FINAL REPORT

Outmigrant Trapping of Juvenile Salmonids in the lower Stanislaus River Caswell State Park Site 1996

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CH2M Hill

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EXECUTIVE SUMMARY

We operated two rotary screw traps side-by-side in the lower Stanislaus River near Caswell State Park (river mile (RM) 8.6) from February 6 through July 1, 1996 to estimate the number of juvenile fall-run chinook salmon migrating out of the Stanislaus River. The estimated number of juvenile chinook salmon that migrated past the traps between February 6 and July 1 was 71,000 with an approximate 95% confidence interval of 43,000 to 100,000. The length distribution was distinctly bimodal, corresponding to fry (31-40 mm) passing before March 25 and smolts (primarily 81-100 mm) passing after March 25. Fry composed 27% of migrants, and smolts composed 73% of migrants. Many fry probably migrated before sampling began, since fry migrants were already abundant when sampling began.

Outmigration peaked in late April during an extended period of constant flow near 1,700-1,800 cfs. The numbers of fish migrating were lowest during March, when flow was highest for the season, near 3,000-4,000 cfs.

We estimated the capture efficiency of the traps by releasing 15 groups of marked natural or hatchery fish (2 groups during daylight and 13 groups during darkness) about 1/4 mile upstream of the traps. Recovery rates of these marked fish varied from 0 to 12.08%, with no fish being recovered from either of the groups released during daylight. Variation in capture efficiency for both traps combined was best accounted for by a logistic regression on river turbidity. Other variables examined for a correlation to capture efficiency included river flow, river turbidity, time-per-trap revolution, water velocity, length of fish at release, and trap position.

The number of chinook estimated at the Caswell site was only 25% of those estimated at the Oakdale site (RM 40) on the lower Stanislaus River, which was being sampled

simultaneously under separate contract. The difference in estimated passage suggests there is high mortality to juvenile chinook in the 34 miles between sites. The passage estimate at the Oakdale site upstream was 284,000 with approximate 95% confidence intervals of 240,000 to 327,000; in contrast the passage estimate at Caswell was 71,000 with approximate 95% confidence intervals of 43,000 to 100,000.

ACKNOWLEDGMENTS

The data reported here were gathered through the efforts of our field staff: Robert Fuller, Andrea Phillips, Trevor Arrighi and Tom Phillips. We are grateful for their dedication and hard work. The clarity and accuracy of this report benefitted greatly from editorial suggestions offered by Sam Lohr, Alice Low and Doug Neeley.

This study was funded and directed by the USFWS. We are grateful to Marty Kjelson, Patricia Brandes, Mark Pierce, Sam Lohr and Craig Fleming for their support and cooperation. We thank Bill Loudermilk, George Niellands, Steve Baumgartner, Clarence Mayott and Tim Heyne with the CDFG for their help with planning, permitting and coordinating with our operations. We also thank the staff at Merced River Fish Facility and CDFG technicians for marking and delivering juvenile chinook to our project site. We recognize and appreciate their efforts to facilitate this study.

We thank Don Thompson, the Tri-Dam Board of Directors, Rick Barzan, Manager of Oakdale Irrigation District and Rick Martin, Manager of South San Joaquin Irrigation District who loaned equipment and manpower to help carry out this study.

We are grateful to B & B Farms who allowed us daily access to the river across their property, as well as use of their property to fill and place sandbags. We are also grateful to the US Army Corps of Engineers (USACE) for granting us special access through their parks, and for their protective surveillance of our equipment. We are especially grateful to Peggy Brooks and Lisa Vacarro at the Knights Ferry USACE office for their continued support of all our activities throughout the year.

We thank the Oakdale Waste Treatment Facility staff, Woody Woodruff, John Lane and Lovanna Brown for protecting and storing our equipment, and providing us access to the river.

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INTRODUCTION

The California Department of Fish and Game (CDFG) and US Fish and Wildlife Service (USFWS) monitored the outmigration of juvenile fall-run chinook salmon from the Stanislaus River by fishing rotary screw traps near Caswell State Park (RM 8.6) during 1994 and 1995. In 1994, the CDFG fished one screw trap and in 1995, the USFWS fished two screw traps at the Caswell site. In 1994, the single trap fished from late April through May, and caught fewer than 300 juvenile chinook. Four mark-recapture tests of trap efficiency that year indicated the trap was catching less than 1% of the chinook that migrated past it. In 1995, two traps were fished from late March through early June. Approximately 1,500 juvenile chinook were captured that year, and four mark-recapture tests indicated that trap efficiency was less than 2%. Catches peaked in 1995 during early April, prior to the date sampling had started in 1994. Further, screw trap sampling upstream near Oakdale (RM 40) in 1995 showed that sampling at Caswell in 1995 had again started after chinook migration peaked in late March. The low catches of outmigrating juvenile chinook and the low capture efficiencies in 1994 and 1995 prevented the estimation of outmigrant abundance.

In 1996, S.P. Cramer & Associates, Inc. (SPCA) was retained to sample with rotary screw traps in the lower Stanislaus River with a goal of estimating the number, size, and timing of juvenile chinook migrating from the Stanislaus River. This goal necessitated that sampling be initiated earlier in the year, and that capture efficiency be increased. To increase trap catches and reduce the variation between efficiency tests, we (SPCA) proposed (1) that the trapping station be moved upstream to a location where the channel could be more easily modified to increase capture rates, or (2) that the channel at Caswell be modified to divert flow towards the traps and increase capture rates.

After much consideration, it was determined that the traps would remain at the Caswell site and we would construct a sandbag wall upstream from the traps to direct flow toward the traps to increase capture efficiency. The primary reason for not moving the traps upstream to an alternate location was the need to keep the traps as close to the confluence with the San Joaquin River as possible, in order to sample the total population of juveniles emigrating from the river.

Sampling at the Caswell site during 1996, reported here, had four objectives:

Ø Estimate the number of juvenile fall-run chinook salmon migrating out of the Stanislaus River in 1996,

Ù Determine the size and smolting characteristics of juvenile chinook and rainbow trout/steelhead migrating out of the Stanislaus River,

Ú Identify factors that influence the time, size and number of juvenile chinook and rainbow/steelhead migrating out of the Stanislaus River,

Û Recover marked juvenile chinook released upstream near Knights Ferry and Oakdale to determine migration rate and survival through the Stanislaus River.

This report is organized by the four objectives.

DESCRIPTION OF STUDY AREA

The headwaters of the Stanislaus River originate on the western slope of the Sierra Nevada Mountains. The Stanislaus River and its tributaries flow southwest and confluence with the San Joaquin River on the floor of the Central Valley (Figure 1). The San Joaquin River flows north and joins the Sacramento River in the Sacramento-San Joaquin Delta. The Stanislaus River is dammed at several locations for the purpose of flood control, power generation and water supply. Water uses include irrigation and municipal needs, as well as recreational activities and water quality control.

Figure 1. Location map of San Joaquin and Stanislaus rivers.

Knights Ferry Bridge	RM 54.6
Orange Blossom Bridge (OBB)	RM 46.9
Highway 120/108 Bridge	RM 41.2
Oakdale Trapping Location	RM 40.1
Caswell Trapping Location	RM 8.6

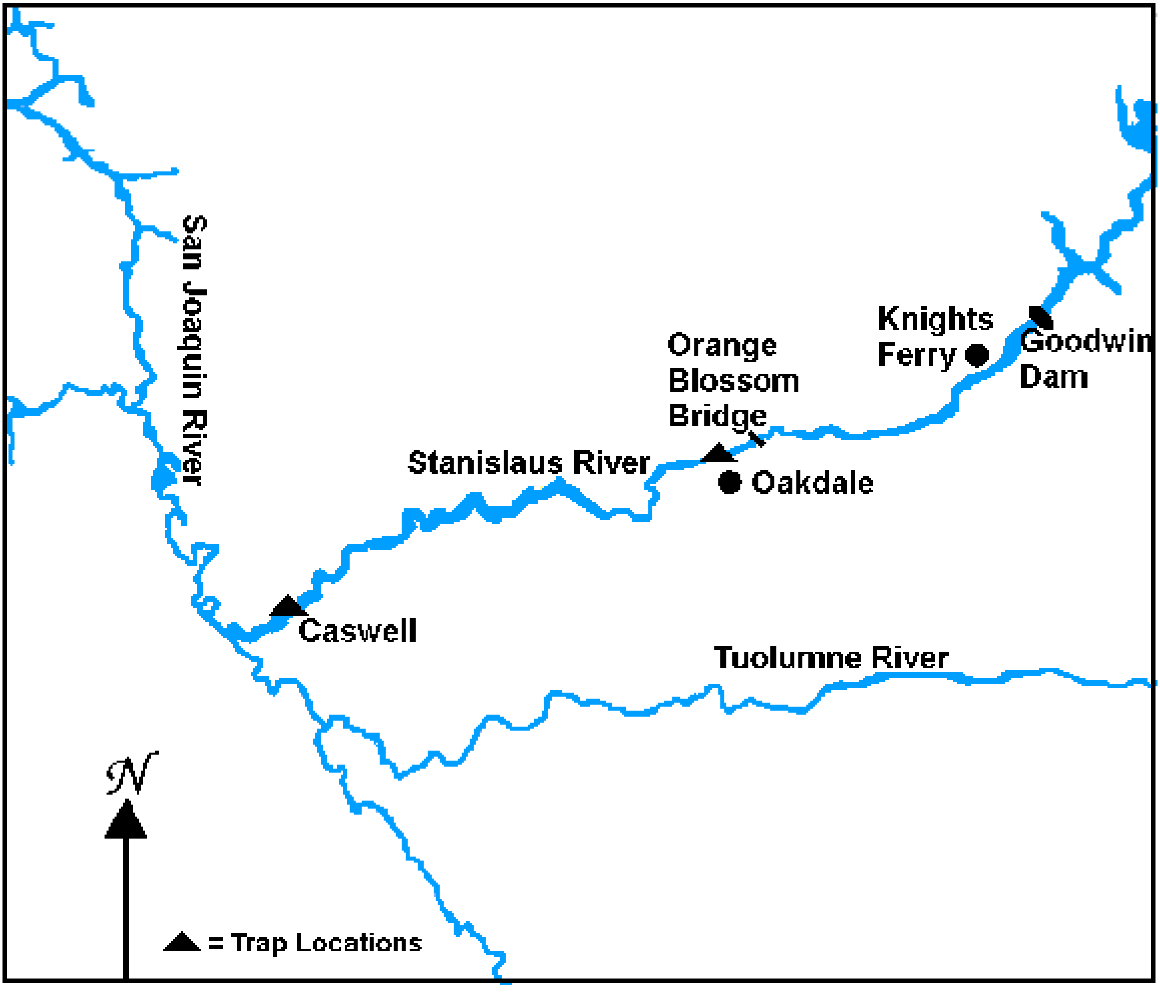


Figure 1. Location map of study area on the Stanislaus River.

Goodwin Dam, approximately 58.4 river miles (RM) upstream from the San Joaquin River confluence, blocks the upstream migration of anadromous fish. The lower river supports fall-run chinook salmon spawning between the town of Riverbank (RM 34) and Goodwin Dam (RM 58.4). Rainbow trout occur in the lower Stanislaus River, although it is not known whether a distinct anadromous run is present. Rainbow trout showing advanced smolting characteristics (scales, darkened fin tips) have been captured at both Oakdale and Caswell. It is assumed that these fish are migrating out of the river and therefore may be steelhead. Genetic tests on rainbow trout in the Stanislaus River are currently underway to determine if a distinct anadromous run exists.

Throughout this report, we reference river miles on the Stanislaus River. River miles were determined with a map wheel and 7.5 minute series USGS quadrangle maps, (Knights Ferry, 1987, Ripon 1980 and Oakdale, 1987). The estimated river miles of our trapping locations and key area landmarks are:

Knights Ferry Bridge	RM 54.6
Orange Blossom Bridge (OBB)	RM 46.9
Highway 120/108 Bridge	RM 41.2
Oakdale Trapping Location	RM 40.1
Caswell Trapping Location	RM 8.6

METHODS

JUVENILE OUTMIGRANT MONITORING

<u>Sampling Gear</u>

We fished two rotary screw traps side-by-side in the mainstem of the Stanislaus River near Caswell State Park to sample juvenile chinook salmon as they migrated downstream. The screw traps, manufactured by E.G. Solutions in Eugene, Oregon, each consisted of a funnel shaped core suspended between two pontoons (Figure 2). Each trap was positioned in the current so that water entered the 8 ft wide funnel mouth. As water entered the funnel and struck the internal screw core, the funnel rotated. Fish were trapped in pockets of water that were forced rearward into a livebox, where they could not escape. Each trap was held in place with 1/4 inch cable fastened to large trees upstream on the north bank. The downstream force of the water on the traps kept the cables near the water surface. Buoys marked the location of the cables for human safety. Although there is some recreational use of the river near the traps by small boats, canoes, and anglers in float tubes, the majority of river use in the vicinity of the State Park occurs downstream from the trap site.

Trap Site Preparation

The Caswell trapping location was chosen by CDFG in 1994 because it was the farthest location downstream with adequate access to install and monitor the traps. In 1996, we moved the traps upstream approximately 100 yards from where they were fished in 1994 and 1995. The trap nearest the left bank (looking upstream) was designated the north trap and the trap nearest the right bank was designated the south trap. These designations are the same as those used by the USFWS in 1995.

Prior to the start of sampling, we determined that low catch rates in previous years were primarily the result of low water velocities at the mouths of the traps. To increase the efficiency of the traps, we decided to move the traps upstream a short distance and add sandbags upstream to divert more flow towards the traps.

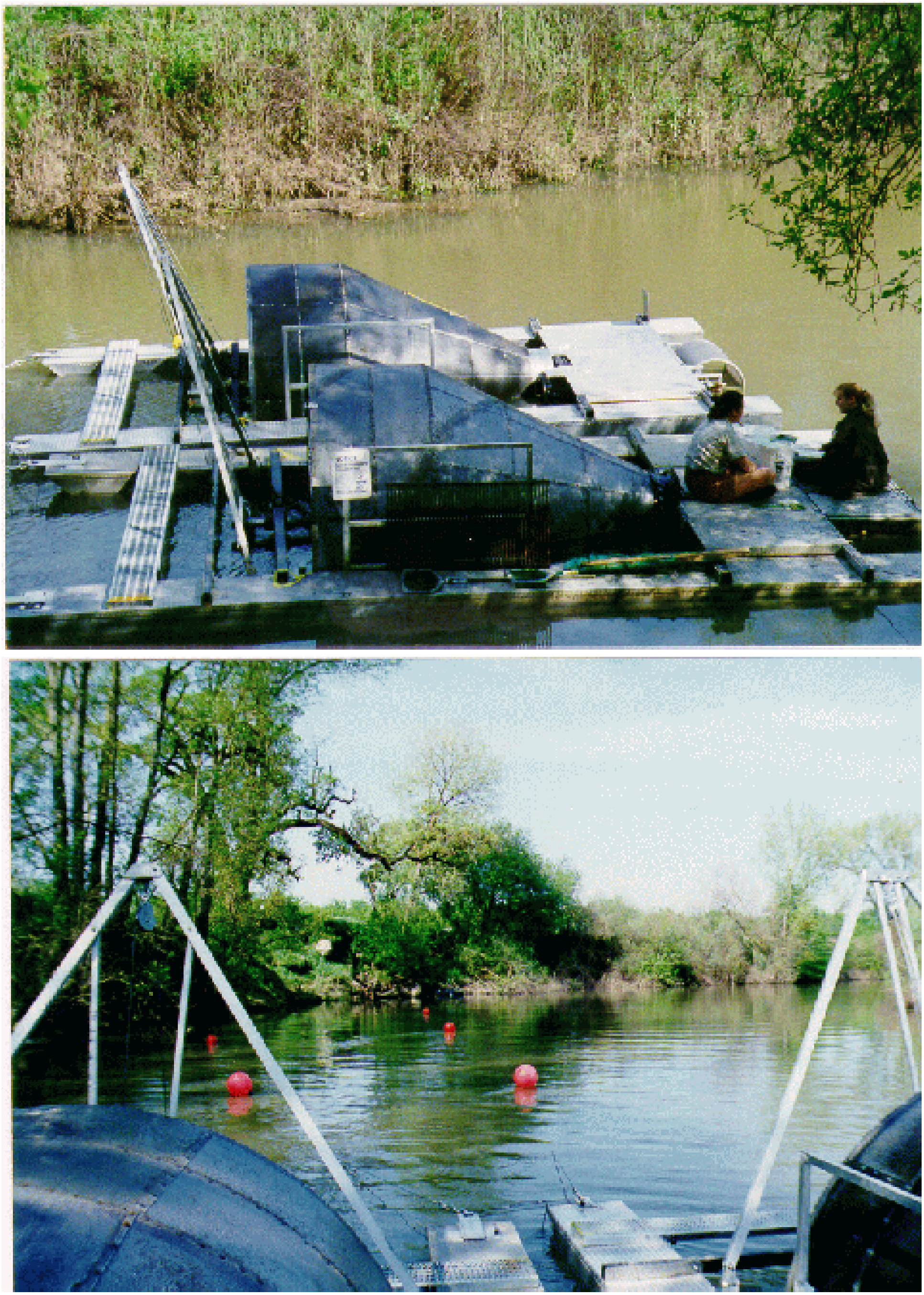


Figure 2. Photographs of the rotary screw traps fishing near Caswell State Park. The buoys marked the position of the cables to prevent entanglement with river users.

users.

We moved the traps upstream approximately 100 yards from where they were fished in 1994 and 1995. We believed the river channel at the upstream location would provide higher catch rates due to the presence of a large sandbar along the south bank. The sandbar, approximately 100 yards long, extends outward toward the middle of the river. Due to the presence of the sandbar along the south bank, the portion of the river extending from the north bank to the middle of the river is relatively deep with higher water velocities.

The sandbar provided a shallow area to construct a sandbag wall to deflect more flow toward the screw traps. Because the average water depth along the sandbar was approximately 2 ft (at low river flow), it was the most suitable location to construct a wall within the river channel. It was proposed to begin at the south bank, upstream from the traps, extend downstream at a 45 degree angle from the bank and end a short distance upstream from the traps. The wall would not block the river, and there would be adequate room for river users (i.e. rafts, boats, inner-tubes) to maneuver past the traps.

Due to high river flows in 1996, we were not able to construct the sandbag deflecting wall. Unusually high precipitation during early February caused the river flow to rise and forced upstream reservoirs to release large amounts of water for flood control purposes through March. Although we planned to construct the wall to withstand normal spring pulse flows of about 2,000 cfs, flow reached almost 4,000 cfs and remained above 3,000 cfs from February 23 to March 23 (see Figures 3 and 4). The high flow increased the average water depth over the sandbar from 2 ft to about 8 ft, a depth at which we were unable to work.

Although we were not able to construct the primary sandbag deflecting wall extending out from the south bank, on April 24 and 25 we added about 750 sandbags to the north bank a short distance upstream from the traps in an effort to increase catch efficiency. The trap nearest the north bank was approximately 5 - 7 ft from the bank, in an area where the velocity was highest. The wall was constructed upstream about 10 ft and extended outward in the river approximately 5 ft. The wall was designed to deflect juvenile chinook traveling downstream along the north bank into the current and make them more vulnerable to capture.

On April 20, a few days before sandbags were added to the north bank, we moved the traps upstream about 50 ft to an area where we measured slightly higher water velocities. The traps remained there for the rest of the sampling period.

In addition to these changes, we moved the traps laterally on 3 occasions to try to increase catches (Appendix 1). The changes were only overnight; we expected that any resulting increase in catch would be obvious. Since catches did not increase in response to the changes, the traps were always moved back to their original positions in the morning.

Safety Measures

Although recreational use of the river near the trap site was relatively low, we took precautions to warn park visitors and river users of the inherent dangers associated with screw traps. Two signs with large letters were placed upstream from the traps to warn river users traveling downstream towards the traps. The first sign (3/4 mile upstream) warned of an "Instream Obstacle Ahead" and recommended portaging on the left bank. The second sign (150 yards upstream) said "Danger Ahead - Stay Left". An arrow also pointed in the direction of the left bank. The signs were approximately 4 ft x 4 ft with black letters on a neon background. Flashing lights, similar to ones seen on roadside construction signs were also placed on the traps to increase visibility at night.

To discourage people along the banks from swimming or floating toward the traps, we also placed numerous warning signs at conspicuous places along the banks. The signs warned of drowning danger near the traps as well as "keep out" and "private property." The signs were in English and Spanish.

