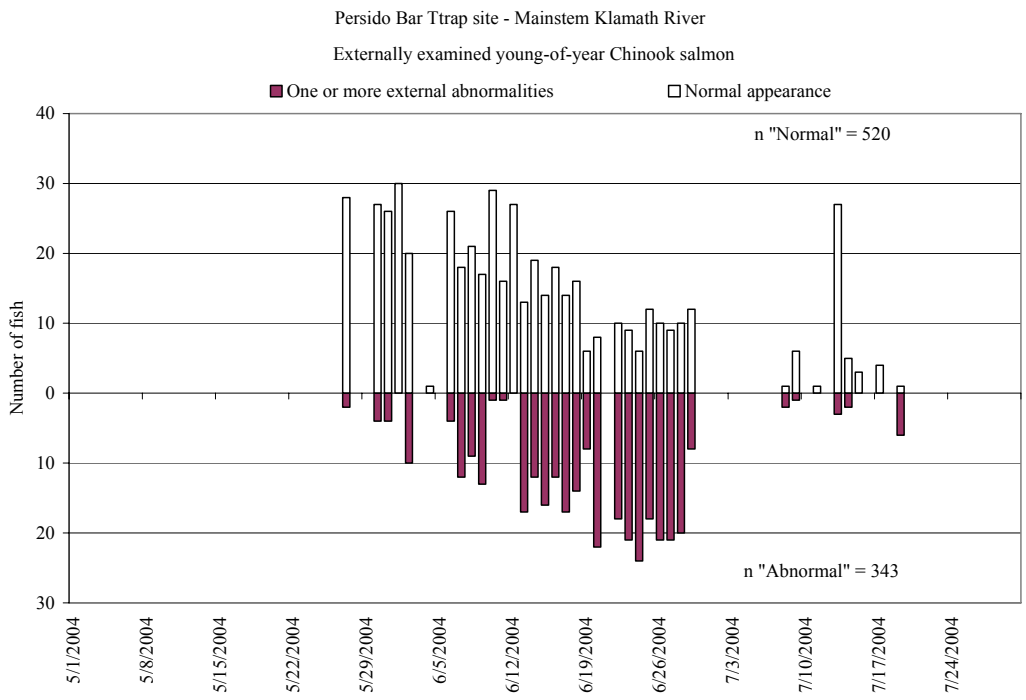

Figure A-3. Young-of-year Chinook salmon external examination results at Persido Bar.

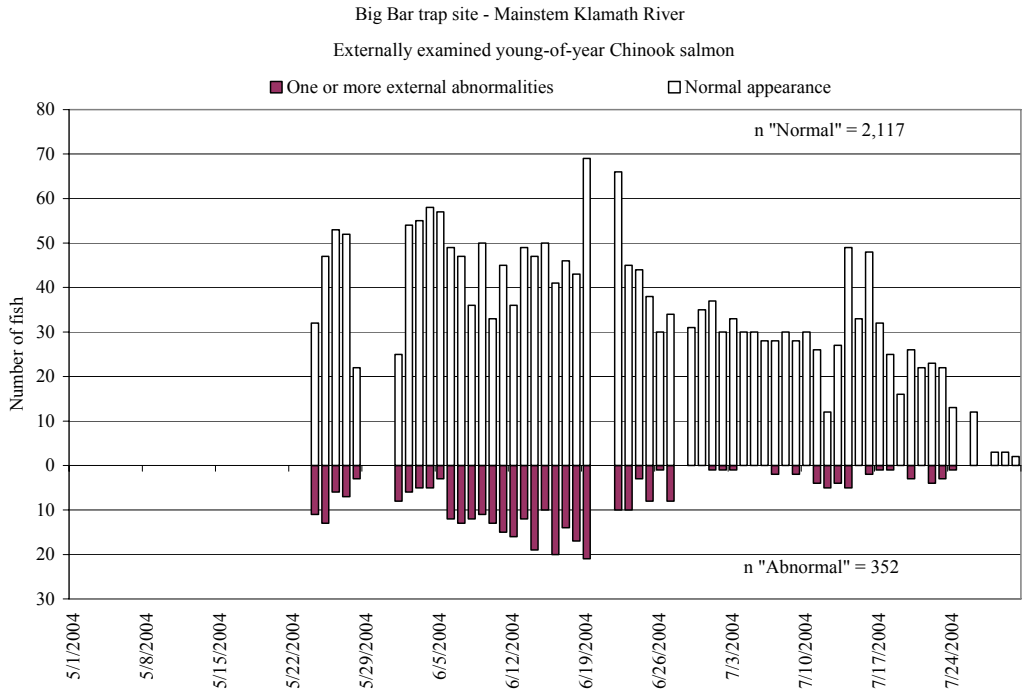

Figure A-4. Young-of-year Chinook salmon external examination results at Big Bar.

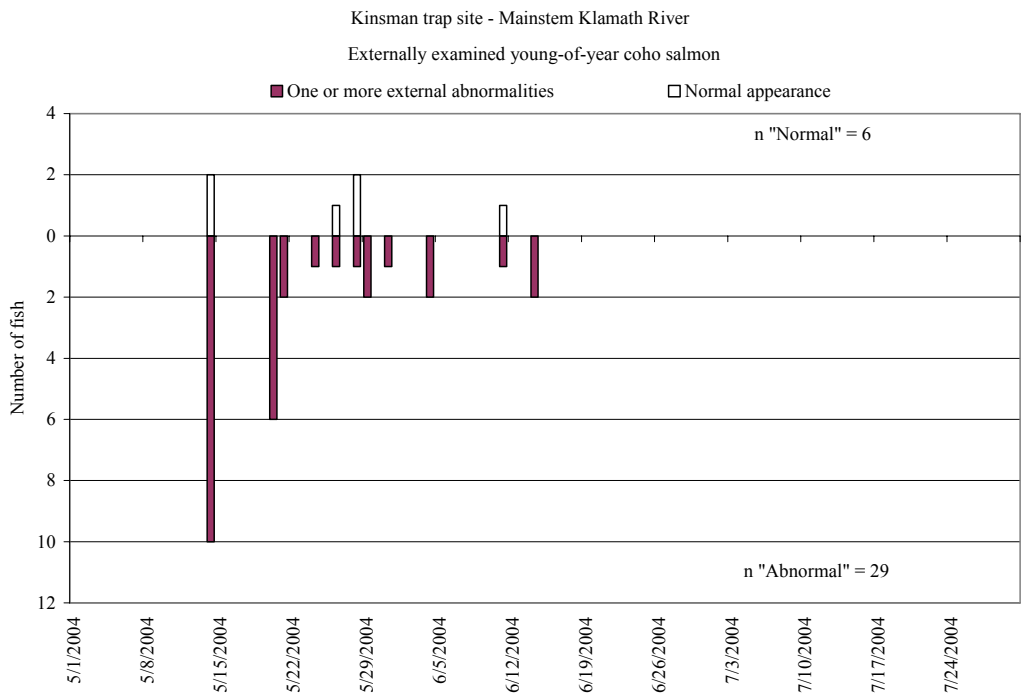

Figure A-5. Young-of-year coho salmon external examination results at Kinsman.

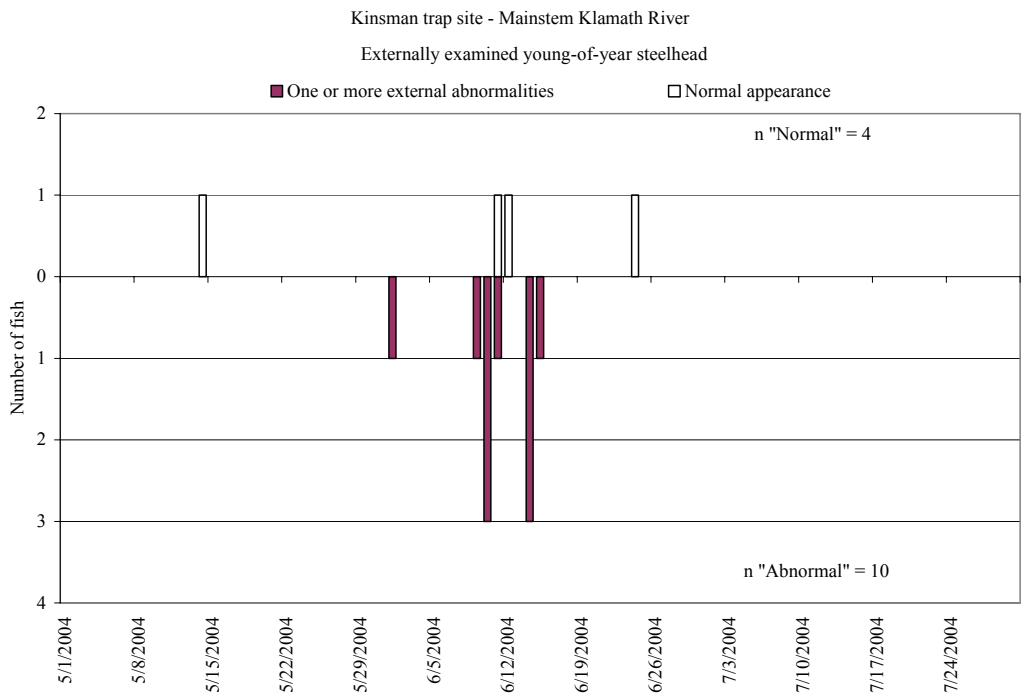

Figure A-6. Young-of-year steelhead external examination results at Kinsman.

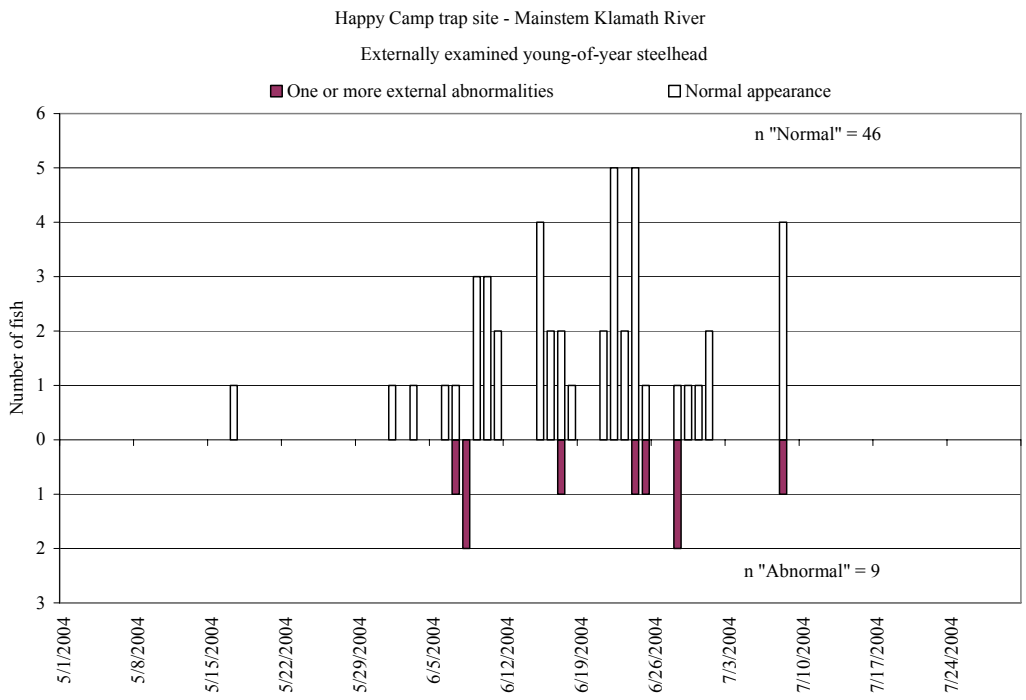

Figure A-7. Young-of-year steelhead external examination results at Happy Camp.

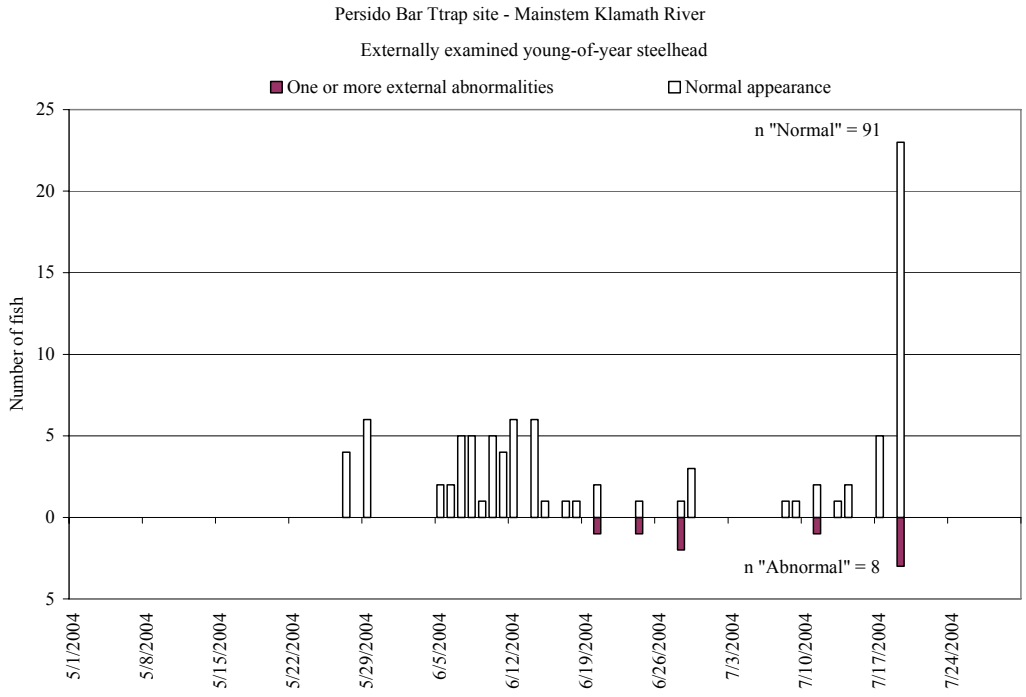

Figure A-8. Young-of-year steelhead external examination results at Persido Bar.

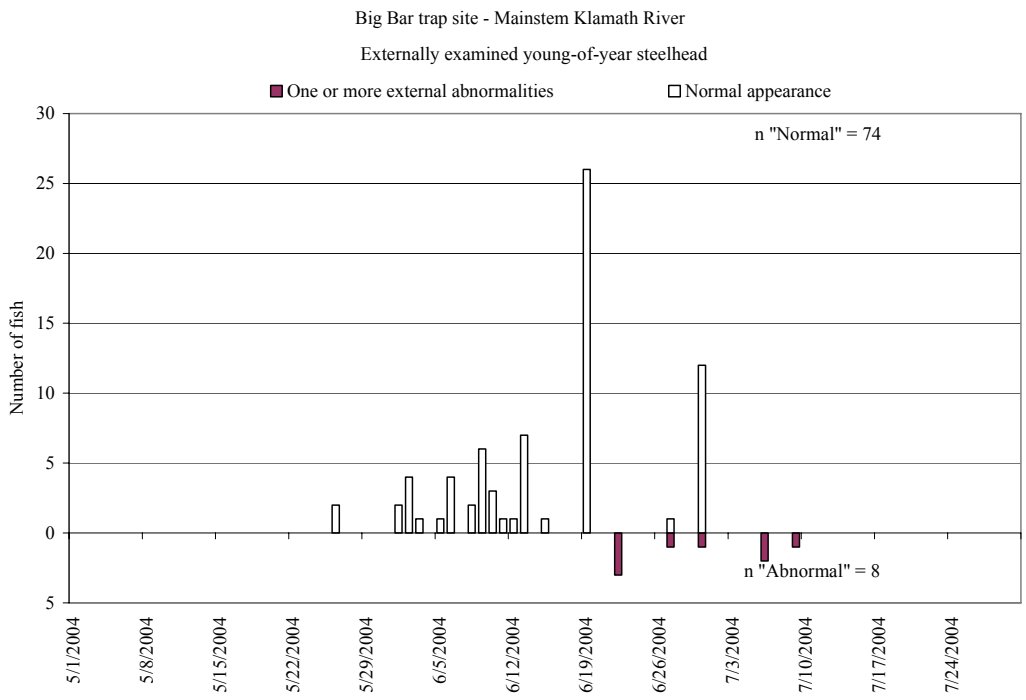

Figure A-9. Young-of-year steelhead external examination results at Big Bar.

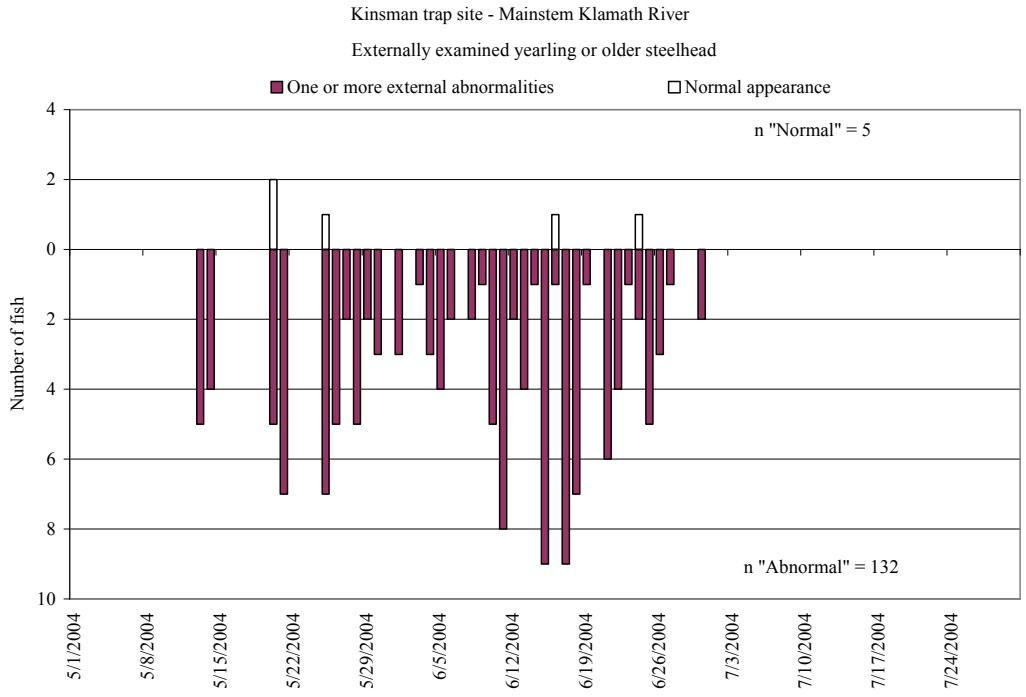

Figure A-10. Steelhead yearling or older external examination results at Kinsman.

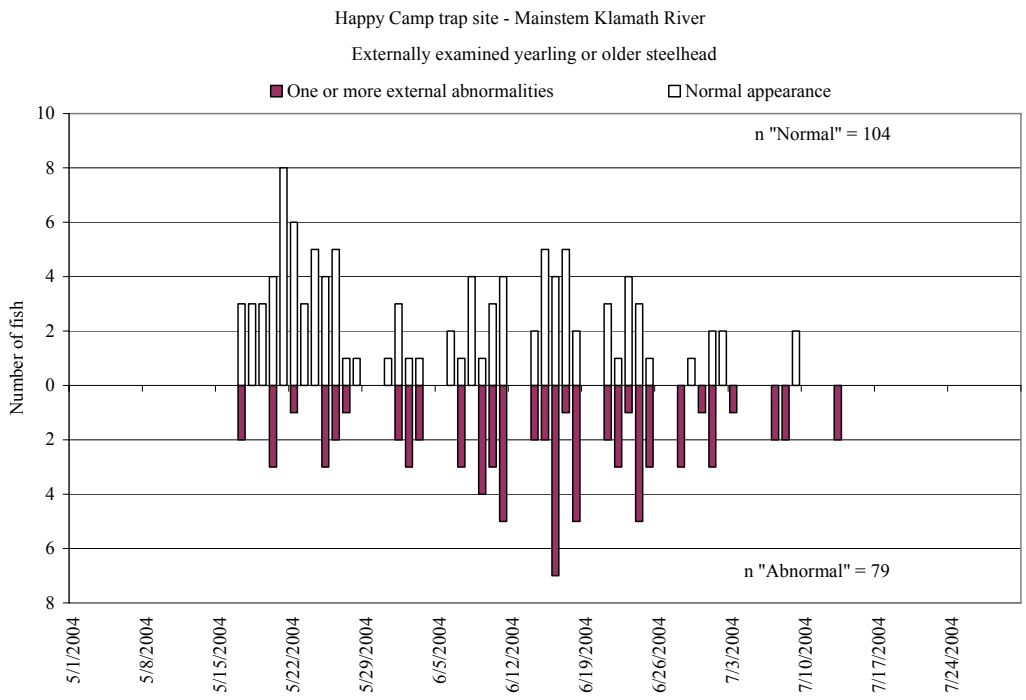

Figure A-11. Steelhead yearling or older external examination results at Happy Camp.

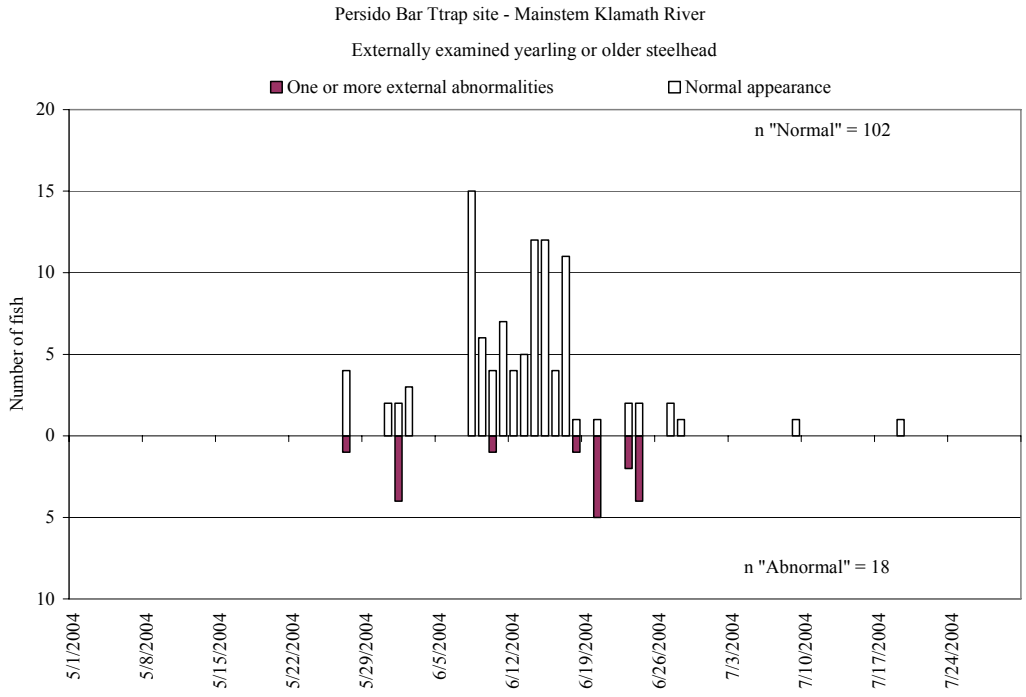

Figure A-12. Steelhead yearling or older external examination results at Persido Bar.

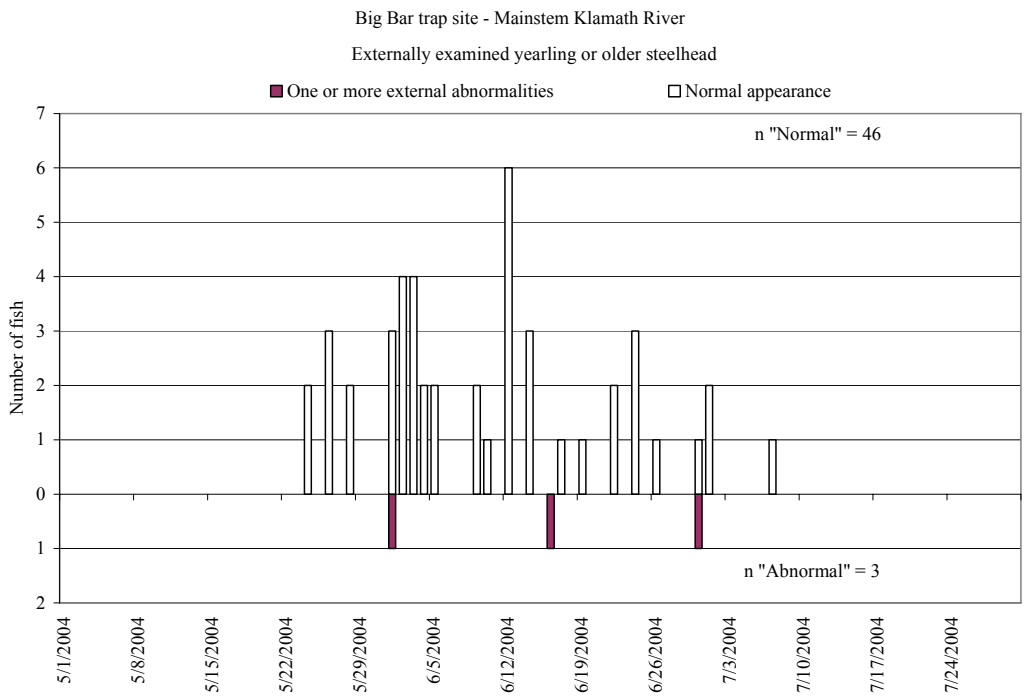

Figure A-13. Steelhead yearling or older external examination results at Big Bar.

Appendix B. Plots of catch-per-unit effort and mortality by trap site.

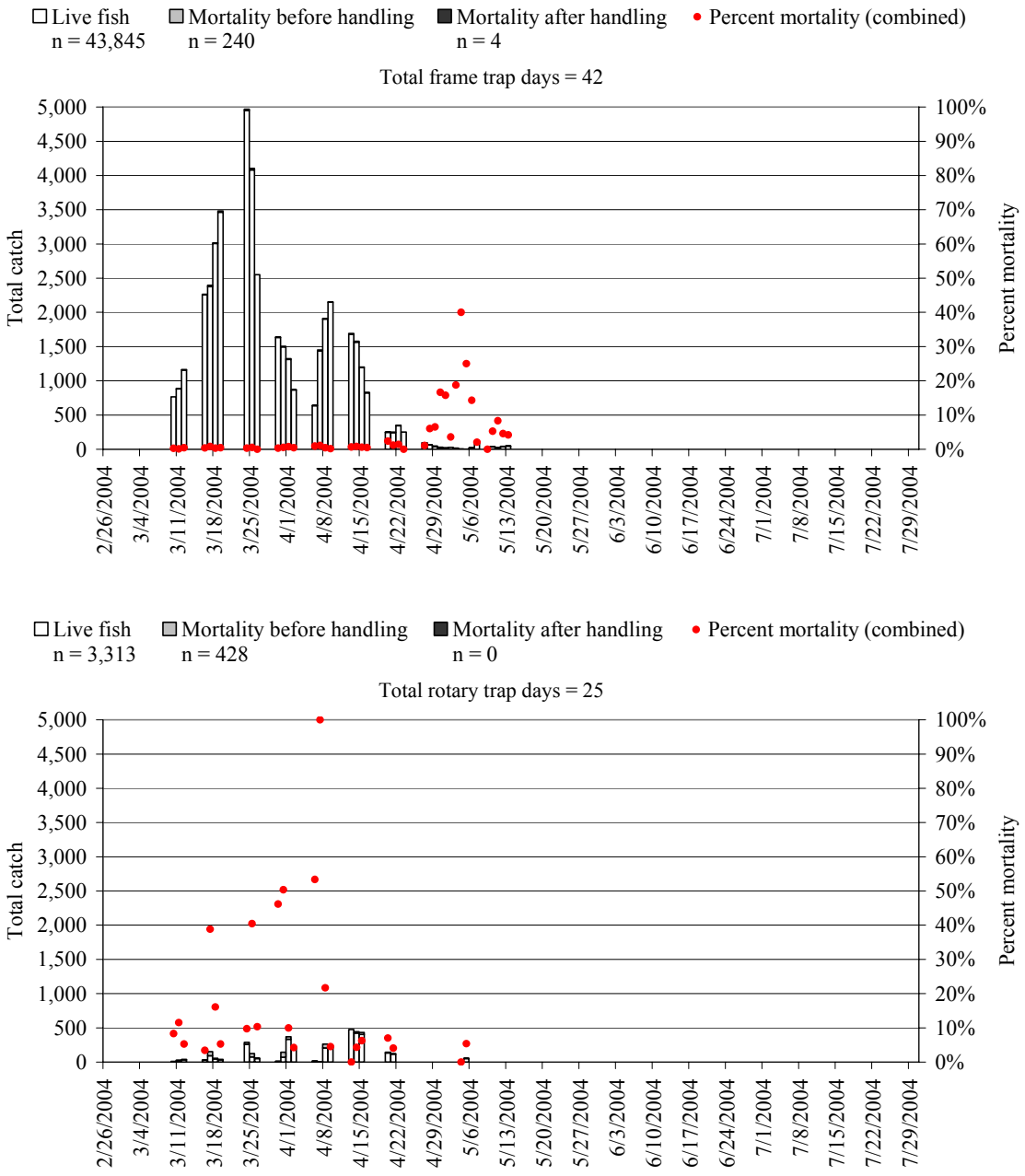

Figure B-1. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Bogus trap site.

