Outmigrant Trapping of Juvenile Salmonids in the Lower Tuolumne River at Grayson 2004

FINAL REPORT

9 March 2005

Prepared by

Andrea N. Fuller

Submitted to

Turlock and Modesto Irrigation Districts

S.P. Cramer & Associates
600 NW Fariss Rd.
Gresham, OR 97030
(503) 491-9577

INTRODUCTION 1

Study Area Description 1
Purpose and History of Study 1

METHODS 2

Juvenile Outmigrant Monitoring 2
Trapping Site and Sampling Gear 2
Trap Monitoring 2

Trap Efficiency Tests 3
Experimental Releases 3
Abundance Estimates 4

Monitoring Environmental Factors 4
Flow Measurements and Trap Speed 4
River Temperature and Relative Turbidity 4

RESULTS 5

Chinook Salmon 5
Number of Chinook Captured 5
Trap Efficiency 6
Estimated Abundance of Chinook Outmigrants 7
Chinook Length at Migration 9
Chinook Developmental Stage at Migration 9

Species Incidentally Captured 11

LITERATURE CITED 12

LIST OF FIGURES

Figure 1. Location map of study area on the Tuolumne River. 1
Figure 2. Daily Chinook catch at Grayson and flow at Modesto (MOD) during 2004...... 5
Figure 3. Estimated trap efficiency at Grayson and river flow at Modesto (MOD). 6
Figure 4. Daily estimated Chinook passage at Grayson using linear regression and flow at Modesto (MOD) during 2004. 7
Figure 5. Daily estimated Chinook passage at Grayson using linear regression and daily average water temperature at Shiloh during 2004. 8
Figure 6. Daily estimated Chinook passage using linear regression and instantaneous turbidity at Grayson during 2004. 9
Figure 7. Daily minimum, average, and maximum fork lengths of Chinook salmon captured at Grayson during 2004. 10
Figure 8. Length frequency of Chinook salmon captured at Grayson during 2004. 10

LIST OF TABLES

Table 1. Lower Tuolumne River outmigrant trapping history. 2
Table 2. Trap efficiency releases conducted at Grayson during 2004. 6
Table 3. Non-salmonid species incidentally captured at Grayson during 2004. 11

INTRODUCTION

Study Area Description

The Tuolumne River is the largest of the three major tributaries (the Tuolumne, Merced, and Stanislaus Rivers) to the San Joaquin River, originating in the central Sierra Nevada and flowing west between the Merced River to the south and the Stanislaus River to the north (Figure 1). The San Joaquin River flows north and joins the Sacramento River in the Sacramento-San Joaquin Delta. The Tuolumne River is dammed at several locations for generation of power, water supply, and flood control – the largest impoundment is Don Pedro Reservoir.

The lower Tuolumne River corridor extends from La Grange Dam to its confluence with the San Joaquin River. The site of La Grange Dam, approximately 52.2 river miles upstream from the San Joaquin River confluence, has been the limit of the upstream migration of anadromous fish since 1871.

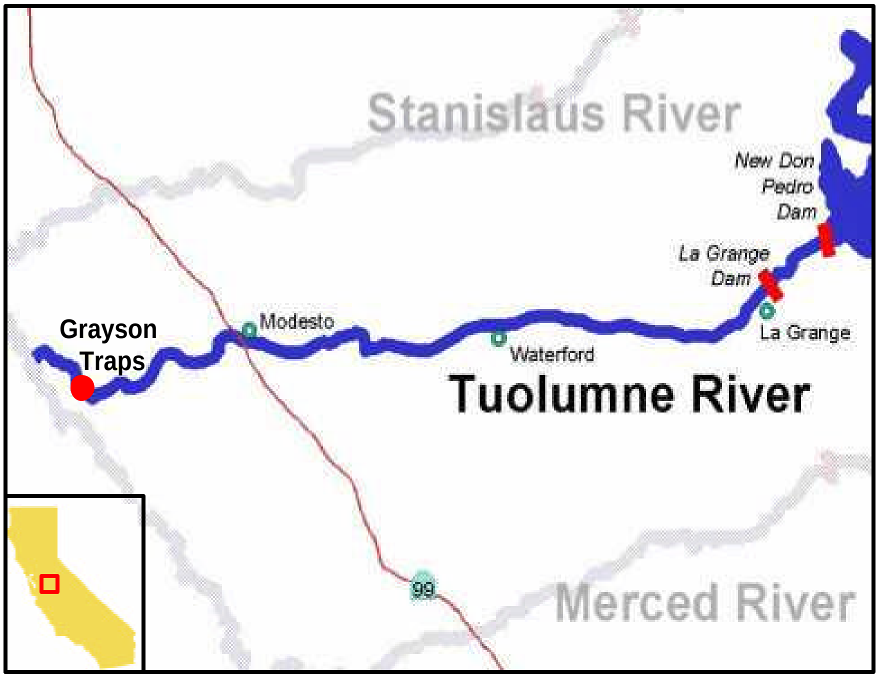

Figure 1. Location map of study area on the Tuolumne River.

Purpose and History of Study

Rotary screw trap monitoring has been conducted annually near the mouth of the Tuolumne River since 1995 for the purpose of monitoring the abundance and migration characteristics of juvenile Chinook salmon and other fishes. Trapping was conducted by the Turlock and Modesto Irrigation Districts (Districts) and the California Department of Fish and Game (CDFG) at the Shiloh Bridge (RM 3.4) from 1995 through 1998 and by CDFG at Grayson (RM 5.2) from 1999 through 2003. The sampling periods have varied greatly between years with monitoring starting as early as January 3 or as late as April 18, and ending as early as May 24 or as late as July 1 (Table 1).

Table 1. Lower Tuolumne River outmigrant trapping history.

Year	***Location***	***Start Date***	***End Date***	***Results Reported In***
1995	Shiloh (RM 3.4)	April 25	June 1	Heyne and Loudermilk 1997
1996	Shiloh (RM 3.4)	April 18	May 29	Heyne and Loudermilk 1997
1997	Shiloh (RM 3.4)	April 18	May 24	Heyne and Loudermilk 1998
1998	Shiloh (RM 3.4)	February 15	July 1	Blakeman 2004
1999	Grayson (RM 5.2)	January 12	June 6	Vasques and Kundargi 2001
2000	Grayson (RM 5.2)	January 9	June 12	Vasques and Kundargi 2001
2001	Grayson (RM 5.2)	January 3	May 29	Vasques and Kundargi 2002
2002	Grayson (RM 5.2)	January 15	June 6	Blakeman 2004
2003	Grayson (RM 5.2)	April 1	June 6	Blakeman 2004

METHODS

Juvenile Outmigrant Monitoring

Trapping Site and Sampling Gear

In 2004, two rotary screw traps were fished side-by-side in the mainstem of the lower Tuolumne River near Grayson (RM 5.2) to sample juvenile salmonids and other fishes as they migrated downstream. The screw traps, manufactured by E.G. Solutions, consisted of a funnel shaped core suspended between two pontoons. Each trap was positioned in the current so that water entered the eight-foot wide funnel mouth. Water entered the funnel and struck the internal screw core, causing the funnel to rotate. As the funnel rotated, fish were trapped in pockets of water and forced rearward into a livebox, where they could not escape.