Trap Monitoring

We installed the rotary screw traps on February 5 and began retrieving catches the morning of February 6 (Figure 3). Sampling continued until July 1; traps were removed July 2. The traps were fished 24 hours per day, 7 days per week. Each morning we removed the contents of the livebox, counted and recorded all fish captured and cleaned the trap and livebox. It was often necessary to clean the traps again during the afternoon to clear away debris accumulated against the funnel walls and in the livebox. At times of high turbid flows and when we had recently released marked fish, we retrieved trap catches both in the morning and later in the day to document daytime catches of juvenile chinook. Following nighttime releases, we retrieved catches every hour or two, depending on the amount of debris buildup and the number of fish being captured.

During natural freshets when fish would accumulate in the livebox fairly rapidly, we monitored the trap every 2 to 3 hours to reduce mortality of juvenile chinook. Plastic mesh fence panels were placed in the rear and side portions of each livebox to provide fish with areas of refuge and to minimize stress and mortality. The fences consisted of ½ inch plastic mesh fastened to pipe frames. The mesh caught wood and plant debris while allowing fish to pass through.

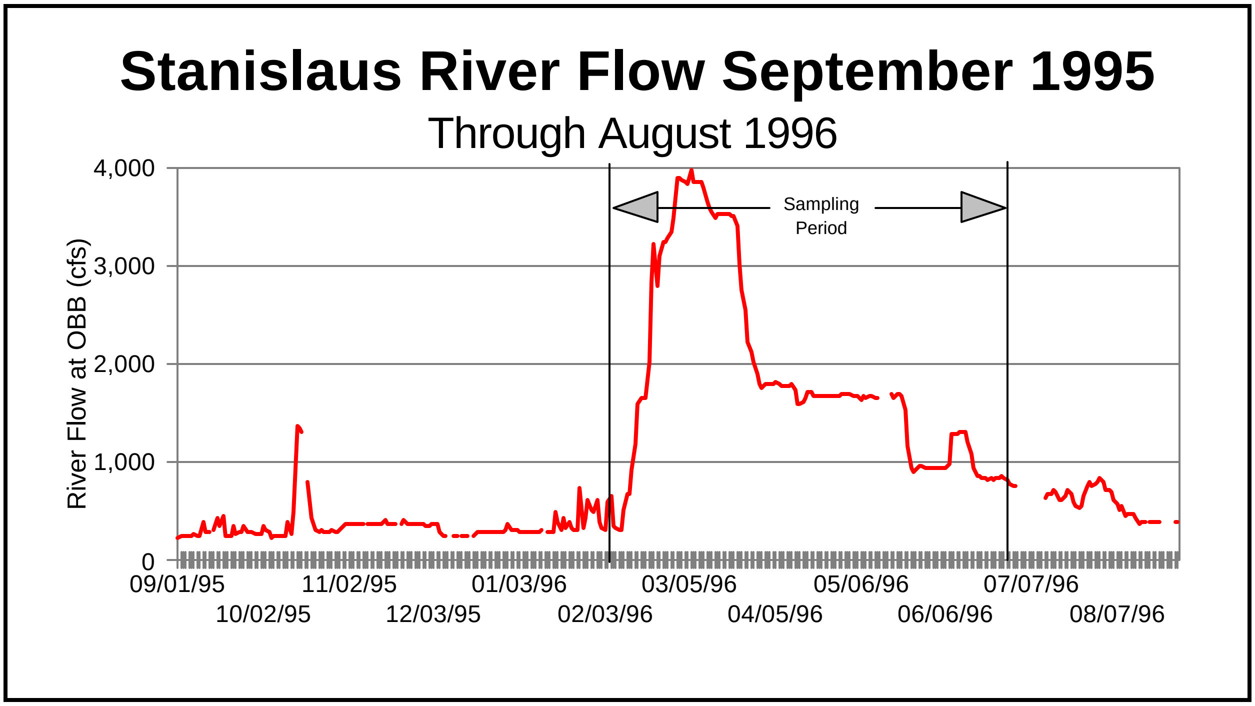


Figure 3. Outmigration sampling period in relation to Stanislaus River flow from September 1995 to August 1996.

During February and March, we measured fork length of a random sample of 30 chinook from each trap twice per week. We measured up to 30 chinook daily from each trap during April through May, and from all fish captured in June. We also measured all rainbow trout/steelhead and all yearling chinook.

During the course of sampling, we moved the traps slightly and modified the trapping location several times. The dates and modification are summarized in Appendix 1. Depth profiles at the Caswell trapping site are given in Appendix 2.

Smolt Appearance Rating

We recorded the external appearance of smolting characteristics for each juvenile chinook and rainbow trout measured. Smolting appearance was rated on a scale of 1 to 3, with 1 an obvious parr and 3 an obvious smolt. We calculated an average smolt appearance rating for each day chinook were rated. Since rating external smolting characteristics is by nature very subjective, we tried to have the same person rate chinook throughout the sampling period. The same person conducted the ratings about 85% of the time, with two other technicians conducting the remaining 15% of the ratings.

TRAP EFFICIENCY TESTS

Release Groups

A total of 15 groups of marked chinook salmon (2 groups of natural migrants and 13 of hatchery origin) were released to estimate trap efficiency between February 14 and June 10 (Table 1). Natural chinook used in mark-recapture experiments had been captured in the screw trap at Oakdale (RM 40). These fish were marked the morning of capture, held, and accumulated for 1-4 days in a net pen at Caswell until there were enough to release (approximately 1,000). We marked natural fish by cold brand and dye inoculation. The CDFG supplied the hatchery fish from the Merced River Fish Facility (MRFF). The hatchery fish were sometimes marked at the hatchery by CDFG and sometimes marked by us. Hatchery fish were always dye inoculated.

Marked hatchery fish were transported to the release site 1/4 mile upstream of the trap by the CDFG on the day of release. When fish were delivered unmarked, they were usually marked the day of arrival and then held 1 - 2 days prior to release. Once marked, fish were transferred to their release site and placed in free-standing net pens in the river where they were allowed to recover at least 6 hours prior to release. The number of fish in each group ranged from 727 to 2,374.

In addition to releasing natural and hatchery fish to estimate trap efficiency, we released one group of 960 marked natural migrants 34 miles upstream near Oakdale on May 4 (Table 1). That group was intended as a pilot test to measure smolt survival and travel time between the Oakdale and Caswell sites.

Table 1. Release data for marked chinook used to test capture efficiency of the rotary screw traps at Caswell State Park during 1996.

Designated Release Group	Release Date	Mark Applied	Mark Type	Fish Stock	Time of Release	Release Location	OBB Flow (cfs)
C 1	Feb 14	dlrn	Brand	Natural	9 pm - 10:30 pm	Caswell	1,179
C 2	Feb 19	drfn	Brand	Natural	9:30 pm - 10:30 pm	Caswell	2,014
C 3	Mar 22	tcbh1	Panjet	Hatchery	10:30 pm - 12:30 am	Caswell	3,413
C 4	Apr 6	dlfh	Brand	Hatchery	10:30 pm - 11:30 pm	Caswell	1,791
C 5	Apr 6	dlrh	Brand	Hatchery	9:30 pm - 10:30 pm	Caswell	1,791
C 6	Apr 6	blfh	Brand	Hatchery	2 pm - 3:00 pm	Caswell	1,791
C 7	Apr 6	blrh	Brand	Hatchery	3 pm - 4:00 pm	Caswell	1,791
C 8	May 2	tcbh2	Panjet	Hatchery	12 am - 1:30 am	Caswell	1,680
C 9	May 2	bcbh1	Panjet	Hatchery	2:30 am - 4 am	Caswell	1,680
C 10	May 4	tcgn	Panjet	Natural	8:00 pm - 9:00 pm	Oakdale*	1,674
C 11	May 10	tcbh3	Panjet	Hatchery	9 pm - 10:30 pm	Caswell	1,667
C 12	May 10	bcbh2	Panjet	Hatchery	11:00 pm - 12:30 am	Caswell	1,667
C 13	May 26	bcbh3	Panjet	Hatchery	9 pm - 10:30 pm	Caswell	921
C 14	May 26	tcbh4	Panjet	Hatchery	11 pm - 12:30 am	Caswell	921
C 15	June 10	bcbh4	Panjet	Hatchery	10:30 pm - 11:30 pm	Caswell	1,279
C 16	June 10	tcbh5	Panjet	Hatchery	11:30 pm - 12:45 am	Caswell	1,279

* Fish released below Oakdale trap for recapture at Caswell to test survival and migration rate from Oakdale to Caswell.
Mark codes describe the type of mark, location applied and origin (hatchery or natural) of fish. "Dot" and "bar" marks are cold brands whereas "top" and "bottom" marks are the locations dyes were injected.
dlrn = dot left rear natural; drfn = dot right front natural; tcbh = top caudal blue hatchery; dlfh = dot left front hatchery; dlrh = dot left rear hatchery; blfh = bar left front hatchery; blrh = bar left rear hatchery; bcbh = bottom caudal blue hatchery; tcgn = top caudal green natural;

Holding Facility and Transport Method

Fish were held in free standing net pens measuring 4 ft x 4 ft x 4 ft and 2 ft x 3 ft x 3 ft. The net pens consisted of 3/16 in. mesh sewn onto frames constructed of ½ in. PVC pipe. The pipe was filled with sand so it would sink and rest on the river bottom. The net pens were located at the release location so fish would not have to be moved at the time of release. The nets were located about 1/4 mile upstream from the trap in an area of low velocity. Plywood was placed on top of the nets to provide shade and protection from predators.

The fish were delivered by the CDFG to Oakdale in a large, aerated transport container. From Oakdale, we transported the fish to the release site at Caswell in 20 gal. insulated coolers. Between 75 and 150 fish were placed in each cooler and transported to Caswell in the bed of a pick-up truck. Depending on circumstances, the total time fish remained in a cooler ranged from 40 to 90 minutes. Water in the coolers was aerated with bottled oxygen during transport and water temperatures remained relatively constant.

Marking Procedure

Juvenile chinook were marked by dye inoculation or cold brand. The first two groups of natural fish released were fry (about 40 mm long) captured in the Oakdale trap. Those fish were too small to inoculate with dye, so we marked them with a cold brand. Branding tools were machined from 4/16 in. welding rod. Each brand was about 8 inches long with insulation at one end functioning as a handle. The marking end was machined to either a "dot" or "bar" approximately 1/16 in. thick. Fish were anesthetized in a mixture of MS-222 (Schoettger and Steucke 1970) before branding. Brands were immersed in liquid nitrogen that was held in insulated containers. To brand a fish, the brand was removed from the liquid nitrogen bath and was held against an anesthetized fish for about one second. After branding, fish were held in net pens for 3 - 4 days to allow the brands to darken prior to release. Any mortalities were removed and counted daily.

We used a MadaJet inoculator to inject Alcian Green and Alcian Blue dyes (Sigma Chemical Company, St. Louis, Missouri) into the fins of hatchery chinook (Hart and Pitcher 1969). The dyes were chosen because of their known ability to provide a highly visible, long lasting mark. Before marking, fish were anesthetized with MS-222 (Schoettger and Steucke 1970). Once anesthetized, fish were inoculated by placing the tip of the inoculator against the top portion of the caudal, dorsal or anal fin. Light pressure was applied as dye was injected into the fin rays. Only one mark was applied to each fish, and fish in each group received the same mark. Location of the mark was varied between groups so that each group could be uniquely identified.

Over the course of the sampling season, we tested the duration each dye remained visible and the effects of marking on mortality. To do this, we marked small groups of fish and held them in a net pen for up to three weeks. Tests were conducted on both natural and hatchery fish. Each time a group of marked fish was held for observation, we also monitored an unmarked control group. Marked fish were held in net pens for as long as 21 days with no loss in mark retention.

Prerelease Sampling

Fish were sampled for mean fork length and brand clarity either the day prior to or the day of release. Fifty fish were randomly removed and anesthetized from each distinctly marked group. Mark clarity was rated as good, present but not identifiable, or absent. “Good” meant the mark was present and identifiable (color if inoculated and "dot" or "bar" if branded). “Present but not identifiable” meant that a mark was present but the color or exact brand symbol was not recognizable. “Absent” meant no mark was evident.

The proportion of fish found to have clear marks in each group was used to estimate the actual number of fish released on February 14, 19, and June 10. These are the only dates that mark retention was estimated to be less than 100%, and it ranged from 98 to 99%. The number of fish released was estimated by the expression:

number released = proportion mark retention * number in group.

Release Procedure

Fish were released directly from the net pens in which they had been held for at least 6 hours. A dip net was used to remove and release about ten fish at a time. We waited from 1 to 5 minutes between releases of each net full, allowing time for fish to swim away before the next release. The time required to release a full marked group ranged from 60 to 120 minutes. This protracted release procedure was intended to prevent the fish from behaving as a single school and to cause them to disperse in time and space as natural migrants would.

MONITORING OF ENVIRONMENTAL FACTORS

Flow Measurements

Daily Stanislaus River flow data was obtained from the California Data Exchange Center (CDEC). All river flows cited throughout this report were measured at the Orange Blossom Bridge (OBB) by the US Geological Survey (USGS). There is also a flow monitoring station at Ripon, and data from the gage is presented in Appendix 3. The flow data are daily averages, so instantaneous flows during freshets were higher. Hourly flow data (at OBB) for the day prior to, day of, and day following each release of marked fish are also presented in Appendix 4. Depth-velocity profiles are given in Appendix 5.

We used two methods to measure the velocity of water entering the trap. First, we measured the water velocity at the time we checked the trap with a Global Flow Probe, manufactured by Global Water (Fair Oaks, CA), beginning February 17. Second, we estimated an average daily trap rotation speed for each trap. The time, in seconds, for one revolution of each trap was recorded every morning. A stopwatch was used to time three separate rotations of each trap.

River Temperature and Turbidity

Water temperature was measured at the trap site each day with a mercury thermometer. An Onset StowAway thermometer also recorded water temperature once per hour. Daily average temperature was derived by averaging the 24 hourly measurements.

Turbidity was measured each day with a LaMotte turbidity meter, Model 2008. A water sample was collected each morning and later tested at the field station. Turbidity was recorded in Nephelometric Turbidity Units (NTU's).

OAKDALE TRAPPING SITE

In addition to the screw traps near Caswell, one screw trap was fished in the Stanislaus River near Oakdale by our same field crew, but under separate contract and research objectives. The Oakdale trap was operated from February 2 to June 8 to determine how juvenile chinook respond to pulse flows, and to measure survival and migration rate in the upper river. Operation procedures at the Oakdale site were similar to those at Caswell, and data obtained at Oakdale were used for comparison to those obtained at Caswell.

DATA REPORTING

For the purpose of consistent data reporting and comparison, we summarized the data on days we performed multiple trap-checks into one daily report. The summarized data is reported each day as the morning, or daily, catch. Therefore, the graphs and tables in this report show only one sample period per day, even when there may have been as many as 12 samples per 24 hour period. Data were summarized from 12:01 pm the previous day to 12:00 pm on the day data were eventually reported. For example, fish that entered the trap at 7 pm on April 24 would have been reported in the catch for April 25. Data for each trap-check (non-summarized) is presented in Appendices 6 and 7.

FINDINGS

OBJECTIVE 1: ESTIMATE THE NUMBER OF JUVENILE CHINOOK MIGRATING OUT OF THE STANISLAUS RIVER IN 1996.

Trap Catches of Chinook

From February 6 to July 1, we captured a total of 2,468 juvenile chinook, with peak catches occurring in late April and early May (Figure 4). Although the seasonal pattern of catches was similar between the two traps fishing at Caswell, the south trap generally captured more juvenile chinook than the north trap (Figure 5). The total catch for the season was 1,673 chinook in the south trap and 795 chinook in the north trap. We did not operate the traps 5 days during the 147 day sampling period due to heavy debris loads. The traps were pulled up February 20 and began fishing again on February 22. The traps were pulled up again on March 2 and began fishing again on March 5.

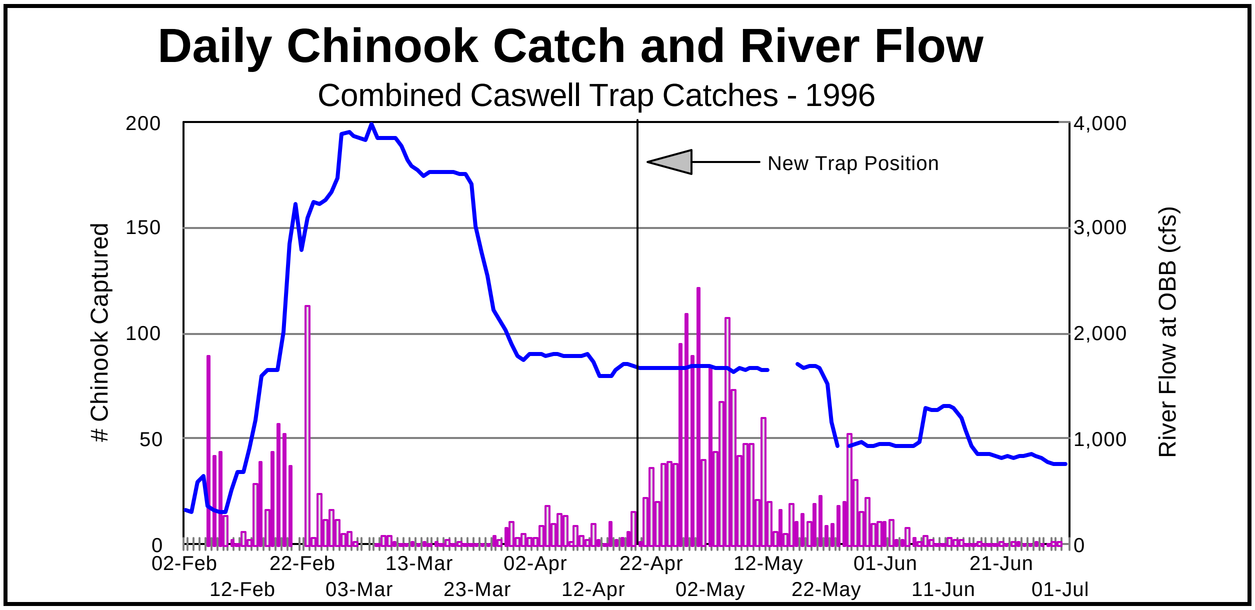


Figure 4. Total daily chinook catch from north and south traps at Caswell and Stanislaus River flow at Orange Blossom Bridge (OBB) during 1996. ["New Trap Position" marks the day (April 20) the traps were moved upstream 50-100 ft in an attempt to increase trapping efficiency.]

We conducted a paired-sample t-test on ln(catch + 1)[1] and determined that the daily mean catch in the south trap was in fact significantly higher than that in the north trap ($t = 5.04$, d.f. = 20, $P = 0.0001$). The daily mean count in the north trap was 5.6 chinook/day compared to 11.8 chinook/day in the south trap.