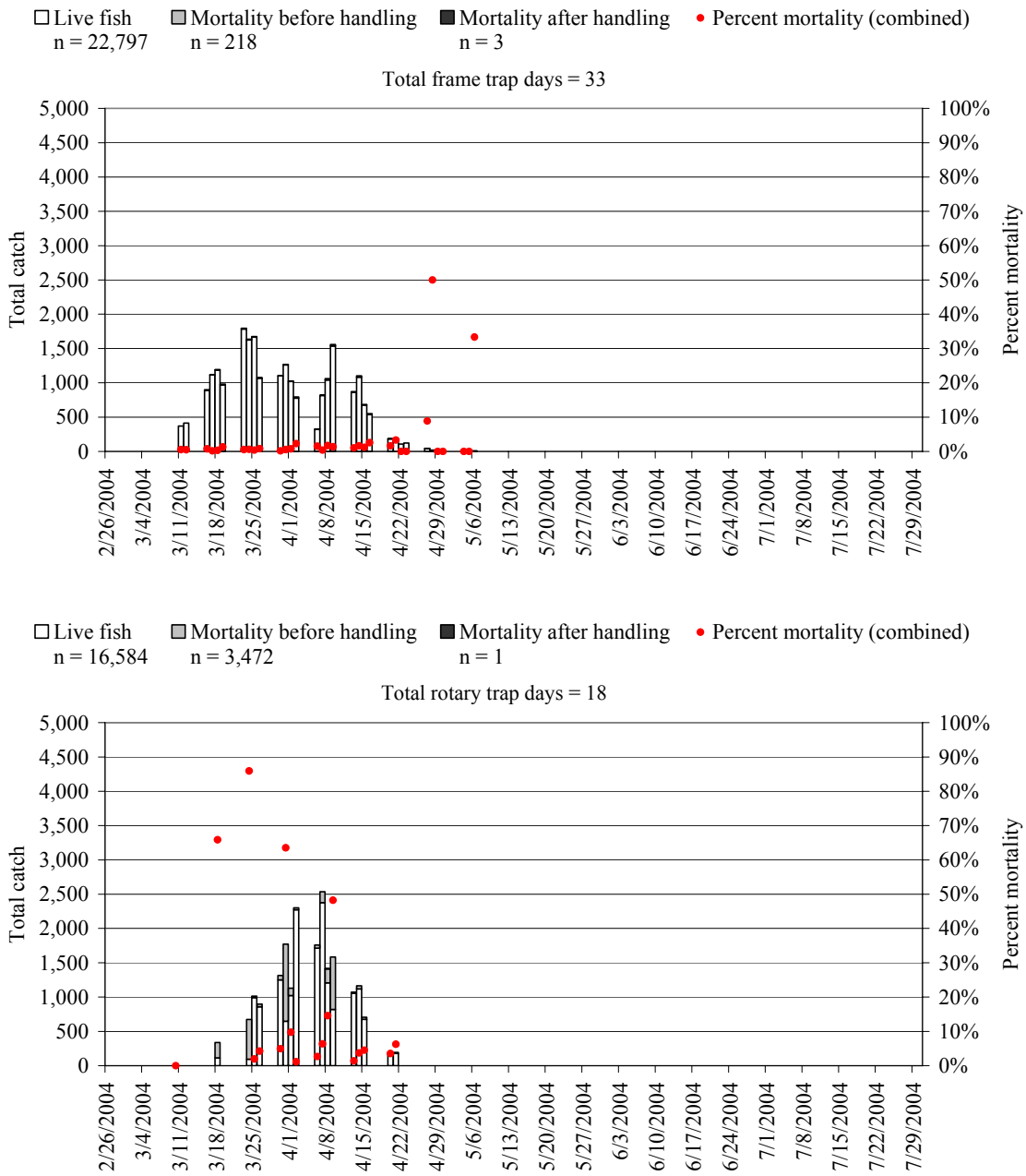

Figure B-2. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the I-5 trap site.

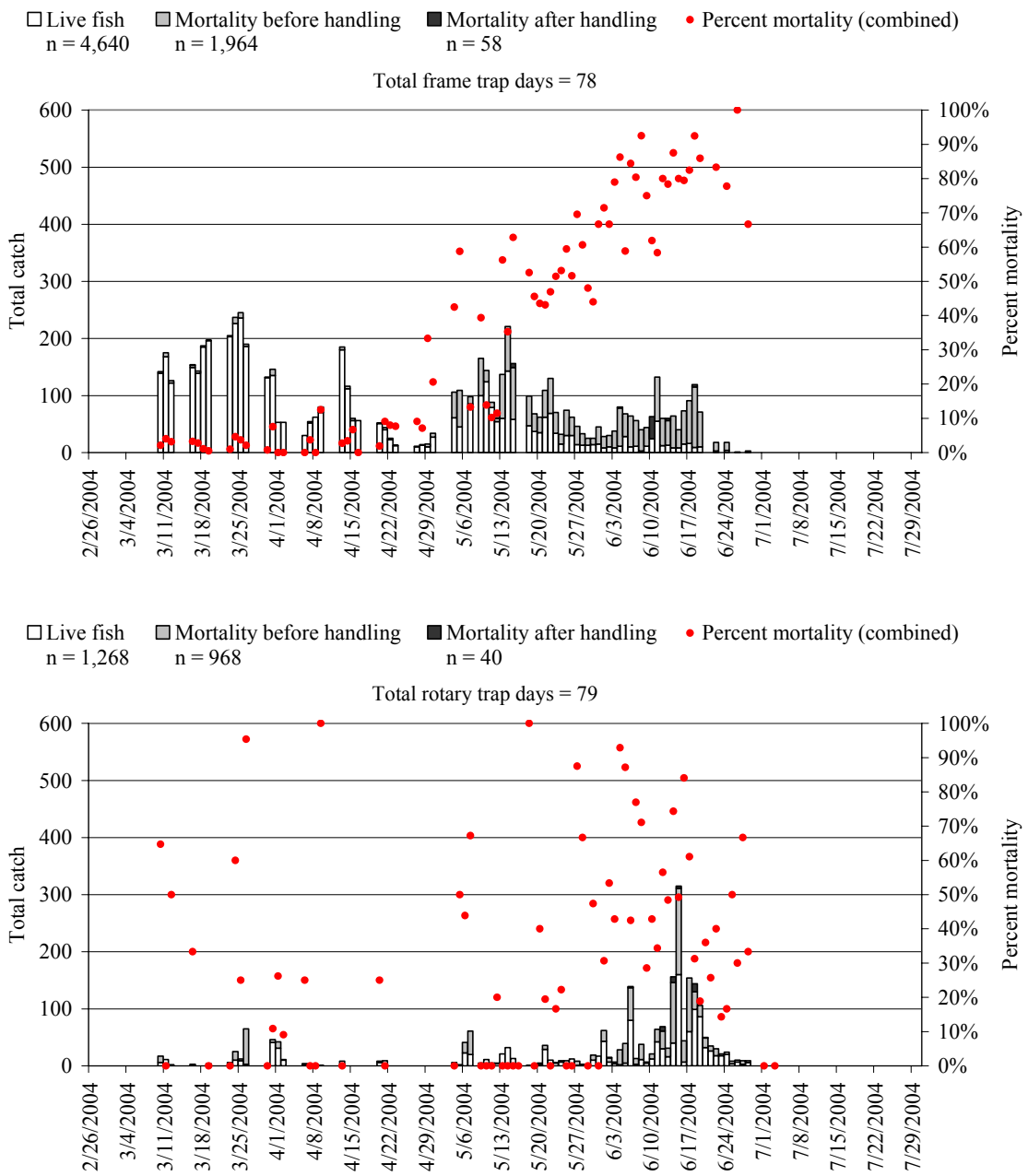

Figure B-3. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Kinsman trap site.

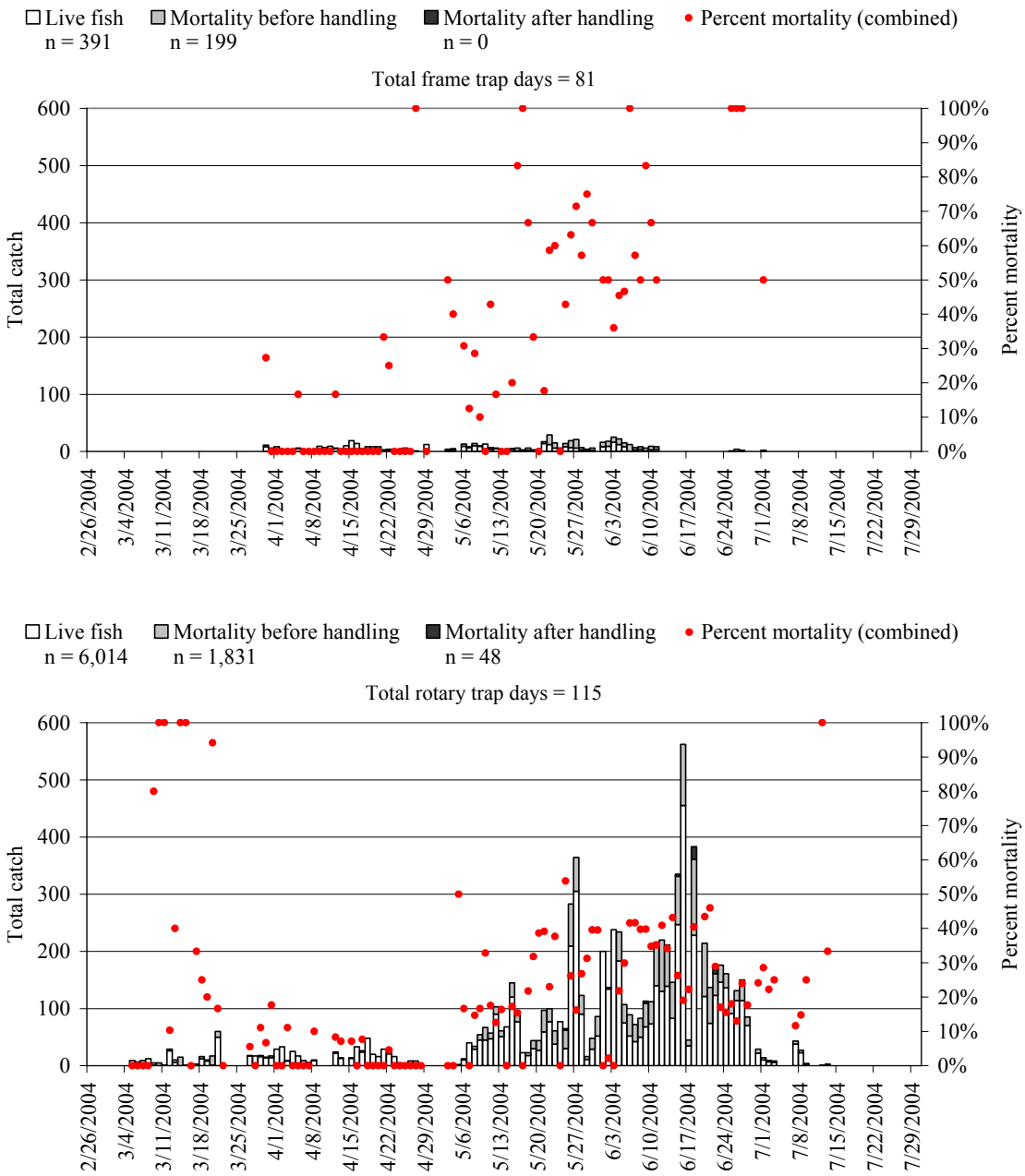

Figure B-4. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Happy Camp trap site.

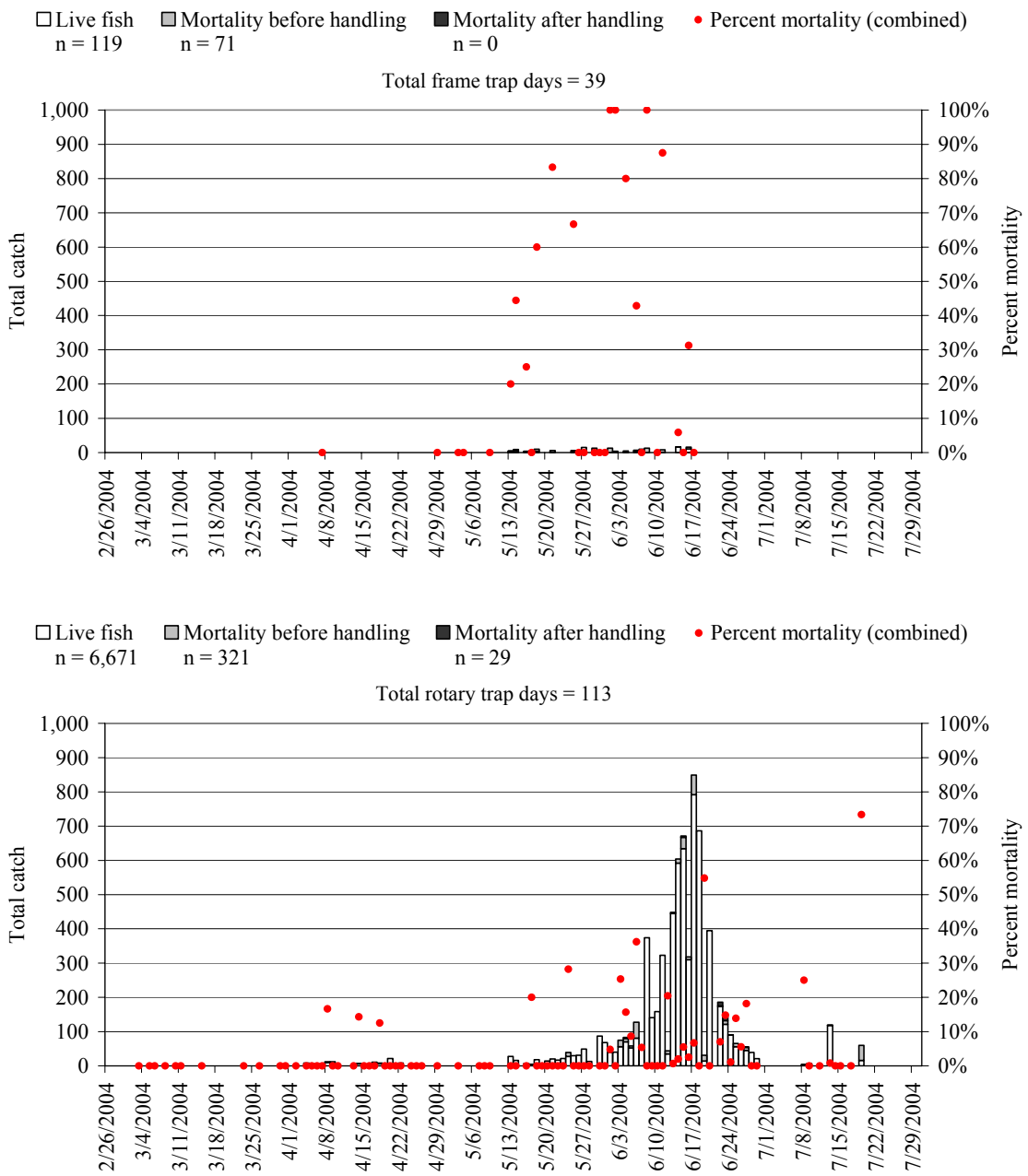

Figure B-5. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Persido Bar trap site.

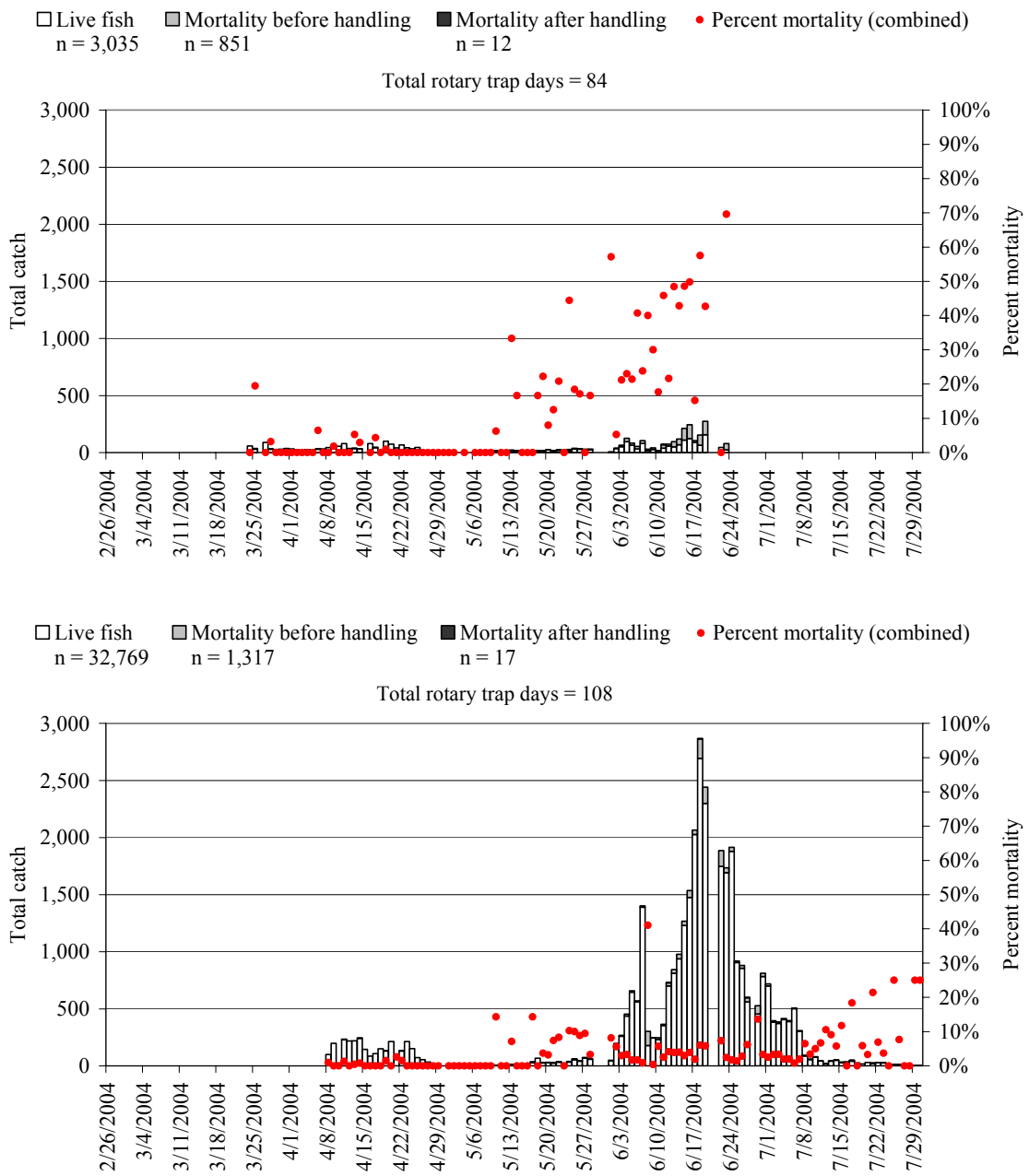

Figure B-6. Young-of-year Chinook salmon catch and mortality observed at rotary trap 1 (top) and 2 (bottom) at the Big Bar trap site.

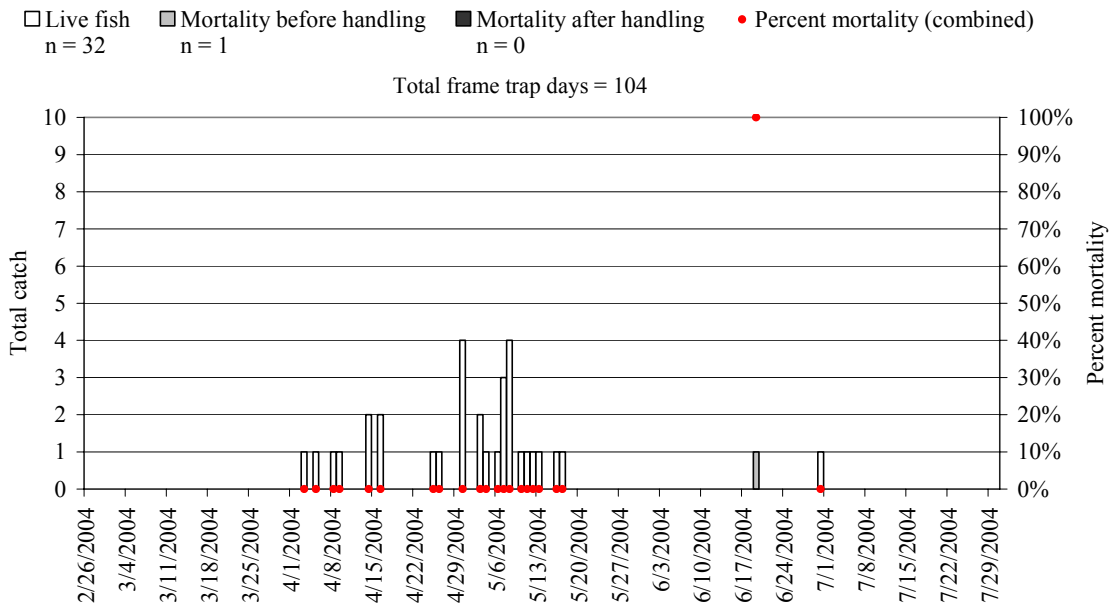

Figure B-7. Young-of-year Chinook salmon catch and mortality observed in the frame traps at the Seiad Creek trap site.

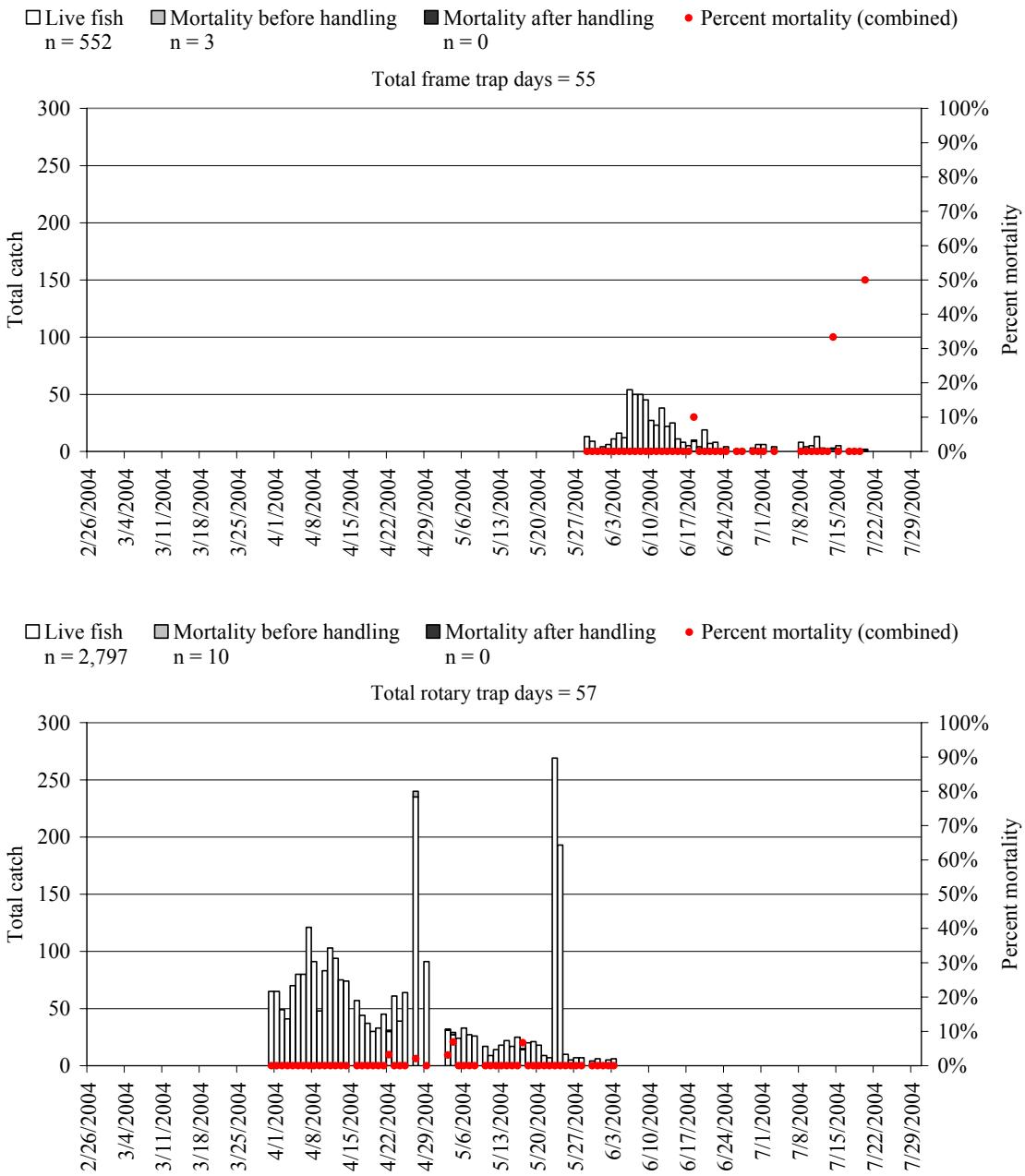

Figure B-8. Young-of-year Chinook salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Elk Creek trap site.