The traps were held in place by an overhead cable strung between an anchor in the north bank levee and a tree on the south bank. Leader cables descended from the overhead cable and were attached to the front of each of the four trap pontoons. The downstream force of the water on the traps kept the leader cables taut.

Trap Monitoring

Initially, CDFG installed two rotary screw traps at Grayson on March 31 and sampling began the morning of April 1. CDFG monitored catches the morning of April 2 and from April 5 through April 9 at which time CDFG removed their traps. SPC subsequently installed the Districts' traps and continued the monitoring effort from April 9 through

June 9. During the sampling period, the traps were operated continuously (24 hours per day, 7 days per week) from April 5 to June 8. An exception was made from May 29 through June 1 when the traps were raised for the Memorial Day holiday.

The traps were checked twice daily during the sampling period, once in the morning and once in the evening. During each trap check, we removed the contents of the liveboxes and identified and counted all fish captured. Random samples of up to 50 Chinook and 20 of each other species were measured and their lengths recorded in millimeters during morning trap checks. Subsamples of up to 20 Chinook and 10 of each other species were examined during all evening trap checks. Chinook smolting appearance was rated on a scale of 1 to 3, with 1 an obvious parr (highly visible parr marks) and 3 an obvious smolt (silvery appearance, easily shed scales, blackened fin tips).

Chinook catch for a given day is the sum of the catches removed from the liveboxes during the morning check plus the catches removed during the evening check on the preceding day. For example, the daily Chinook catch for April 10 is the sum of the catches from the morning trap check on April 10 and the evening trap check conducted on April 9.

After all fish were recorded, we cleaned the traps to prevent accumulation of debris that might impair trap rotation or cause fish mortality within the liveboxes. Trap cleaning included removal of debris from against the trap and from within the liveboxes. The amount of debris load in the liveboxes was estimated and recorded whenever the traps were checked.

Trap Efficiency Tests

Experimental Releases

Trap efficiency evaluations were conducted weekly from April 7 through May 25, with a total of eight groups of marked Chinook salmon released to estimate trap efficiency. All release groups consisted of fish reared and marked at Merced River Hatchery by CDFG. Fish were marked by dye inoculation, sampled for length and mark retention, and delivered to the release site by CDFG. Fish were delivered to the release site and placed in net pens on the morning of the release day. All efficiency groups were released at the same site used in previous years by CDFG, which lies about one-quarter mile upstream of the traps on the south bank. Releases groups ranged from 1,941 to 2,013 smolts, with mean fork length at release ranging from 79.1 mm to 91.9 mm. All groups were released after dark.

To facilitate comparison between years, release procedures were the same as those used in past years as described by CDFG staff. Marked fish were released directly from the net pens. The time required to release each marked group was approximately 30 minutes. Following the release of marked fish, the traps were not checked again until the following morning.

Abundance Estimates

Daily fish passage was estimated by multiplying the day's catch by a trap efficiency estimate. Daily passage estimates were then summed to obtain total estimated outmigrant passage for the entire sampling period.

Trap efficiency estimates were derived by two different methods and were used to calculate two separate outmigration passage estimates. The first method was used to facilitate comparison of abundance estimates between years and applied an approach previously employed by CDFG (Vasques and Kundargi 2001). This trap efficiency estimate was obtained by regressing the observed trap efficiency test results against river flow at Modesto. The resulting regression equation was then used to predict trap efficiency for a given day based on the daily average river flow at Modesto.

The second method does not require establishing a relationship of trap efficiency to flow. Rather, the observed trap efficiency from each weekly test was applied to the daily catches from the date that the test was conducted until the day before the next test was conducted. For example, trap efficiency tests were conducted on April 13 and April 20 so the observed trap efficiency on April 13 was used to expand daily catches from April 13 through April 19.

Monitoring Environmental Factors

Flow Measurements and Trap Speed

Daily average flow in the Tuolumne River at the Modesto gauging station was obtained at http://waterdata.usgs.gov/ca/nwis/dv/?&site_no=11290000. Two methods were used to measure the velocity of water entering the traps. First, we measured the water velocity entering the traps each day with a Global Flow Probe, manufactured by Global Water (Fair Oaks, CA). Second, each morning we calculated an average daily trap rotation speed for each trap by measuring the time, in seconds, for three contiguous revolutions. Separate measurements were taken each morning before and after the traps were cleaned. The average time per revolution before and after cleaning was then calculated for each trap.

River Temperature and Relative Turbidity

Instantaneous water temperature was measured daily with a mercury thermometer at the trap site. An hourly recording thermograph was also maintained by the Districts near the Grayson trapping site at Shiloh (RM 3.4). This thermograph was stolen during the study period and data was not available from May 28 through the end of sampling on June 9. Instantaneous turbidity was measured daily with a LaMotte turbidity meter, model 2020. A water sample was collected each morning and later tested at the field station. Turbidity was recorded in nephelometric turbidity units (NTU).

RESULTS

Chinook Salmon

Number of Chinook Captured

Juvenile Chinook salmon outmigration in the San Joaquin Basin typically extends from January through May (Vasques and Kundargi 2001; SRFG 2004). Since no sampling occurred at Grayson from January through March, the 2004 outmigration data is incomplete.

Daily catches of juvenile Chinook at Grayson between April 1 and June 9 ranged from 0 to 42 fish and totaled 509 fish during 2004 (Figure 2). Peak catches occurred on April 8-9 and April 28-29 following declines in river flow a few days prior. Most fish were captured between April 6 and May 16 and only one unmarked Chinook salmon was captured after May 16. From May 16 through the end of sampling on June 8 flows gradually declined from approximately 650 cfs to 250 cfs. The origin of the single fish captured on May 26 is questionable because it coincides with the release and recapture of marked fish for a trap efficiency test and no unmarked fish were captured during the 9 days preceding or during the 11 sampling days that followed. There is no way of confidently determining whether this fish was of Tuolumne River origin or was an unmarked individual from the trap efficiency release group.