1 *For the data transformation ln(catch + 1), "ln" represents natural log. The catch data-base was the total catch over seven-day periods to minimize the occurrence of zero counts. The transformation was applied to catch + 1 because, even using the seven-day totals, there were still four zero counts, all associated with the north trap. (It is not possible to take the log of zero counts.)*

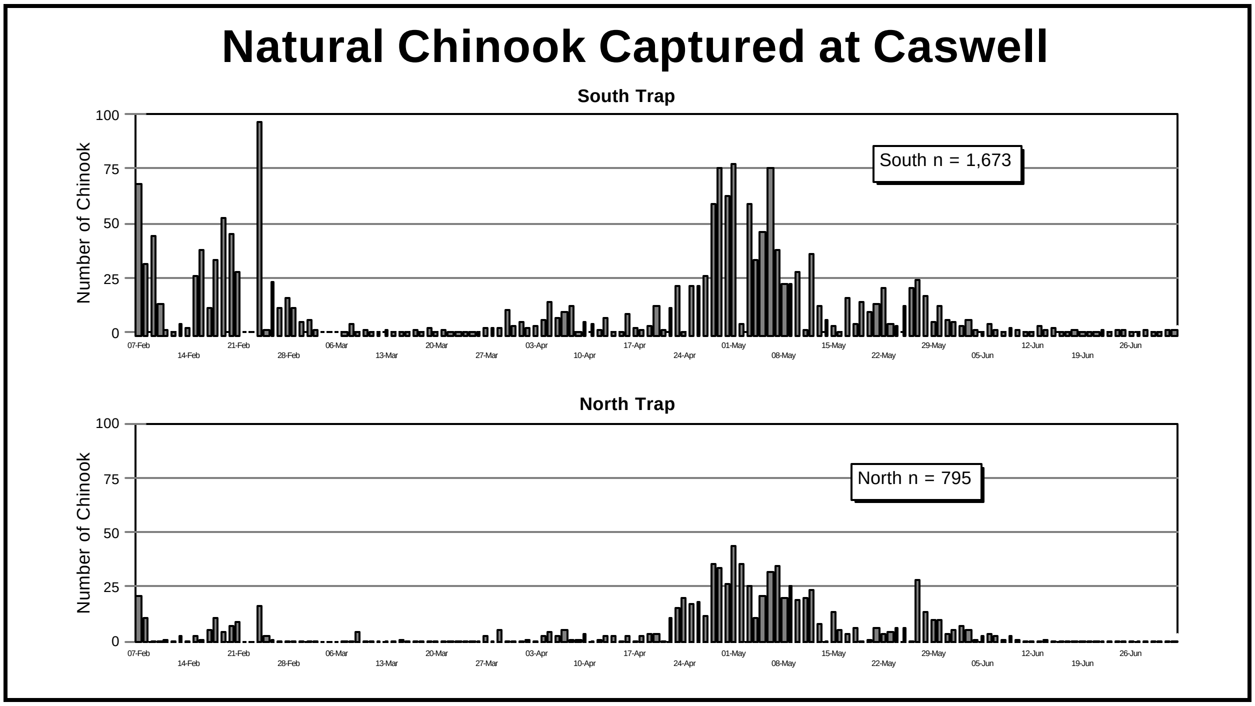


Figure 5. Daily chinook catch in the north and south Caswell traps during 1996, uncorrected for trap efficiency.

Since the catch differed between the traps, we did not combine traps catches until we also determined to what extent the two traps caught different sizes of fish. We compared the lengths of chinook captured in each trap during the seven-day periods using a weighted[2] paired-sample t-test. No significant difference between the mean size of fish caught at the two traps (t = 0.89, d.f. = 14, P = 0.39) was found.

2 *The weight was the harmonic mean of the numbers of fish measured in the north and south traps. This harmonic mean is referred to as the effective number and is used to partially account for variation in sample size between traps and among seven-day periods.*

Capture Efficiency

We made 15 releases of marked fish to test capture efficiency over a range of stream flow and environmental conditions. The number and frequency of these releases was limited by catches of natural migrants and the availability of hatchery fish. The percentages of marked fish recovered in both traps combined varied from 0% to 12.08% (Table 2). The zero percentages were associated with the only day-time releases made. Although there was some post-marking mortality, it occurred either within hours of marking or after about 14 days. We observed the same pattern of mortality during our tests in 1995. Marked fish that died soon after marking were not released and were subtracted from the number marked.

Table 2. Number and percentages of recoveries in the screw traps at Caswell for all mark-recapture experiments. Table includes a non-efficiency-test release (May 4) at Oakdale (River Mile 40.1) that was not included in the release vs recovery size comparison.

Release Date	Fish Stock	Release Location	Mark Retention	# Released	# Recaptured	% Recaptured	OBB Flow (cfs)
Feb 14[1]	Natural	Caswell	0.99	1324	160	12.08	1179
Feb 19[1]	Natural	Caswell	0.98	1078	61	5.66	2014
Mar 22	Hatchery	Caswell	1	1097	15	1.37	3413
Apr 6	Hatchery	Caswell	1	746	22	2.95	1791
Apr 6	Hatchery	Caswell	1	748	8	1.07	1791
Apr 6	Hatchery	Caswell	1	727	0	0	1791
Apr 6	Hatchery	Caswell	1	748	0	0	1791
May 2	Hatchery	Caswell	1	1979	151	7.63	1680
May 2	Hatchery	Caswell	1	1990	88	4.42	1680
May 4[2]	Natural	Oakdale	1	960	2	0.21	1674
May 10	Hatchery	Caswell	1	2242	50	2.23	1667
May 10	Hatchery	Caswell	1	2341	59	2.52	1667
May 26	Hatchery	Caswell	1	2374	159	6.7	921
May 26	Hatchery	Caswell	1	2298	125	5.44	921
June 10[1]	Hatchery	Caswell	0.99	1559	43	2.76	1279
June 10[1]	Hatchery	Caswell	0.99	1981	59	2.98	1279

[1] February 14 and 19 and June 10 release totals adjusted for mark retention. All release groups were evaluated for mark retention prior to release.

[2] May 4 group released below Oakdale to test survival from Oakdale to Caswell.

The origin of fish, time of day when fish were released, river flow and turbidity, and size of fish varied between efficiency tests (Appendix A). The first release was conducted on February 14 and the last on June 10. Thirteen of the 15 groups released for trap efficiency tests were hatchery fish and 2 groups were natural migrants captured at Oakdale (Table 2). Two groups were released during middle of the day, and all others were released after dark. Fish were released at river flows ranging from 921 cfs to 3,413 cfs and had mean lengths per release ranging from 33.8 mm to 91.6 mm (Table 3 and Appendix 8).

To determine if the traps were size selective, we compared pre-release mean lengths of sampled chinook to the length of fish sampled at recapture (Figure 6; Appendix 9) using chinook released as part of the trap-efficiency test. A paired-sample t-test was conducted to determine whether there was statistical evidence of a mean difference in lengths at release and recovery. The mean difference was not significantly different than zero at the 10% significance level (P = 0.16, Table 3).

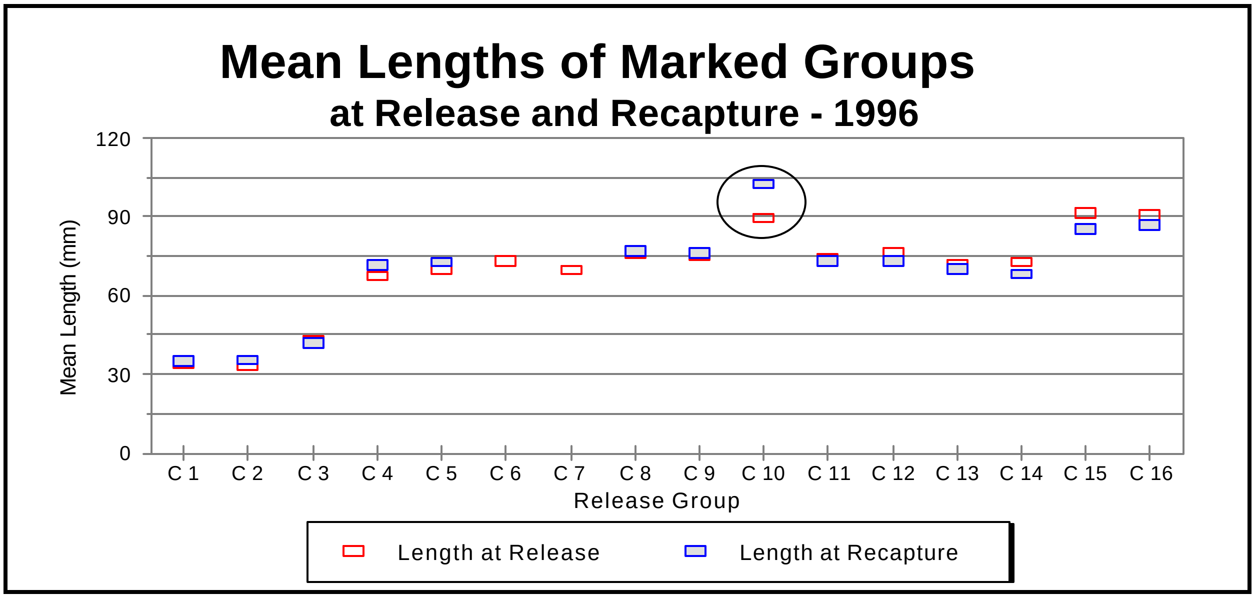


Figure 6. Mean lengths at release and Caswell recapture (circled group, released below Oakdale trap, was not part of trap efficiency test).

Table 3. Mean length (mm) of marked groups at release and at recapture for all trap efficiency tests.

		Number Measured		Mean Length		
Date	Source	At Release	At Recapture	At Release	At Recapture	Difference
14-Feb	Natural	30	62	34.3	35.2	0.9
19-Feb	Natural	30	56	33.8	35.5	1.7
22-Mar	Hatchery	30	15	42.7	41.8	-0.9
06-Apr	Hatchery	30	22	67.4	71.6	4.2
06-Apr	Hatchery	30	8	70.2	72.9	2.7
06-Apr[1]	Hatchery	30	--	73.2	--	--
06-Apr[1]	Hatchery	30	--	69.7	--	--
02-May	Hatchery	30	30	76.1	76.7	0.6
02-May	Hatchery	30	30	75.5	75.9	0.4
10-May	Hatchery	30	50	74.2	73.4	-0.8
10-May	Hatchery	30	55	76.1	72.9	-3.2
26-May	Hatchery	30	60	71.7	69.9	-1.8
26-May	Hatchery	30	65	72.7	68.2	-4.5
10-Jun	Hatchery	30	43	91.6	85.5	-6.1
10-Jun	Hatchery	30	56	90.5	86.8	-3.7
					weighted[2] mean difference =	1.20
					standard error =	0.804
					t-ratio (12 d.f.) =	1.49

1 Releases excluded from the mean computation due to no recoveries
2 Weights are harmonic means of numbers of measured released and recovered fish

In order to predict the capture efficiency for each day of the sampling season, we needed to relate the efficiency (response variable) estimated in each of our tests to a predictor variable that was measured on every day that the screw traps were operating. Since efficiency is expressed as a proportion, we used simple logistic regression to predict the trapping efficiency from the predictor variable. We examined the following six predictor variables:

1 - daily flow in cubic-feet/second (cfs) on the day of release;

2 - turbidity (NTU) measured on the morning following release;

3 - time per screw-trap-revolution (time/revolution) measured on the morning following the release (data in Appendixes 10 and 11) ;

4 - average water velocity in feet/second (f/s) on the morning following release (Appendixes 12 and 13);

5 - length of fish (mm) (see Appendix A for complete discussion); and

6 - trap position indicator (the trap was moved upstream part way through the sampling period, indicator variable = 1 for upstream and 0 for downstream position).

Simple logistic regression coefficients significantly differed from 0 for turbidity (P = 0.018), flow (P = 0.077), and water velocity (P = 0.094). Regression coefficients were not significant (P > 0.1) for any of the other predictor variables.

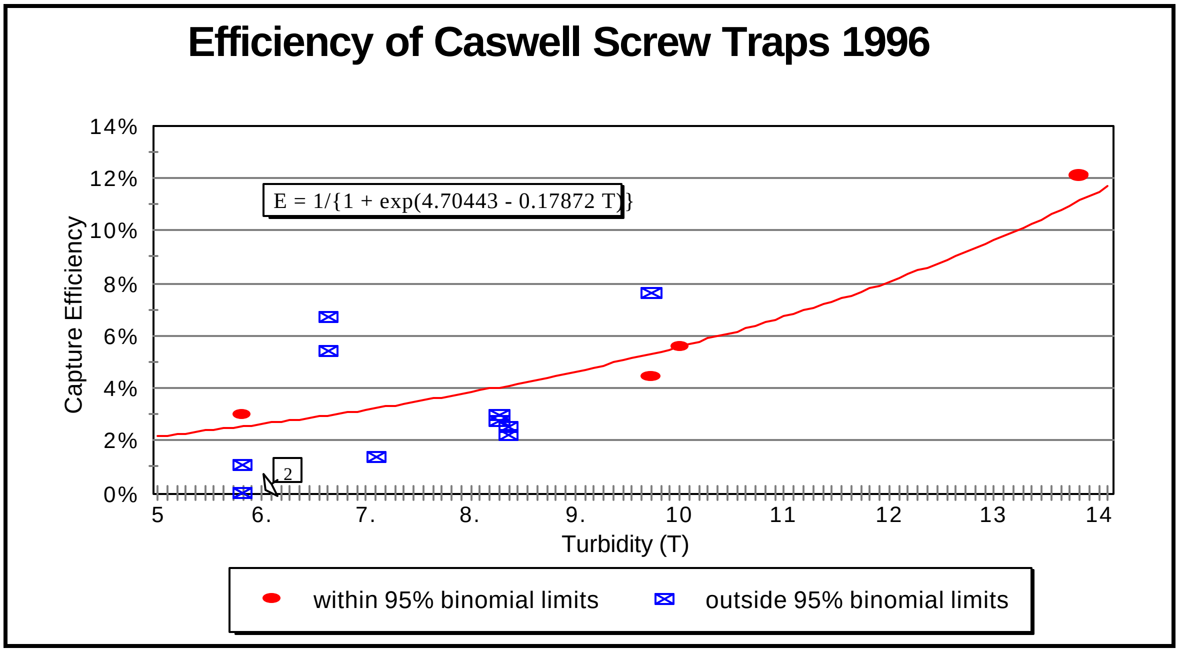
For reasons discussed in Appendix A, we focused on turbidity and flow as predictor variables. Even for the simple logistic regressions based on these variables, the fit was poor (Figure 7). As indicated in the figure, most of the efficiency estimates fell outside the binomially-based approximate confidence intervals for both turbidity and flow-based predictors (Appendix A). Therefore, we investigated the effects of removing unusually small or unusually large data points:

! Unusually high turbidity: For the release groups, the highest efficiency (0.121 for fish released February 14 and recovered February 15) was almost double the second highest efficiency of 0.076, and that highest efficiency occurred on a recovery day of high turbidity (14.7 NTU on February 15). Only two other days had turbidities this high, and those were adjacent days (February 14 and 16). The unusually high turbidity associated with the high trapping efficiency contributed to the level of significance of fit on turbidity, but it also contributed to the greatest outlier in the fit on flow (Figure 7). Since this turbidity reading was unusual, regressions were run that excluded the 14 February release. The fit based on turbidity was considerably better than that based on flow when the February 14 release was included, but the turbidity fit was slightly poorer when that release was excluded than when included (Appendix A).

! Releases with no recoveries: The two estimated efficiencies of zero were associated with the only day-time releases (both on April 6). These zero efficiencies were the greatest outliers in the fit on turbidity (Figure 7). When the two daytime releases were excluded, the fit on turbidity improved dramatically (although it was still poor), but the fit for flow changed little (Appendix A).

Since there was no a-priori reason for excluding the high-turbidity-day data set, it was retained. The day-time releases that yielded no recoveries were also retained. With trapping-efficiency rates apparently differing depending on whether fish were passing during the day or night, it would be preferable to stratify, expanding day-time and night-time counts using different trapping efficiency predictors to obtain outmigration indices. However, this was not possible because the only two day-time releases produced no recoveries, and dividing (expanding) the day-time count by a zero-efficiency estimate is not possible. Therefore the day-time and night-time releases were both used to obtain a common efficiency predictor. If that predictor were used to expand day-time counts, it would likely produce under-estimates of outmigration; and if used to expand night-time counts, it would probably produce over-estimates. Instead, the efficiency fits, using all 15 Caswell releases, were used to expand twenty-four-hour counts to obtain the daily outmigration index, and the overall direction of the bias is unknown.

The generally poor precision for predicting efficiency was probably not due to the statistical procedure used. Logistic regression based on flow was also used on data for Oakdale. The resulting fit was very good (Figure 8). However, the average trapping efficiency at Oakdale (14.7%) was about four times greater than that at Caswell (3.8%). The Oakdale site may be a better evaluation site than the Caswell site from the standpoint of statistical precision because there may be a greater relative sampling variability associated with lower efficiencies (which were realized at the Caswell site) than with higher efficiencies (which were realized at the Oakdale site).



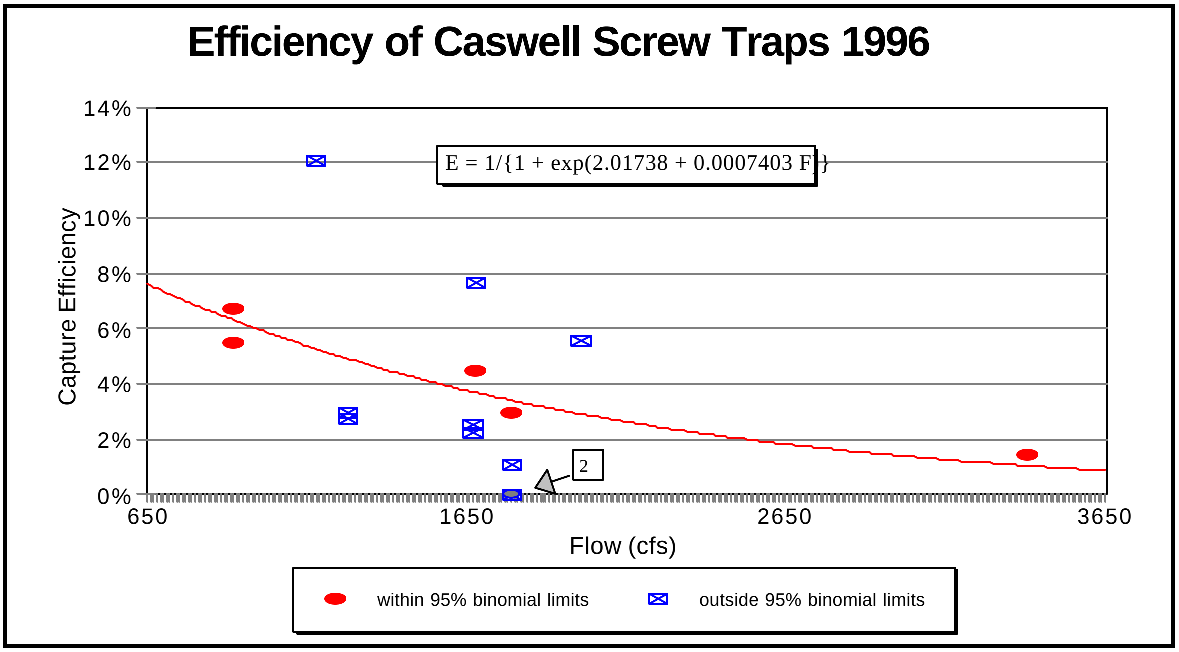


Figure 7. Relation between actual estimates and predictions of mark-recapture efficiencies at Caswell site based on turbidity (top graph) and river flow (bottom graph). Data and regression from Appendix A.

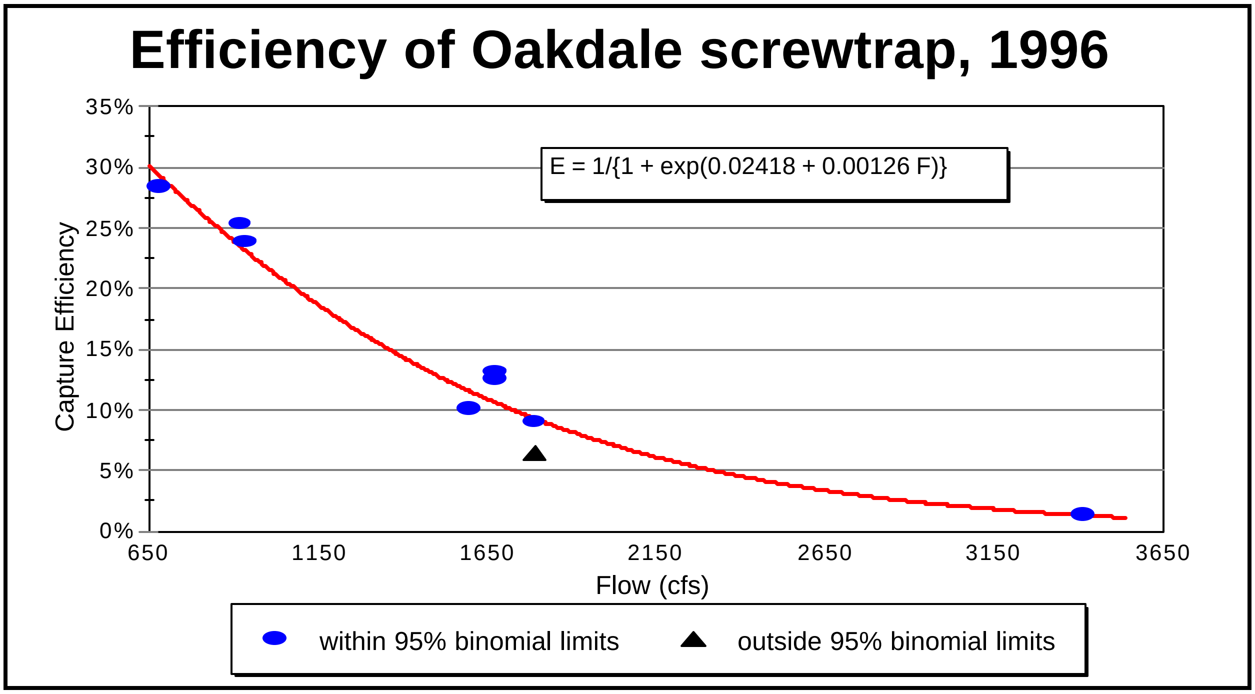


Figure 8. Relation between actual estimates and predictions of mark-recapture Oakdale efficiencies based on river flow (Appendix A; Demko and Cramer 1997).