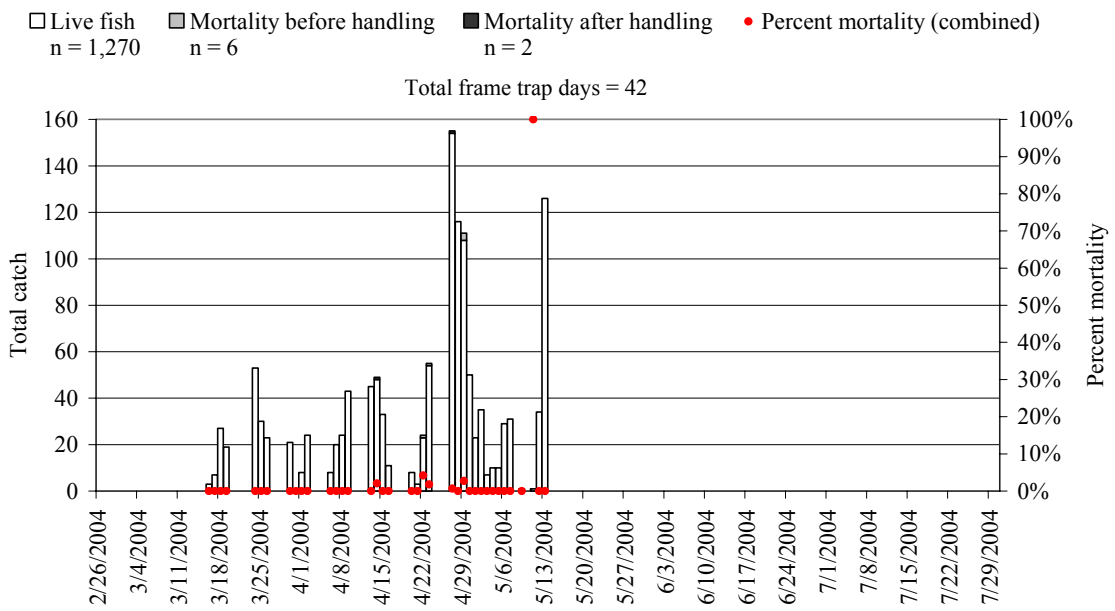

Figure B-9 Young-of-year coho salmon catch and mortality observed in the frame trap at the Bogus trap site. Ten live coho salmon were captured in the rotary trap at this site with no mortality (data not shown).

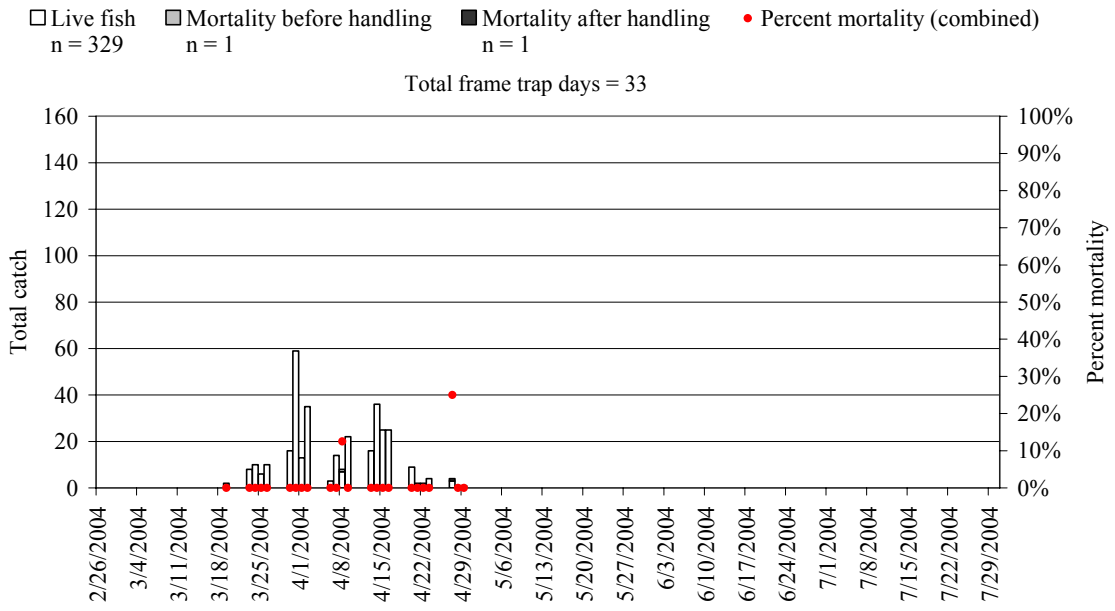

Figure B-10. Young-of-year coho salmon catch and mortality observed in the frame trap at the I-5 trap site. Seventeen live young-of-year coho salmon and one mortality (before handling) were captured in the rotary trap at this site (data not shown).

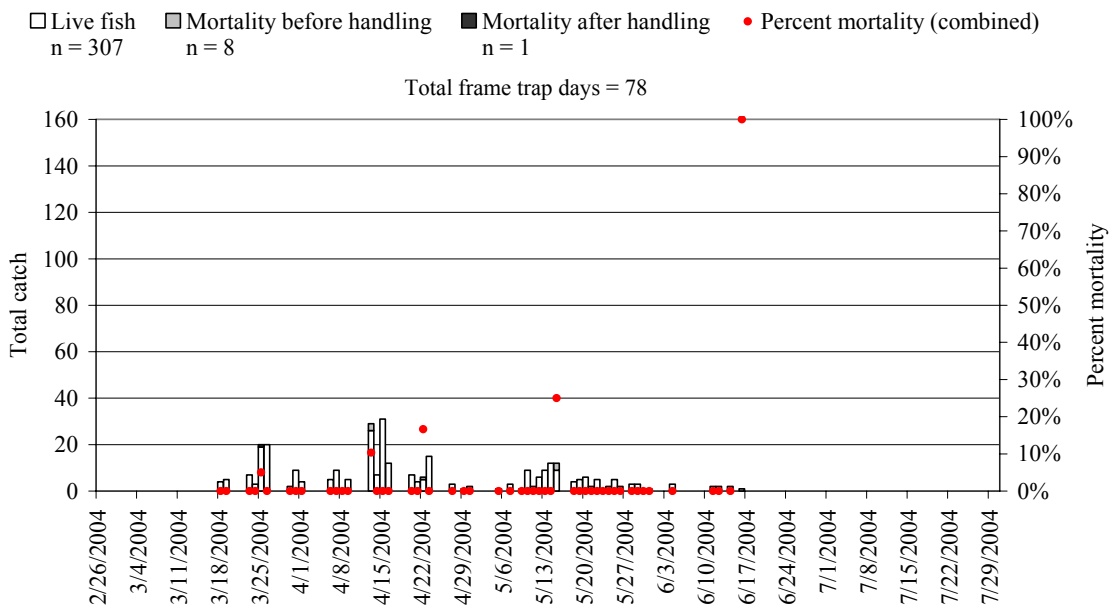

Figure B-11. Young-of-year coho salmon catch and mortality observed in the frame trap at the Kinsman trap site. No young-of-year coho salmon were captured in the rotary trap at this site.

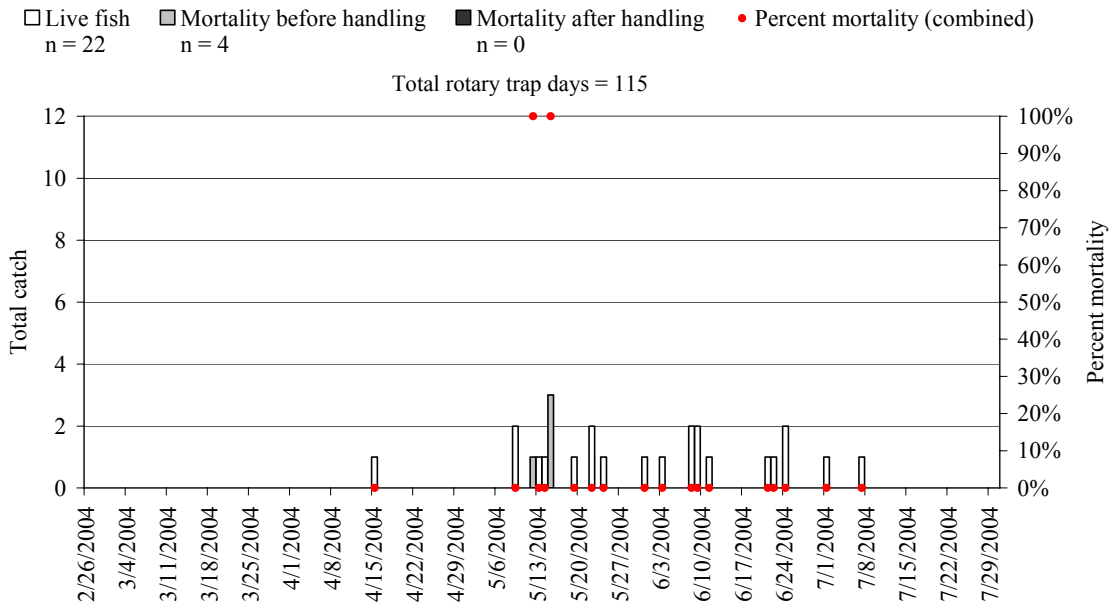

Figure B-12. Young-of-year coho salmon catch and mortality observed in the rotary trap at the Happy Camp trap site. Nine live young-of-year coho salmon and no mortalities were captured in the frame trap at this site (data not shown).

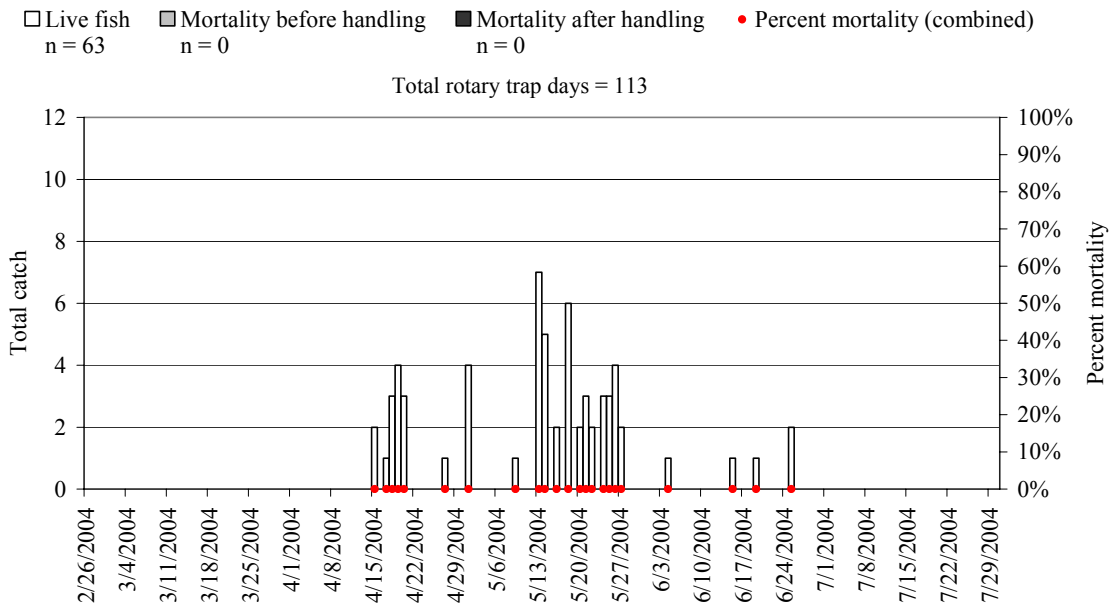

Figure B-13. Young-of-year coho salmon catch and mortality observed in the rotary trap at the Persido Bar trap site. One live young-of-year coho salmon was captured in the frame trap at this site (data not shown).

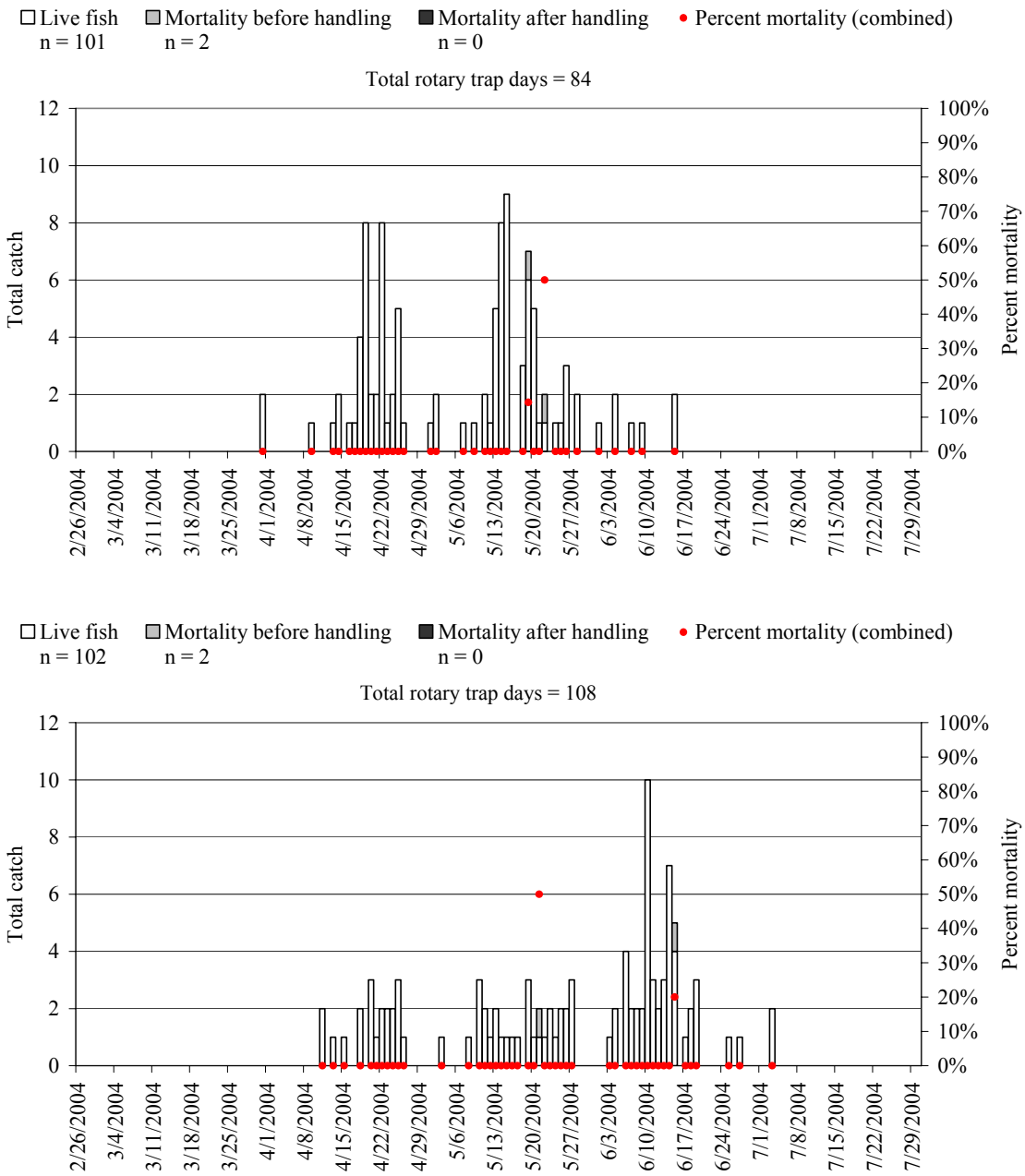

Figure B-14. Young-of-year coho salmon catch and mortality observed at rotary trap 1 (top) and 2 (bottom) at the Big Bar trap site.

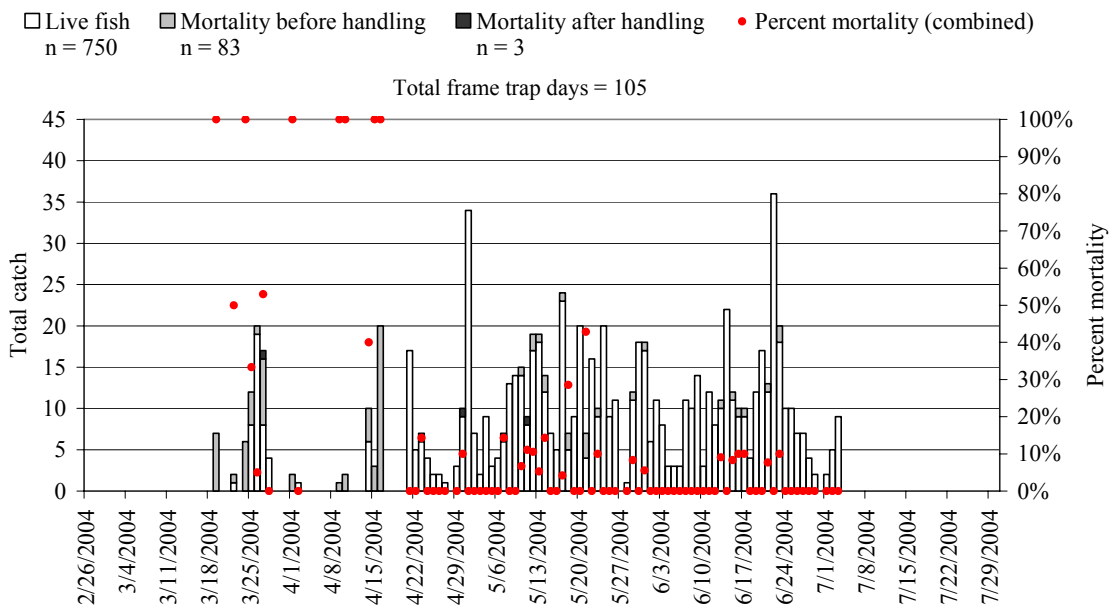

Figure B-15. Young-of-year coho salmon catch and mortality observed in the frame trap at the Horse Creek trap site. No young-of-year coho salmon were captured in the rotary trap at this site.

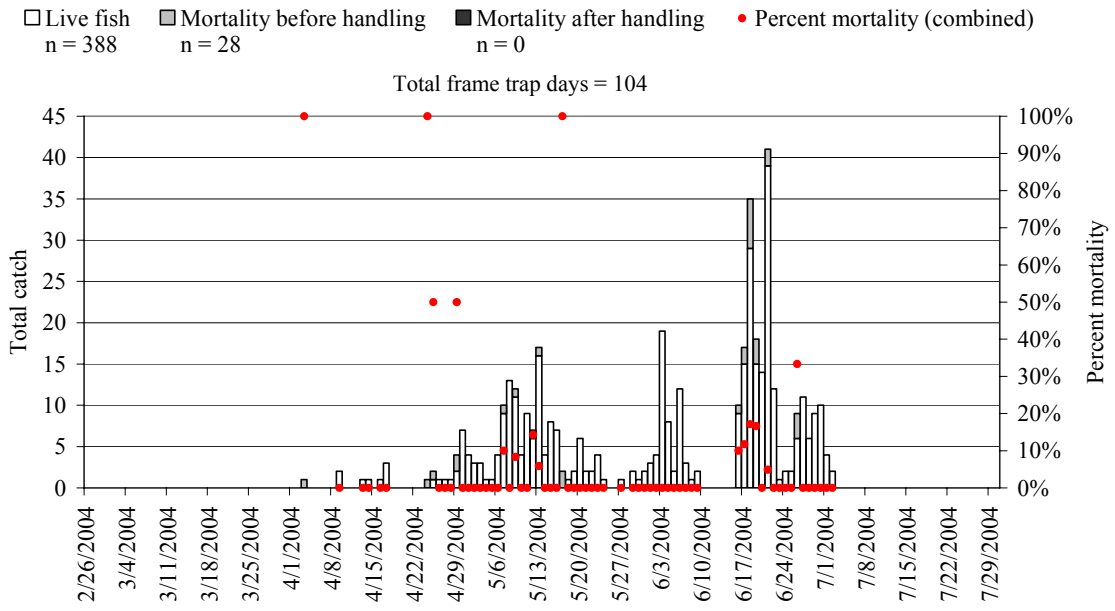

Figure B-16. Young-of-year coho salmon catch and mortality observed in the frame traps at the Seiad Creek trap site.

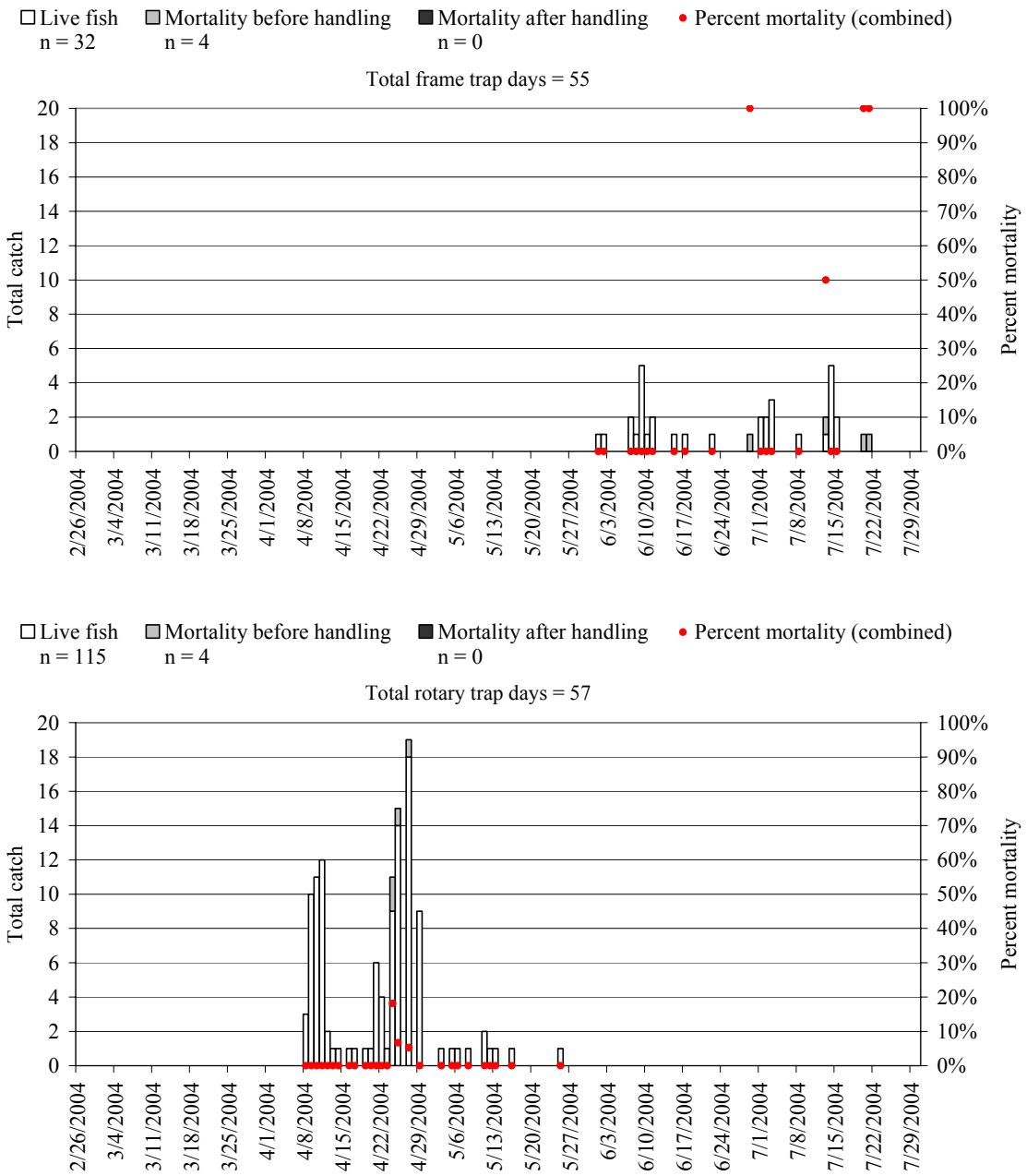

Figure B-17. Young-of-year coho salmon catch and mortality observed in the frame trap (top) and rotary trap (bottom) at the Elk Creek trap site.

Appendix C. Condition factor scatter-plots

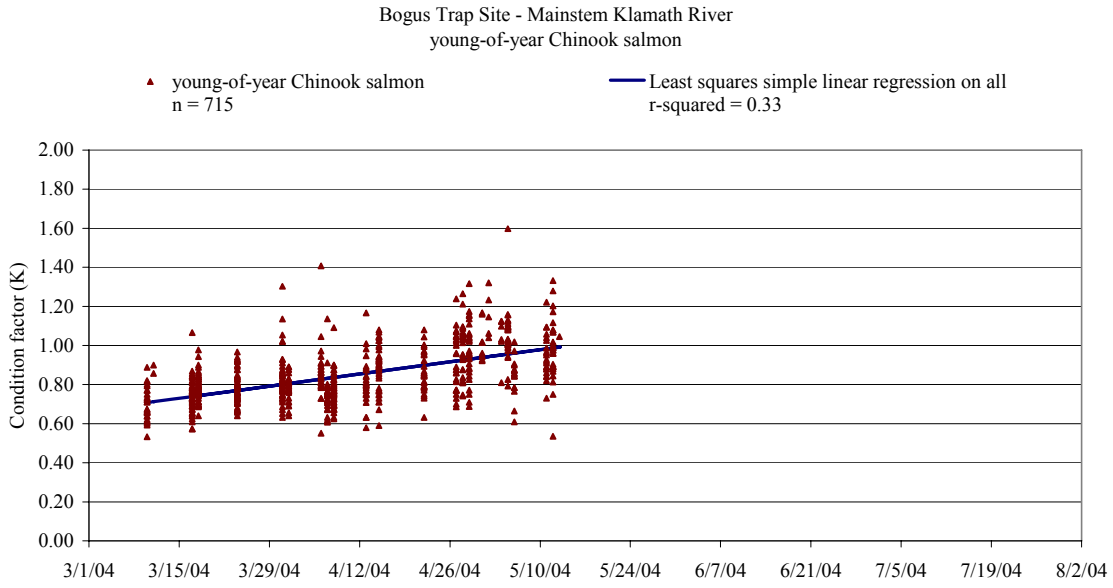

Figure C-1. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for 2004 young-of-year Chinook salmon at the Bogus trap site. Mean = 0.844, standard deviation = 0.143 over the whole trapping period.

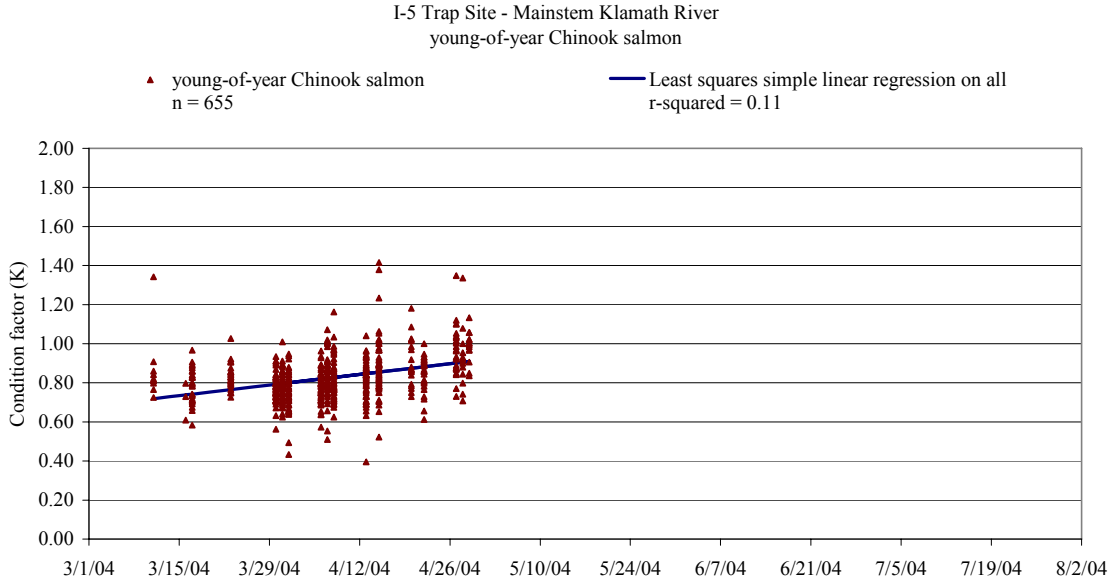

Figure C-2. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for 2004 young-of-year Chinook salmon at the I-5 trap site. Mean = 0.824, standard deviation = 0.126 over the whole trapping period. Not pictured is one fish with condition factor of 2.11 captured April 13.