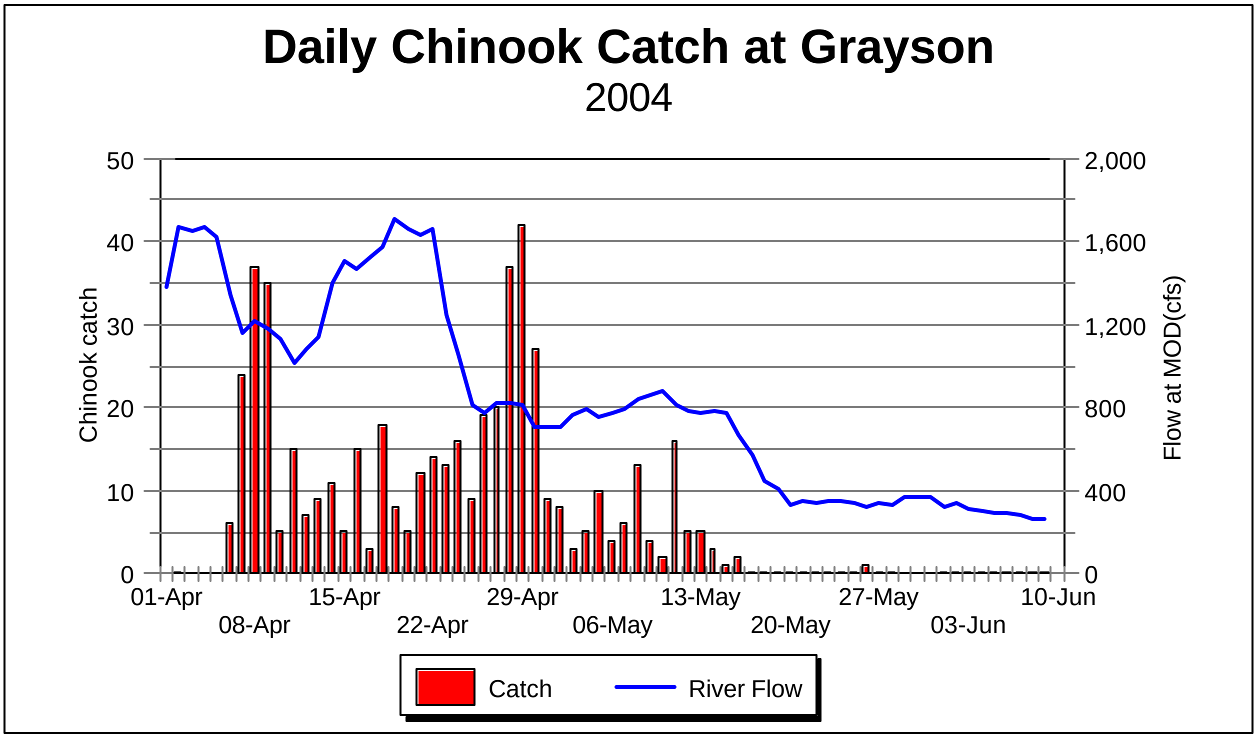

Figure 2. Daily Chinook catch at Grayson and flow at Modesto (MOD) during 2004.

Trap Efficiency

We released 8 groups of marked juvenile Chinook, all of hatchery origin, between April 7 and May 25, 2004 to estimate trapping efficiency (Table 2). All releases during 2004 occurred at night in flows ranging from 337 cfs to 1,660 cfs as measured at Modesto.

Table 2. Trap efficiency releases conducted at Grayson during 2004.

Release Date	Mark	Release Time	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
07-Apr-04	Bottom caudal green	nd	2006.0	7	0.3%	nd	75.4	1160
13-Apr-04	Dorsal fin green	2030	1991.9	84	4.2%	79.1	73.6	1140
20-Apr-04	Anal fin green	2000	1979.8	48	2.4%	81.2	78.9	1660
27-Apr-04	Top caudal green	2020	1941.0	118	6.1%	85.7	85.1	826
04-May-04	Bottom caudal green	2030	2007.9	50	2.5%	89.9	87.5	789
11-May-04	Anal fin green	2040	1971.5	104	5.3%	86.0	78.6	815
18-May-04	Dorsal fin green	2045	1996.0	178	8.9%	88.2	76.7	446
25-May-04	Top caudal green	2045	2013.0	59	2.9%	91.9	89.9	337

Trap efficiencies ranged from 0.3% to 8.9% (Table 2) and were weakly correlated to flow (Figure 3). Since mark-recapture estimates can be biased when recaptures are few (Robson and Regier 1964; Jensen 1981), abundance estimates were based on estimates of trap efficiency when the total number of recaptures exceeded seven (Roper and Scarnecchia 1999). Therefore, the trap efficiency test conducted on April 7 was excluded from abundance estimate calculations.

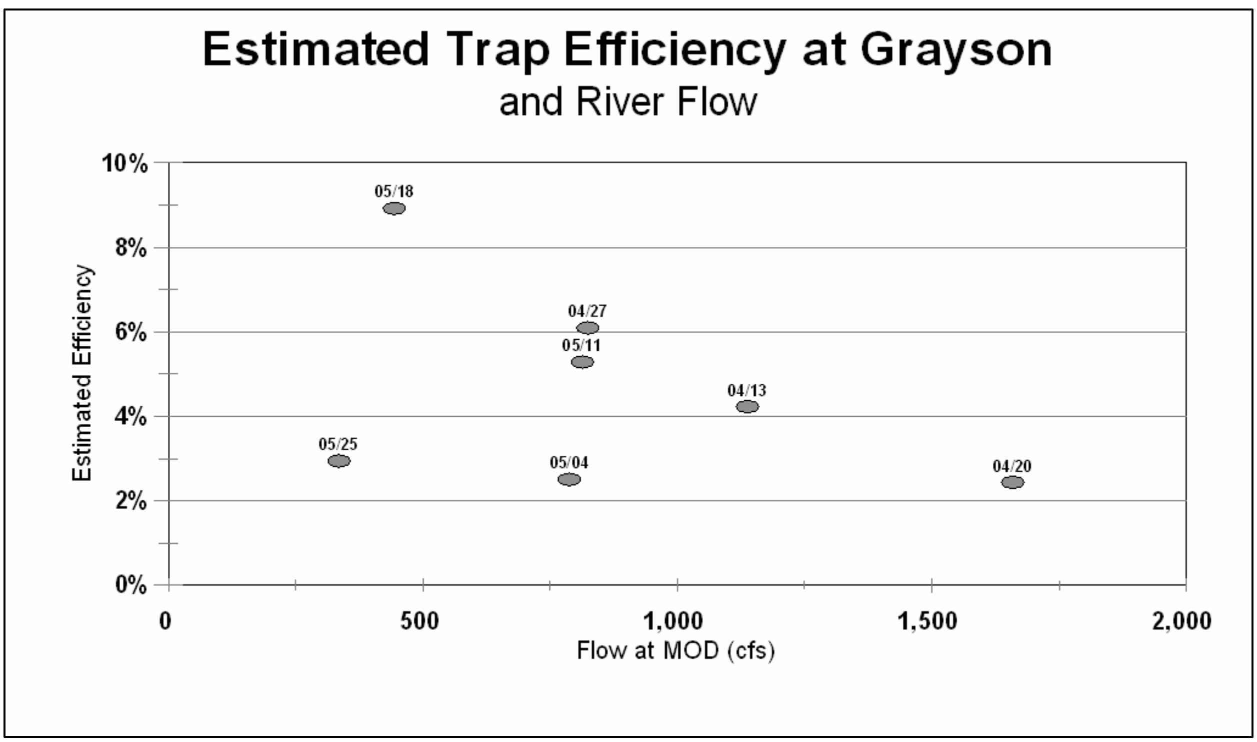

Figure 3. Estimated trap efficiency at Grayson and river flow at Modesto (MOD).