Estimated Outmigrant Abundance

The abundance of juvenile chinook passing the Caswell trap site each day was estimated by dividing the daily catch of chinook in the two traps (count) by the predicted capture efficiency:

$$\text{Daily Outmigrants} = \frac{\text{Count}}{\text{Efficiency}}$$

The estimates[3] are given in Table 4. Capture efficiency for each day was predicted from logistic regression on turbidity. Values for the predictor variables were missing on some days, and those values were interpolated in a manner described in Appendix A.

Table 4. Number of chinook captured and estimated number of chinook passing the Caswell trapping site from February 6 through July 1, 1996.

Date	Orange Blossom Bridge Flow (cfs)	Chinook Adjusted Catch	Efficiency	Estimated Daily Passage
Feb 6	355	89	0.09	959
Feb 7	320	42	0.10	442
Feb 8	306	44	0.10	459
Feb 9	300	13	0.10	135
Feb 10	516	2	0.08	24
Feb 11	678	0	0.07	0
Feb 12	681	6	0.07	81
Feb 13	913	2	0.06	32
Jan 14	1179	28	0.05	532
Feb 15	1595	29	0.04	739
Feb 16	1648	16	0.04	423
Feb 17	1652	44	0.04	1,168
Feb 18	1650	57	0.04	1,511
Feb 19	2014	52	0.03	1,788
Feb 20	2841	37	0.02	2,316
Feb 21	3223	25 *	0.01	2,046
Feb 22	2797	9 *	0.02	570
Feb 23	3093	113	0.01	8,501
Feb 24	3245	3	0.01	252
Feb 25	3232	24	0.01	1,999
Feb 26	3271	11	0.01	943
Feb 27	3341	16	0.01	1,443
Feb 28	3481	11	0.01	1,099
Jan 29	3894	5	0.01	677
Mar 1	3897	6	0.01	814
Mar 2	3866	1	0.01	133

3 *Standard errors of the daily outmigration estimates and estimates of cumulative outmigration over days along with their standard errors are given in Appendix A.*

Date	Orange Blossom Bridge Flow (cfs)	Chinook Adjusted Catch	Efficiency	Estimated Daily Passage
Mar 3	3856	3 *	0.01	413
Mar 4	3836	2 *	0.01	216
Mar 5	3975	2 *	0.01	261
Mar 6	3850	0	0.01	0
Mar 7	3847	4	0.01	523
Mar 8	3842	4	0.01	521
Mar 9	3849	1	0.01	131
Mar 10	3782	0	0.01	0
Mar 11	3641	0	0.01	0
Mar 12	3584	1	0.01	108
Mar 13	3552	0	0.01	0
Mar 14	3489	1	0.01	101
Mar 15	3529	0	0.01	0
Mar 16	3524	1	0.01	103
Mar 17	3519	0	0.01	0
Mar 18	3530	2	0.01	207
Mar 19	3522	0	0.01	0
Mar 20	3503	1	0.01	102
Mar 21	3509	0	0.01	0
Mar 22	3413	0	0.01	0
Mar 23	3010	0	0.01	0
Mar 24	2761	0	0.02	0
Mar 25	2539	0	0.02	0
Mar 26	2226	4	0.03	160
Mar 27	2125	2	0.03	75
Mar 28	2024	7	0.03	242
Mar 29	1896	10	0.03	316
Mar 30	1790	3	0.03	88
Mar 31	1748	5	0.04	142
Apr 1	1794	3	0.03	88
Apr 2	1791	3	0.03	88
Apr 3	1794	8	0.03	235
Apr 4	1788	18	0.03	526
Apr 5	1809	9	0.03	267
Apr 6	1791	14	0.03	410
Apr 7	1780	13	0.03	378
Apr 8	1779	1	0.03	29
Apr 9	1775	8	0.03	232
Apr 10	1776	4	0.03	116
Apr 11	1791	2	0.03	59
Apr 12	1731	9	0.04	253

Date	Orange Blossom Bridge Flow (cfs)	Chinook Adjusted Catch	Efficiency	Estimated Daily Passage
Apr 13	1598	2	0.04	51
Apr 14	1595	0	0.04	0
Apr 15	1599	10	0.04	256
Apr 16	1656	2	0.04	53
Apr 17	1706	3	0.04	83
Apr 18	1711	6	0.04	166
Apr 19	1679	15	0.04	406
Apr 20	1670	1	0.04	27
Apr 21	1675	22	0.04	594
Apr 22	1673	36	0.04	970
Apr 23	1668	20	0.04	537
Apr 24	1673	38	0.04	1,024
Apr 25	1676	39	0.04	1,053
Apr 26	1676	38	0.04	1,026
Apr 27	1662	95	0.04	2,540
Apr 28	1668	109	0.04	2,926
Apr 29	1684	89	0.04	2,417
Apr 30	1683	121	0.04	3,283
May 1	1684	40	0.04	1,086
May 2	1680	84	0.04	2,275
May 3	1659	44	0.04	1,174
May 4	1674	67	0.04	1,806
May 5	1662	107	0.04	2,860
May 6	1640	73	0.04	1,921
May 7	1664	42	0.04	1,124
May 8	1650	47	0.04	1,246
May 9	1663	47	0.04	1,257
May 10	1667	21	0.04	563
May 11	1653	60	0.04	1,594
May 12	1644	20	0.04	528
May 13	1,662 *	6	0.04	160
May 14	1,668 *	16	0.04	430
May 15	1,673 *	5	0.04	135
May 16	1,673 *	19	0.04	512
May 17	1698	10	0.04	274
May 18	1658	14	0.04	373
May 19	1693	10	0.04	273
May 20	1697	19	0.04	521
May 21	1670	23	0.04	618
May 22	1525	8	0.04	194
May 23	1151	9	0.05	168

Date	Orange Blossom Bridge Flow (cfs)	Chinook Adjusted Catch	Efficiency	Estimated Daily Passage
May 24	936	18	0.06	289
May 25	901	20	0.06	313
May 26	921	52	0.06	825
May 27	955	30	0.06	487
May 28	958	15	0.06	244
May 29	935	22	0.06	352
May 30	935	9	0.06	144
May 31	939	10	0.06	161
Jun 1	945	10	0.06	161
Jun 2	939	11	0.06	177
Jun 3	933	2	0.06	32
Jun 4	936	2	0.06	32
Jun 5	933	7	0.06	112
Jun 6	929	3	0.06	48
Jun 7	976	1	0.06	16
Jun 8	1281	4	0.05	82
Jun 9	1275	2	0.05	41
Jun 10	1279	0	0.05	0
Jun 11	1300	0	0.05	0
Jun 12	1308	3	0.05	62
Jun 13	1292	2	0.05	41
Jun 14	1200	2	0.05	39
Jun 15	1077	0	0.06	0
Jun 16	928	0	0.06	0
Jun 17	848	1	0.07	15
Jun 18	850	0	0.07	0
Jun 19	844	0	0.07	0
Jun 20	829	0	0.07	0
Jun 21	821	1	0.07	15
Jun 22	833	0	0.07	0
Jun 23	811	1	0.07	15
Jun 24	825	1	0.07	15
Jun 25	842	0	0.07	0
Jun 26	852	0	0.07	0
Jun 27	831	1	0.07	15
Jun 28	815	0	0.07	0
Jun 29	776	0	0.07	0
Jun 30	757	1	0.07	14
Jul 1	752	1	0.07	14

* Missing value substitutions. Methods of adjustment given in the Appendix A. Associated daily passage estimates not given in figures of daily passage

The estimated total number of outmigrants passing Caswell from February 6 through July 1 was 71,000 chinook with an approximate 95% confidence interval of 43,000 to 100,000 (Figure 9). (If we had used flow to predict trap efficiency, the estimate would have been 78,000 chinook with a much wider approximate 95% confidence interval of 26,000 to 130,000.) Methods for approximating standard errors used in confidence intervals are discussed in Appendix A. The approximate confidence intervals for daily passage were large, encompassing impossibly negative lower limits through nearly half of the passage period (Appendix A).

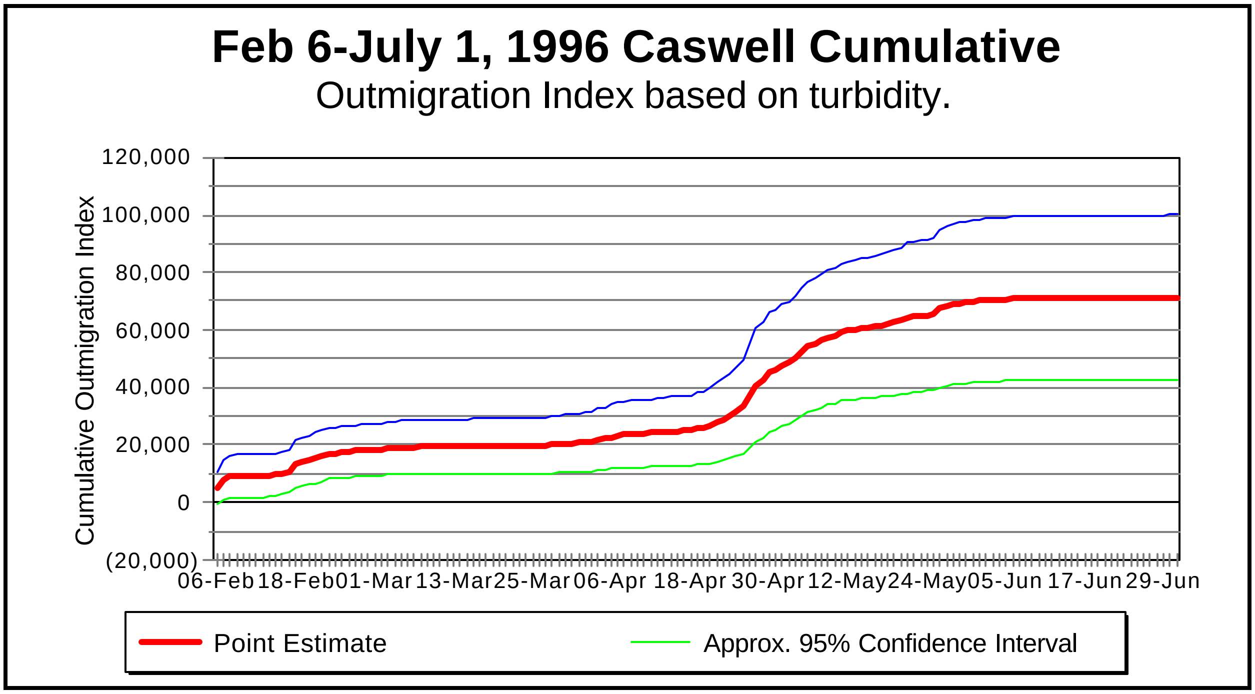


Figure 9. Estimates and 95% confidence intervals of cumulative migration index of juvenile chinook passing the Caswell trapping site from February 6 through July 1, 1996 [Appendix A].

Daily fluctuations in abundance estimated at the Oakdale site at River Mile 40, 34 miles upstream of the Caswell site, indicate that major peaks and troughs in abundance at the Caswell site are associated with those at Oakdale (Appendix A). Daily estimates of chinook abundance at the Oakdale site were positively correlated with daily estimates at the Caswell site (Appendix A). Trapping efficiency was substantially higher at Oakdale than at Caswell, and the regression using flow to predict capture efficiency at Oakdale supplied a substantially more precise cumulative outmigration index than the regression using turbidity at Caswell (Figure 10 versus Figure 9). The timing of peaks in outmigration were similar between the two sites, particularly after mid-April when the fish reached smolt size. The lag-time correlations between the two location's count data and between their outmigration indices (Appendix A) indicate that the maximum correlation is near or on the same day; the maximum correlation r = 0.53) between the outmigrant indices occurs when the estimates at Oakdale are correlated with the same day's estimates at Caswell (lag = 0 days). Again, the Oakdale site may be a better evaluation site than the Caswell site because of the better statistical precision associated with Oakdale's higher trapping efficiencies.

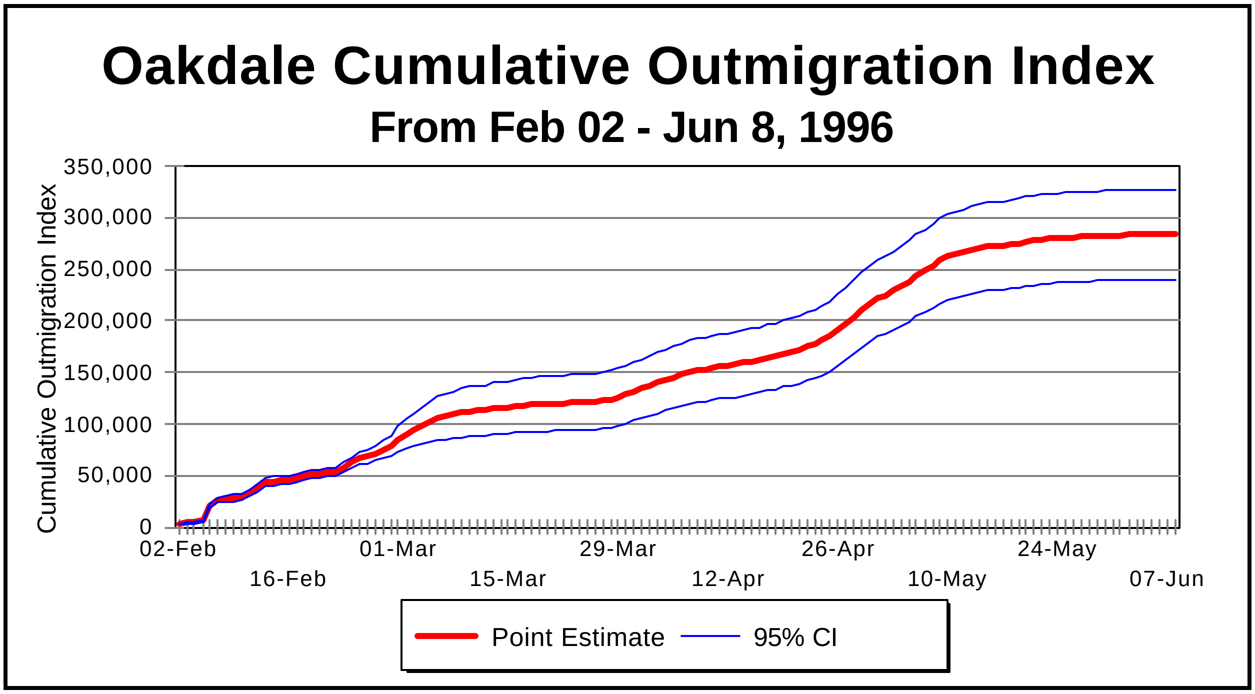


Figure 10. Estimate and 95% confidence bands for the cumulative number of juvenile chinook passing the Oakdale (RM 40) trapping site, February 2 through June 8, 1996. [Appendix A; Demko and Cramer (1997)].

The differences in estimated abundance between the Oakdale and Caswell sites suggest there is a high rate of mortality of juvenile chinook as they migrate the 34 miles from Oakdale to Caswell. The flow-based estimated number of juvenile chinook passing Oakdale between February 2 and June 8 was 284,000 (approximate 95% confidence interval: 240,000 to 327,000), compared to the earlier mentioned turbidity-based estimate of 71,000 chinook passing Caswell between February 6 and July 1 (approximate 95% confidence interval: 43 thousand to 100 thousand).

We also captured a variety of non-salmonid fishes throughout the sampling season. These fish were identified to the lowest taxonomic level that was readily distinguishable. Fish were counted, and subsamples were measured. All data on these fish are presented in

Appendixes 14-17.

OBJECTIVE 2: DETERMINE THE SIZE AND SMOLTING CHARACTERISTICS OF JUVENILE CHINOOK AND RAINBOW/STEELHEAD MIGRATING OUT OF THE STANISLAUS RIVER.

Length at Outmigration

The mean fork lengths of chinook varied considerably over the course of sampling, ranging from less than 40 mm during the first two weeks of sampling to around 100 mm in late May and June (Figure 11). Mean lengths were generally below about 50 mm until March 26, when there was a sudden increase in mean length to 77.5 mm as catches in the screw traps began to increase (Figure 12; Appendix 18). The sharp increase in length coincided with a sharp drop in flow (Figure 12), but not with a sharp change in number of migrants. The drop in flow may have caused some movement of rearing fish as the physical characteristics of their rearing area changed. The mean lengths of fish captured at Caswell were very similar to the mean lengths of fish captured at Oakdale (Figure 12; Appendix 19), which indicates that chinook generally were not pausing to rear for extended periods between RM 40 and RM 6.

During the entire sampling season, we captured only 4 rainbow/steelhead at Caswell (Figure 13). Two of the rainbow/steelhead were captured the first day of sampling, February 6, and measured 260 and 275 mm. Both fish displayed advanced smolting characteristics and were rated as "3" on our index scale (Figure 13). The other two rainbow trout/steelhead were captured February 19 and June 6 and measured 34 and 94 mm, respectively. In addition to the 4 rainbow/steelhead captured at Caswell, 13 were captured upstream at Oakdale (Appendix 20).

We did not capture any yearling chinook at Caswell during 1996. Four yearling chinook were captured at Oakdale between early February and early April, and they ranged in size from approximately 150 to 250 mm.