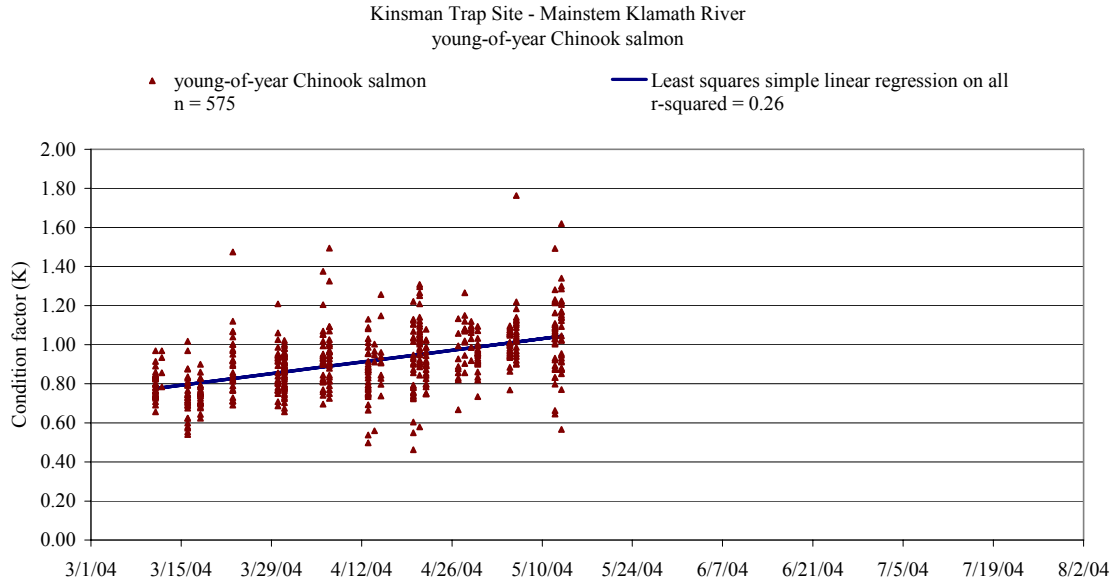

Figure C-3. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year Chinook salmon at the Kinsman trap site. Mean = 0.912, standard deviation = 0.163 over the whole trapping period.

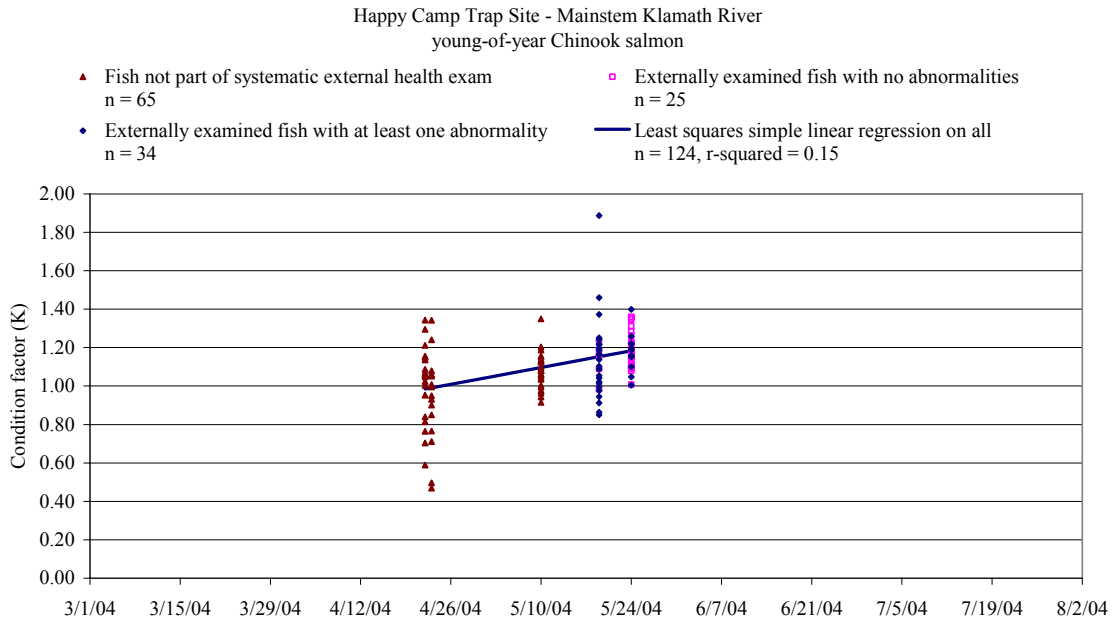

Figure C-4. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year Chinook salmon at the Happy Camp trap site. Mean = 1.098, standard deviation = 0.203 over the whole trapping period. Not pictured is one fish (not included in systematic external exam) with condition factor 2.09 captured May 10.

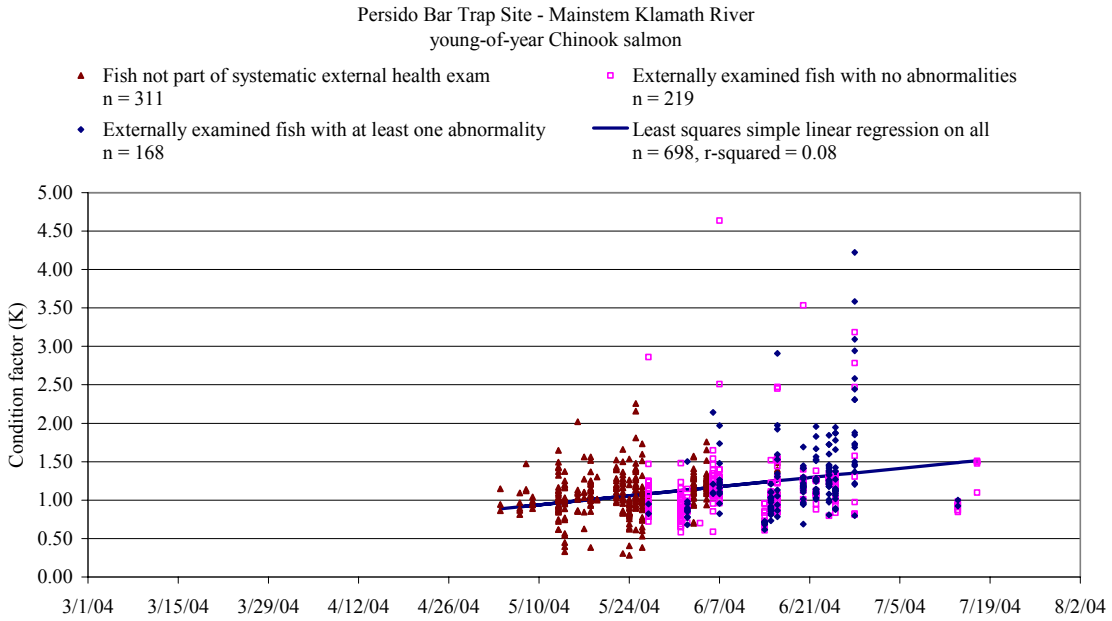

Figure C-5. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year Chinook salmon at the Persido Bar trap site. Mean = 1.155, standard deviation = 0.447 over the whole trapping period. Not pictured is one fish with no external abnormalities and condition factor of 5.36 captured June 28.

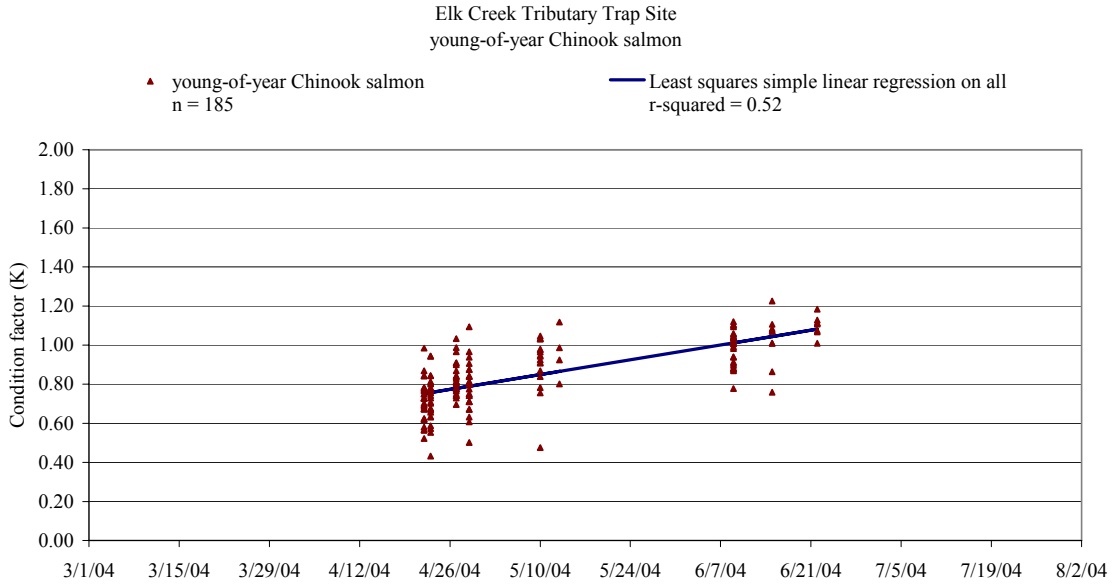

Figure C-6. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for Elk Creek young-of-year Chinook salmon. Mean = 0.845, standard deviation = 0.157 over the whole trapping period.

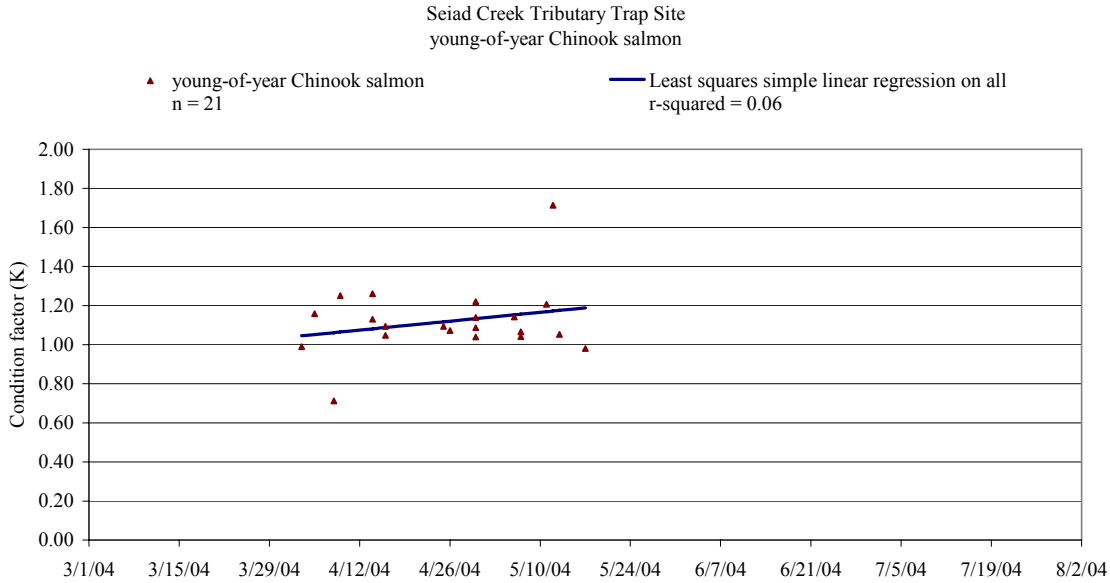

Figure C-7. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for Seiad Creek young-of-year Chinook salmon. Mean = 1.119, standard deviation = 0.179 over the whole trapping period.

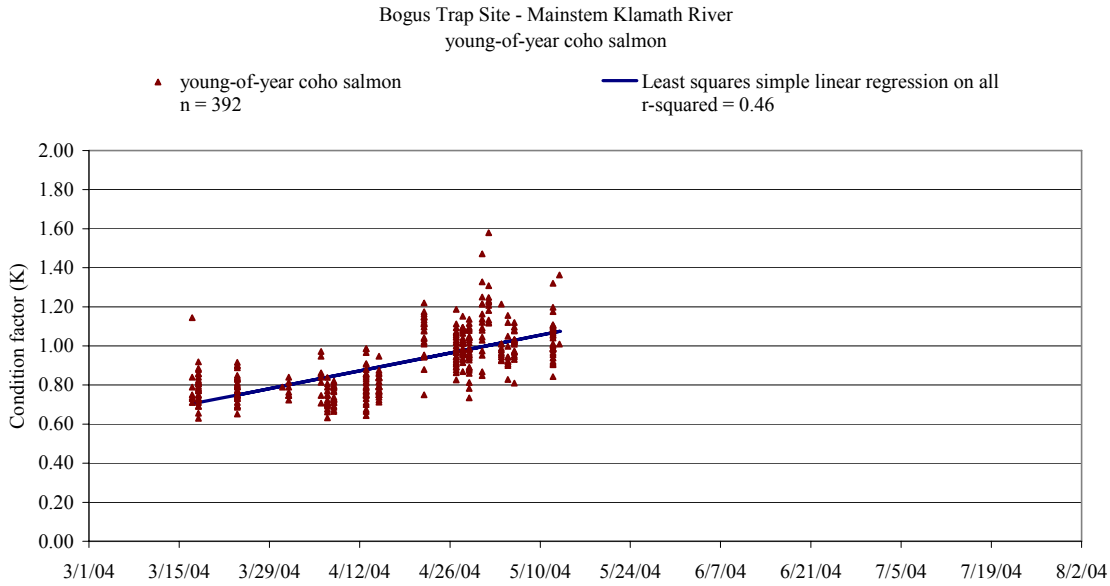

Figure C-8. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year coho salmon at the Bogus trap site. Mean = 0.913, standard deviation = 0.158 over the whole trapping period.

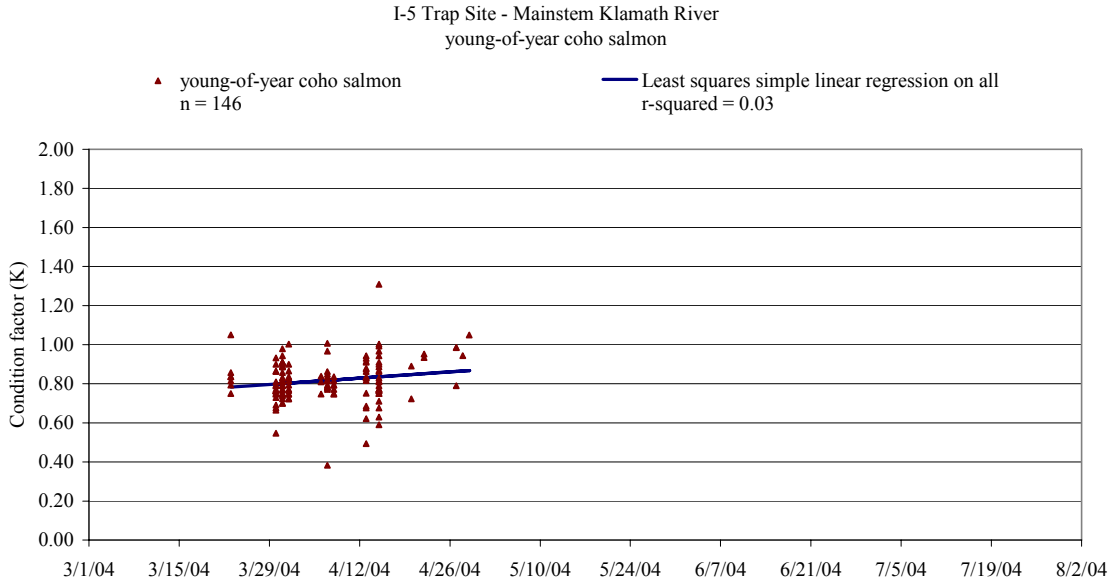

Figure C-9. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year coho salmon at the I-5 trap site. Mean = 0.816, standard deviation = 0.108 over the whole trapping period.

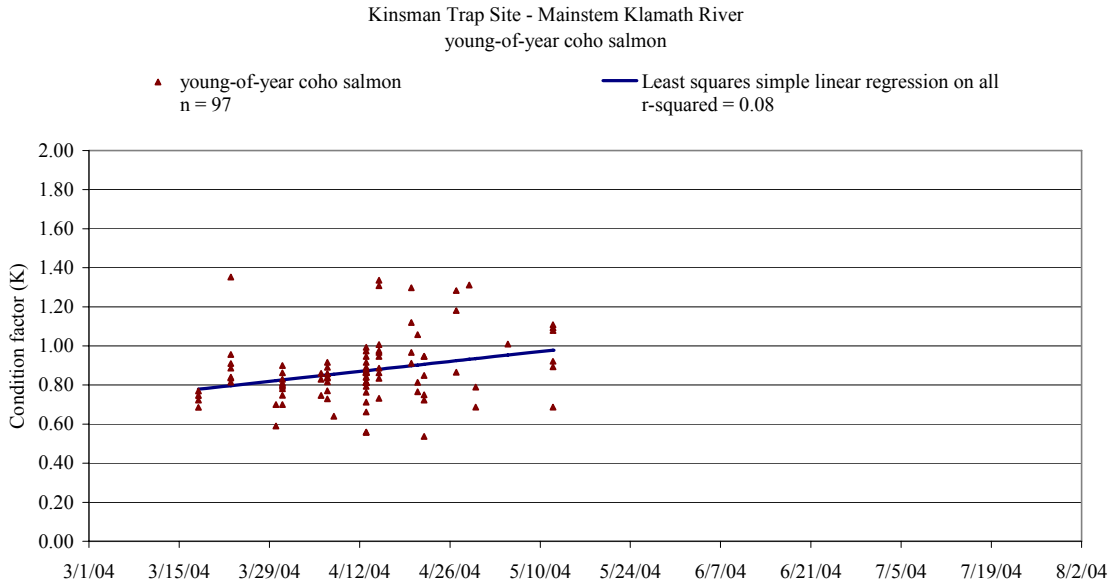

Figure C-10. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year coho salmon at the Kinsman trap site. Mean = 0.871, standard deviation = 0.164 over the whole trapping period.

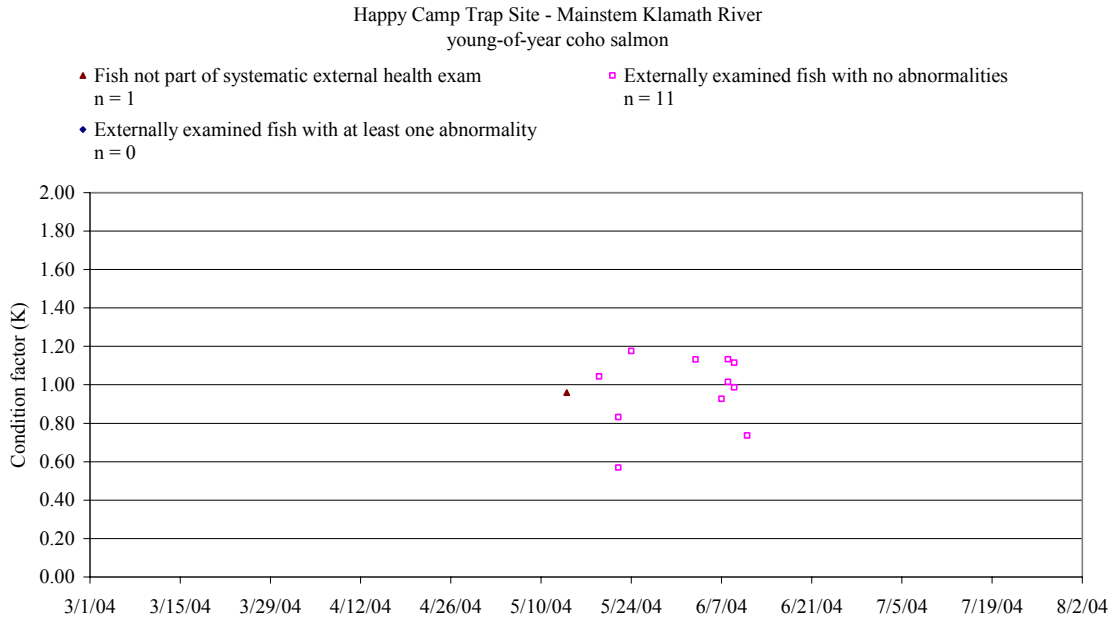

Figure C-11. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year coho salmon at the Happy Camp trap site. Mean = 0.969, standard deviation = 0.181 over the whole trapping period.

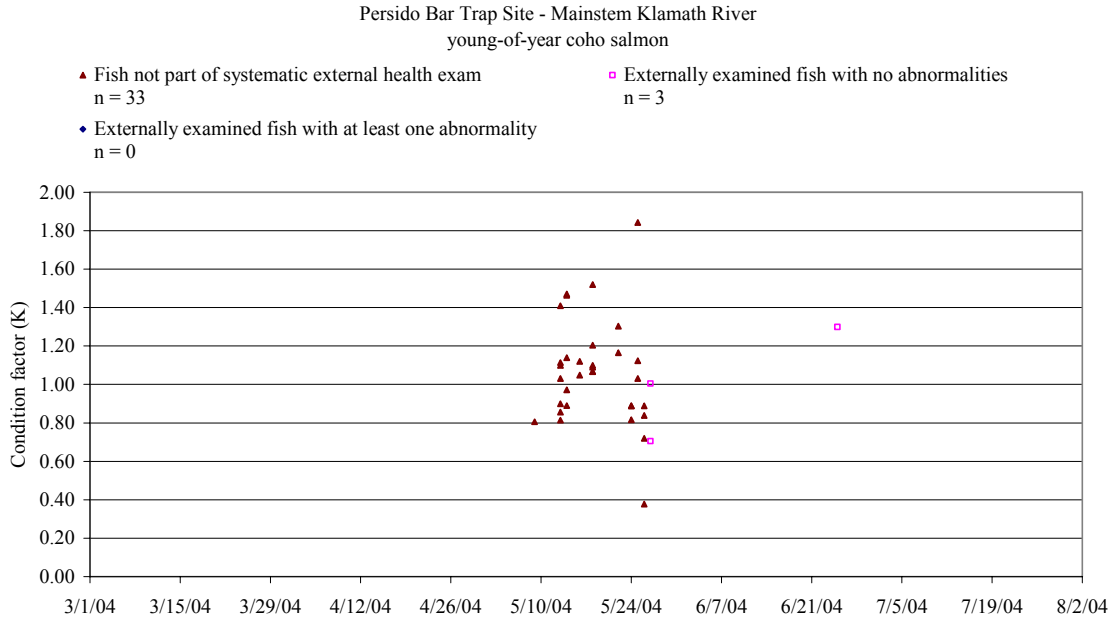

Figure C-12. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year coho salmon at the Persido Bar trap site. Mean = 1.058, standard deviation = 0.272 over the whole trapping period.

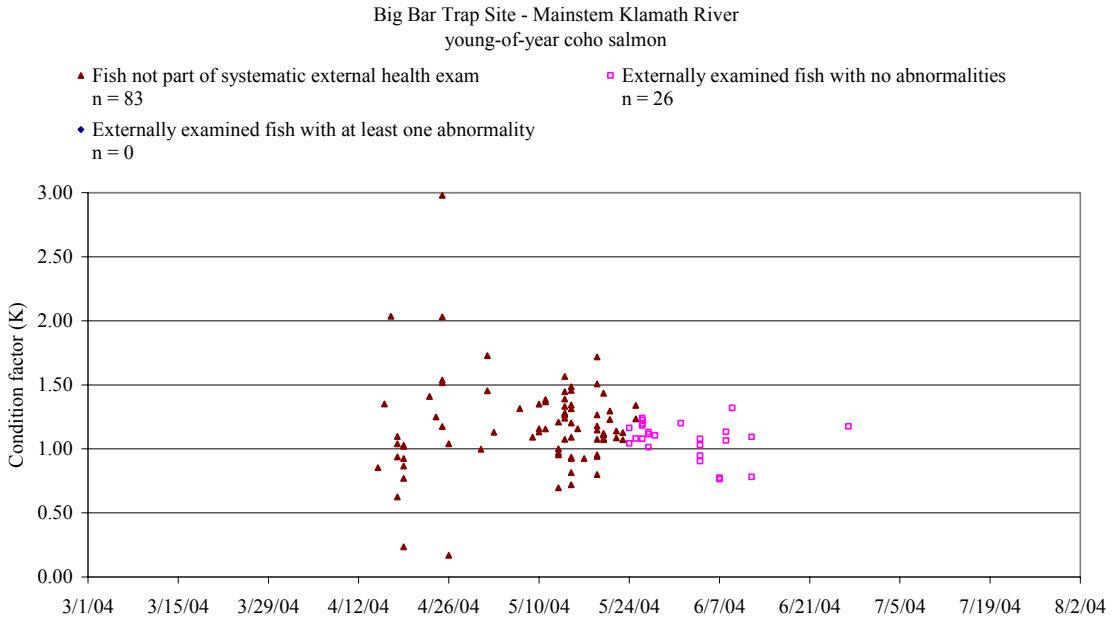

Figure C-13. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for 2004 young-of-year coho salmon at the Big Bar trap site. Mean = 1.176, standard deviation = 0.375 over the whole trapping period. Not pictured is one fish with no external abnormalities and condition factor of 3.10 captured June 3.

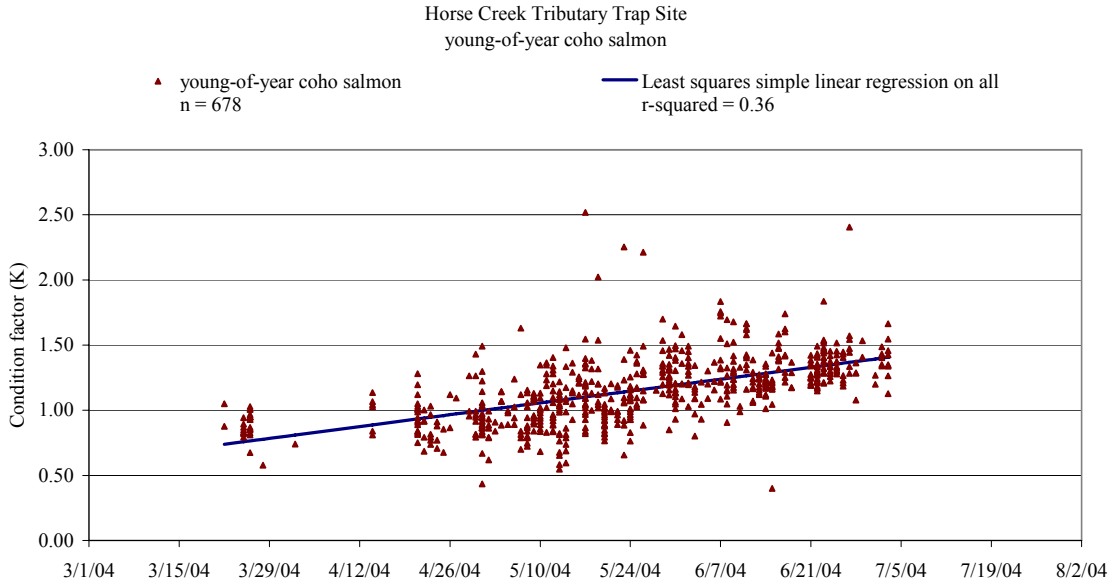

Figure C-14. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for 2004 young-of-year coho salmon at the Horse Creek trap site. Mean = 1.148, standard deviation = 0.254 over the whole trapping period.