Estimated Abundance of Chinook Outmigrants

Based on weekly trap efficiency estimates, a total of 13,134 Chinook salmon were estimated to have passed Grayson between April 1 and June 9. Estimated daily trap efficiencies predicted by linear regression yielded a very similar estimate of 12,567 Chinook salmon.

River flow at Modesto gradually increased from approximately 1,000 cfs on April 12 and to approximately 1,700 cfs on April 19 and remained at this level until April 22 before gradually declining to 700 cfs on April 30 (Figure 4). No apparent increase in migration activity was observed in association with increasing flow; however, increases in migration activity were observed following reductions in flow. Peak estimated passages of 786 to 976 Chinook per day occurred on April 8-9 and on April 28-29, both following reductions in flow. With the exception of one Chinook of uncertain origin captured on May 26, passage ceased after May 16 when flows declined to less than 650 cfs.

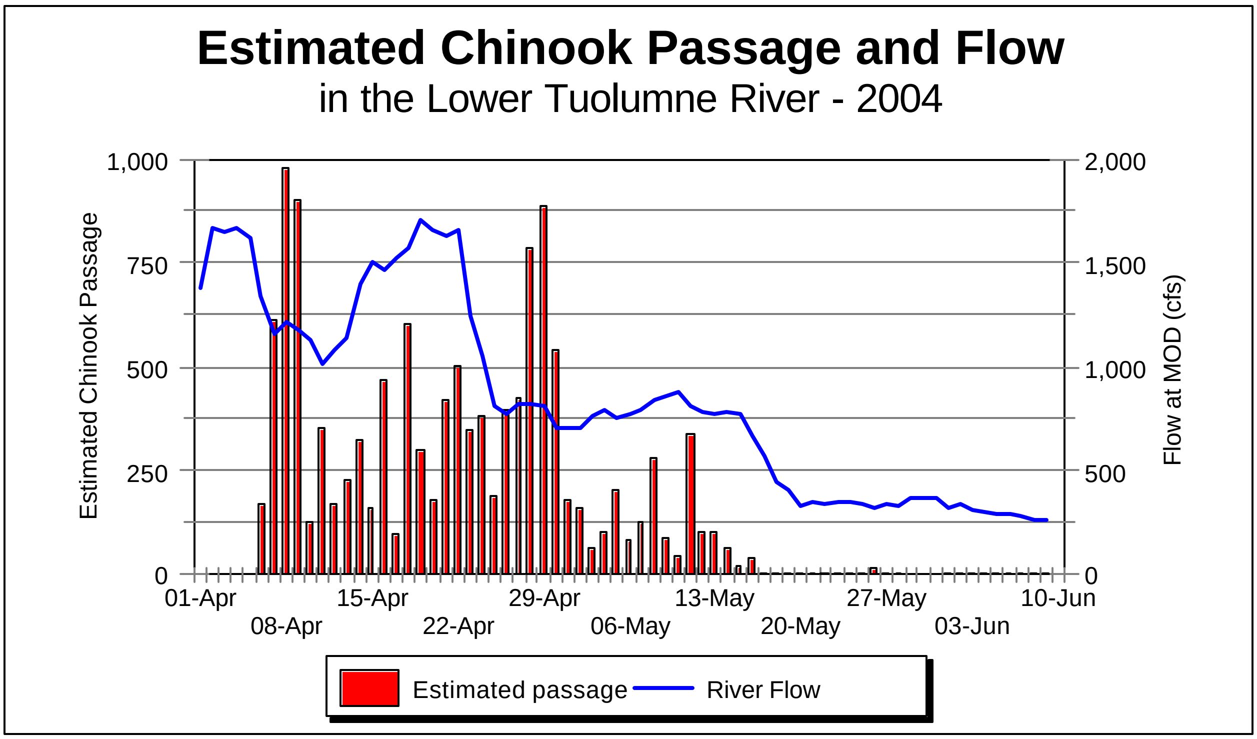

Figure 4. Daily estimated Chinook passage at Grayson using linear regression and flow at Modesto (MOD) during 2004.

During the first couple weeks of monitoring, daily average water temperature at Shiloh fluctuated between 59°F and 62°F and then gradually increased to approximately 70°F by late May (Figure 5). All but one Chinook were captured when water temperatures were at or below 67°F.

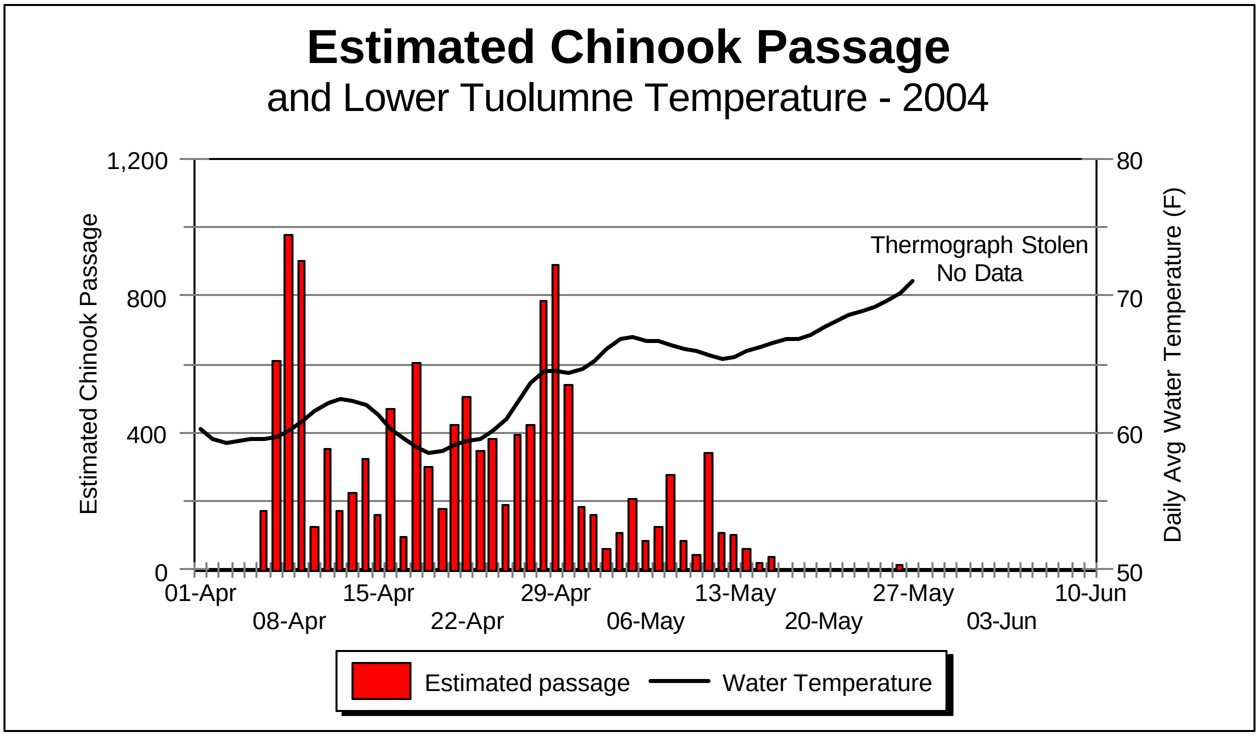

Figure 5. Daily estimated Chinook passage at Grayson using linear regression and daily average water temperature at Shiloh during 2004.