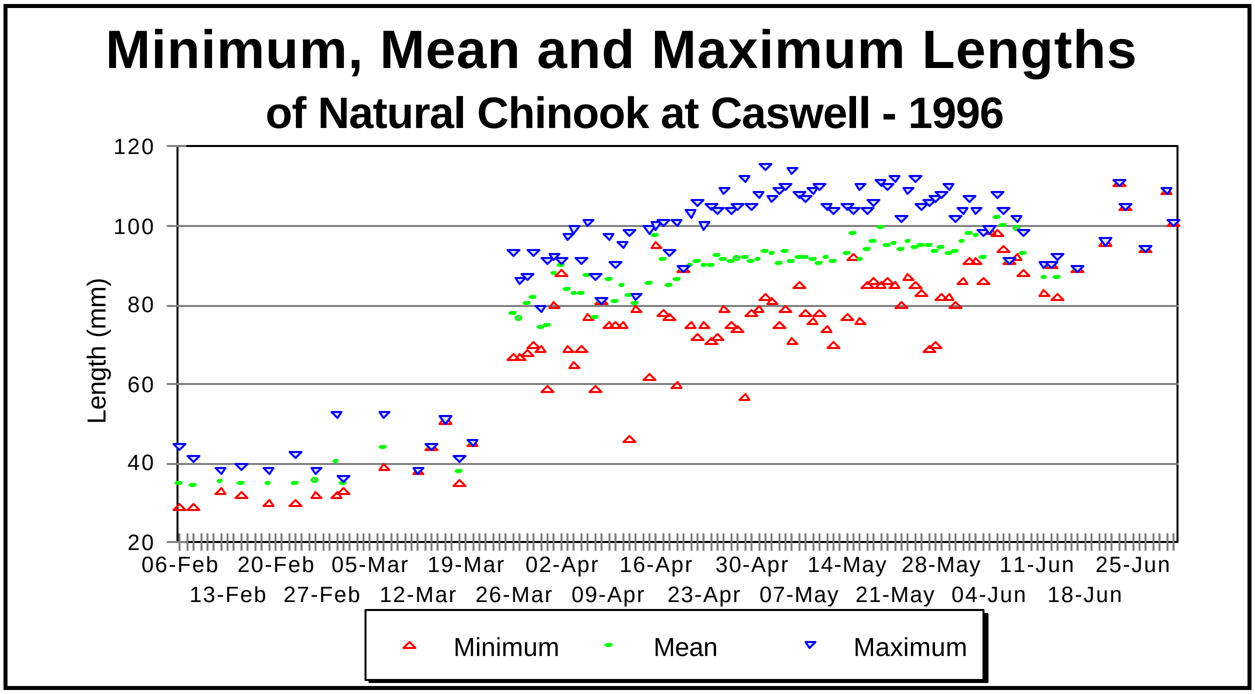
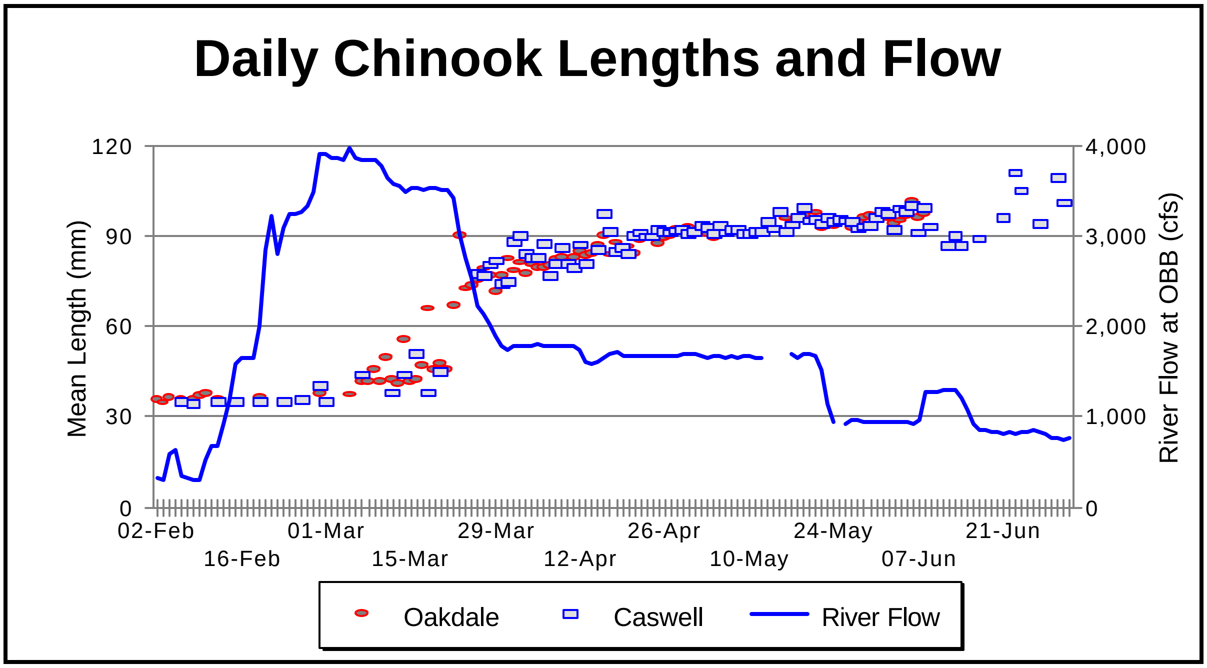


Figure 11. Minimum, mean and maximum lengths of juvenile chinook on the days chinook were measured. During the early part of sampling we were measuring juvenile chinook twice per week. In late March we began measuring chinook every day. Mean lengths for each trap are in Appendix 7.



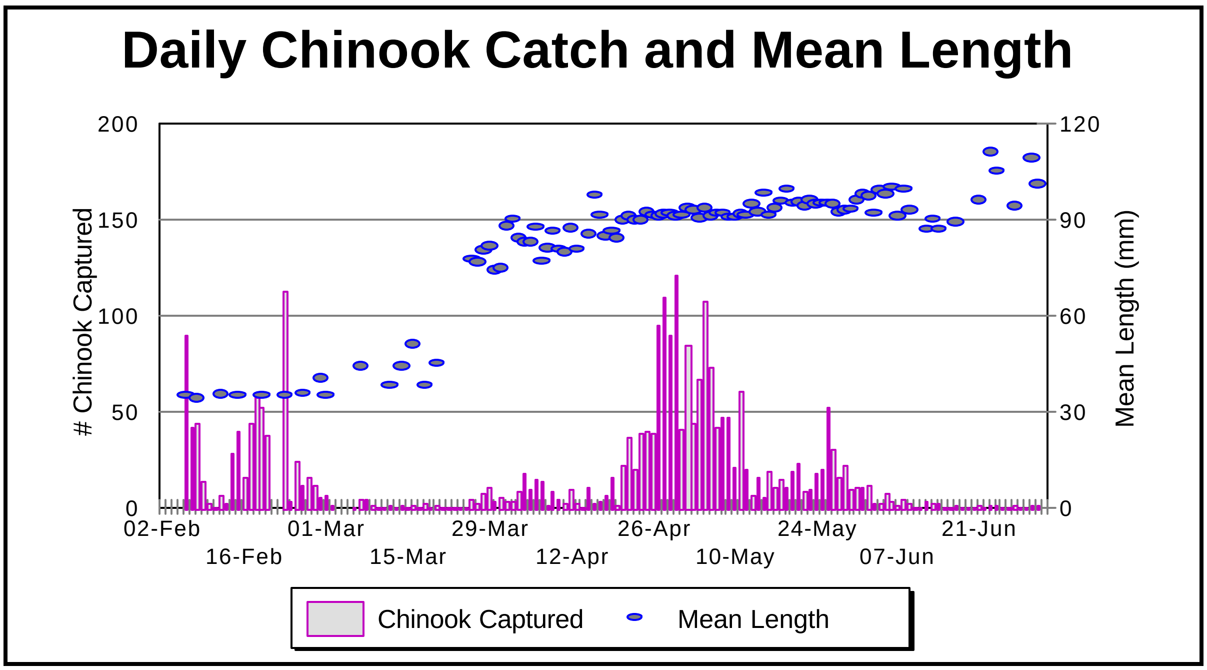


Figure 12. Daily chinook catch and mean lengths at Caswell compared to mean lengths at Oakdale and river flow at OBB.

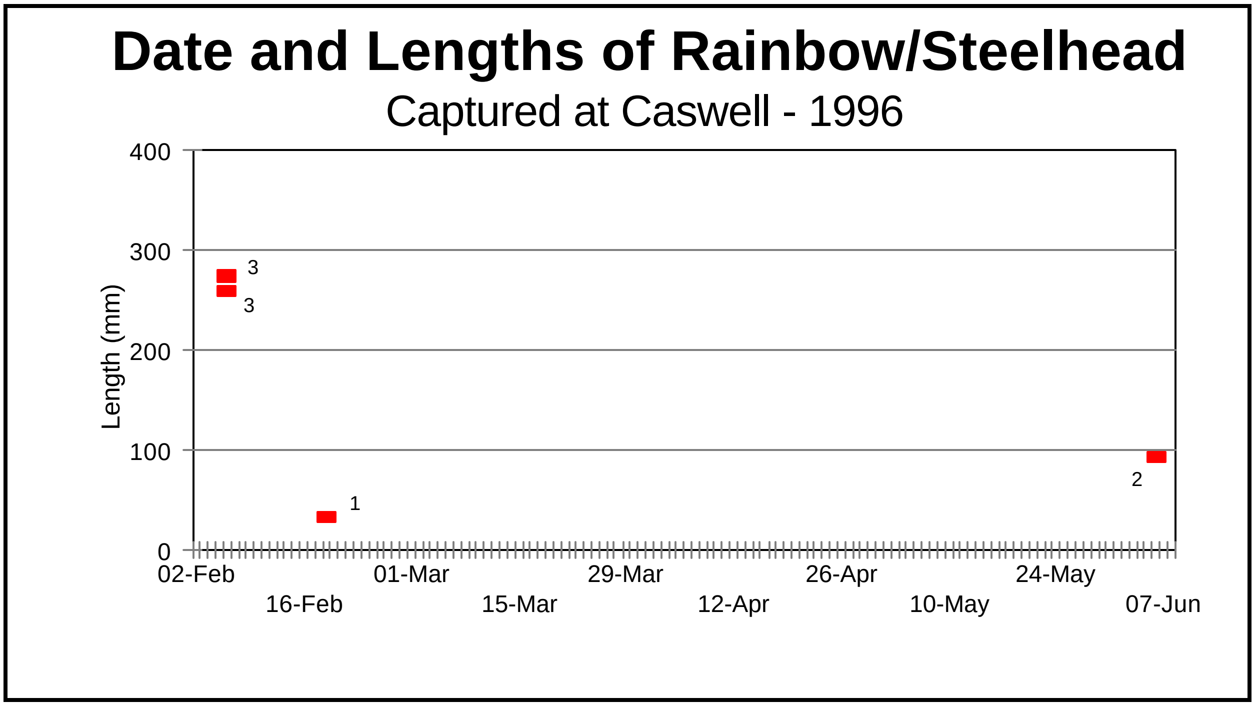
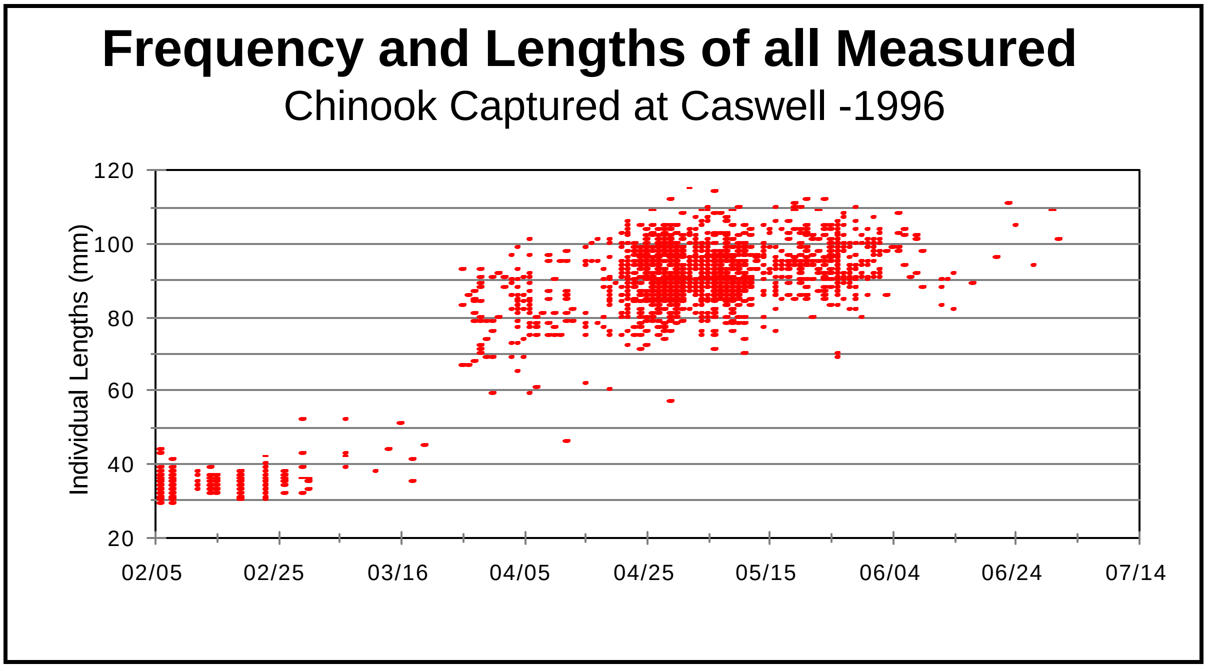


Figure 13. Fork lengths of rainbow trout/steelhead at date of captured at Caswell during 1996. Numbers next to data points indicate the smolt appearance rating for each fish captured. See Appendix 20 for Caswell and Oakdale rainbow trout/steelhead data.

Because there was a dramatic shift in the size of fish captured after March 25, we calculated separate length-frequency distributions for fish measured before and after that date (Figure 14). Those distributions clearly show that chinook passing Caswell were either newly emerged fry (31-40 mm) or they were smolts (primarily 81-100 mm)(Figure 14; Appendix 21). Thus, if fish did not emigrate immediately as fry, they remained to rear until they had reached the smolt size. The distinct bimodal distribution of outmigrant sizes may have been related to flows being high and relatively constant at 1,700-1,800 cfs from March 29 through May 21. If flows had fluctuated, the fluctuations might have stimulated fish to migrate at a variety of sizes, as was found at Oakdale in 1995 (Demko and Cramer 1996). The daily estimates of outmigrant abundance at Caswell in 1996 indicated that 27% of migrants were fry that passed before March 25, and 73% were smolts that passed after March 25. Large numbers of fry probably passed the site before the start of trapping on February 6, because our catches of fry were highest on the first day of sampling.

Smolt Appearance Index

The external appearance of smolt characteristics among fish captured in the trap increased substantially beginning March 26 (Figure 15 and Appendix 22). On only one occasion prior to March 26 was the daily smolt index value greater than 1. After March 26, the daily value fluctuated between 2 and 3 for the rest of the sampling season.



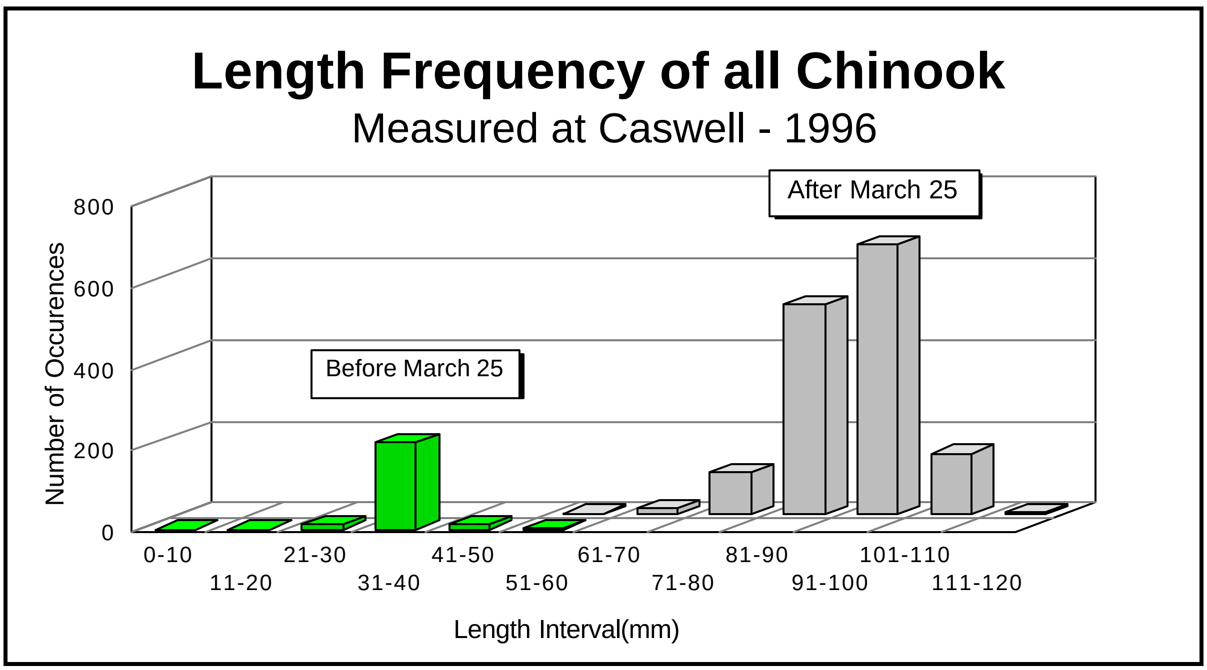


Figure 14. Scatter plot and length frequency histogram of all chinook measured at Caswell in 1996.

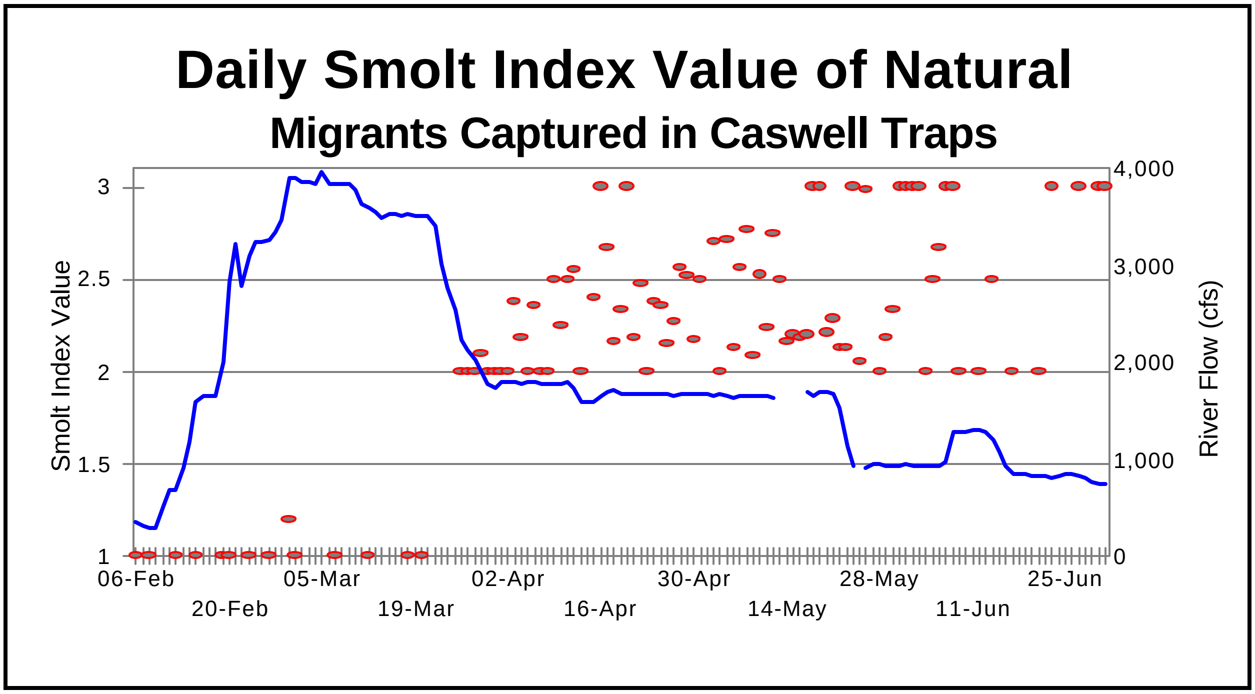
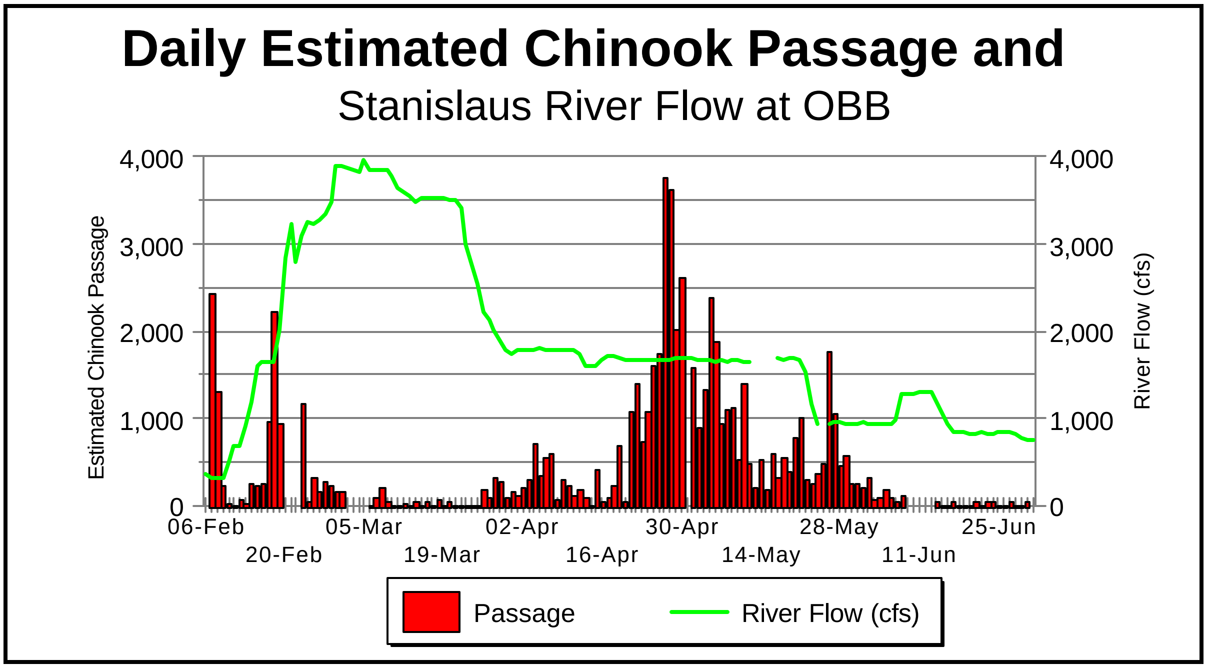


Figure 15. Daily smolt index value of natural chinook captured in the Caswell screw traps during 1996. See Appendix 22 for data.