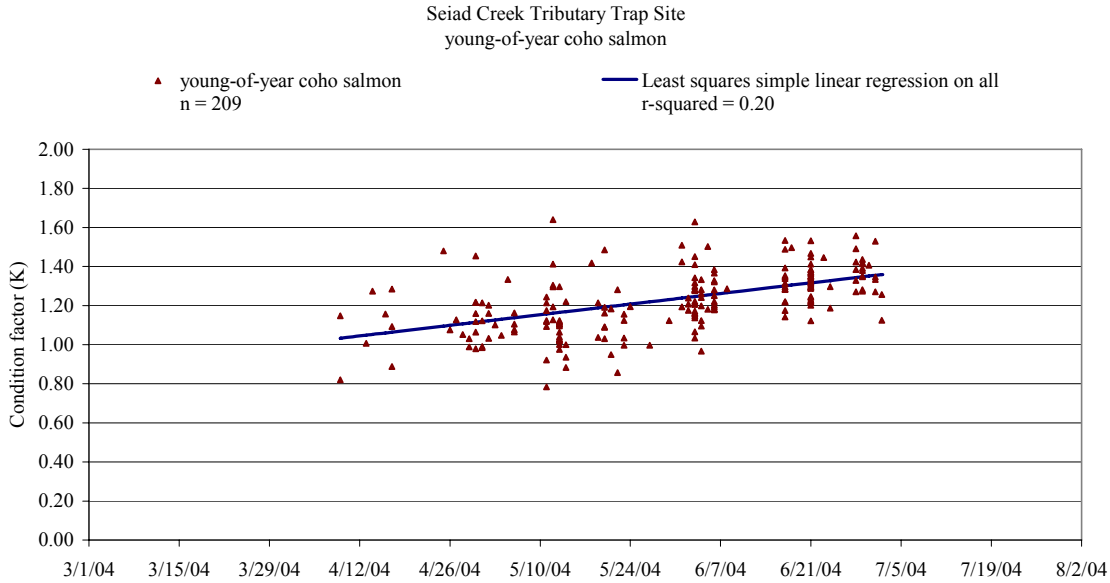

Figure C-15. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for 2004 young-of-year coho salmon at the Seiad Creek trap site. Mean = 1.231, standard deviation = 0.186 over the whole trapping period. Not pictured is one fish with condition factor of 2.67 captured May 11.

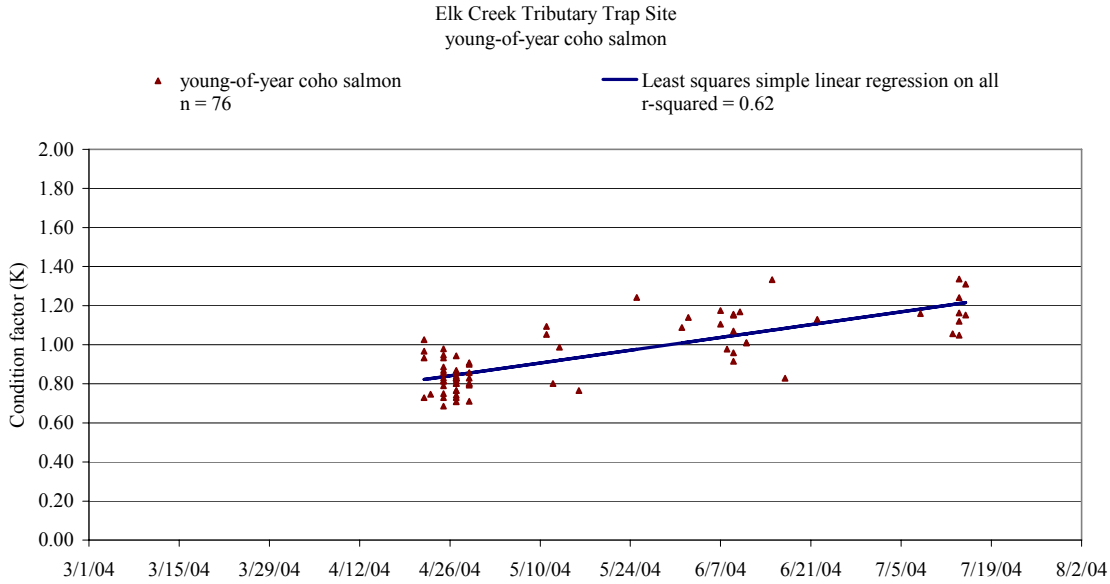

Figure C-16. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for 2004 young-of-year coho salmon at the Elk Creek trap site. Mean = 0.936, standard deviation = 0.167 over the whole trapping period.

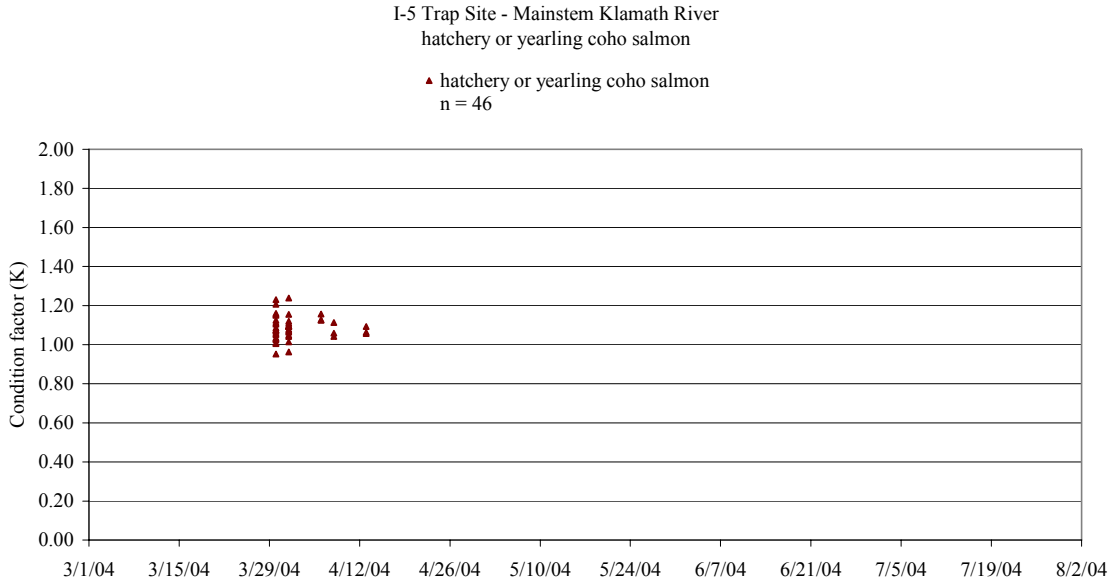

Figure C-17. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for 2004 hatchery or yearling coho salmon at the I-5 trap site. Mean = 1.087, standard deviation = 0.060 over the whole trapping period.

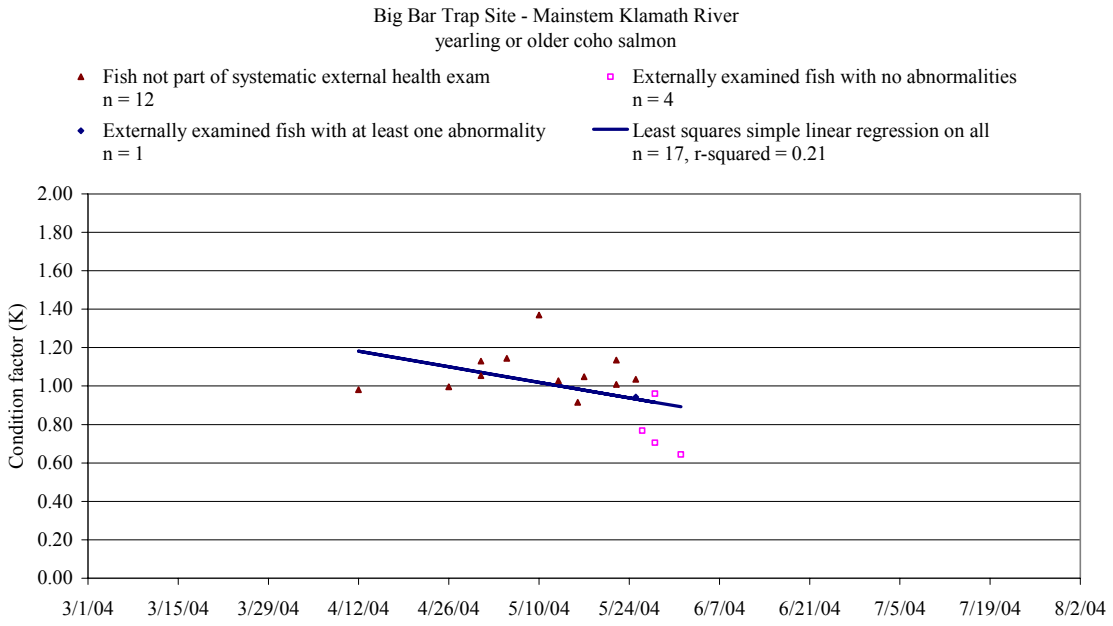

Figure C-18. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for hatchery or yearling coho salmon at the Big Bar trap site. Mean = 0.992, standard deviation = 0.173 over the whole trapping period.

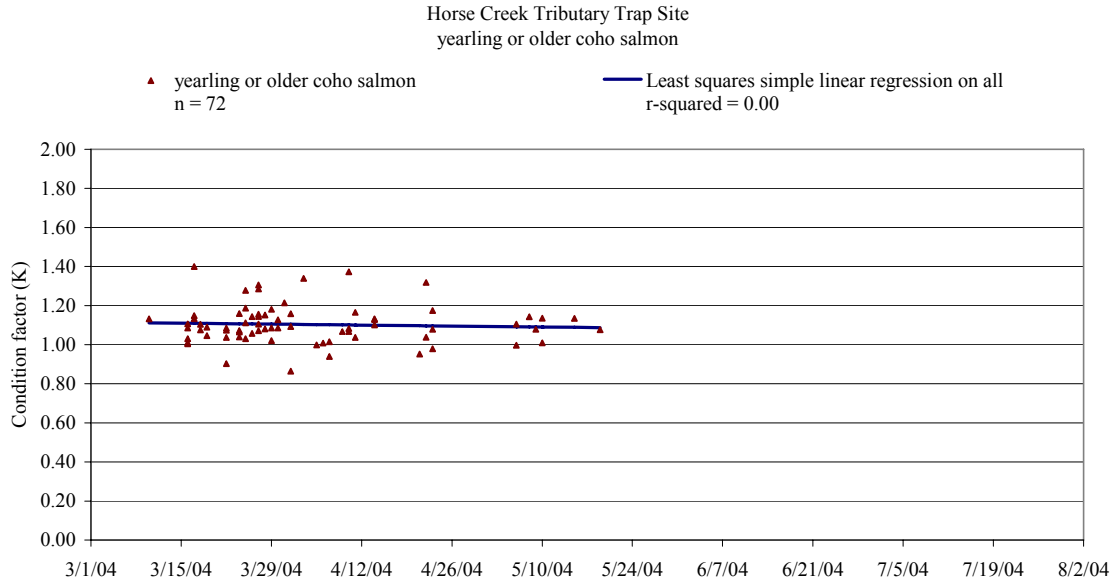

Figure C-19. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling coho salmon at the Horse Creek trap site. Mean = 1.103, standard deviation = 0.100 over the whole trapping period.

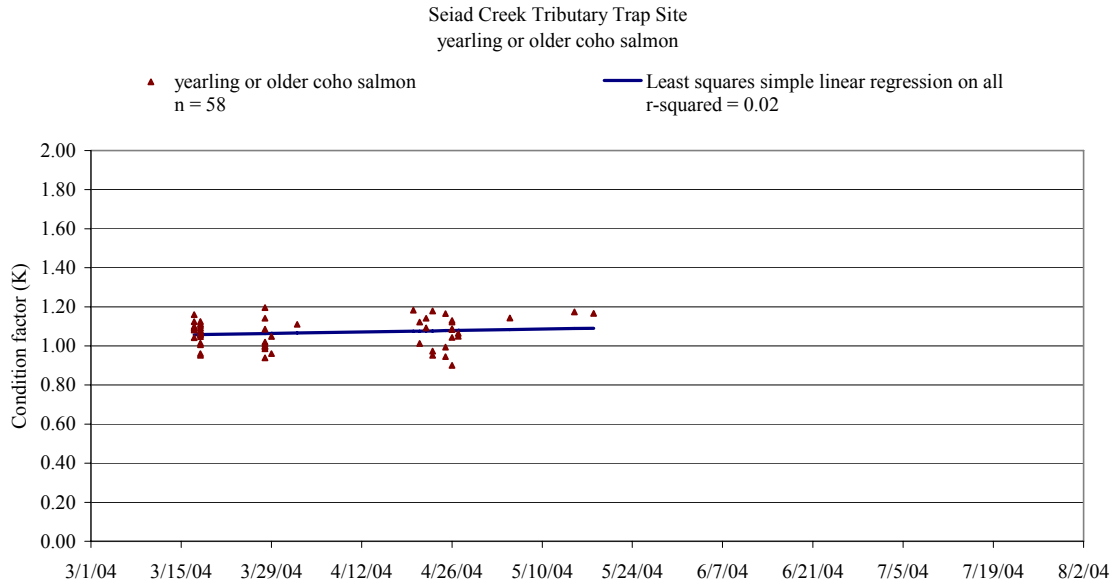

Figure C-20. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling coho salmon at the Seiad Creek trap site. Mean = 1.067, standard deviation = 0.070 over the whole trapping period.

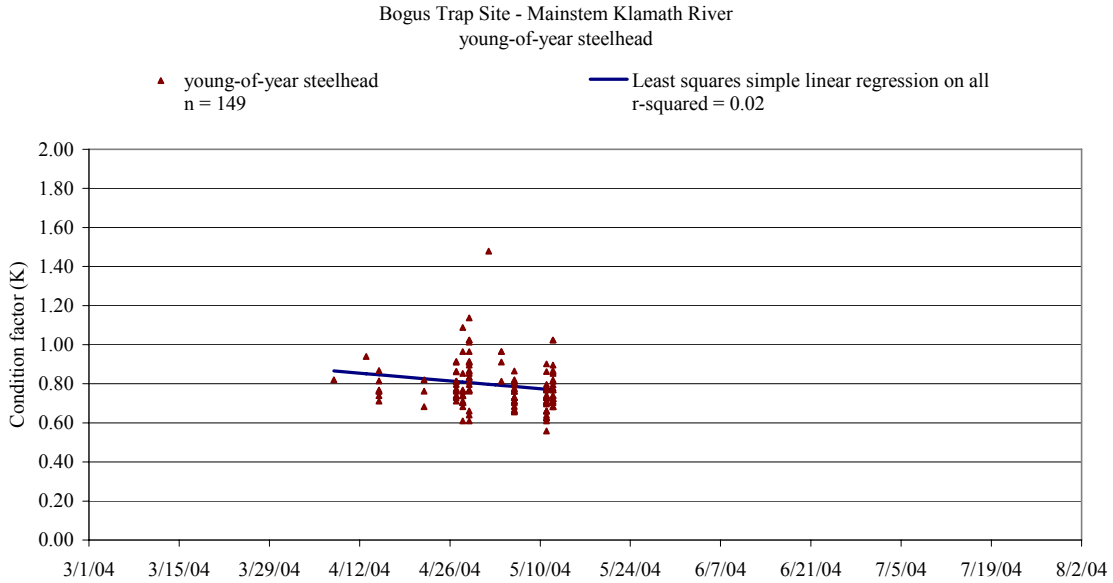

Figure C-21. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year steelhead at the Bogus trap site. Mean = 0.793, standard deviation = 0.170 over the whole trapping period. Not pictured is one fish with condition factor of 2.30 captured May 3.

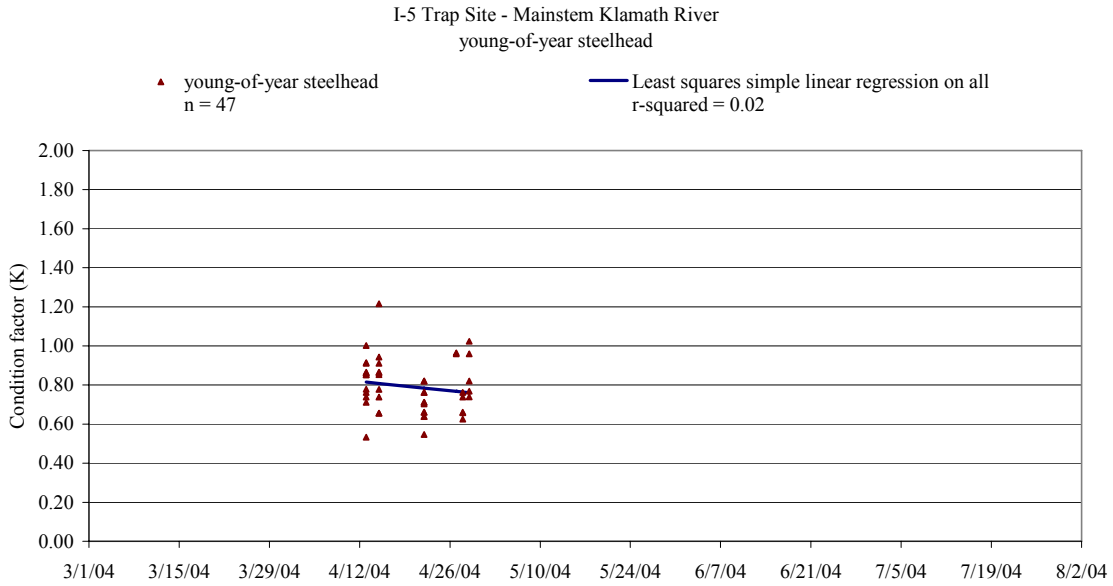

Figure C-22. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year steelhead at the I-5 trap site. Mean = 0.792, standard deviation = 0.134 over the whole trapping period.

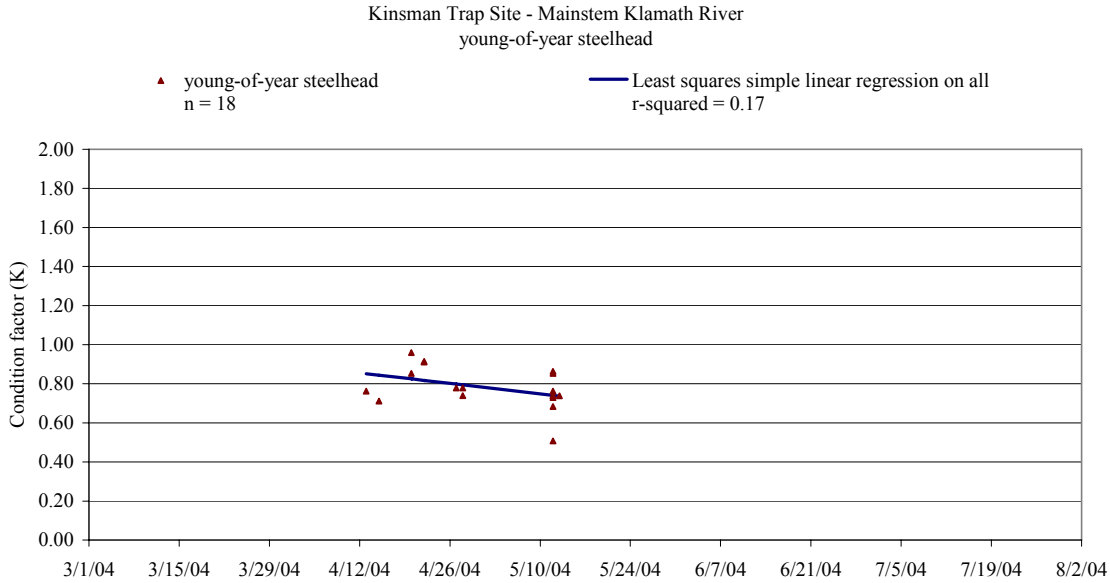

Figure C-23. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year steelhead at the Kinsman trap site. Mean = 0.779, standard deviation = 0.104 over the whole trapping period.

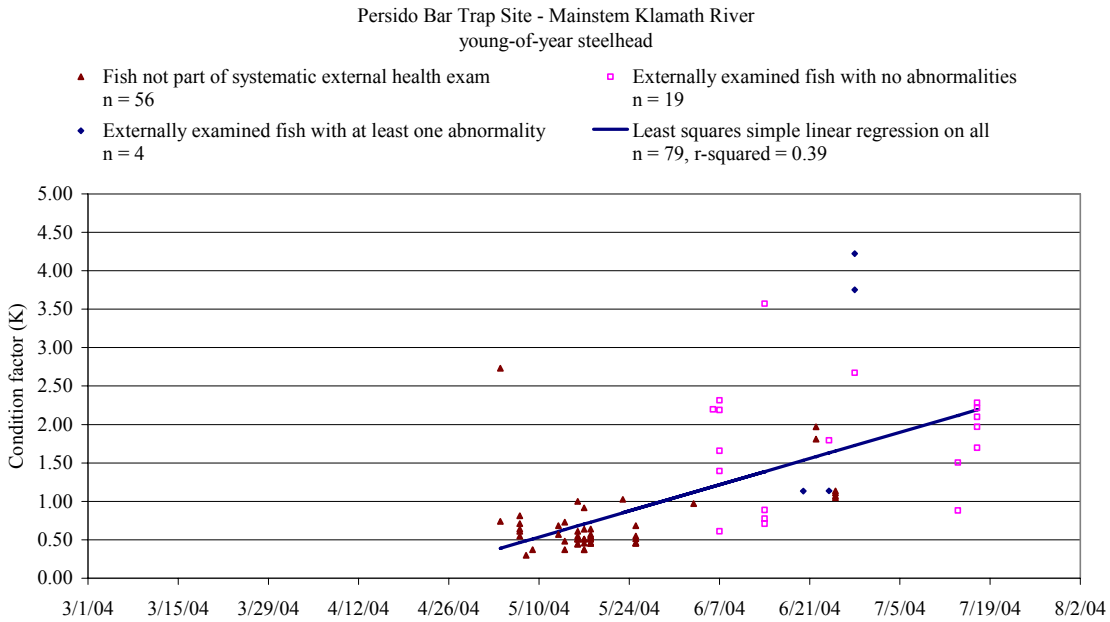

Figure C-24. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year steelhead at the Persido Bar trap site. Mean = 1.040, standard deviation = 0.837 over the whole trapping period.

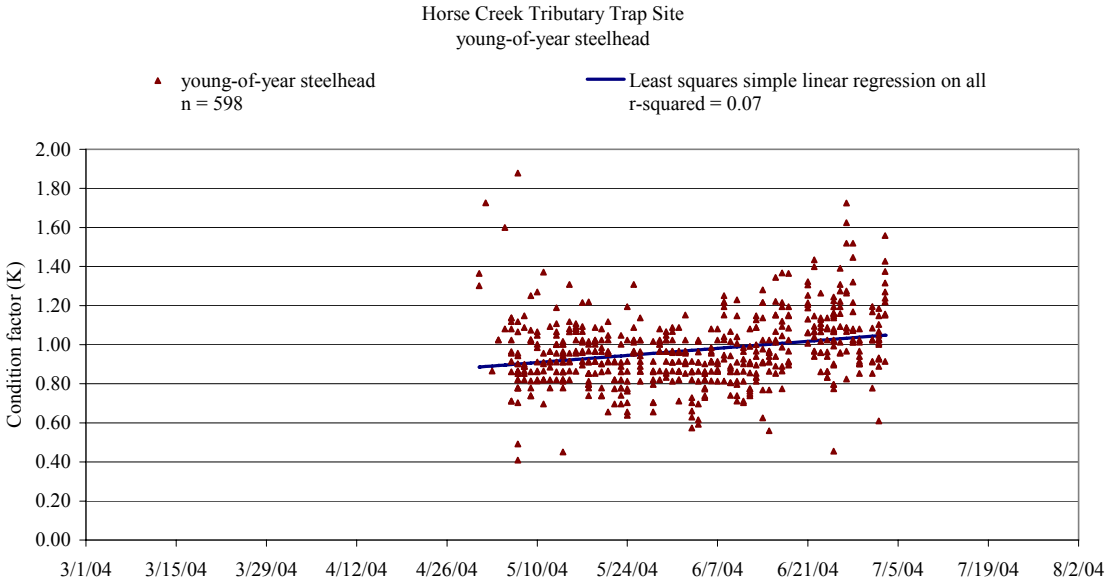

Figure C-25. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year steelhead at the Horse Creek trap site. Mean = 0.969, standard deviation = 0.177 over the whole trapping period.

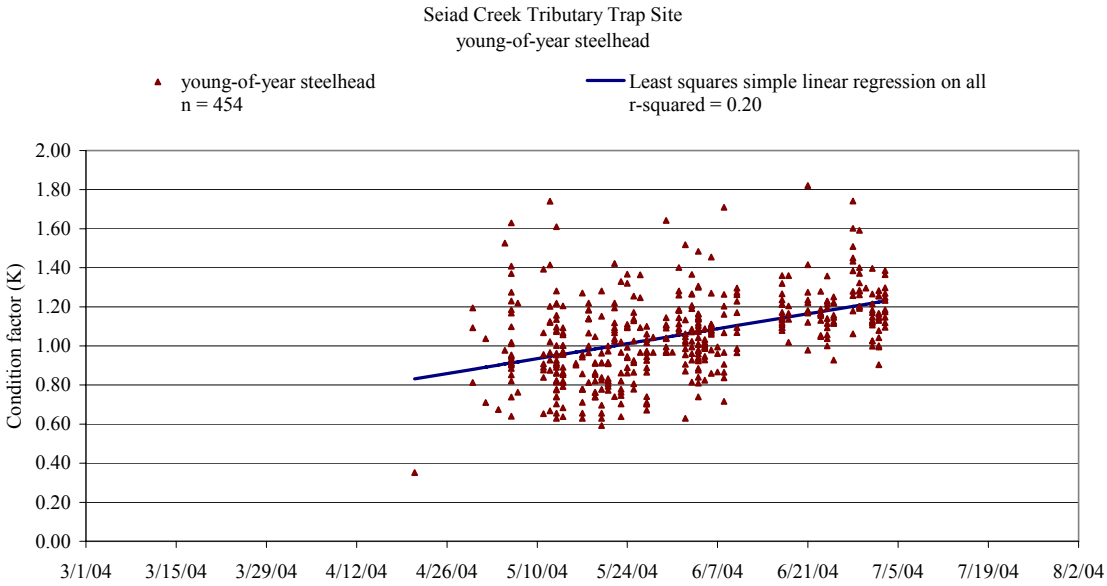

Figure C-26. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year steelhead at the Seiad Creek trap site. Mean = 1.055, standard deviation = 0.216 over the whole trapping period. Not pictured is one fish with condition factor of 2.13 captured June 23.

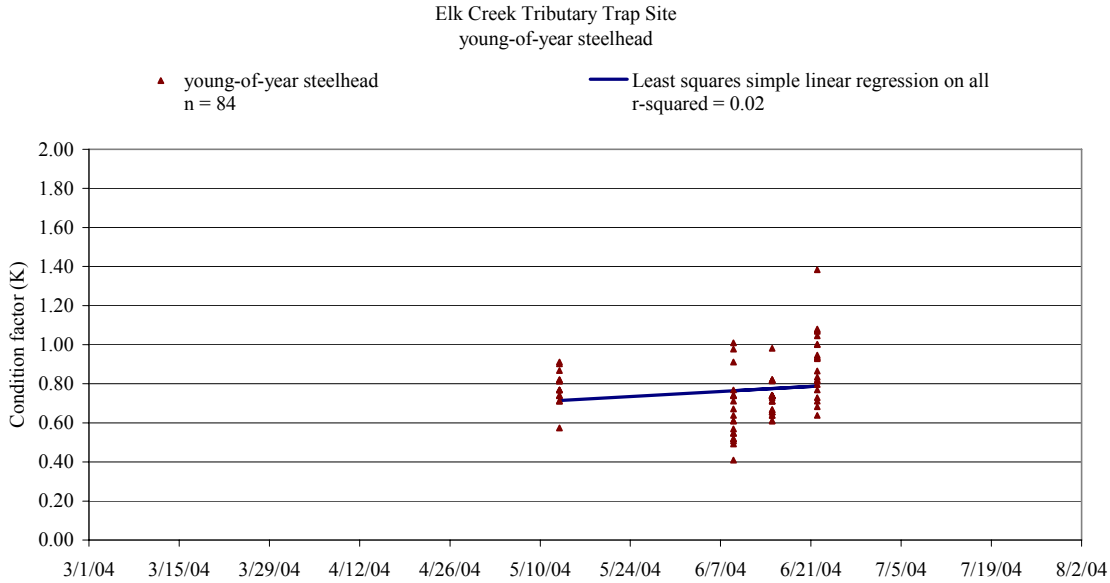

Figure C-27. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for young-of-year steelhead at the Elk Creek trap site. Mean = 0.766, standard deviation = 0.158 over the whole trapping period.