Turbidity data collected by CDFG from April 1 through April 9 and by S.P. Cramer & Associates (SPC) from April 10 through the remainder of the sampling period appeared to be very different (Figure 6) and does not appear to be flow related. The disparity between the two datasets is likely due to differences in the turbidity meters used by CDFG and SPC. Ideally, the same meter and vial should be used to obtain turbidity readings throughout the sampling period. Based on data collected by SPC during the majority of the sampling period, turbidity ranged from 1.7 NTU to 5.6 NTU. Fluctuations in turbidity do not appear to correspond to fluctuations in Chinook passage.

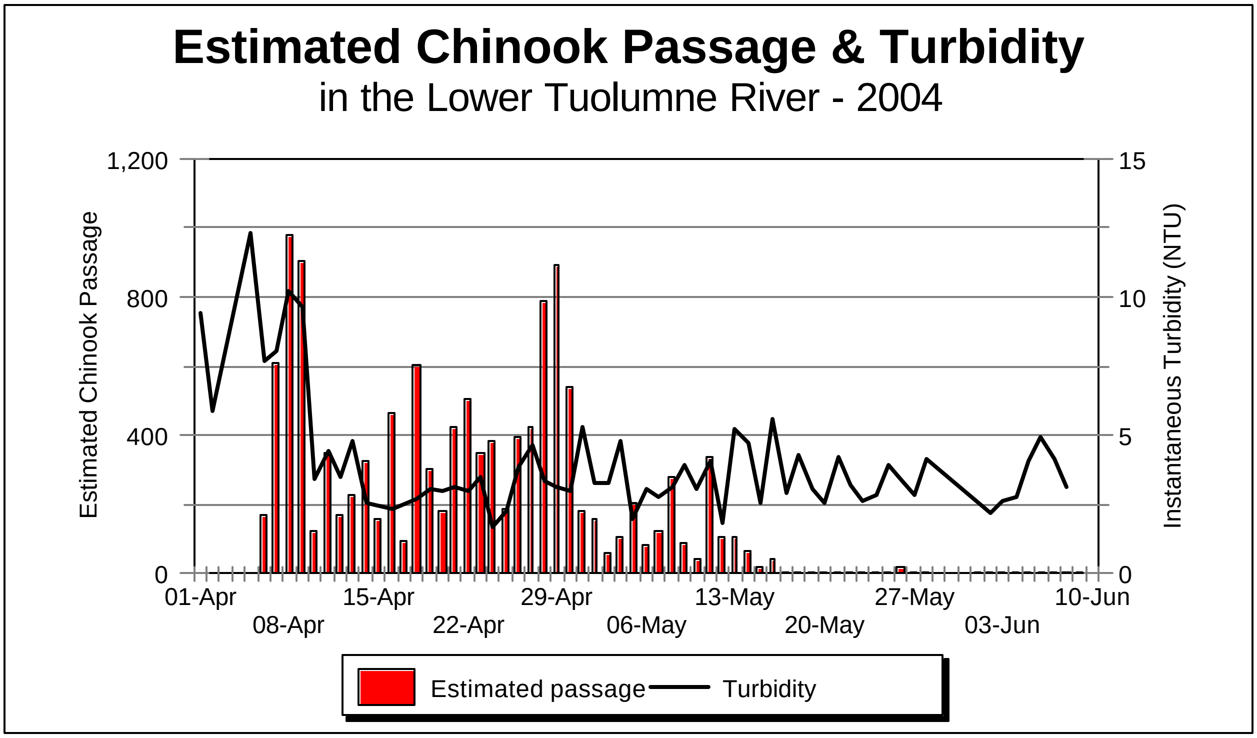

Figure 6. Daily estimated Chinook passage using linear regression and instantaneous turbidity at Grayson during 2004.

Chinook Length at Migration

Individual forklengths of Chinook salmon captured at Grayson during 2004 ranged from 37 mm to 110 mm (Figure 7). Chinook measuring 80 mm to 89 mm were most common (53%), followed by those measuring 70 mm to 79 mm (30%) and 90 mm to 99 mm (11%; Figure 8). Less than 5% of the Chinook captured at Grayson during 2004 were smaller than 70 mm forklength and 1% were larger than 99 mm fork length.

Chinook Developmental Stage at Migration

All Chinook captured at Grayson during 2004 appeared to be smolting, with 93% classified as obvious smolts (e.g., smolt index 3). The remaining 7% were at an intermediate stage of smolting and classified as smolt index 2.

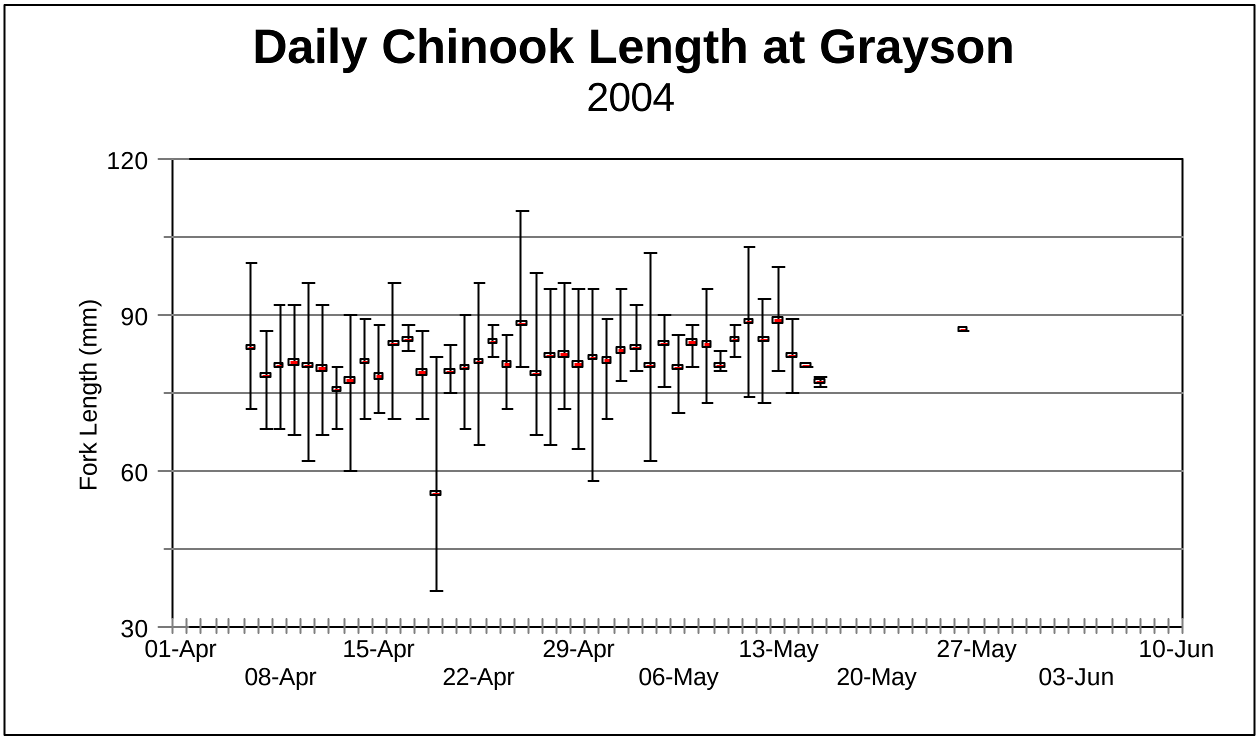

Figure 7. Daily minimum, average, and maximum fork lengths of Chinook salmon captured at Grayson during 2004.