OBJECTIVE 3: IDENTIFY FACTORS THAT INFLUENCE THE TIME, SIZE AND NUMBER OF JUVENILE CHINOOK AND RAINBOW/STEELHEAD MIGRATING OUT OF THE STANISLAUS RIVER.

Effect of Streamflow on Chinook Outmigration

The timing of peak smolt outmigration in 1996 occurred during an extended period of nearly constant flow. Smolt passage peaked between April 19 through May 11, but flow remained nearly constant at 1,700-1,800 cfs from March 29 through May 21 (Figure 16). Therefore, a change in flow is not necessary to stimulate smolt outmigration, even though it has been suggested by past sampling in the Stanislaus River that a sharp increase in flow can trigger outmigration (Demko and Cramer 1996).



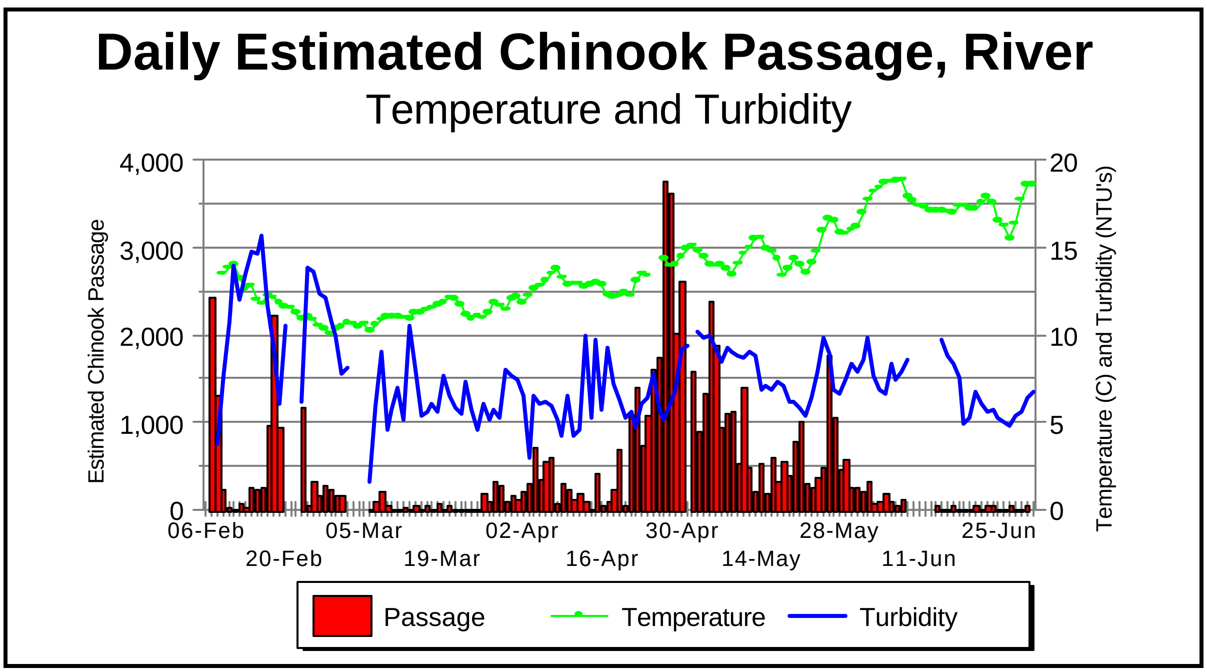


Figure 16. Daily estimated downstream passage of juvenile chinook at Caswell compared with river flow, turbidity, and temperature in 1996.

The other two sharp increases in passage in 1996 were associated with sharp changes in river flow. The first consisted of fry in mid-February soon after the traps were installed, and the second consisted of smolts in late May (Figure 16) when flow dropped sharply. Flows were only between 400 to 800 cfs at the time we installed the trap in early February (see Figure 3), and the large catches of fry at that time suggested that may have been the peak of fry outmigration. Fry passage peaked again for about 2 weeks during a substantial increase in flow (Figure 16), and it is possible that the large change in flow stimulated movement or displaced fry downstream. A sharp decrease in flow in late May appeared to stimulate increased migration of smolts, but only for about 2 days (Figure 16). Decreasing flow has been shown to stimulate migration of juvenile chinook in the Rogue River (Cramer et al. 1985).

The period of lowest downstream movement, when most juvenile chinook were still present in the river, was during the time of highest river flow. From late February through the end of March, catches (and passage estimates) of juvenile chinook were very low, while river flow remained above 3,000 cfs for most of that period. Thus, after the movement of emerging fry, high flows did not stimulate juvenile chinook to migrate.

Effect of Turbidity and Temperature on Chinook Outmigration

The period of peak chinook passage did not coincide with high turbidity levels (Figure 16). Turbidity was highest at the beginning of the year when we did see a spike in outmigration of fry. The spike also coincided with a spike in the proportion of migrants passing Oakdale that were accounted for at Caswell. This coincidence is consistent with the theory that high turbidity during juvenile outmigration increases their survival by reducing predator effectiveness. For the majority of the sampling season, including the peak migration period, turbidity fluctuated between approximately 5 and 10 NTU's.

River temperature at Caswell increased slowly and steadily starting at about 10/C in early March and increasing to about 17/C by the end of May (Figure 16; Appendix 23). Passage of smolts peaked, independent of any change in flow, at about the time the river temperature climbed above 13/C at Caswell. These smolts started their migration above Oakdale, where the fish were rearing, and the temperatures there had just begun to exceed 10/C. Don Chapman Consultants (1989) performed regular underwater observations of yearling chinook in the Wenatchee River, Washington, and noted that the behavior of overwintering chinook changed in the fall when temperatures dropped below 10/C. Chapman found that juveniles changed from free ranging to hiding themselves in cobble and boulder substrates when temperatures dropped below 10/C. Thus, it may be that chinook migration will be triggered when temperature rises above 10/C in the rearing area, if there is an absence of stimuli from sharp changes in flow. It is likely that fish size and time of year are also important determinants of a fish's readiness to migrate. Additional years of data are needed before we can evaluate the relative importance of these factors.

OBJECTIVE 4: RECOVER MARKED JUVENILE CHINOOK RELEASED UPSTREAM NEAR KNIGHTS FERRY AND OAKDALE TO DETERMINE MIGRATION RATE AND SURVIVAL THROUGH THE STANISLAUS RIVER.

We recovered 11 marked chinook at Caswell that had been released at Oakdale or upstream (Table 5). Eight fish were recaptured from 5 different groups released at Oakdale and 3 from one group released at Knights Ferry. There were two other groups released at Knights Ferry and 6 others near Oakdale (5 trap efficiency groups and 1 group released below the traps) from which no marked chinook were recaptured at Caswell.

A total of 8,998 marked chinook were released in the upper river at Oakdale or upstream during 1996, and the expanded number estimated to have arrived at Caswell (assuming no mark loss) was 300, or 3.3%. The expanded percentage of fish estimated to have reached Caswell from each of the groups that were recovered ranged from 5% to 10%. These groups were released at flows ranging from 681 to 3,413 cfs and with mean lengths at release ranging from 34 to 86.1 mm (Table 5). Because so few marked fish released in the upper river were recovered at Caswell, the effects of river flow and size of fish on survival and migration rate cannot be determined. However, these results tend to confirm the finding, based on estimates of total daily passage at the two traps, that survival from Oakdale to Caswell is low.

Table 5. Number of days after release that marked fish released at Oakdale and Knights Ferry were recovered at the Caswell site.

Release Date	Location	Number Released	Origin	Release Mean Length	Length @ Recovery	Date Recovered	Days Traveled	Migration Rate
02/12/96	Oakdale	969	Natural	34	ND	02/17/96	5	6.80
02/12/96	Oakdale	969	Natural	34	35	02/18/96	6	5.67
02/12/96	Oakdale	969	Natural	34	ND	02/19/96	7	4.86
03/22/96	Oakdale	617	Hatchery	44	100	04/15/96	24	1.42
04/06/96	Oakdale	500	Hatchery	71	79	04/09/96	3	11.33
04/06/96	Oakdale	500	Hatchery	71	74	04/09/96	3	11.33
04/22/96	Knights Ferry	930	Natural	86	91	04/27/96	5	6.80
04/22/96	Knights Ferry	930	Natural	86	85	04/28/96	6	5.67
04/22/96	Knights Ferry	930	Natural	86	89	04/29/96	7	4.86
05/04/96	Oakdale	547	Hatchery	76	80	05/06/96	2	17.00
05/26/96	Oakdale	304	Hatchery	72	80	05/31/96	5	6.80

Migration rates from the time of release to the time of recovery at Caswell varied from 1.5 miles/day to 17.5 miles/day and averaged 6.6 miles/day. Migration rates were determined by dividing the number of miles traveled by the number of days after release that the fish was captured. Seven of the 11 fish, including three fry, made the trip in 5 to 7 days

(4.9 to 6.8 miles/day; Table 5; Appendix 24).

CONCLUSIONS

1. The estimated number of juvenile chinook that passed Caswell Park during February 6 through July 1 was 71,000 with approximate 95% confidence intervals of 43,000 and 100,000. The wide confidence interval resulted from variability in the estimates of trapping efficiency. The fork length distribution was distinctly bimodal, corresponding to fry (31-40 mm) passing before March 25 and smolts (primarily 81-100 mm) passing after March 25. Fry composed 27% of migrants, and smolts composed 73% of migrants. Many fry probably migrated before sampling began, because catches were high when sampling began.

2. Neither changes in flow nor certain flow rates are necessary to stimulate outmigration of juvenile chinook. The outmigration of smolts peaked mid-April to mid-May during an extended period of constant flow near 1,700-1,800 cfs. Few chinook migrated out of the river during the extended period of highest flow near 3,000-4,000 cfs in March, when most fish probably had not reached smolting size (81-100 mm fork length).

3. There was no evidence that juvenile chinook paused to rear for extended periods between RM 40 and RM 6. Timing of emigration and mean lengths of fish captured at Oakdale and Caswell were similar.

4. The much lower numbers of chinook estimated to have passed the Caswell site (71,000 fish with approximate 95% confidence interval: 43,000 to 100,000) than the Oakdale site (284,000 fish with approximate 95% confidence interval: 240,000 to 327,000) indicates there may be high mortality to juvenile chinook in the 34 miles between sites. An alternative explanation for the difference is that many fish may pass Caswell during the day when trap efficiency is low. This alternative warrants further investigation.

RECOMMENDATIONS

1. Measures should be taken to increase sampling efficiency, which is also likely to increase the precision of passage estimates. We believe this can best be accomplished by installing walls that divert more flow into the traps. Higher efficiencies will reduce the number of marked fish needed to conduct trap efficiency tests and therefore allow for additional tests under more environmental conditions. Higher efficiencies will also increase the number of fish recaptured from releases made at Oakdale and Knights Ferry, allowing for better estimation of migration rates and survival from the upper to the lower river.

2. Factors contributing to the low estimate of juvenile chinook passage at Caswell compared to that 34 miles upstream at Oakdale should be investigated. The possible bias in passage estimation that would result from high rates of day-time passage at Caswell (the number of emigrants would be under estimated) should be investigated. Acoustic monitoring of diel patterns in fish movement could be used to test for this bias. Alternatively, radio tagging and tracking of juveniles could be used to monitor diel patterns of movement, and to provide reconnaissance data on location and timing of juvenile mortality between the Oakdale and Caswell sites.

3. Initiate sampling in January or early February. An attempt should be made to begin sampling before freshets occur in late January and early February, when newly

emerged fry may be displaced from the Stanislaus River.

4. Install an Onset light meter and record hourly light intensity data (lumens) during mark-recapture tests. This would provide an alternative measure for turbidity and underwater visibility.

5. Sampling protocol should differentiate between fish captured at day and night, by enumerating catches in the morning and again in the evening. Periodic sampling in the evening may be sufficient if daytime captures are near zero. Trapping efficiency during daylight hours should be estimated by releasing marked groups of 3,000 to 5,000 fish. We did not recover any fish from groups of about 750 chinook released during daylight in 1996.

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Appendix A. Estimated 1996 Trapping Efficiency and Fish Outmigration Index at Caswell

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The daily trap count at Caswell was expanded by dividing by the predicted daily trapping efficiency (proportion of fish trapped) to estimate the daily outmigration index:

$$Outmigration\ Index = \frac{Count}{Efficiency}$$

Predicting 1996 Trapping Efficiency

There were two screw traps operating at Caswell, one being referred to as the north trap, and the other being referred to as the south trap. Fifteen Caswell releases were made to estimate these screw-traps' trapping efficiencies. Estimated efficiencies were simply the proportions of fish released a short distance above the Caswell screw traps that were later captured in those traps. Count data were available for most days from February 6 through July 1 (hereafter referred to as passage days); whereas the efficiency estimates were only available on only 8 of those days[4]. In order to predict the efficiency for each passage day, the efficiency had to be related as a response or "dependent" variable to a predictor or "independent" variable that was measured on every day that the screw traps were operating. Substituting a given day's value of the predictor variable into the predictive relation would then provide an estimate of that day's efficiency.

The predictive relation used to relate efficiency to the predictor variable (x) was the logistic:

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4 *Many of the 15 releases represented multiple releases on the same day: The number of releases were: 1 on Feb 14, 1 on Feb 19, 1 on March 22, 4 on Apr 6, 2 on May 2, 2 on May 10, 2 on May 26, and 2 on June 10.*

$$Efficiency = \frac{1}{1 + e^{(a + b*x)}}$$

or, using the "logit" transform,

$$logit\ (Efficiency) = \ln[\frac{Efficiency}{1 - Efficiency}] = -a - b*x$$

In the above equations "exp" is the exponential function, "ln" is the natural log, "a" is a coefficient associated with the x = 0 intercept {Efficiency = 1/[1+exp(a)] when x = 0}, and "b" is the linear regression coefficient relating the logit transform to predictor variable x. The principle reason for choosing the logistic model is that the predicted efficiency can never be less than 0 and can never exceed 1 (100%). The logistic regression used assumes that the underlying distribution of the number of captured fish is binomial when the model is accurate.

Six predictor variables were investigated:

- x(1) - daily flow in cubic-feet/second (cfs) on the day of release;
- x(2) - turbidity (NTU) measured on the morning following release;
- x(3) - time per screw-trap-revolution (time/revolution) measured on the morning following the release;
- x(4) - average water velocity in feet/sec (f/s) measured on the morning following release;
- x(5) - length of fish (mm); and
- x(6) - trap position indicator (the trap was moved further upstream part way through the efficiency study, indicator = 1 for upstream and 0 for downstream positions).

The values of the variables used in the logistic regression are presented in Table A.1. For some releases the associated predictor variable wasn't measured, in which case the value of the variable from the adjacent day or the mean of the values from the two adjacent days was substituted.

Table A.1. Variables used to estimate alternative logistic model parameters for the purpose of predicting efficiency.

			Time/Revolution		Water Velocity		Fish	Trap	Number	Proportion Trapped		
			North	South	North	South	Length	Location	of Fish	North	South	Both
Date	Flow	Turbidity	Trap	Trap	Trap	Trap	(cm)	Indicator *	Released	Trap	Trap	Traps
02/14/96	1179	14.7	41.16	17.98	1.80	2.74	34.30	0	1324	0.0287	0.0921	0.1208
02/19/96	2014	10.5	39.30	17.42	1.90	2.59	33.80	0	1100	0.0236	0.0318	0.0555
03/22/96	3413	7.3	20.57	13.50	2.59	3.09	42.70	0	1097	0.0046	0.0091	0.0137
04/06/96	1791	5.9	27.00	17.00	1.89	2.01	67.40	0	746	0.0094	0.0201	0.0295
04/06/96	1791	5.9	27.00	17.00	1.89	2.01	70.20	0	748	0.0053	0.0053	0.0107
04/06/96	1791	5.9	27.00	17.00	1.89	2.01	73.20	0	727	0.0000	0.0000	0.0000
04/06/96	1791	5.9	27.00	17.00	1.89	2.01	69.70	0	748	0.0000	0.0000	0.0000
05/02/96	1680	10.2	16.20	17.20	2.77	2.93	76.10	1	1979	0.0131	0.0632	0.0763
05/02/96	1680	10.2	16.20	17.20	2.77	2.93	75.50	1	1990	0.0141	0.0302	0.0442
05/10/96	1667	8.7	16.18	17.15	2.38	2.24	74.20	1	2242	0.0107	0.0116	0.0223
05/10/96	1667	8.7	16.18	17.15	2.38	2.24	76.10	1	2341	0.0107	0.0145	0.0252
05/26/96	921	6.8	19.88	20.29	2.58	2.49	71.70	1	2374	0.0253	0.0417	0.0670
05/26/96	921	6.8	19.88	20.29	2.58	2.49	72.70	1	2298	0.0239	0.0305	0.0544
06/10/96	1279	8.6	17.14	23.01	2.33	1.78	91.60	1	1559	0.0148	0.0128	0.0276
06/10/96	1279	8.6	17.14	23.01	2.33	1.78	90.50	1	1981	0.0167	0.0131	0.0298

* Position "1" is about 5 to 6 feet further into the river than position "0"

The length of fish was based on fish measured at release. This would not typically be the appropriate measure for predictive purposes because the only river-run fish that can be measured are those actually trapped; therefore length of fish measured at recovery would be more appropriate to use. However, for some of the releases, the number of recoveries was so small that the precision of the length measures would be poor. There were even two releases (the only day-time releases made) with no recoveries, meaning that there were no recovery lengths. For those releases for which both recovery lengths and release lengths were measured, a weighted paired-sample t-test was conducted to determine whether there was statistical evidence of differences in lengths at release and recovery (Table A.2). The mean difference was not significantly different than 0 ($P = 0.16$).

Table A.2. Comparisons in lengths (cm) of fish at times of release and recovery (Caswell, 1996).

		Number Measured		Mean Length		
Date	Source	At Release	At Recapture	At Release	At Recapture	Difference
14-Feb	Natural	30	62	34.3	35.2	-0.9
19-Feb	Natural	30	56	33.8	35.5	-1.7
22-Mar	Hatchery	30	15	42.7	41.8	0.9
06-Apr	Hatchery	30	22	67.4	71.6	-4.2
06-Apr	Hatchery	30	8	70.2	72.9	-2.7
06-Apr	Hatchery	30	-	73.2	-	-
06-Apr	Hatchery	30	-	69.7	-	-
02-May	Hatchery	30	30	76.1	76.7	-0.6
02-May	Hatchery	30	30	75.5	75.9	-0.4
10-May	Hatchery	30	50	74.2	73.4	0.8
10-May	Hatchery	30	55	76.1	72.9	3.2
26-May	Hatchery	30	60	71.7	69.9	1.8
26-May	Hatchery	30	65	72.7	68.2	4.5
10-Jun	Hatchery	30	43	91.6	85.5	6.1
10-Jun	Hatchery	30	56	90.5	86.8	3.7
* Excluded from mean computations						
Number of releases for comparison						13
Mean						0.80769
Variance						8.89577
t-ratio						0.97640

One basis for selecting among the six predictor variables was a measure of variation referred to as the "deviance". The deviance is analogous to the residual or error sums of squares from least squares regression wherein the predictor variable producing the smallest residual sums of squares is usually regarded as the "best" predictor variable. The relative magnitude of the deviance served as an analogous criterion for choosing among the predictor variables.

Two of the predictors, time/revolution and water velocity, were separately measured for each trap. The other measures (flow, turbidity, fish length at release, and trap location) were not trap specific, and the same measure applied to both traps. Logistic fits of efficiency on each of the above predictor variables were initially made for each trap separately. The deviances associated with these predictor variables are given in Table A.3.

Table A.3. Deviances associated with logistic fits of estimated efficiency on predictor variables, Caswell, 1996.