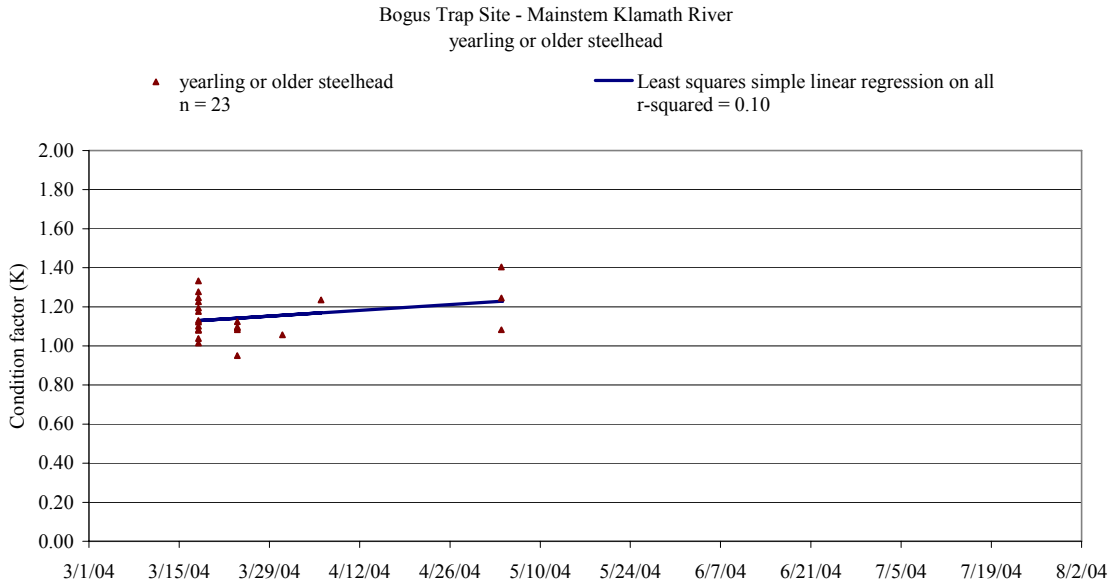

Figure C-28. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead (hatchery and wild fish included) at the Bogus trap site. Mean = 1.148, standard deviation = 0.108 over the whole trapping period.

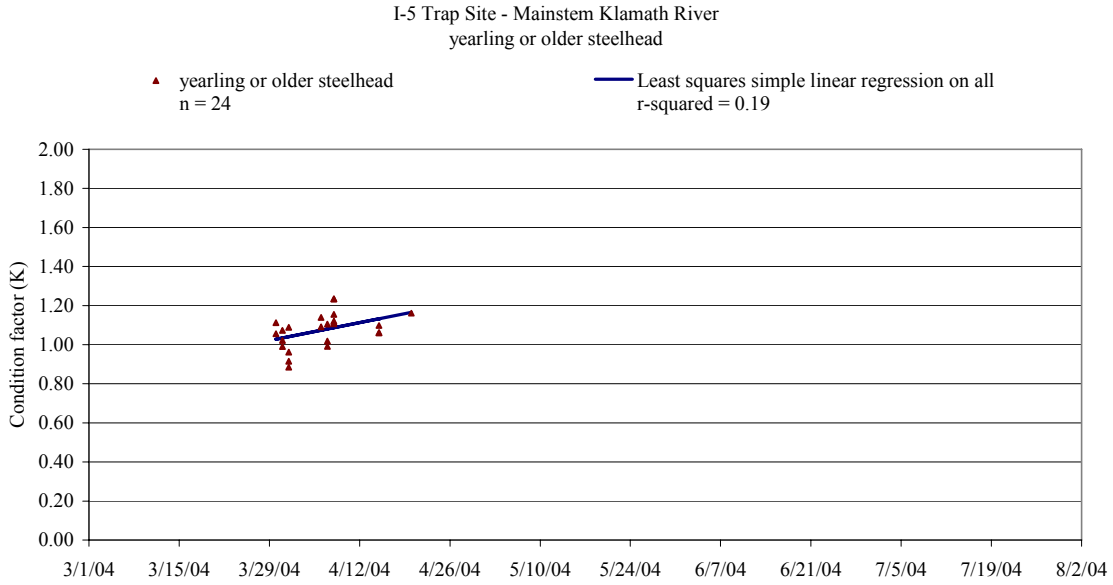

Figure C-29. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead (hatchery and wild fish included) at the I-5 trap site. Mean = 1.075, standard deviation = 0.087 over the whole trapping period.

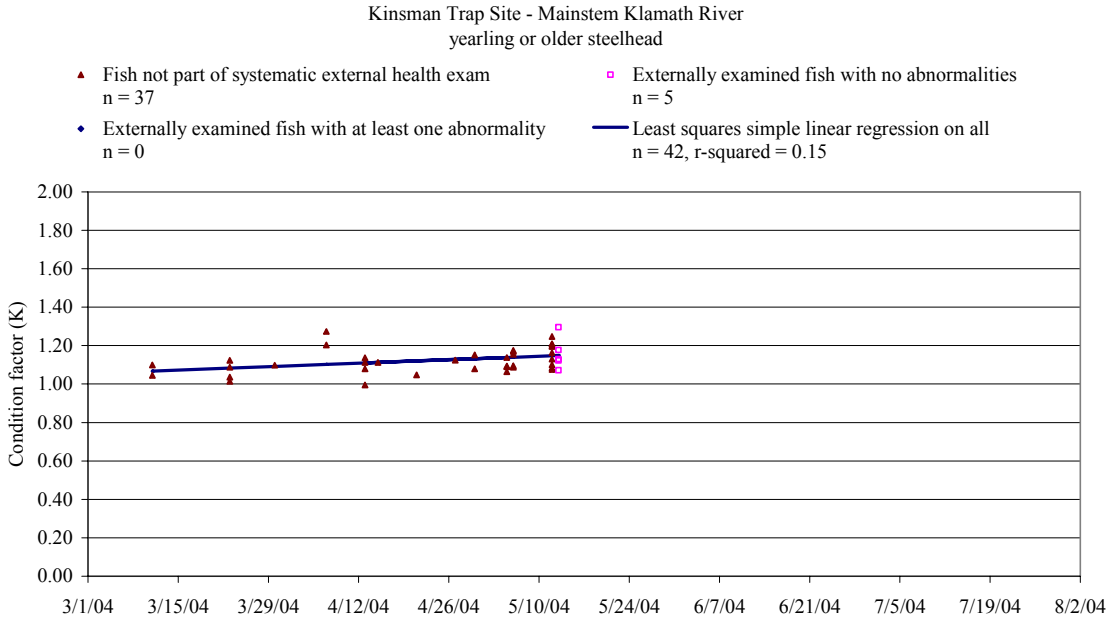

Figure C-30. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead (hatchery and wild fish included) at the Kinsman trap site. Mean = 1.126, standard deviation = 0.066 over the whole trapping period.

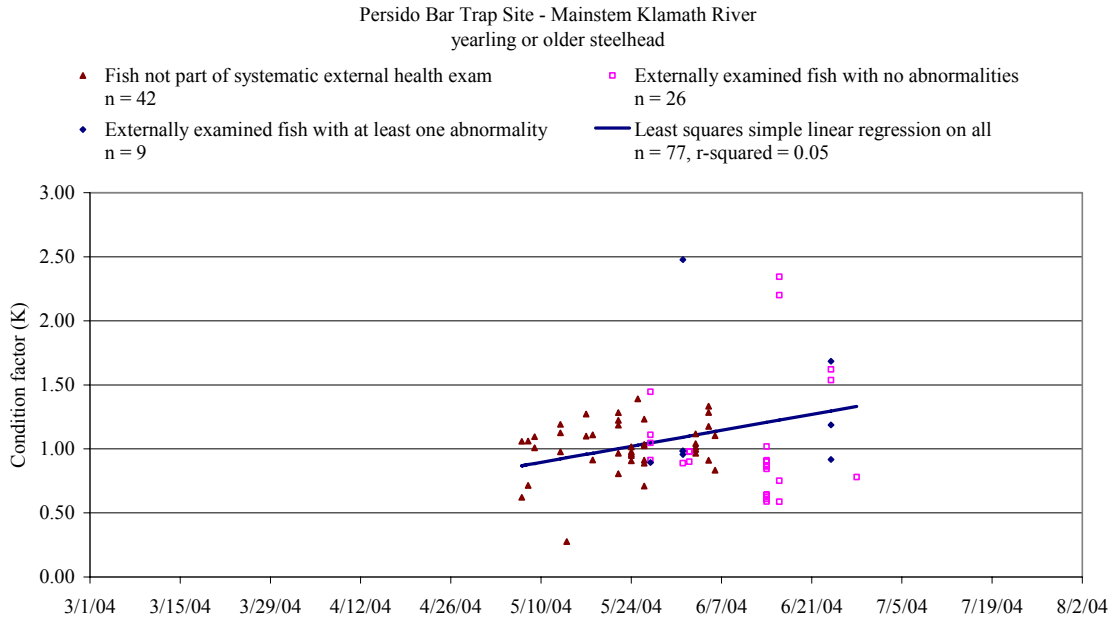

Figure C-31. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead (hatchery and wild fish included) at the Persido Bar trap site. Mean = 1.088, standard deviation = 0.516 over the whole trapping period. Not pictured is one fish with an external abnormality and condition factor of 4.34 captured June 24.

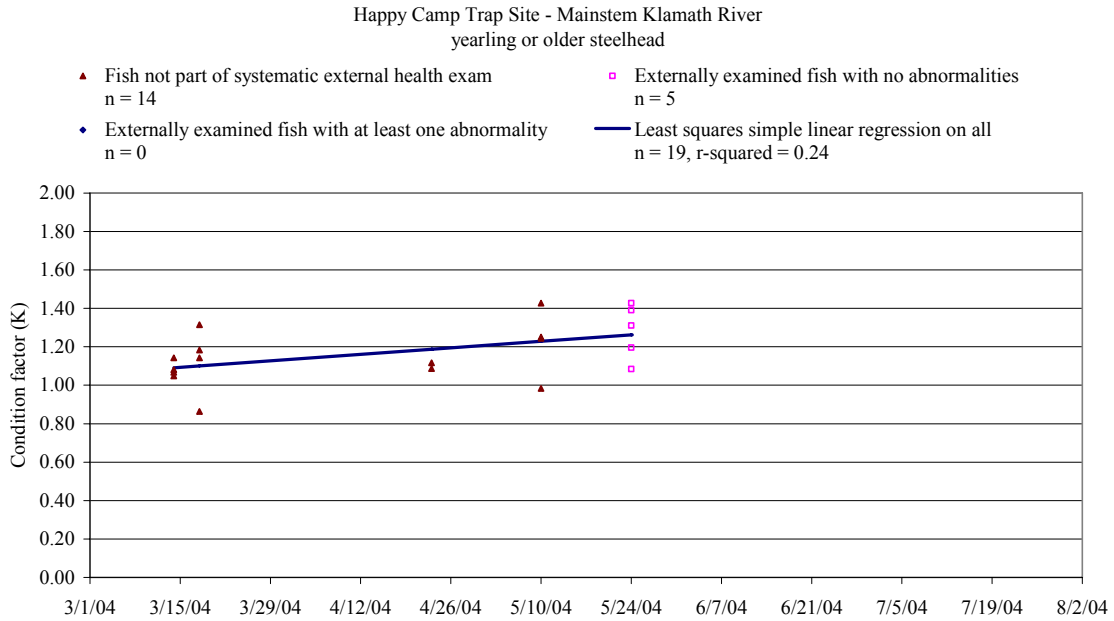

Figure C-32. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead (hatchery and wild fish included) at the Happy Camp trap site. Mean = 1.177, standard deviation = 0.152 over the whole trapping period.

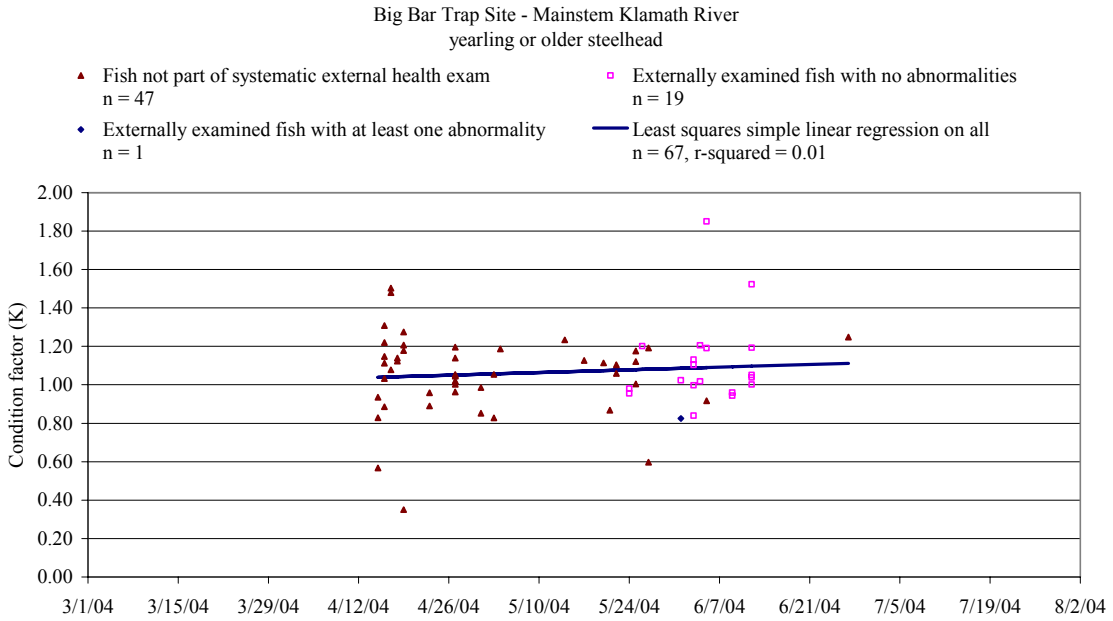

Figure C-33. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead (hatchery and wild fish included) at the Big Bar trap site. Mean = 1.066, standard deviation = 0.216 over the whole trapping period.

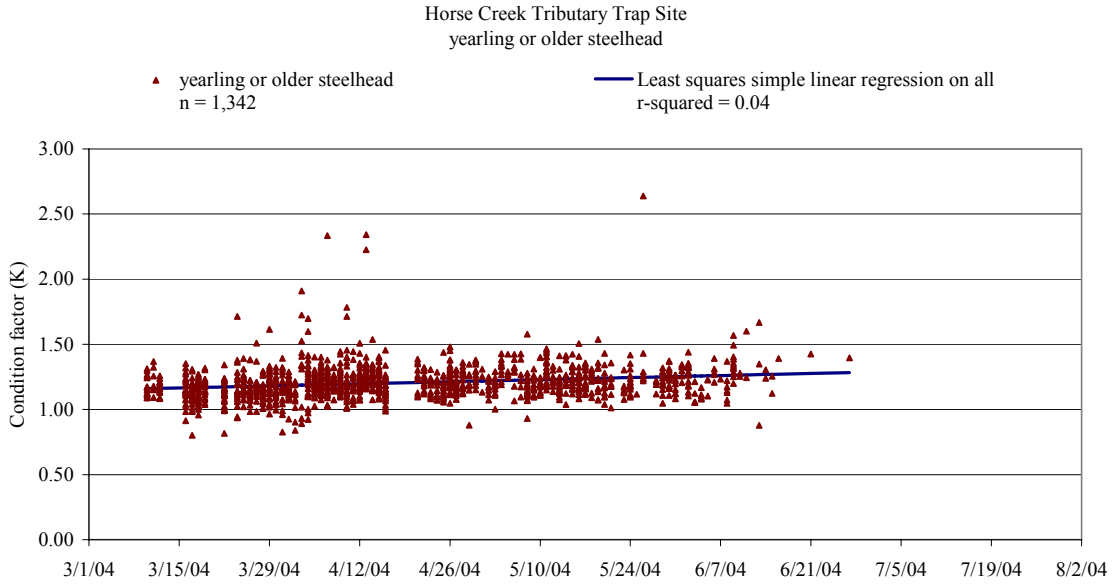

Figure C-34. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead at the Horse Creek trap site. Mean = 1.205, standard deviation = 0.129 over the whole trapping period.

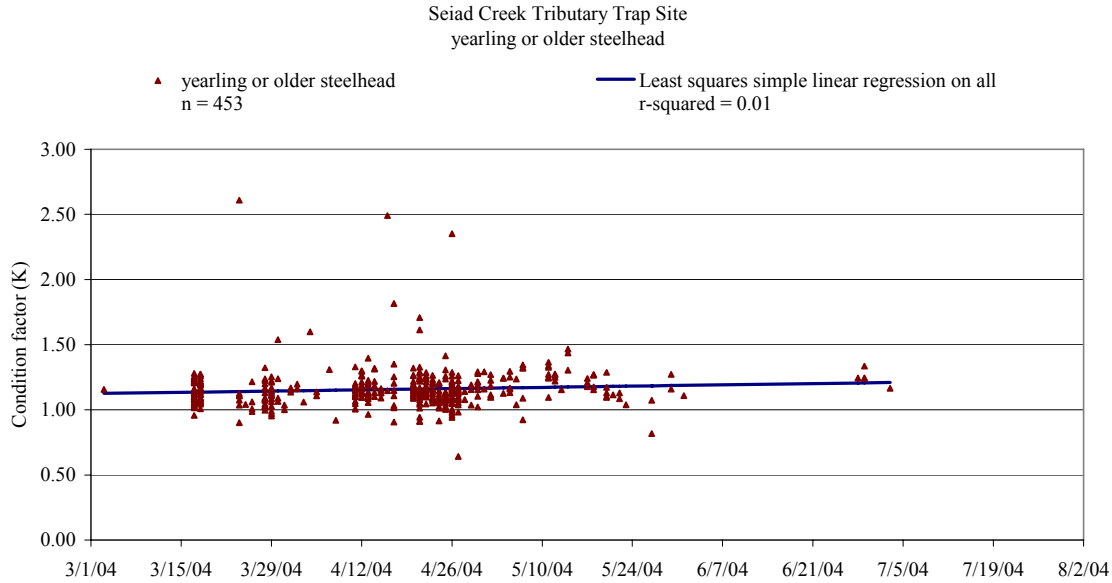

Figure C-35. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead at the Seiad Creek trap site. Mean = 1.156, standard deviation = 0.155 over the whole trapping period.

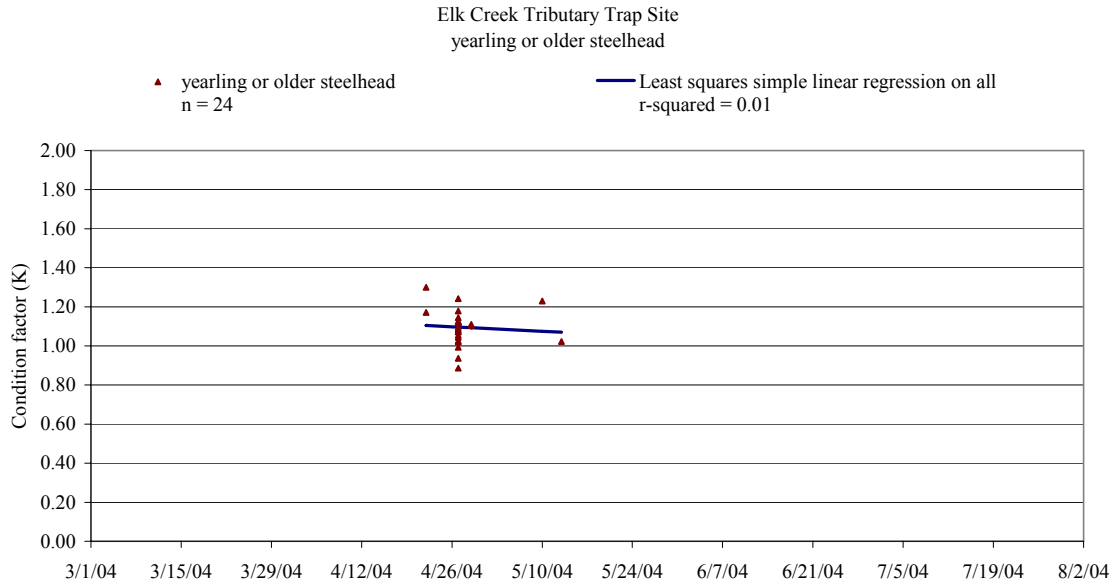

Figure C-36. Fulton's condition factor ($K = (W \cdot L^{-3})\ 10^5$) for yearling and older steelhead at the Elk Creek trap site. Mean = 1.095, standard deviation = 0.093 over the whole trapping period.

Appendix D. Scatter plots of salmonid fork lengths by trap site

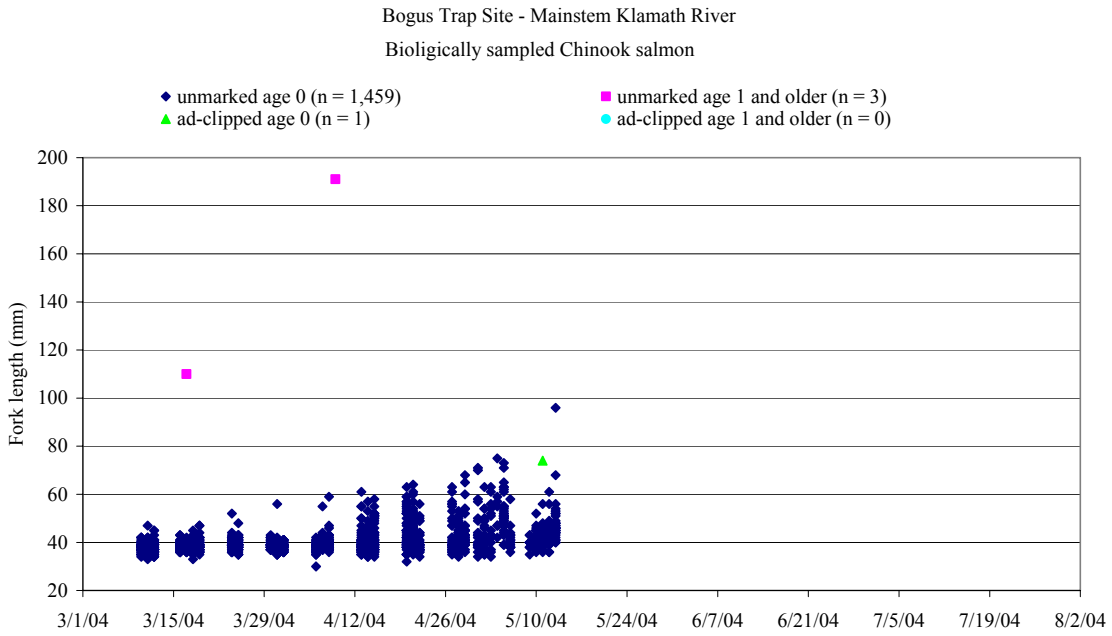

Figure D-1. Scatter-plot of biologically sampled Chinook salmon fork lengths at the Bogus trap site. Not shown is an unmarked fish of 245 mm fork length captured March 11. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

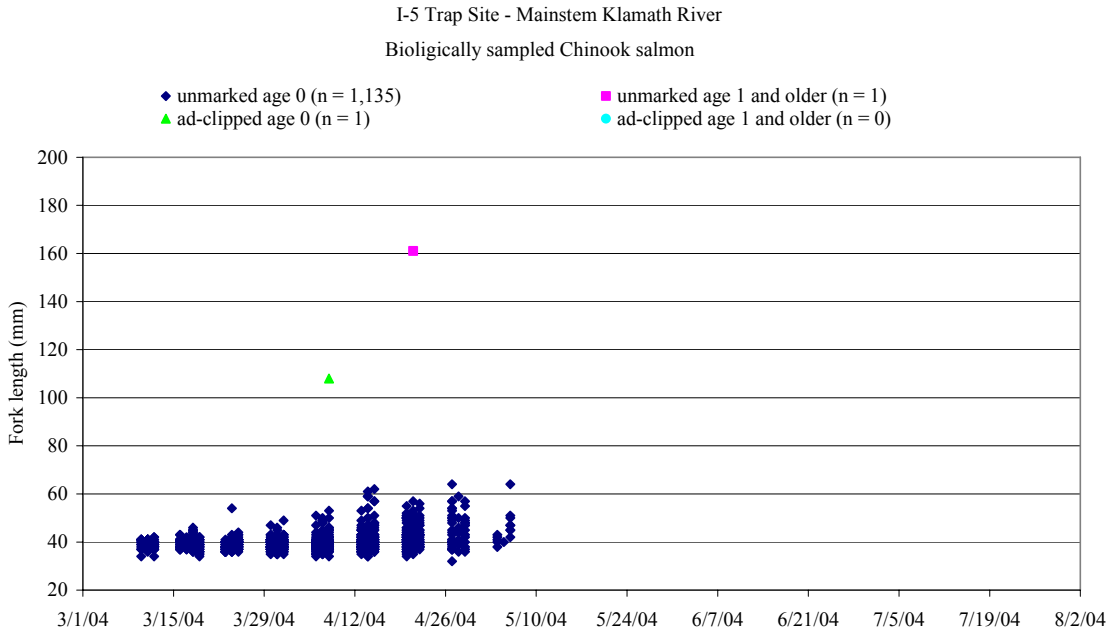

Figure D-2. Scatter-plot of biologically sampled Chinook salmon fork lengths at the I-5 trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

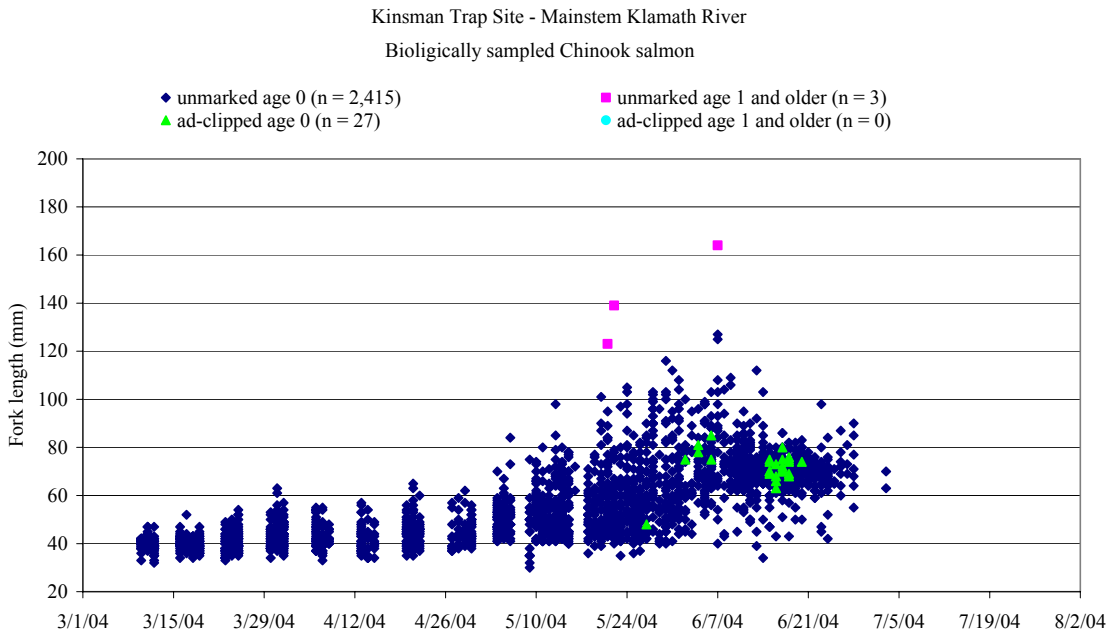

Figure D-3. Scatter-plot of biologically sampled Chinook salmon fork lengths at the Kinsman trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