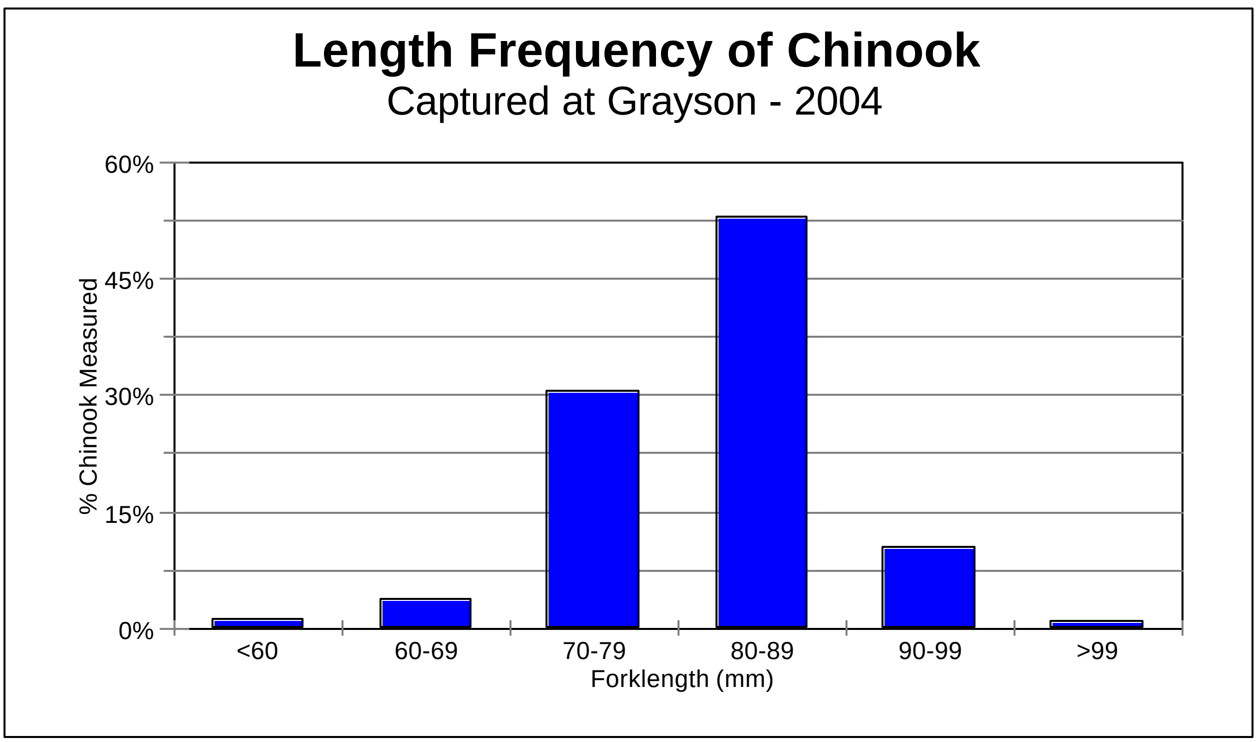

Figure 8. Length frequency of Chinook salmon captured at Grayson during 2004.

Species Incidentally Captured

A total of 2,365 non-salmonids representing at least 19 species (5 native, 14 introduced) were captured incidentally during operation of the Grayson trap during 2004 (Table 3, Appendix B). Incidental catch of non-salmonids was dominated by introduced species including white catfish, channel catfish, carp, golden shiner, red shiner, fathead minnow, mosquitofish, inland silverside, American and threadfin shad, bluegill, green sunfish, and largemouth and smallmouth bass. Native non-salmonid species captured included Pacific lamprey, hitch, Sacramento sucker, Sacramento pikeminnow, and Sacramento blackfish. No rainbow/steelhead trout were captured at Grayson during the 2004 sampling period.

Table 3. Non-salmonid species incidentally captured at Grayson during 2004.

Common Name	Scientific Name	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)
Catfish Family					
Channel catfish	*Ictalurus punctatus*	12	34	85.7	290
White catfish	*Ictalurus catus*	625	29	62.3	315
Unidentified catfish	-	29	10	12.7	18
Herring Family					
American shad	*Alosa sapidissima*	1	480	480.0	480
Threadfin shad	*Dorosoma petenense*	3	115	123.3	135
Lamprey Family					
Pacific lamprey	*Lampetra tridentata*	4	128	140.3	151
Lamprey - unidentified	-	4			
Livebearer Family					
Mosquitofish	*Gambusia affinis*	68	22	33.9	49
Minnow Family					
Carp	*Cyprinus carpio*	1	185	185.0	185
Fathead minnow	*Pimephales promelas*	3	41	53.0	72
Hitch	*Lavinia exilicauda*	1	46	46.0	46
Golden shiner	*Notemigonus crysoleucas*	5	41	81.0	125
Red shiner	*Cyprinella lutrennsis*	56	21	44.6	116
Sac. blackfish	*Orthodon microlepidotus*	2	90	90.0	90
Sac. pikeminnow	*Ptychochelius grandi s*	2	32	32.0	32
Silverside Family					
Inland silverside	*Menidia beryllina*	15	18	45.4	89
Sucker Family					
Sacramento sucker	*Catostomus occidentalis*	17	20	27.6	35
Sunfish Family					
Bass– unid. species	-	29	15	37.9	223
Bluegill	*Lepomis macrochirus*	37	30	97.3	145
Green sunfish	*Lepomis cyanellus*	2	121	130.5	140
Largemouth bass	*Micropterus salmoides*	638	15	23.6	72
Smallmouth bass	*Micropterus dolomieu*	785	17	27.9	148
Unidentified sunfish	-	8	15	18.4	23
Unidentified species	-	18	18	20.3	22

LITERATURE CITED

Blakeman, D. 2004a. 1998 juvenile Chinook salmon capture and production indices using rotary-screw traps on the lower Tuolumne River. California Department of Fish and Game, Technical report submitted to Tuolumne River Technical Advisory Committee, Turlock, CA.