			Fit on North Trap		Fit on South Trap		Combined		Fit on Both Traps	
Dates Excluded	Variable	Degrees of Freedom (DF)	Deviance (Dev)	Dev/DF	Deviance (Dev)	Dev/DF	Deviance (Dev)	Dev/DF	Deviance (Dev)	Dev/DF
None	Flow	13	63.46	4.88	363.73	27.98	427.19	32.86	370.73	28.52
	Turbidity	13	101.29	7.79	238.61	18.35	339.90	26.15	303.39	23.34
	Time/Revolution	13	105.84	8.14	418.50	32.19	524.34	40.33	392.72	30.21
	Water Velocity	13	112.75	8.67	258.90	19.92	371.65	28.59	380.40	29.26
	Fish Length	13	108.58	8.35	344.66	26.51	453.24	34.86	405.57	31.20
	Trap Location	13	108.45	8.34	418.39	32.18	526.84	40.53	475.11	36.55
May 26	Flow	11	63.05	5.73	396.03	36.00	459.08	41.73	366.29	33.30
	Turbidity	11	35.71	3.25	239.92	21.81	275.63	25.06	105.86	9.62
Feb 14	Flow	12	57.31	4.78	252.47	21.04	309.78	25.82	266.27	22.19
	Turbidity	12	98.96	8.25	237.53	19.79	336.49	28.04	298.56	24.88

By far the lowest north-trap deviance was that associated with flow; whereas the largest was associated with water velocity. At the south trap the lowest deviance was associated with turbidity, and water velocity came in a close second. It would be less confusing and more consistent to use one predictor variable for both traps than different predictor variables for the different traps (e.g., flow for the north trap and turbidity or water velocity for the south trap). We focus on two measures of deviance to determine which predictor variable is most effective over both traps. The two deviance measures are: 1) deviances added over traps, "Combined" in Table A.3, and 2) the deviance of a single fit using pooled counts over traps, "Fit on Both Traps" in Table A.3. In the latter case, the north and south trap information for predictor variables time/revolution and water velocity were weighted, the weights used were the means over releases of the estimated efficiencies, 0.013 and 0.025 for the north and south traps, respectively. With the exception of water velocity, the combined deviances over the North and South Trap fits were greater than those based on a single fit. In the case of water velocity, the two deviances were nearly equal. This indicates that the single fit using both traps was generally a better fit[5] than combining the

5 *The combined deviance as calculated may actually underestimate the variation from the two fits. The counts from both traps are made on the same days with the same or highly correlated predictor variables; therefore, counts and responses for the two traps are*

individual trap fits.

Based on the single fit using both traps, the deviance was smallest for turbidity followed by flow then by water velocity, the associated coefficients being different at the 10% significance level[6]: turbidity (P = 0.018), flow (P = 0.077), and water velocity (P = 0.094). The other variables were not considered because the coefficients associated with these variables were not significant (P<0.1). Water velocity was rejected because its measure was unavailable on 21 or 14% of the 147 days evaluated passage days (6 February to 1 July); and, on many of those unavailable days toward the beginning of season, there were no proximal data from which reasonable interpolations of water velocity could be made. Water velocity may be a useful predictor in future years if it can be measured throughout the passage period; however, this was not the case in 1996.

The prediction equations for the other two considered predictor variables (turbidity and flow) are

$$Efficiency\ (Turbidity) = \frac{1}{1 + \exp(4.704 - 0.0001787\ Turbidity)}$$

$$Efficiency\ (Flow) = \frac{1}{1 + \exp(2.017 + 0.0007403\ Flow)}$$

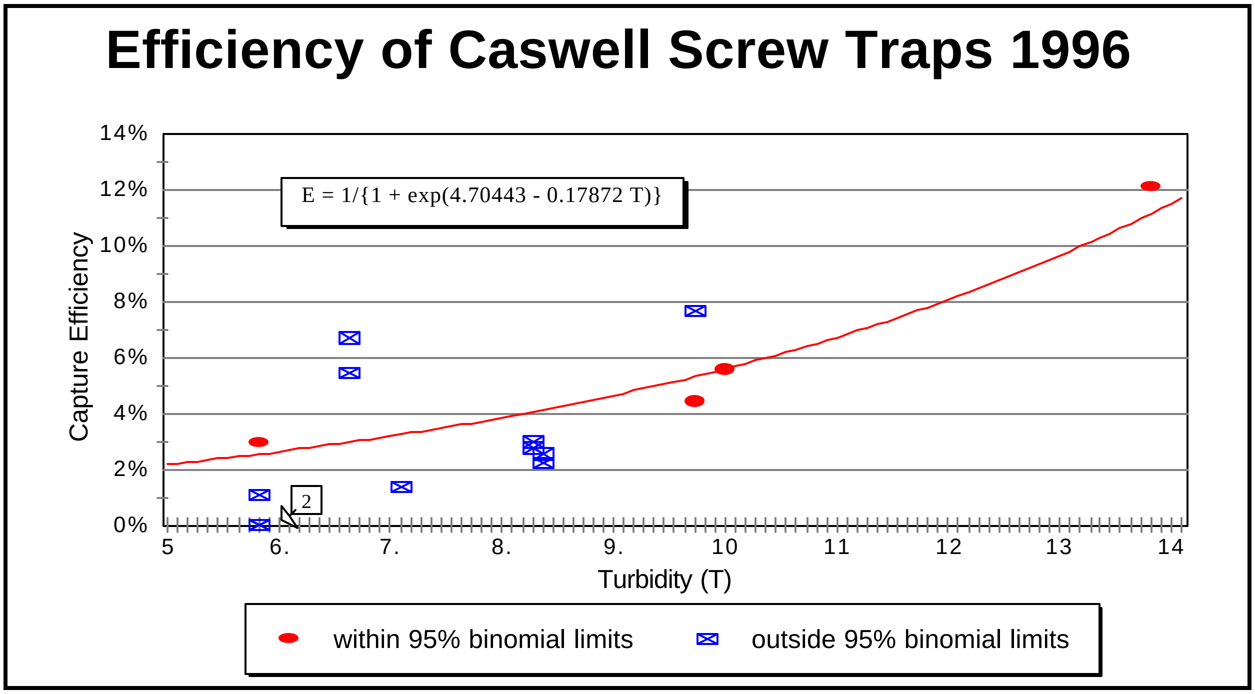
These selected predictor variables gave poor fits. The actual efficiency estimates and the predicted efficiency responses to turbidity and to flow are respectively given in Figures A.1 and Figure A.2. If the fit is accurate, the deviance should be approximately equal to the degrees of freedom, or the deviance/degrees-of-freedom ratio (Dev/d.f.) should be near one. As can be seen from Table A.3, all Dev/d.f. values were much larger than 1 (significant at P < 0.001 based on chi-square test of deviance values). These poor fits are reflected in the

expected to be positively correlated; however the positive correlation is not taken into account in the combining of the deviances. If there were a positive correlation, the appropriate combined deviance would be even greater than that presented; therefore, the difference between combined deviance and the deviance from the single fit is underestimated. It should be noted that the degrees of freedom are for the same sampled day and should not be combined.

6 Significance test based on F-tests of differences in deviances associated with including and not the variable.

figures. As indicated in the figures, most of the efficiency estimates fall outside the binomially based approximate confidence intervals[7], many well outside the intervals.

There were two estimated efficiencies of 0.0 (day-time releases on April 6 had no recoveries). These contributed to the greatest outliers in the fit on turbidity (Figure A.1). Additional fits were made excluding these releases. The fit on turbidity improved dramatically, Dev/d.f. decreasing from 23.34 to 9.62 (Table A.3); whereas the fit on flow did not, Dev/d.f. increasing slightly from 28.52 to 32.30. (It should be noted that the smaller turbidity Dev/d.f. of 9.62 is still extremely large and still results in a poor fit.)



$$e - 1.96*\sqrt{\frac{e*(1-e)}{n}};\ e + 1.96*\sqrt{\frac{e(1-e)}{n}}$$

7 The 95% confidence intervals were estimated by
e being the predicted efficiency for the given flow and n being the number of fish released.

Figure A.1. Predicted efficiency, $1/[1 + e^{4.70443 + 0.17872*Turbidity}]$ (line), and actual efficiency estimates (x) from 1996 Caswell releases.

One unusually high turbidity reading was included during the efficiency evaluation--14.7 on the morning of February 15 (following the February 14 release). Over all evaluated passage days, February 6 through July 1, only three days had turbidities reaching this value, and these were adjacent recovery days (February 14 and 16). The actual estimated efficiency (0.121) associated with this high turbidity reading (14.7) was much higher than any associated with other releases (the next highest two efficiencies were 0.076 associated with turbidity 10.2 and 0.067 associated with turbidity 6.8, Table A.1). The unusually high turbidity contributed to the greatest outlier in the fit on flow (Figure A.2). Since this turbidity reading was unusual, regressions were run that excluded the 14 February release. For the single fit using both traps, the deviance for turbidity was less than that for flow when the February 14 release was included (turbidity deviance of 303 less than flow deviance of 371 from Table A.3), but the opposite was true when that release was excluded (turbidity deviance of 299 greater than flow deviance of 266).

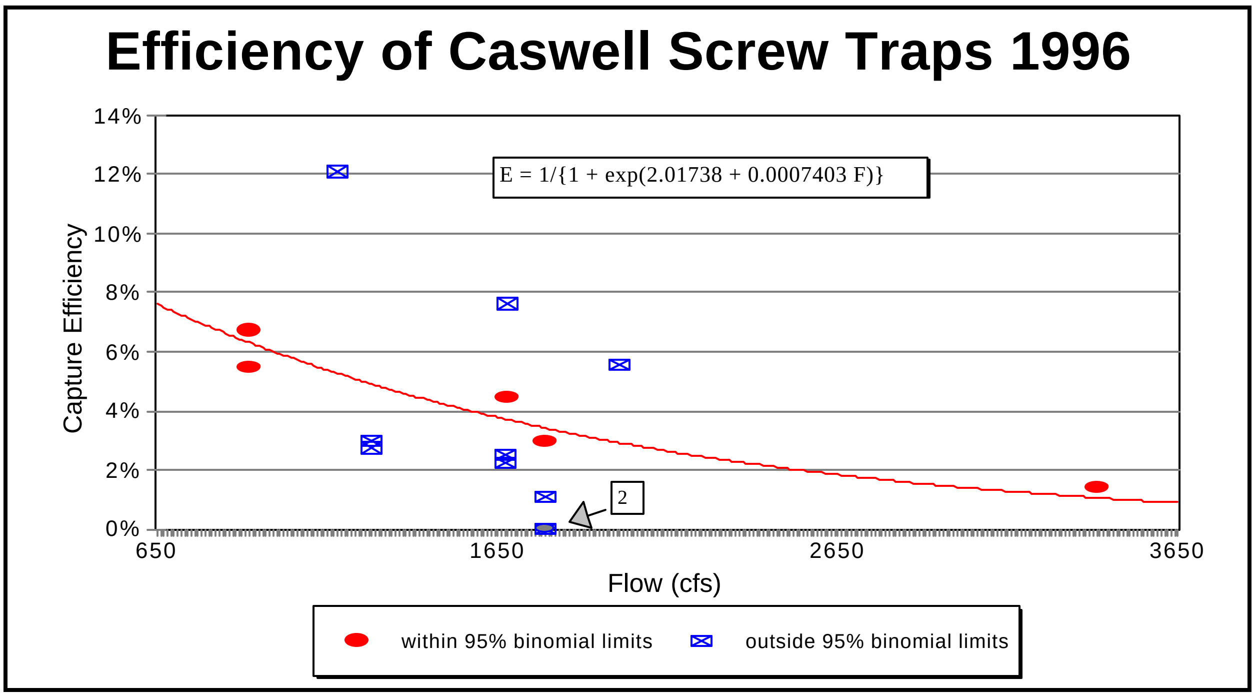


Figure A.2. Predicted efficiency, $1/[1 + e^{2.01738 + 0.0007403*Flow.}]$ (line), and actual efficiency estimates (x) from 1996 Caswell releases.

Since there was no a-priori reason for excluding the high-turbidity-day data set, it was retained. Nor were the day-time releases that yielded no recoveries excluded. With trapping-efficiency rates apparently differing depending on whether fish were passing during the day or night, it would be preferable to stratify, estimating day-time and night-time outmigration indices using different trapping efficiency predictors. However, this was not possible because the only two day-time releases produced no recoveries, and dividing the day-time count by a zero-efficiency estimate is not possible. Therefore the day-time and night-time releases were both used to obtain a common efficiency estimator which, if applied to day counts, would probably produce under-estimates of outmigration and, if applied to night counts, would probably produce an over-estimates. In summary, the efficiency fits were based on simple logistic regression using all 15 Caswell releases (day-time and night-time) and were used to expand 24-hour counts.

The poor precision observed is unlikely to be in a major way due to the logistic regression procedure used to predict efficiency. An analogous method was used at Oakdale. The efficiency prediction based on logistic regression of estimated efficiency on flow (Figure A.3) was very good. [It should be noted that the average trapping efficiencies at the Caswell traps were extremely low, the average over all releases being 0.013 (1.3%) for the north trap and 0.025 (2.5%) for the south trap; whereas the average trapping efficiency at Oakdale was much higher, 0.147 (14.7%); there may be greater relative sampling variability in the field associated with lower efficiencies than with higher efficiencies.]

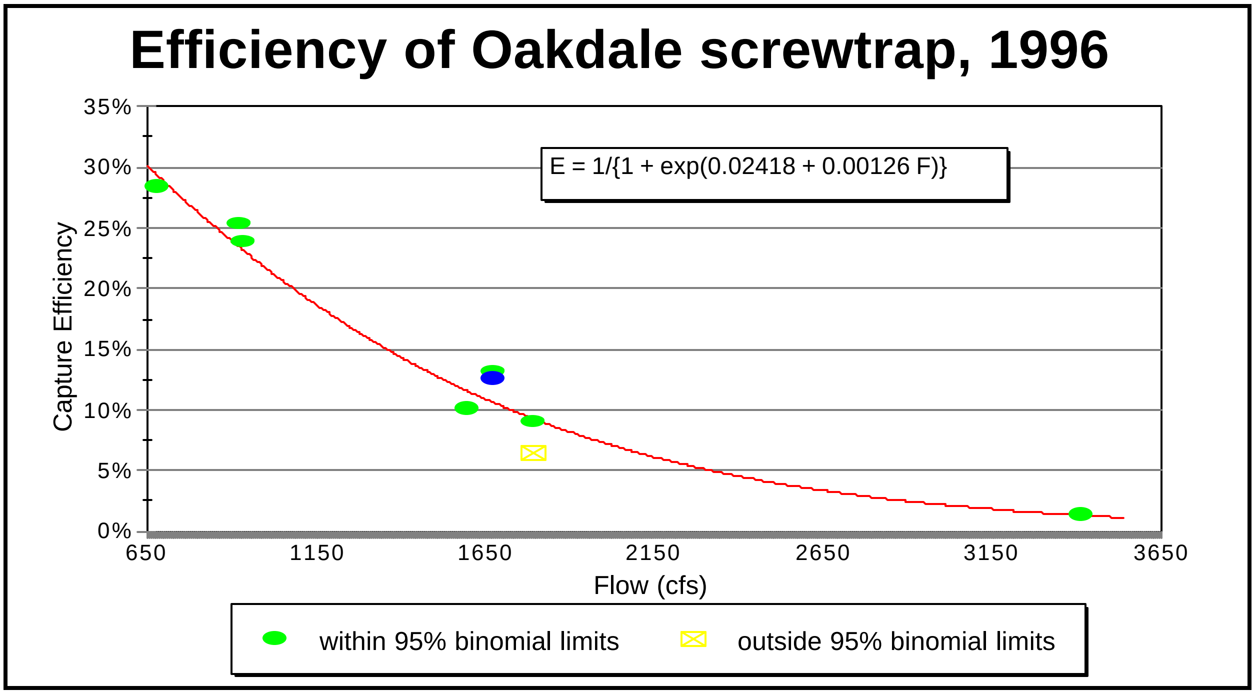


Figure A.3. Predicted efficiency, $1/[1 + e^{0.02418 + 0.00126*Flow.}]$ (line), and actual efficiency estimates (x) from 1996 Oakdale releases.

1996 Count, Flow, and Turbidity Data

Substituting the efficiency-to-flow predictor into the outmigration index estimation equation gives:

$$Outmigration\ Index = \frac{Count}{Efficiency} = \frac{Count}{\left[\frac{1}{1 + exp(a + b*x)}\right]} = Count*[1 + exp(a + b*x)]$$

Within the dates of evaluation there were passage days when flow, turbidity, or count data were not available. Methods of interpolation were developed to compute values of flow, turbidity, and count when they were missing. Interpolated values were needed to estimate the cumulative outmigration index. The methods of interpolation are discussed below.

Missing Flow Information: Missing flows were replaced by the average of available flow data from five days preceding the date with the missing value through five days following the date with the missing value. The basis for selecting this interval was lag correlations. Flows were correlated between adjacent days (lag = 1), between days that were two days apart (lag = 2), between days that were three days apart {lag = 3), etc. Flows were highly correlated for lags 1 through 5 (refer to Table A.4.), the correlation coefficient only declined about 0.02 per lag-unit, 0.99 at lag = 1 to 0.90 at lag = 5; however, the rate of decline increased for lag > 5. Given that lag correlations were high and since there was little variation among flows within the ±5 day interval around a missing value, the substituted flow probably did not differ greatly from the actual flow.

Missing Turbidity Information: Missing turbidities were replaced by the mean of available turbidity data from days immediately adjacent to the day with missing turbidity. The lag = 1 correlation between turbidities was low (r = 0.69), then the correlations dropped below 0.6 for lag > 1; therefore, including more than adjacent days in the missing turbidity substitution seemed inappropriate. Given the low lag = 1 correlation, the precision associated with the missing value substitution is likely to be low.

Table A.4. Time lag correlations among flows, turbidity, screw-trap counts, and natural logs of screw-trap counts, Caswell, 1996.

Lag	Correlation between Days	Flow(i) with Flow (i+lag)	Turbidity(i) with Turbidity (i+lag)	Count(i) with Count(i+lag)	ln[Count(i)+1] with ln[Count(i+lag)+1]
0	i; i	1.000	1.000	1.000	1.000
1	i; i+1	0.991	0.693	0.738	0.802
2	i; i+2	0.973	0.586	0.724	0.785
3	i; i+3	0.953	0.476	0.613	0.747
4	i; i+4	0.930	0.399	0.524	0.662
5	i; i+5	0.901	0.330	0.531	0.621
6	i; i+6	0.867	0.248	0.481	0.640
7	i; i+7	0.827	0.138	0.383	0.571
8	i; i+8	0.787	0.164	0.346	0.541

9	i; i+9	0.744	0.240	0.322	0.546
10	i; i+10	0.696	0.203	0.208	0.459

Missing Count Information. When day i had no count information, the count(i) substitution was based on:

$$\ln[Count\ (i) + 1] = a\ (i) + 0.172 * [Turbidity\ (i) - x(i)]$$

wherein

$$a(i) = Mean\ of\ \ln[Count(i-2)+1],\ \ln[Count(i-1)+1],\ \ln[Count(i+1)+1],\ \ln[Count(i+2)+1]$$

$$x(i) = means\ of\ associated\ turbidities$$

The value "0.172" is the estimated least squares linear regression coefficient between ln[Count +1] and Turbidity (coefficient significantly less than 0 with P<<0.001). The means are based on days in which there are actual counts available. The counts are based only on days that are adjacent to or only one removed from the day with the missing value because the lag ln[Count + 1] correlations drop below 0.75 for lag > 2, the lag = 1 and lag = 2 correlations being 0.80 and 0.79, respectively (refer to Table A.4.).

1996 Outmigration Index based on flow

Figure A.4 presents the daily screw-trap counts and the estimated daily outmigration index (count/efficiency) plotted against daily flow. There was essentially no linear relation between flow and screw-trap count and between flow and outmigration index (respective correlation coefficients being -0.11 and 0.13).