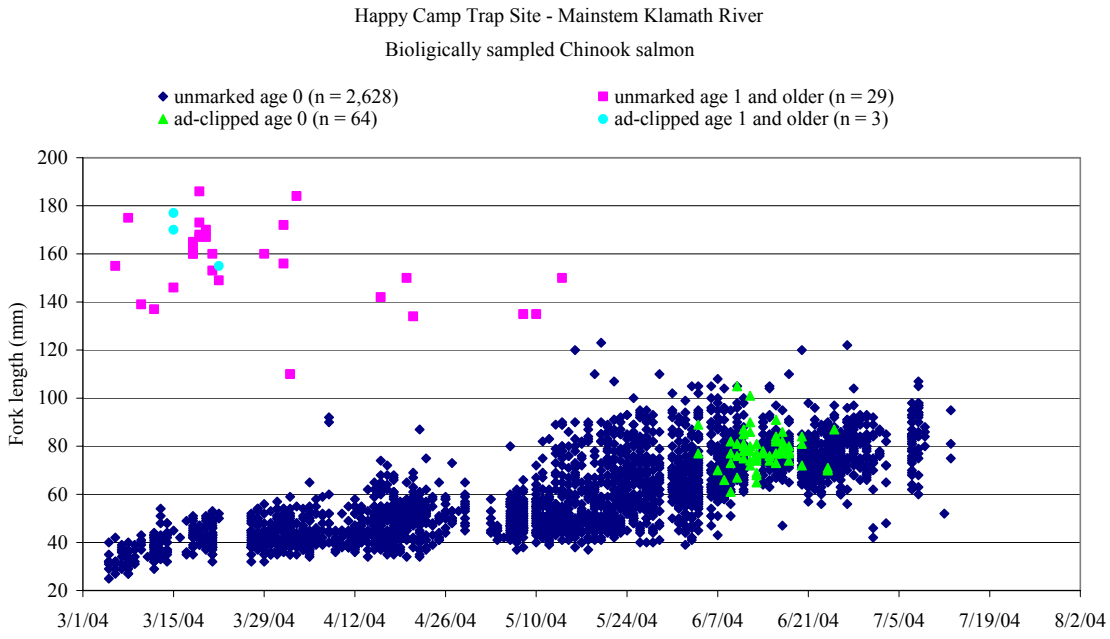

Figure D-4. Scatter-plot of biologically sampled Chinook salmon fork lengths at the Happy Camp trap site. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

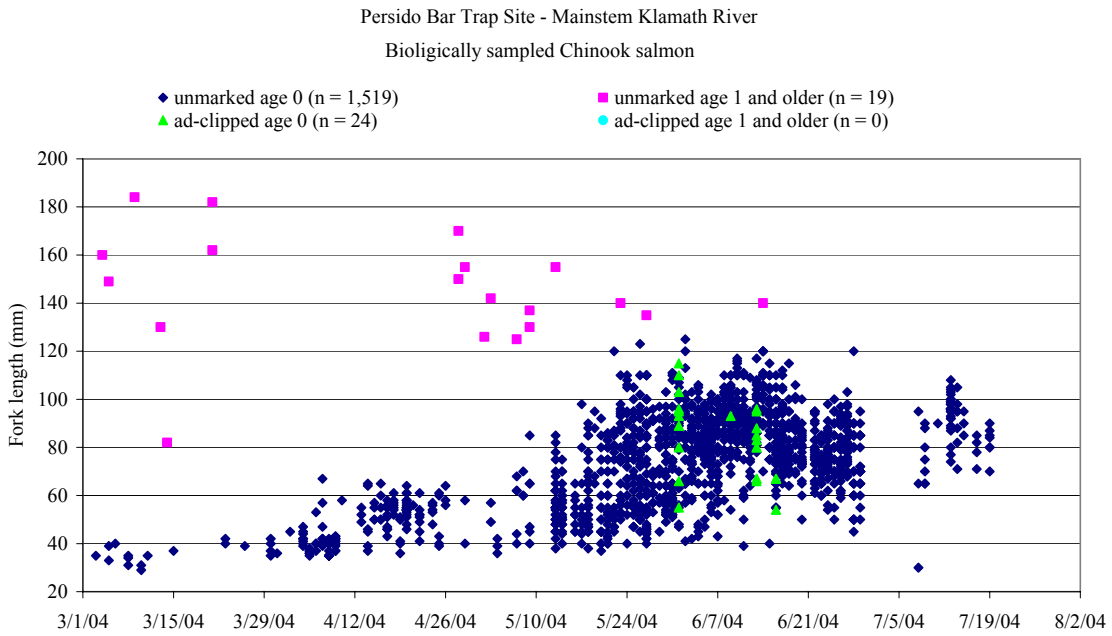

Figure D-5. Scatter-plot of biologically sampled Chinook salmon fork lengths at the Persido Bar trap site. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

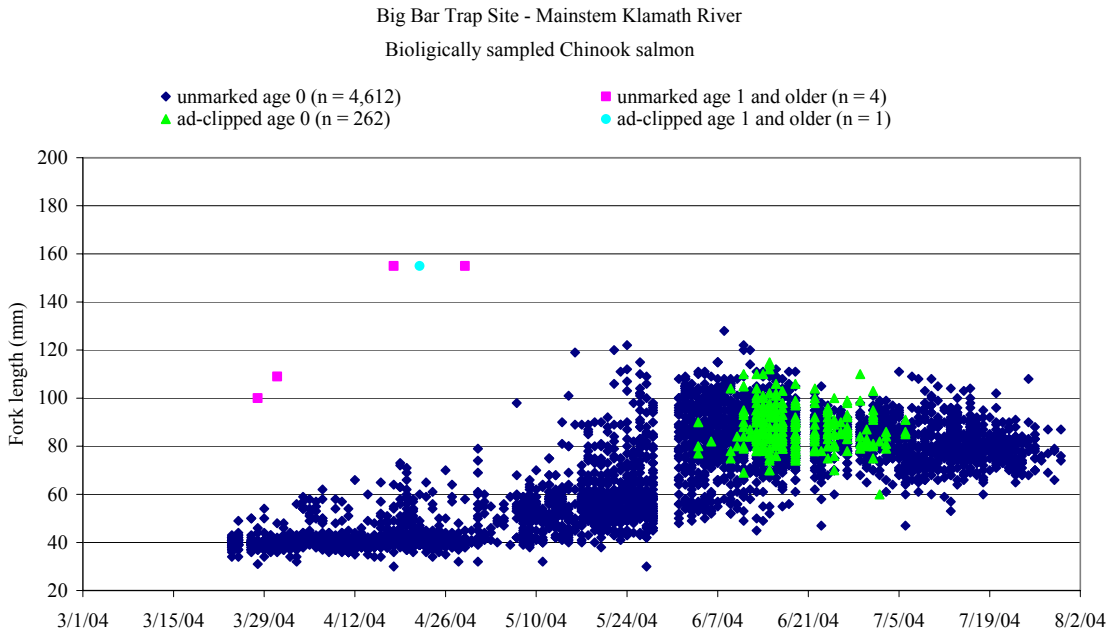

Figure D-6. Scatter-plot of biologically sampled Chinook salmon fork lengths at the Big Bar trap site. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

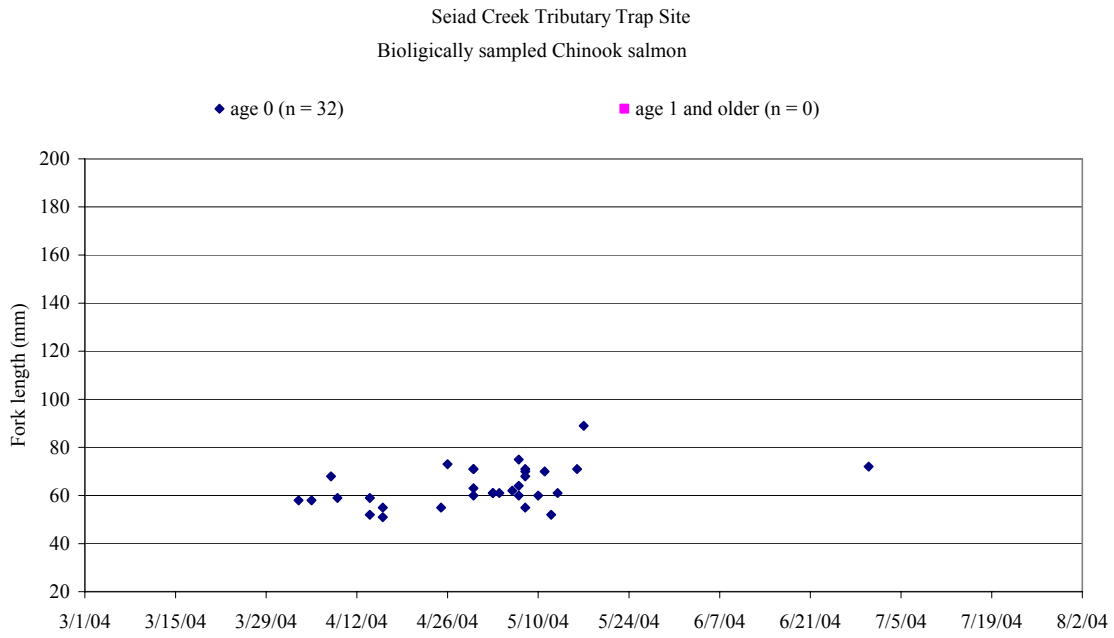

Figure D-7. Scatter-plot of biologically sampled Chinook salmon fork lengths at the Seiad Creek trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

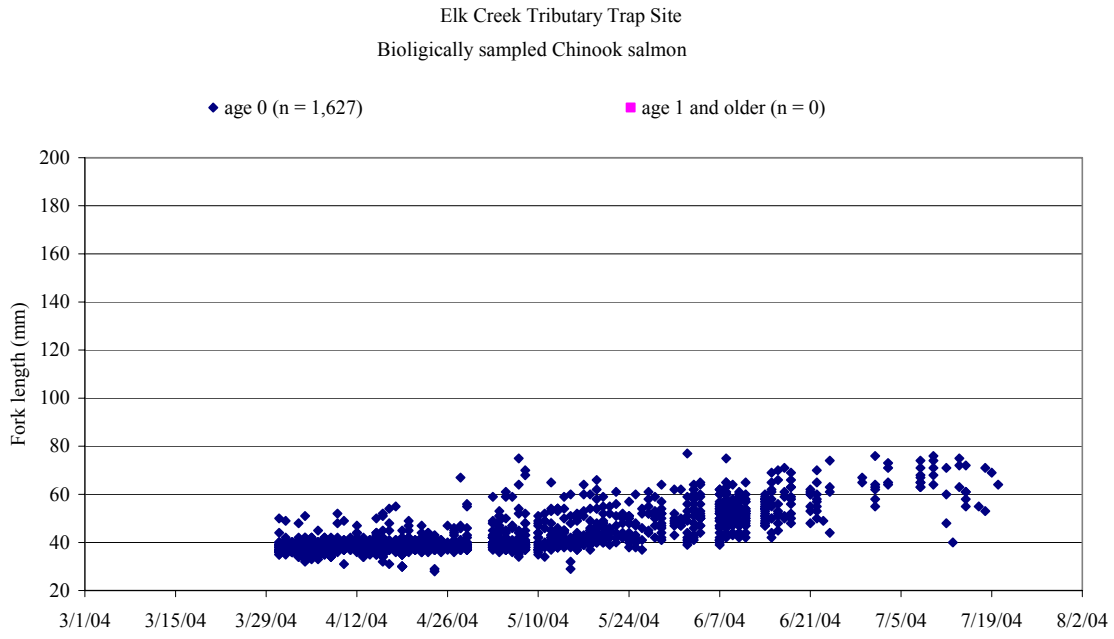

Figure D-8. Scatter-plot of biologically sampled Chinook salmon fork lengths at the Elk Creek trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

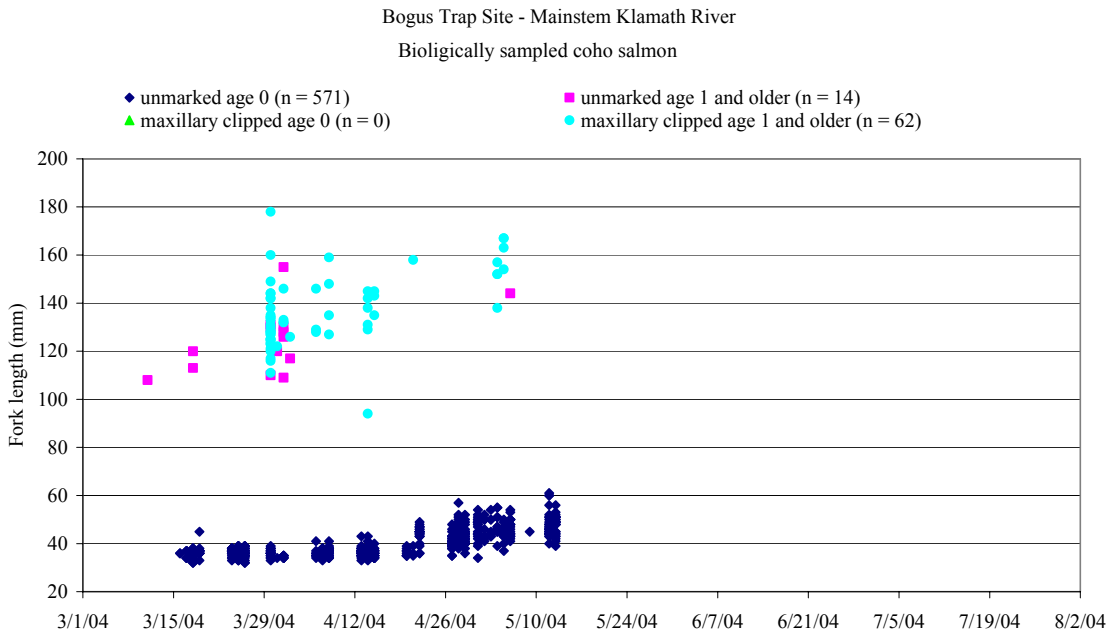

Figure D-9. Scatter-plot of biologically sampled coho salmon fork lengths at the Bogus trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

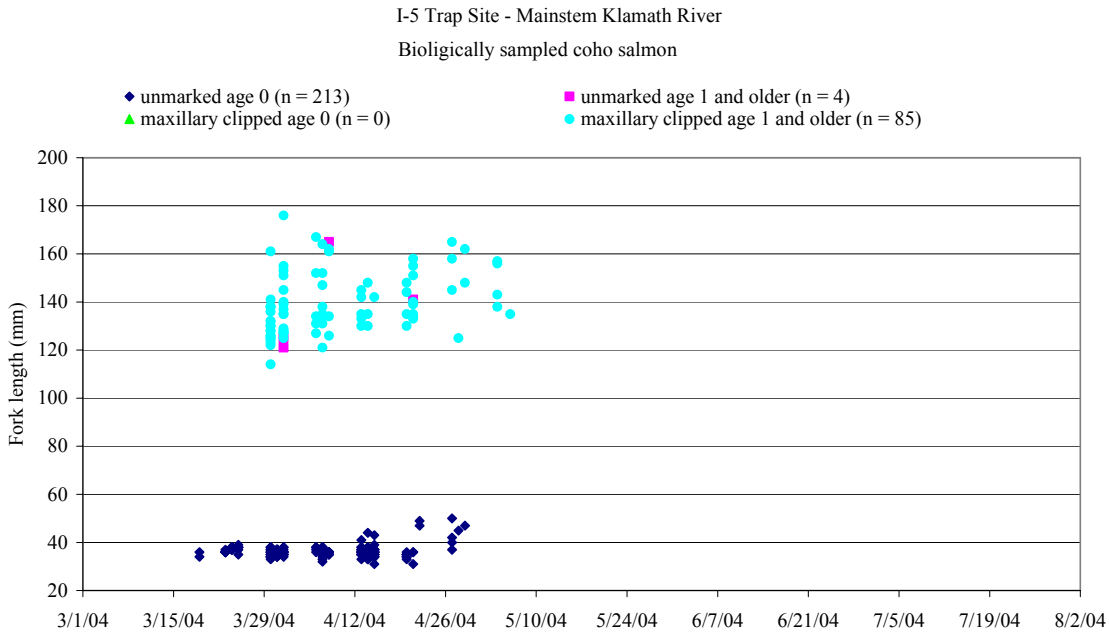

Figure D-10. Scatter-plot of biologically sampled coho salmon fork lengths at the I-5 trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

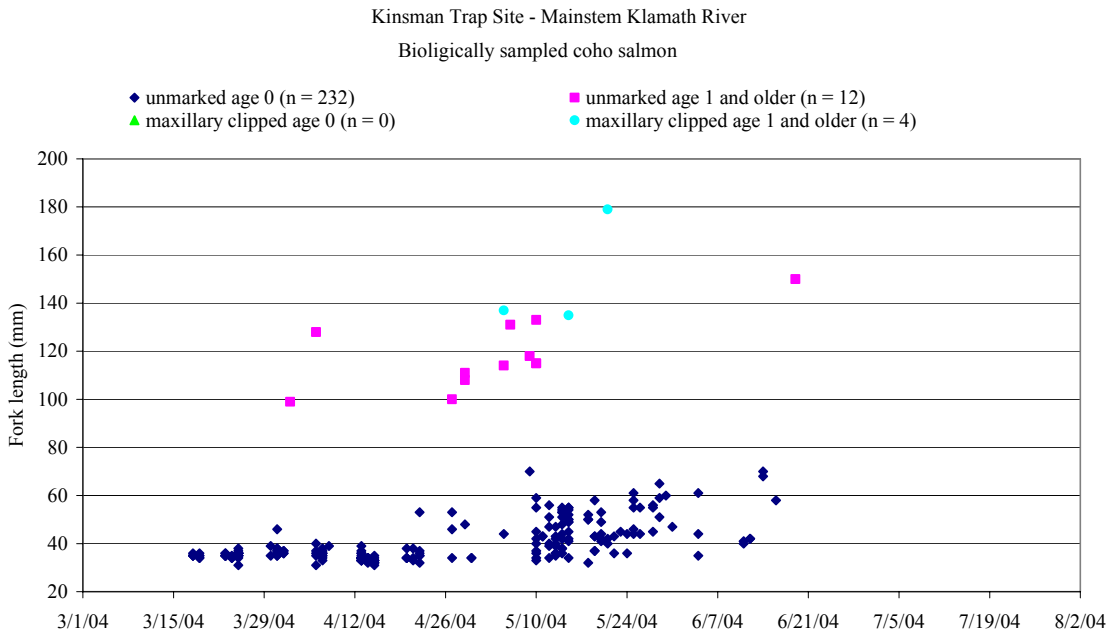

Figure D-11. Scatter-plot of biologically sampled coho salmon fork lengths at the Kinsman trap site. Not shown is a maxillary clipped 208 mm fork length fish captured June 1, 2004. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

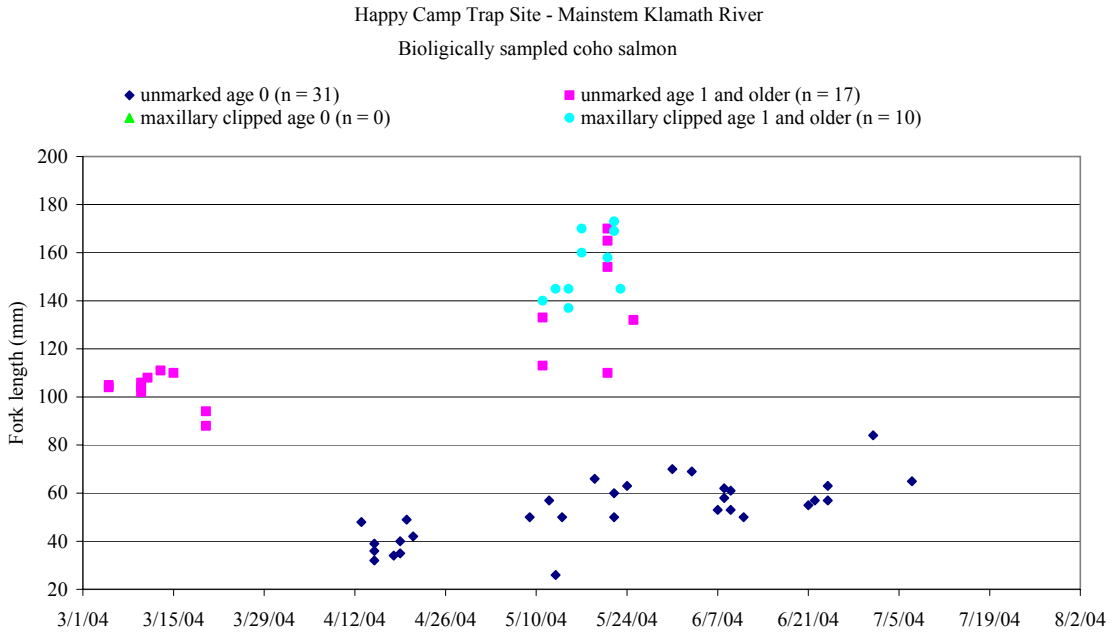

Figure D-12. Scatter-plot of biologically sampled coho salmon fork lengths at the Happy Camp trap site. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

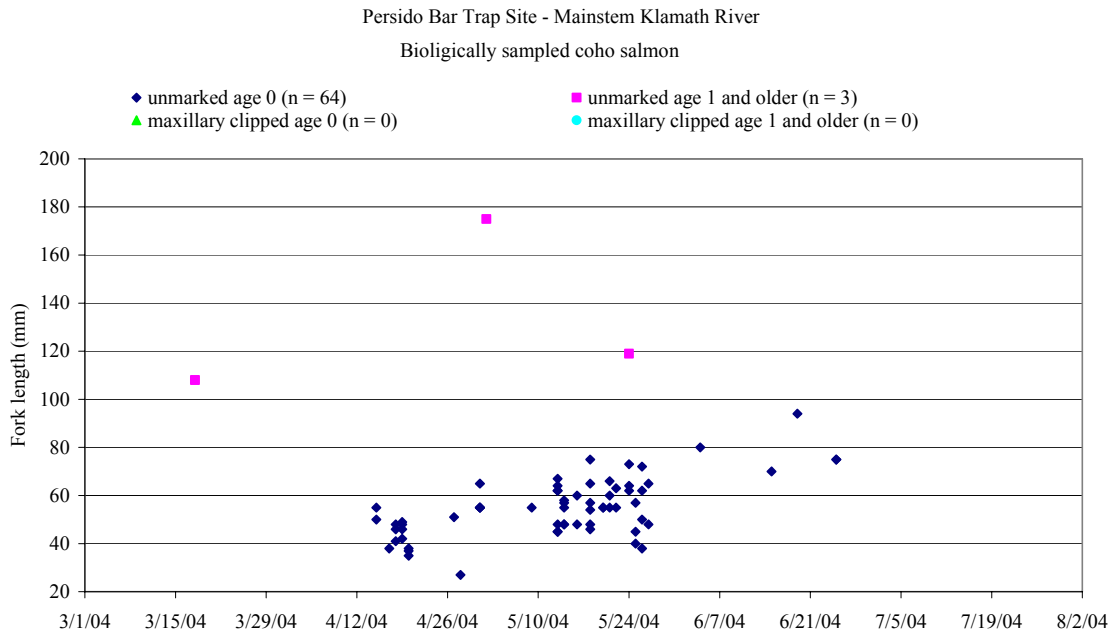

Figure D-13. Scatter-plot of biologically sampled coho salmon fork lengths at the Persido Bar trap site. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

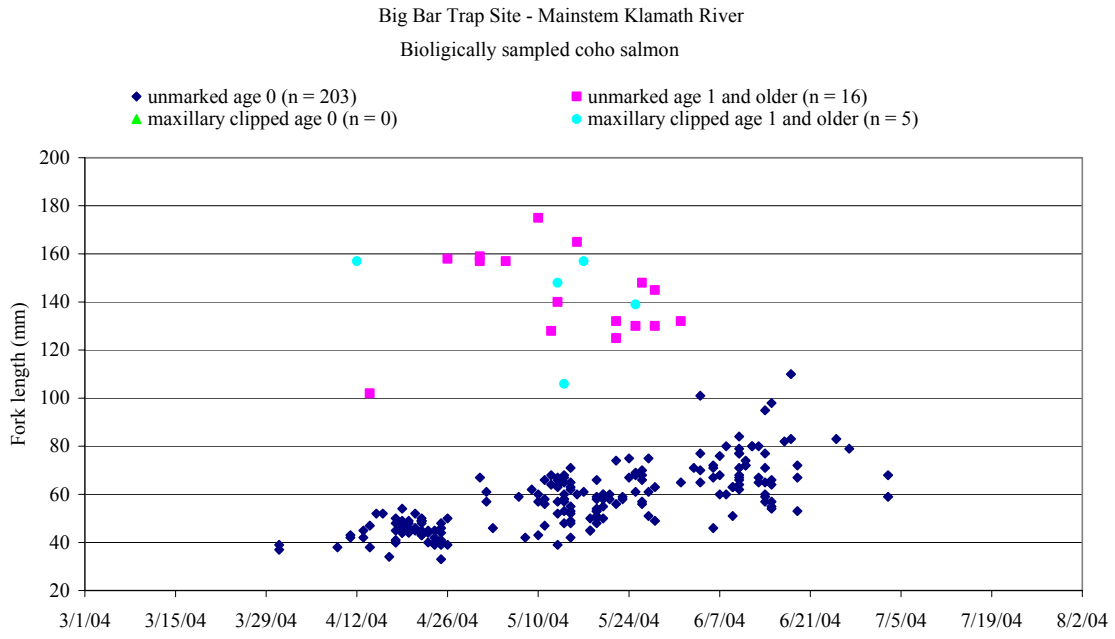

Figure D-14. Scatter-plot of biologically sampled coho salmon fork lengths at the Big Bar trap site. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

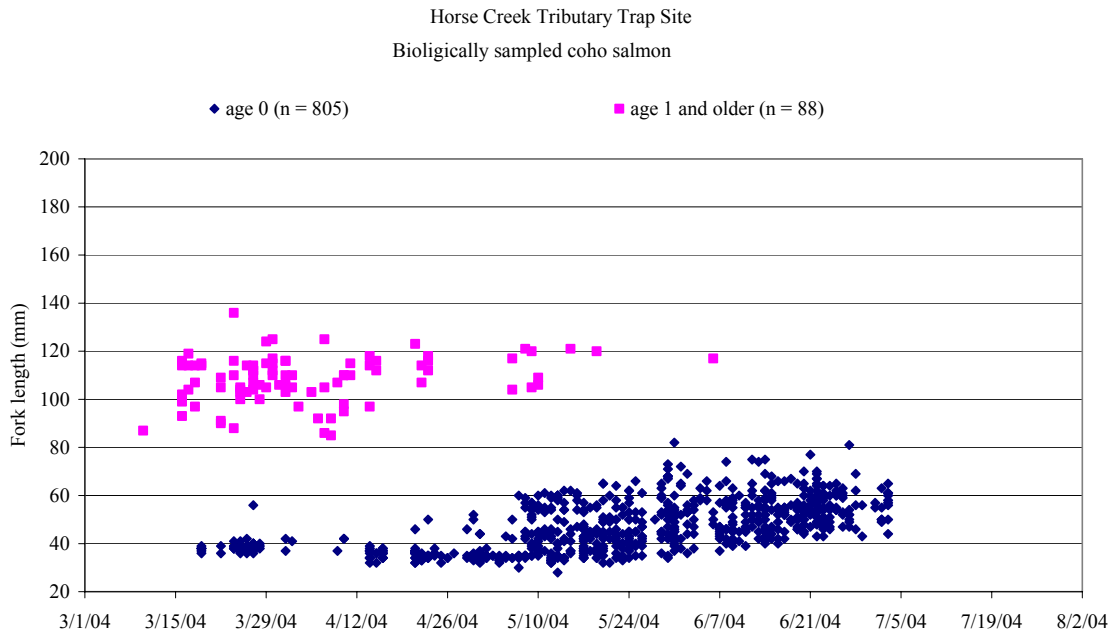

Figure D-15. Scatter-plot of biologically sampled coho salmon fork lengths at the Horse Creek trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

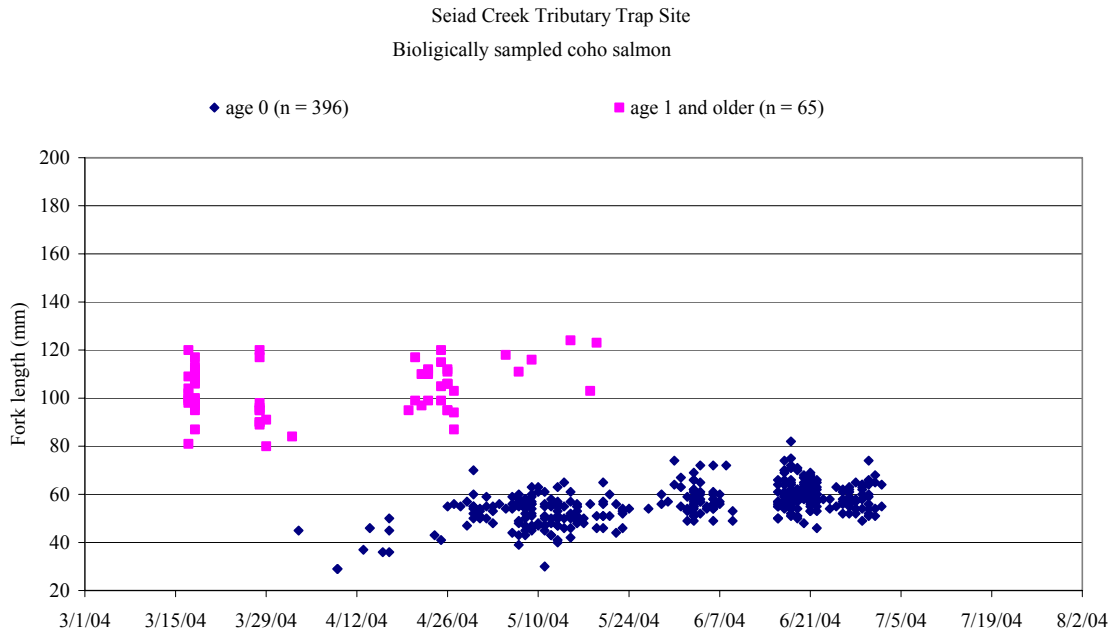

Figure D-16. Scatter-plot of biologically sampled coho salmon fork lengths at the Seiad Creek trap site. "Unmarked" indicates no hatchery fin clip. Ages were assigned in the field based on fork length and time of year.