Blakeman, D. 2004b. 2002 juvenile Chinook salmon capture and production indices using rotary-screw traps on the lower Tuolumne River. California Department of Fish and Game, Technical report submitted to Tuolumne River Technical Advisory Committee, Turlock, CA.

Blakeman, D. 2004c. 2003 juvenile Chinook salmon capture and production indices using rotary-screw traps on the lower Tuolumne River. California Department of Fish and Game, Technical report submitted to Tuolumne River Technical Advisory Committee, Turlock, CA.

Heyne, T. and W. Loudermilk. 1997. Rotary screw trap capture of Chinook salmon smolts on the Tuolumne River in 1995 and 1996: Contribution of assessment of survival and production estimates. Federal Energy Regulatory Commission annual report, FERC project #2299-024.

Heyne, T. and W. Loudermilk. 1998. Rotary screw trap capture of Chinook salmon smolts with survival and production indices for the Tuolumne River in 1997. Federal Energy Regulatory Commission annual report, FERC project #2299-024.

Jensen, A.L. 1981. Sample size for single mark and single recapture experiments. Transactions of the American Fisheries Society. 110: 455-458.

Robson, D.S. and H.A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Trans. Am. Fish. Soc. 93: 215-226.

Roper, B.B., and D.L. Scarnecchia. 1999. Emigration of age-0 Chinook salmon (Oncorhynchus tshawytscha) smolts from the upper South Umpqua River basin OR. Canadian Journal of Fisheries and Aquatic Sciences 56:939-946.

Stanislaus River Fish Group. 2004. A summary of Fisheries Research in the Lower Stanislaus River. Working Draft. March 2004. Available on the SRFG website at http://www.delta.dfg.ca.gov/srfg/

Vasques, J. and K. Kundargi. 2002. 2001 Juvenile Chinook capture and production indices using rotary screw traps on the lower Tuolumne River. California Department of Fish and Game, San Joaquin Valley Southern Sierra Region, Anadromous Fisheries Program.

Vasques, J. and K. Kundargi. 2001. 1999-2000 Grayson Screw Trap Report. California Department of Fish and Game Anadromous Fisheries Project, San Joaquin Valley Southern Sierra Region (Region 4). March 2001.

Appendix A. Daily Chinook catch, length, and passage at Grayson and environmental data from 2004.

		Fork Length (mm)			Weekly Method		Regression Method		Flow	Temperature	
Date	Catch	Min	Avg	Max	Efficiency	Passage	Efficiency	Passage	at Modesto	at Shiloh	Turbidity
01-Apr-04	ns	ns	ns	ns	ns	ns	ns	ns	1380	60.3	9.4
02-Apr-04	0	-	-	-	-	-	-	-	1670	59.6	5.9
03-Apr-04	ns	ns	ns	ns	ns	ns	ns	ns	1650	59.2	ns
04-Apr-04	ns	ns	ns	ns	ns	ns	ns	ns	1670	59.4	ns
05-Apr-04	ns	ns	ns	ns	ns	ns	ns	ns	1620	59.6	12.3
06-Apr-04	6	72.0	83.7	100.0	4.2%	142.3	3.5%	170.8	1340	59.5	7.7
07-Apr-04	24	68.0	78.3	87.0	4.2%	569.1	3.9%	611.1	1160	59.7	8
08-Apr-04	37	68.0	80.2	92.0	4.2%	877.4	3.8%	976.4	1220	60.2	10.2
09-Apr-04	35	67.0	80.7	92.0	4.2%	830.0	3.9%	901.7	1180	60.9	9.6
10-Apr-04	5	62.0	80.0	96.0	4.2%	118.6	4.0%	125.1	1130	61.6	3.43
11-Apr-04	15	67.0	79.5	92.0	4.2%	355.7	4.3%	351.1	1010	62.2	4.46
12-Apr-04	7	68.0	75.4	80.0	4.2%	166.0	4.1%	170.3	1080	62.5	3.49
13-Apr-04	9	60.0	77.2	90.0	4.2%	213.4	4.0%	226.5	1140	62.4	4.8
14-Apr-04	11	70.0	80.9	89.0	4.2%	260.8	3.4%	325.9	1400	62.0	2.57
15-Apr-04	5	71.0	78.0	88.0	4.2%	118.6	3.1%	160.1	1510	61.3	ns
16-Apr-04	15	70.0	84.4	96.0	4.2%	355.7	3.2%	466.6	1470	60.2	2.37
17-Apr-04	3	83.0	85.0	88.0	4.2%	71.1	3.1%	96.8	1520	59.5	ns
18-Apr-04	18	70.0	78.8	87.0	4.2%	426.8	3.0%	603.0	1570	58.9	2.69
19-Apr-04	8	37.0	55.5	82.0	4.2%	189.7	2.7%	300.4	1710	58.5	3.06
20-Apr-04	5	75.0	79.0	84.0	2.4%	206.2	2.8%	180.0	1660	58.7	2.97
21-Apr-04	12	68.0	79.8	90.0	2.4%	495.0	2.8%	421.5	1630	59.0	3.11
22-Apr-04	14	65.0	80.9	96.0	2.4%	577.4	2.8%	504.0	1660	59.4	3
23-Apr-04	13	82.0	84.7	88.0	2.4%	536.2	3.7%	347.3	1240	59.6	3.5
24-Apr-04	16	72.0	80.3	86.0	2.4%	659.9	4.2%	382.8	1050	60.1	1.7
25-Apr-04	9	80.0	88.2	110.0	2.4%	371.2	4.7%	190.2	810	61.0	2.25
26-Apr-04	19	67.0	78.6	98.0	2.4%	783.7	4.8%	393.9	770	62.3	3.88
27-Apr-04	20	65.0	82.1	95.0	6.1%	329.0	4.7%	426.0	826	63.7	4.67
28-Apr-04	37	72.0	82.2	96.0	6.1%	608.6	4.7%	785.7	820	64.6	3.34
29-Apr-04	42	64.0	80.2	95.0	6.1%	690.9	4.7%	888.9	813	64.5	3.14
30-Apr-04	27	58.0	81.7	95.0	6.1%	444.1	5.0%	542.1	702	64.3	2.97
01-May-04	9	70.0	81.1	89.0	6.1%	148.0	5.0%	181.0	705	64.6	5.3
02-May-04	8	77.0	83.0	95.0	6.1%	131.6	5.0%	160.7	703	65.3	3.3
03-May-04	3	79.0	83.7	92.0	6.1%	49.3	4.8%	62.0	765	66.1	3.3
04-May-04	5	62.0	80.0	102.0	2.5%	200.8	4.8%	104.6	789	66.9	4.75
05-May-04	10	76.0	84.3	90.0	2.5%	401.6	4.9%	205.8	755	67.0	1.98
06-May-04	4	71.0	79.8	86.0	2.5%	160.6	4.8%	82.9	769	66.7	3.04
07-May-04	6	80.0	84.5	88.0	2.5%	240.9	4.8%	125.8	794	66.6	2.79
08-May-04	13	73.0	84.1	95.0	2.5%	522.1	4.7%	279.1	842	66.4	3.16
09-May-04	4	79.0	80.0	83.0	2.5%	160.6	4.6%	86.5	858	66.1	3.89