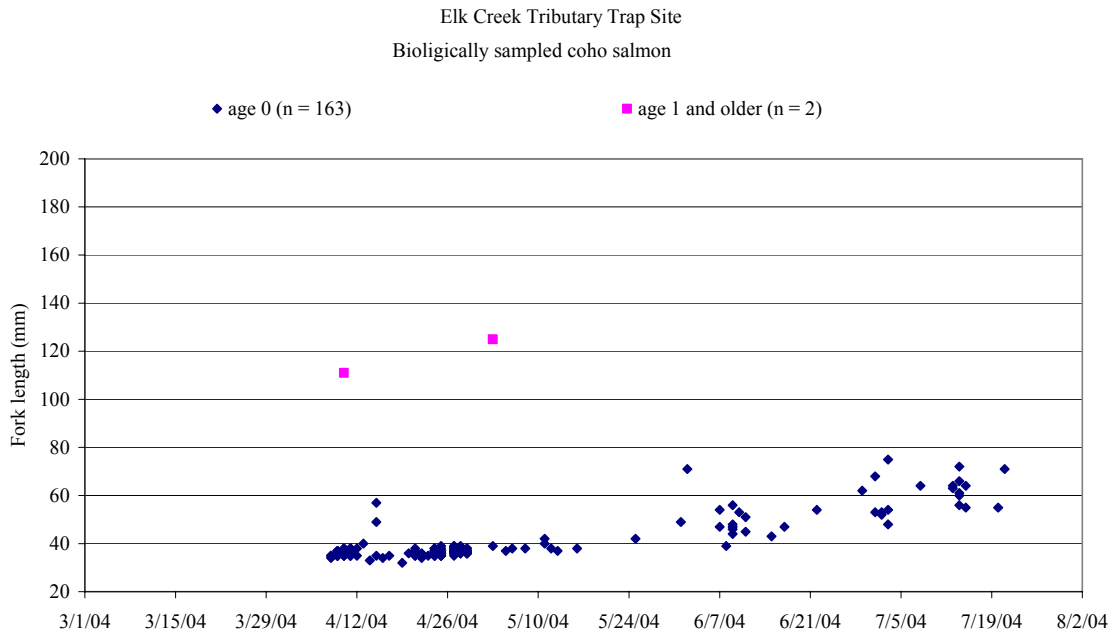

Figure D-17. Scatter-plot of biologically sampled coho salmon fork lengths at the Elk Creek trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

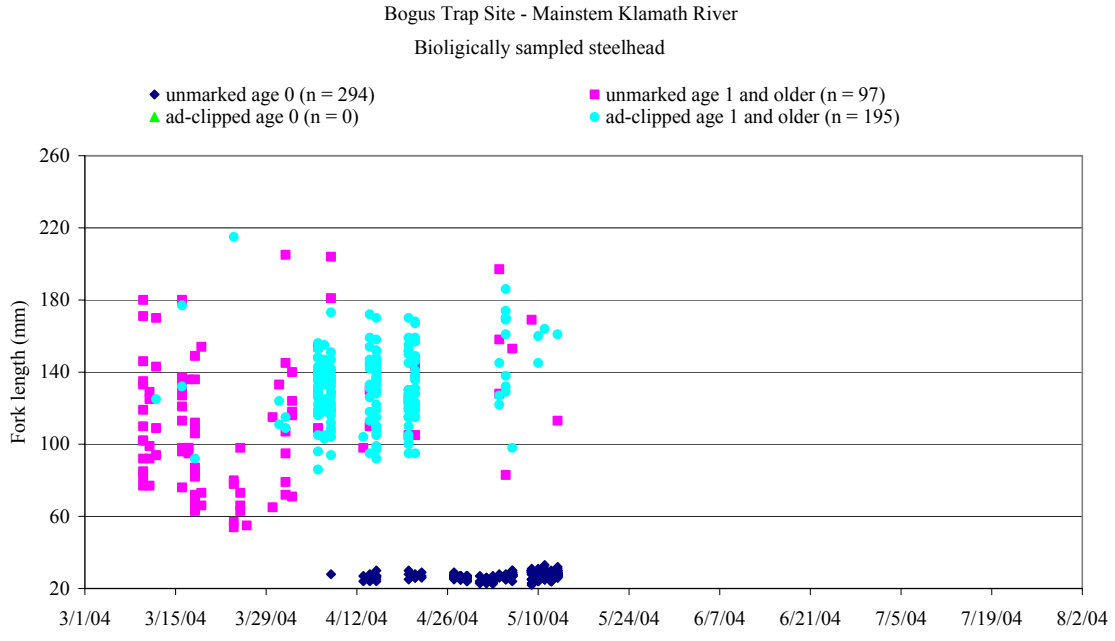

Figure D-18. Scatter-plot of biologically sampled steelhead fork lengths at the Bogus trap site. Unmarked fish of 382 mm (March 16), 265 mm (March 17, 400 mm (March 17), and 470 mm (march 24) are not shown. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

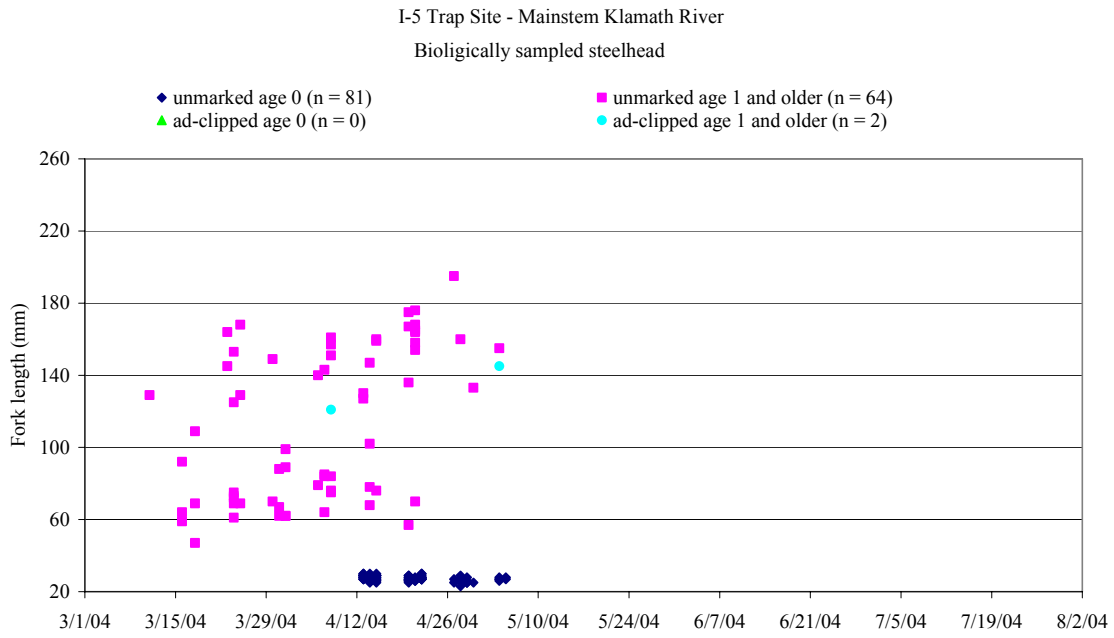

Figure D-19. Scatter-plot of biologically sampled steelhead fork lengths at the I-5 trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

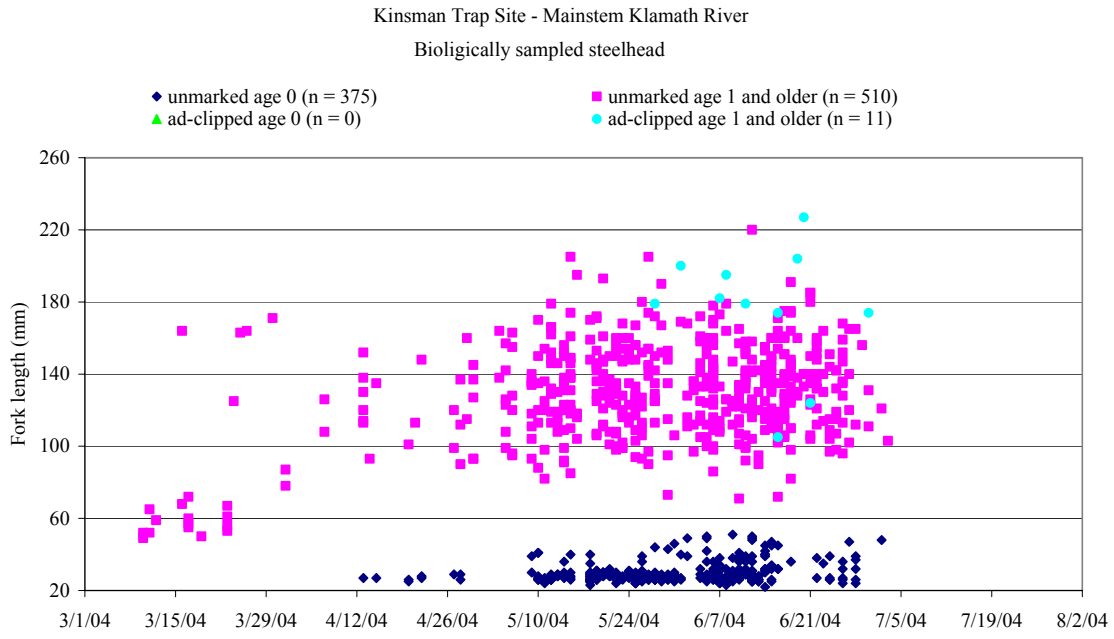

Figure D-20. Scatter-plot of biologically sampled steelhead fork lengths at the Kinsman trap site. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

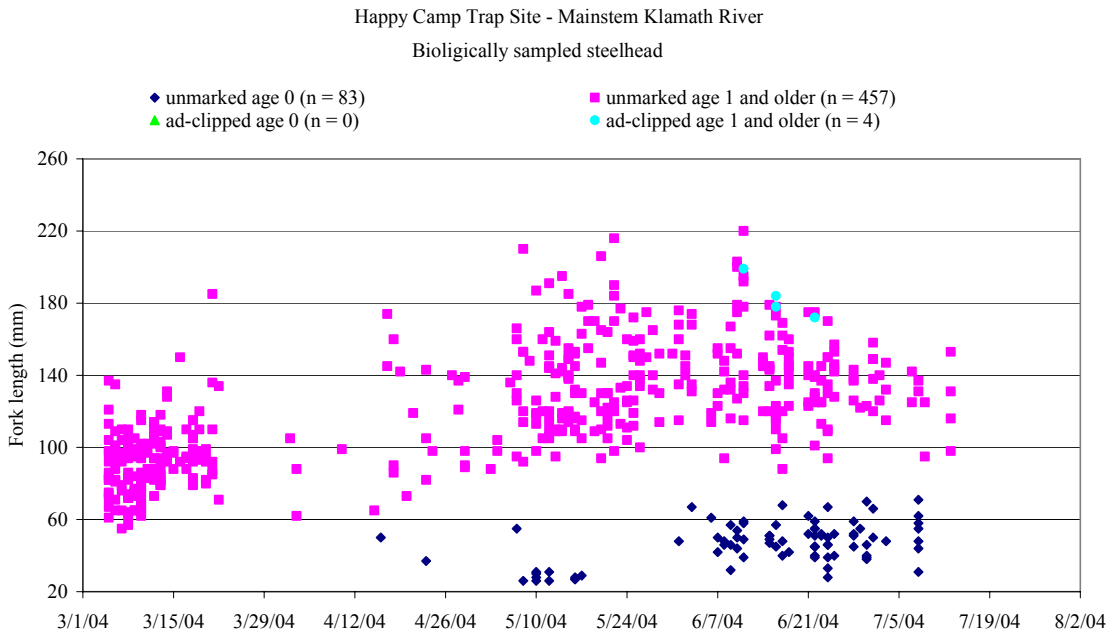

Figure D-21. Scatter-plot of biologically sampled steelhead fork lengths at the Happy Camp trap site. Not shown is an unmarked fish of 310 mm captured June 2. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

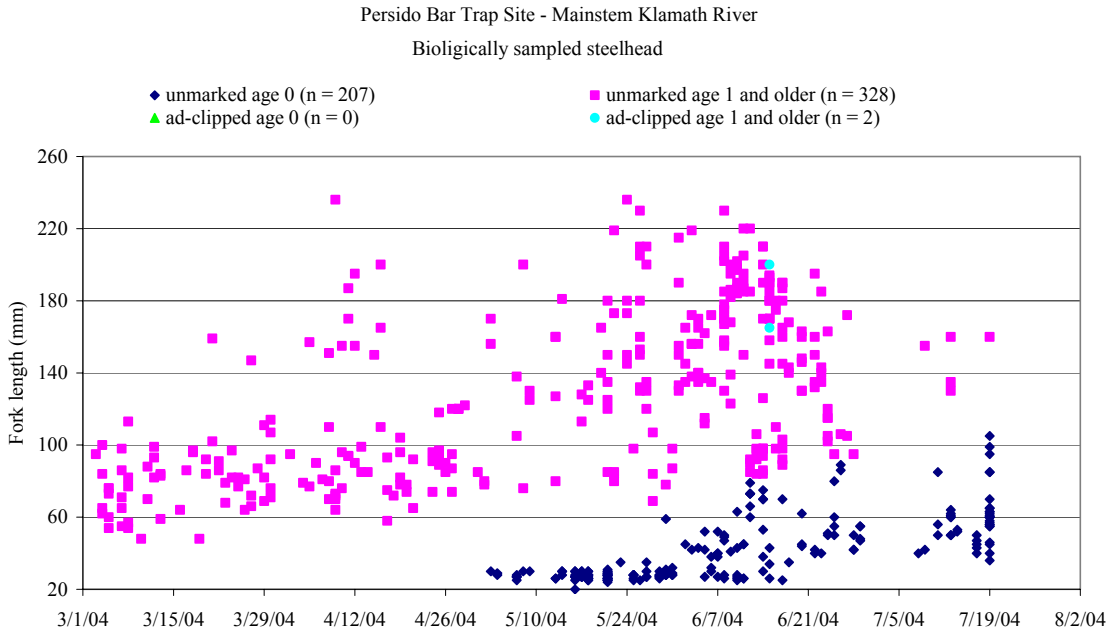

Figure D-22. Scatter-plot of biologically sampled steelhead fork lengths at the Persido Bar trap site. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

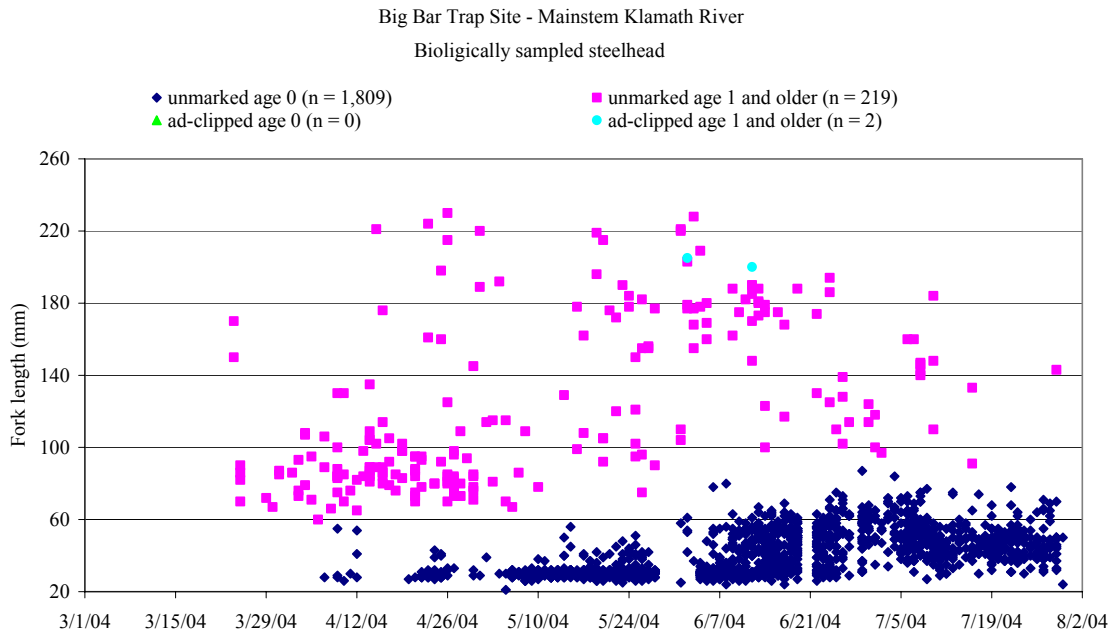

Figure D-23. Scatter-plot of biologically sampled steelhead fork lengths at the Big Bar trap site. Not shown is an additional unmarked fish of 425 mm captured April 13, and one of 289 mm captured May 25. "Unmarked" indicates no hatchery mark. Age classes were assigned in the field based on fork length and time of year.

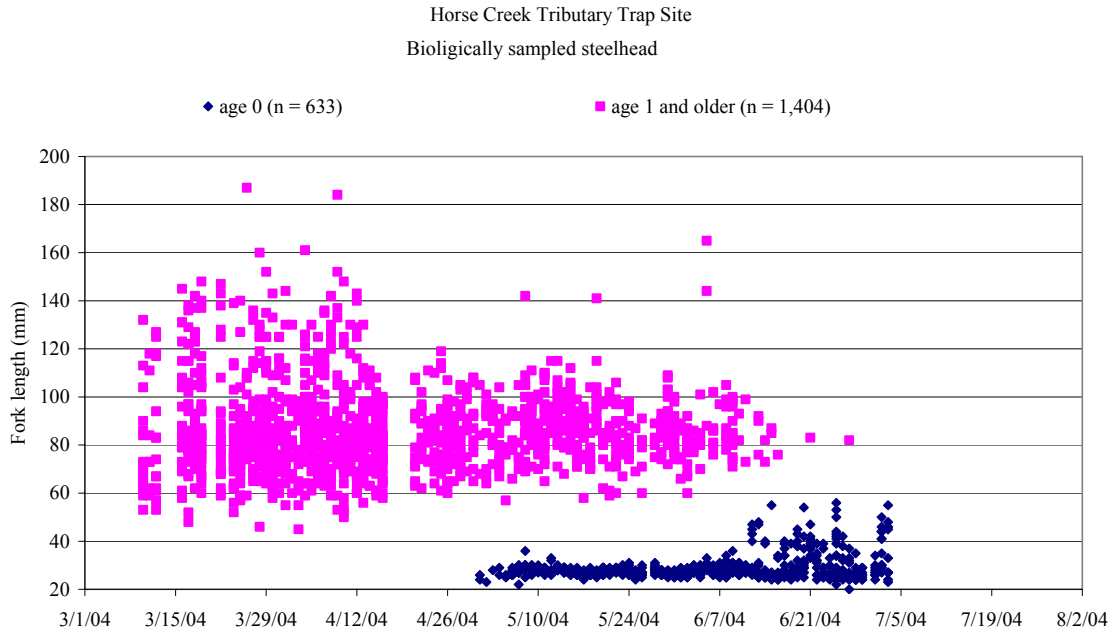

Figure D-24. Scatter-plot of biologically sampled steelhead fork lengths at the Horse Creek trap site. Not shown is an additional unmarked fish of 280 mm captured March 24. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

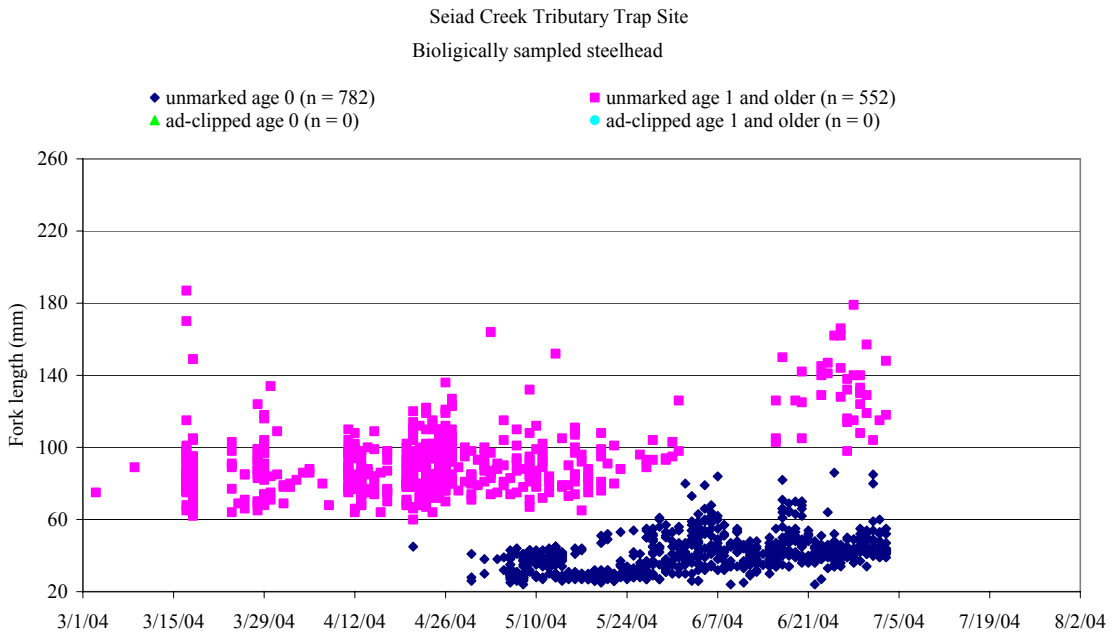

Figure D-25. Scatter-plot of biologically sampled steelhead fork lengths at the Seiad Creek trap site. Not shown is an additional unmarked fish of 280 mm captured May 12. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.

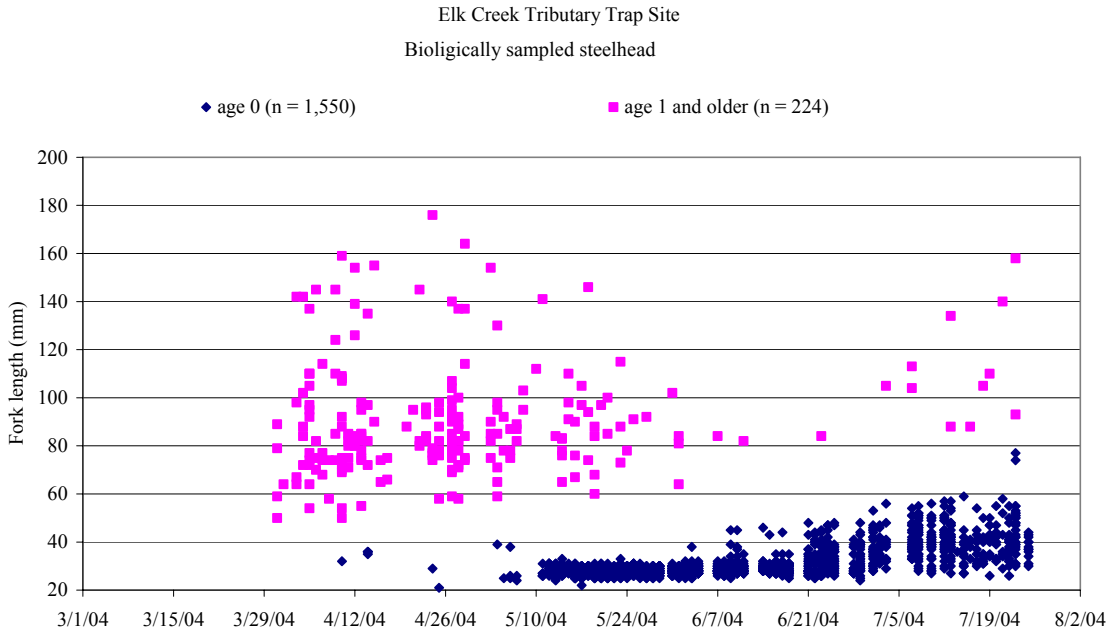

Figure D-26. Scatter-plot of biologically sampled steelhead fork lengths at the Elk Creek trap site. Not shown is an additional unmarked fish of 295 mm captured July 3. "Unmarked" indicates no hatchery fin clip. Age classes were assigned in the field based on fork length and time of year.