Date	Catch	Fork Length (mm) Min	Avg	Max	Weekly Method Efficiency	Passage	Regression Method Efficiency	Passage	Flow at Modesto	Temperature at Shiloh	Turbidity
10-May-04	2	82.0	85.0	88.0	2.5%	80.3	4.6%	43.8	882	65.9	3.03
11-May-04	16	74.0	88.6	103.0	5.3%	303.3	4.7%	339.0	815	65.6	4.05
12-May-04	5	73.0	85.0	93.0	5.3%	94.8	4.8%	104.4	785	65.4	1.84
13-May-04	5	79.0	88.8	99.0	5.3%	94.8	4.8%	103.8	773	65.6	5.21
14-May-04	3	75.0	82.0	89.0	5.3%	56.9	4.8%	62.5	781	65.9	4.71
15-May-04	1	80.0	80.0	80.0	5.3%	19.0	4.8%	20.8	776	66.2	2.56
16-May-04	2	76.0	77.0	78.0	5.3%	37.9	5.1%	39.5	667	66.5	5.58
17-May-04	0	-	-	-	5.3%	0.0	5.3%	0.0	572	66.8	2.88
18-May-04	0	-	-	-	8.9%	0.0	5.6%	0.0	446	66.8	4.29
19-May-04	0	-	-	-	8.9%	0.0	5.7%	0.0	409	67.1	3.07
20-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	327	67.7	2.57
21-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	349	68.1	4.19
22-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	341	68.5	3.24
23-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	355	68.9	2.6
24-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	346	69.2	2.85
25-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	337	69.6	3.94
26-May-04	1	87.0	87.0	87.0	2.9%	34.1	5.8%	17.1	325	70.2	3.39
27-May-04	0	-	-	-	2.9%	0.0	5.8%	0.0	338	71.1	2.83
28-May-04	0	-	-	-	2.9%	0.0	5.8%	0.0	336	ns	4.11
29-May-04	ns	ns	ns	ns	ns	ns	ns	ns	369	ns	ns
30-May-04	ns	ns	ns	ns	ns	ns	ns	ns	373	ns	ns
31-May-04	ns	ns	ns	ns	ns	ns	ns	ns	372	ns	ns
01-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	323	ns	ns
02-Jun-04	0	-	-	-	2.9%	0.0	5.8%	0.0	343	ns	2.22
03-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	315	ns	2.62
04-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	304	ns	2.79
05-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	296	ns	4.04
06-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	291	ns	4.94
07-Jun-04	0	-	-	-	2.9%	0.0	6.0%	0.0	280	ns	4.12
08-Jun-04	0	-	-	-	2.9%	0.0	6.0%	0.0	265	ns	3.11
09-Jun-04	0	-	-	-	2.9%	0.0	6.0%	0.0	259	ns	ns

Appendix B. Non-salmonids captured at Grayson during 2004.

Date	AMS	BAS	BGS	C	CAT	CHC	FHM	GSF	GSN	HCH	LAM	LMB	MQK	MSS	PL	RSN	SASQ	SASU	SCB	SMB	SNF	TFS	UNID	WHC
01-Apr-04																								
02-Apr-04																								
03-Apr-04																								
04-Apr-04																								
05-Apr-04																								
06-Apr-04						1							3		1									31
07-Apr-04			2										14		1					1				27
08-Apr-04			1										3		2	1								18
09-Apr-04			1			1							2											17
10-Apr-04		1																						4
11-Apr-04			2											3										18
12-Apr-04								1		1			1											8
13-Apr-04			1																					14
14-Apr-04				1																				9
15-Apr-04																								13
16-Apr-04																								15
17-Apr-04													1											1
18-Apr-04														1										7
19-Apr-04																								1
20-Apr-04			1			1							1	1										17
21-Apr-04																								8
22-Apr-04																					1			16
23-Apr-04													1											8
24-Apr-04		1										1												16
25-Apr-04		1											2			4		1						16
26-Apr-04											1					1								13
27-Apr-04												1												28
28-Apr-04													1	1					1					27
29-Apr-04						1										1				1				23
30-Apr-04		1				1						37	1					1						9
01-May-04			1									56	2	1				1						6
02-May-04									1			28	2											9
03-May-04												9	1											8
04-May-04												7	1					1						6
05-May-04													1					1		1				23
06-May-04						2			1			1	1											2

Date	AMS	BAS	BGS	C	CAT	CHC	FHM	GSF	GSN	HCH	LAM	LMB	MQK	MSS	PL	RSN	SASQ	SASU	SCB	SMB	SNF	TFS	UNID	WHC
07-May-04																1								9
08-May-04												1												15
09-May-04						1						1											1	6
10-May-04						1						1						1						1
11-May-04			1											1			1	2						20
12-May-04			1															3						12
13-May-04																								4
14-May-04						1						2						2		1		1		9
15-May-04																								12
16-May-04			1									2		2								1	1	9
17-May-04											1		1			1		1						17
18-May-04			1						2			25	1			6		3				1		8
19-May-04												4		2		1							1	6
20-May-04			1				1					9	5			5	1							17
21-May-04			1			1						11	5			4								7
22-May-04			1				1		1		1			2									12	8
23-May-04							1					2	1			3							3	2
24-May-04			1									1	1											3
25-May-04			1									1	2											4
26-May-04			2									6												9
27-May-04	1	24	2									24	1			1				12				3
28-May-04			2									5	2							8				9
29-May-04																								
30-May-04																								
31-May-04																								
01-Jun-04																								
02-Jun-04		1										1	2			11				174				
03-Jun-04			3			1						6	5			2			1	118				3
04-Jun-04			2									2	2			1				111				2
05-Jun-04			2		5							4	1			3				96				3
06-Jun-04			4					1			1	360	1	1		1				113				3
07-Jun-04			1		18							24				6				112				2
08-Jun-04			1		6							6				3				28	7			3
09-Jun-04																				9				1
Total	1	29	37	1	29	12	3	2	5	1	4	638	68	15	4	56	2	17	2	785	8	3	18	625

Key to species codes

AMS	American shad
BAS	Bass, unidentified species
BGS	Bluegill
C	Carp
CAT	Catfish, unidentified species
CHC	Channel catfish
FHM	Fathead minnow
GSF	Green sunfish
GSN	Golden shiner
HCH	Hitch
LAM	Lamprey, unidentified species
LMB	Largemouth bass
MQK	Mosquitofish
MSS	Inland silverside
PL	Pacific lamprey
RSN	Red shiner
SASQ	Sacramento pikeminnow
SASU	Sacramento sucker
SCB	Sacramento blackfish
SMB	Smallmouth bass
SNF	Sunfish, unidentified species
TFS	Threadfin shad
UNID	Unidentified species
WHC	White catfish