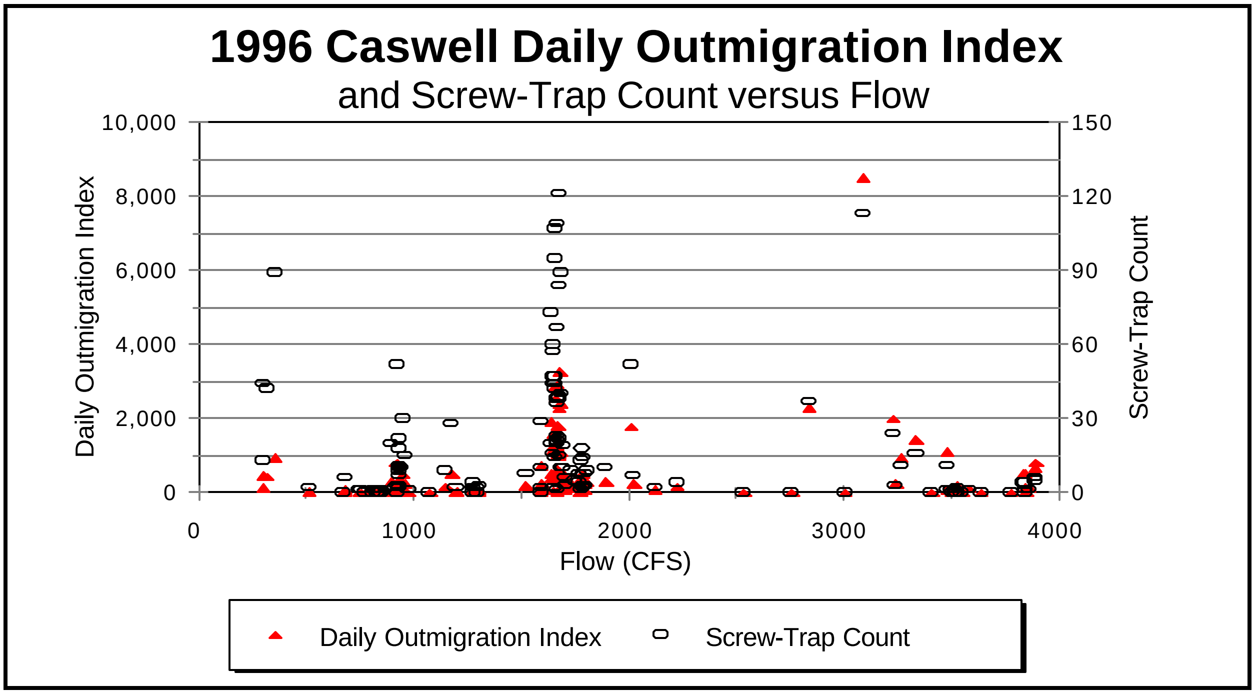


Figure A.4. 1996 Caswell daily outmigration index based on efficiency-to-flow prediction and screw-trap count versus flow.

Figure A.5 presents the estimated daily outmigration indices over days. The estimated cumulative outmigration indices along with their 95% confidence intervals are plotted in Figure A.6. The estimated February 6 through July 1 cumulative outmigration index was 78 thousand with an approximate 95% confidence interval of 26 thousand and 130 thousand. Methods of approximating standard errors (SE) used in confidence intervals are discussed in Appendix A1.

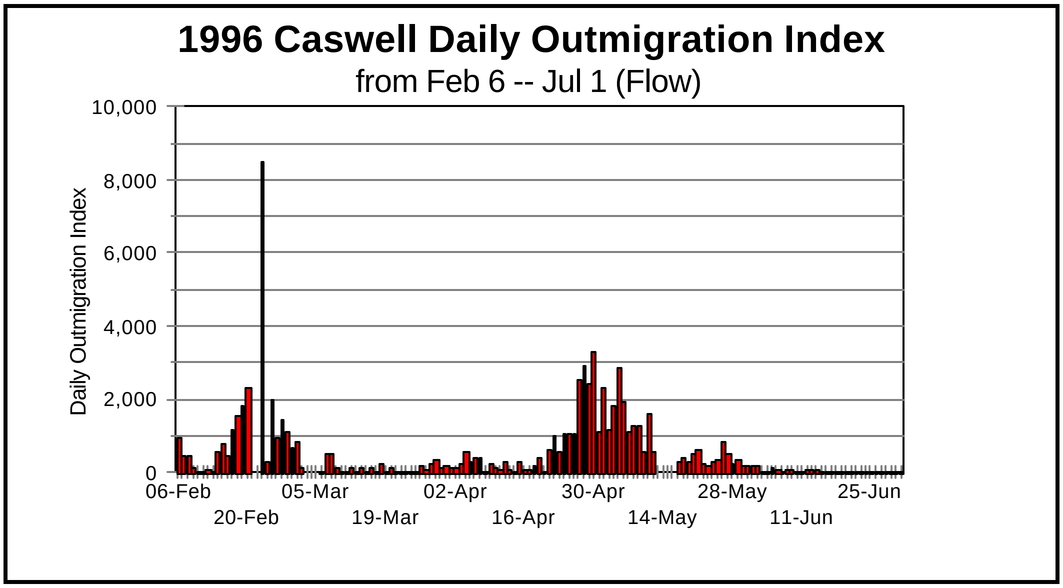


Figure A.5. 1996 Caswell daily outmigration index from February 6 through July 1 based on efficiency-to-flow predictor.

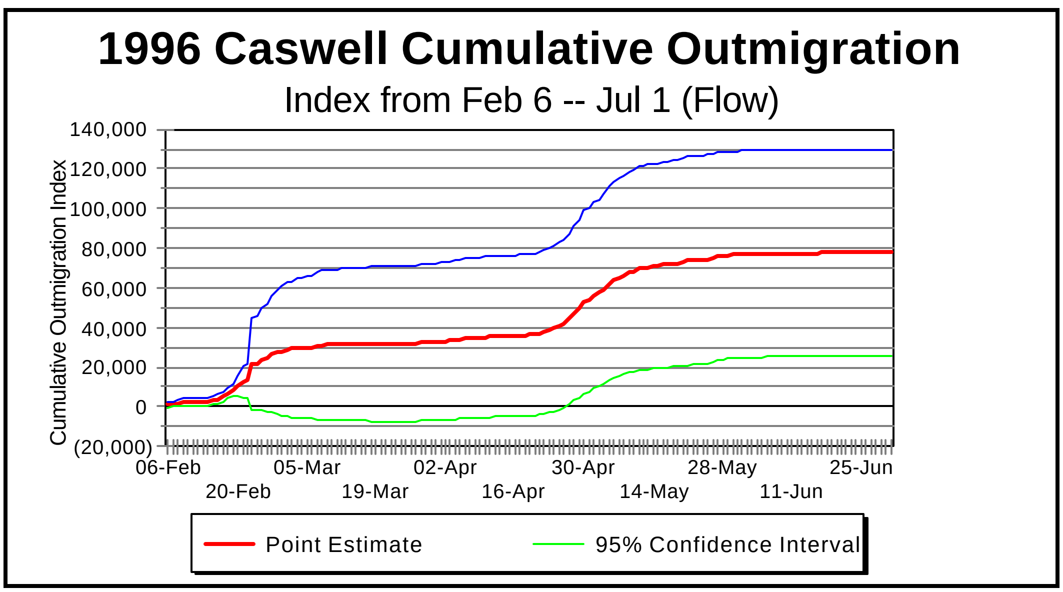


Figure A.6. 1996 Caswell cumulative outmigration index from February 6 through July 1 based on efficiency-to-flow predictor.

The approximate confidence intervals of the cumulative outmigration index were extremely large, encompassing impossibly negative lower limits through nearly half of the passage period. The coefficient of variation (CV) of the estimated February 6 through July 1 cumulative outmigration index was also large

$$CV = 100 \left[\frac{SE\ (\ Estimated\ Cumulative\ Outmigration\ Index\ )}{Estimated\ Cumulative\ Outmigration\ Index} \right] = 34\%$$

Appendix A2 presents 1996 flows, screw-trap counts, and efficiency-to-flow predictions, as well as associated daily and cumulative outmigration index estimates and their approximate standard errors. In the appendices those values with asterisks are replacements for missing values.

1996 Outmigration Index based on turbidity

Figure A.7 presents the daily screw-trap counts and the estimated daily outmigration index (count/efficiency) plotted against daily turbidity. There was a slight positive linear relation between turbidity and screw-trap count (correlation coefficient = 0.25) but not between turbidity and outmigration index (correlation coefficient = 0.00).

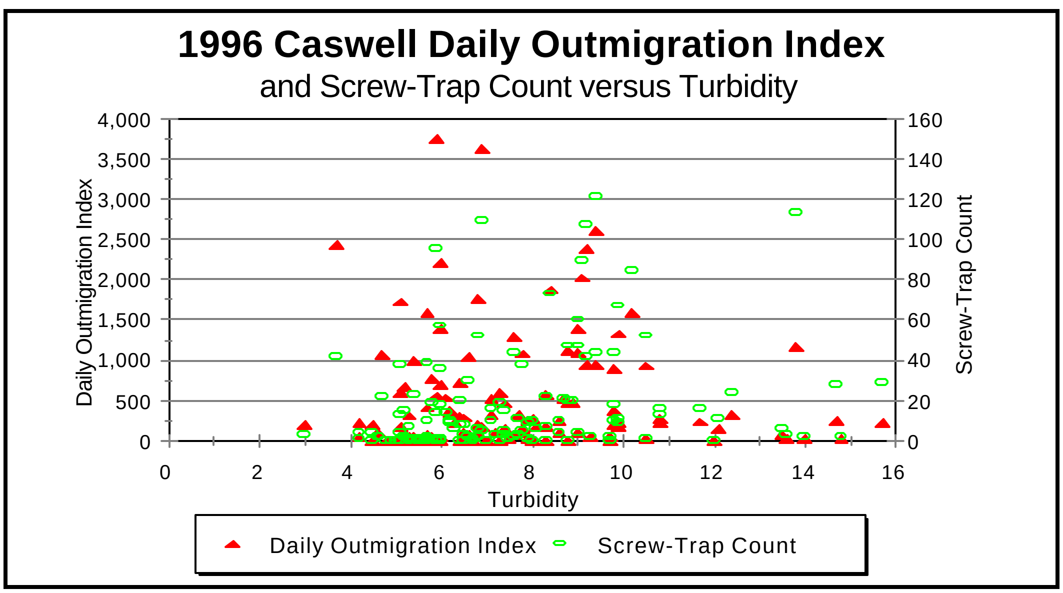


Figure A.7. 1996 Caswell daily outmigration index based on efficiency-to-turbidity predictor and screw-trap count versus turbidity.

Figure A.8 presents the estimated daily outmigration indices over days. The estimated cumulative outmigration indices along with their 95% confidence intervals are plotted in Figure A.9. The estimated February 6 through July 1 cumulative outmigration index was 71 thousand with an approximate 95% confidence interval of 43 thousand and 100 thousand. The confidence intervals, although smaller than that realized from the efficiency-to-flow predictor, are still very extremely large. The coefficient of variation (CV) of the estimated February 6 through July 1 cumulative outmigration index was 20%.

Appendix A.3 presents 1996 turbidity, screw-trap counts, and efficiency-to-turbidity predictions, as well as associated daily and cumulative outmigration index estimates and their approximate standard errors. In the appendices those values with asterisks are replacements for missing values.

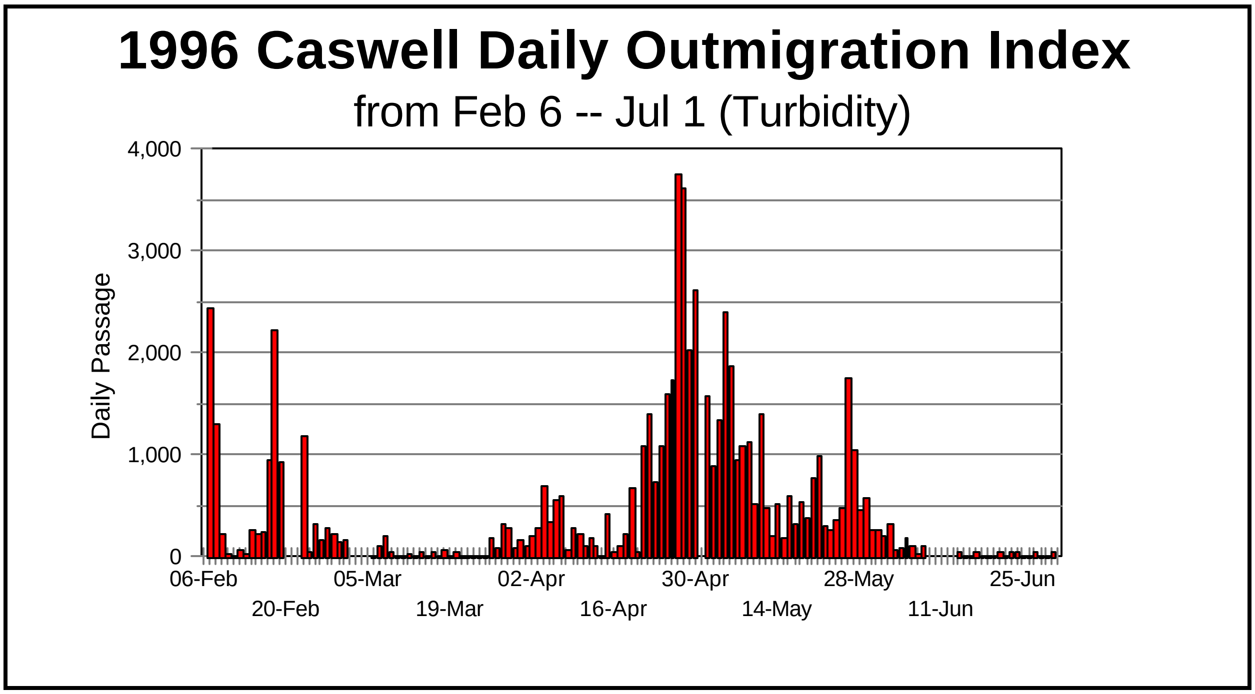


Figure A.8. 1996 Caswell daily outmigration index from February 6 through July 1 based on efficiency-to-turbidity predictor.

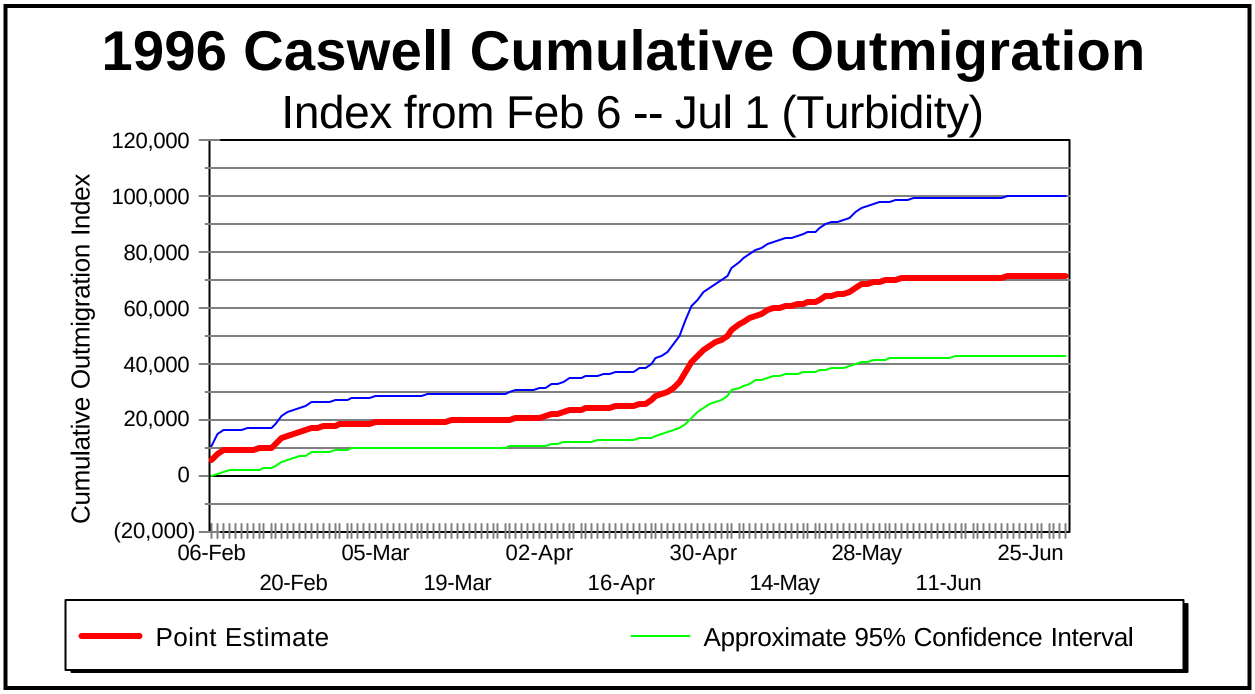


Figure A.9. 1996 Caswell cumulative outmigration index from February 6 through July 1 based on efficiency-to-turbidity predictor.

Use of Oakdale Outmigration Index

The Oakdale data set may be a better indicator of outmigration at Caswell than the Caswell data set itself. The Oakdale cumulative outmigration index was estimated quite precisely, as indicated in Figure A.10, the CV for Oakdale's February 2 through June 8 cumulative outmigration index being only 7.8%.

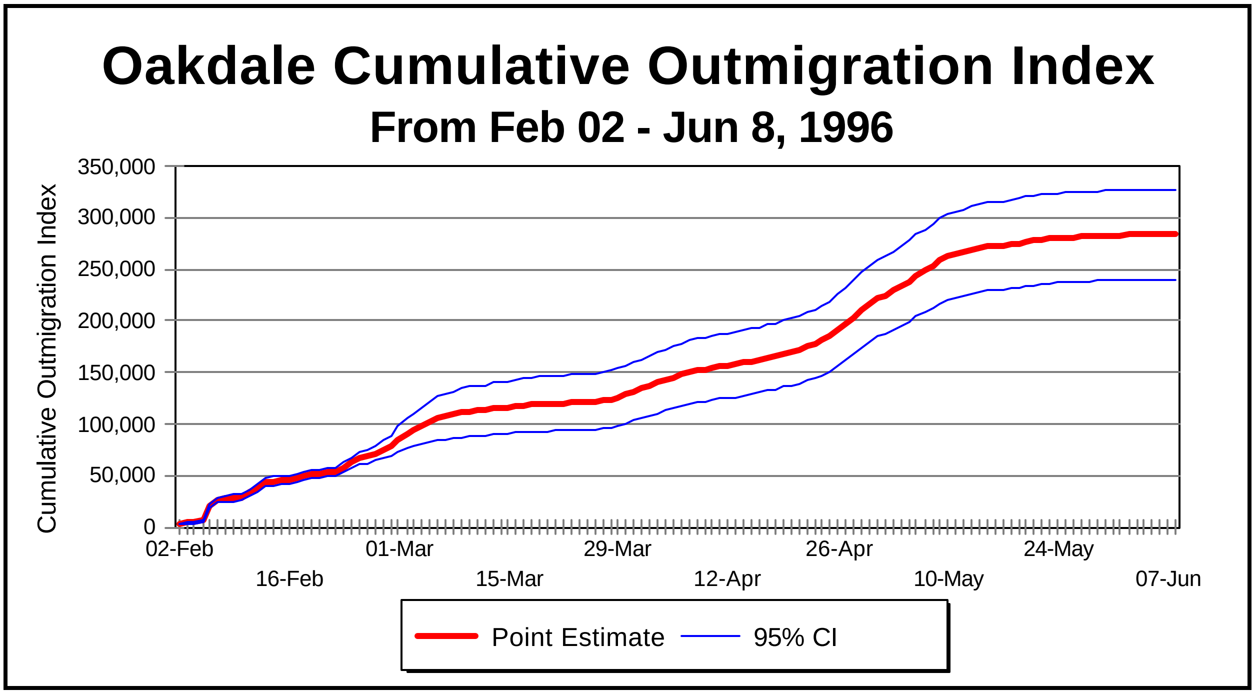


Figure A.10. 1996 Oakdale cumulative outmigration index from February 2 through June 8.

Plots of the actual efficiency-to-flow Caswell and Oakdale screw-trap counts are presented in Figure A.11, and plots of their respective outmigration indices are presented in Figure A.12, These figures indicate similar times of peaking, particularly from mid-season on. The lag-time correlations both between the two location's count data and between their outmigration indices (Table A.5) indicate that the maximum correlation is near or on the same day; e.g., the maximum count correlation (r = 0.45) occurs when the counts at Oakdale are correlated with next day's counts at Caswell (lag = +1) and the maximum outmigration-index correlation (r = 0.53) occurs when the index values at Oakdale are correlated with the same day's index values at Caswell (lag = 0). In the case of the outmigration index, it is unlikely that a changing condition, such as flow upon which the efficiency predictions were based, is triggering this common peaking because the indices are uncorrelated with flow at both Caswell and at Oakdale (r = -0.05 for Oakdale and R = 0.13 for Caswell). Further, the joint peaking observed toward the end of April and beginning of May was a period when the flows barely changed. It may be this peaking corresponds to the point of peak outmigration[8], and that Oakdale, because of its more precise predictor, is a better indicator of the peaking and the relative magnitude of the peaking than is Caswell. (Note there is also a small peaking in the in the Caswell index in early April, but a much larger peaking in the Oakdale index.) Earlier peaks tend to be erratic, and they may more reflect a general movement of fry and not an active outmigration of smolts.

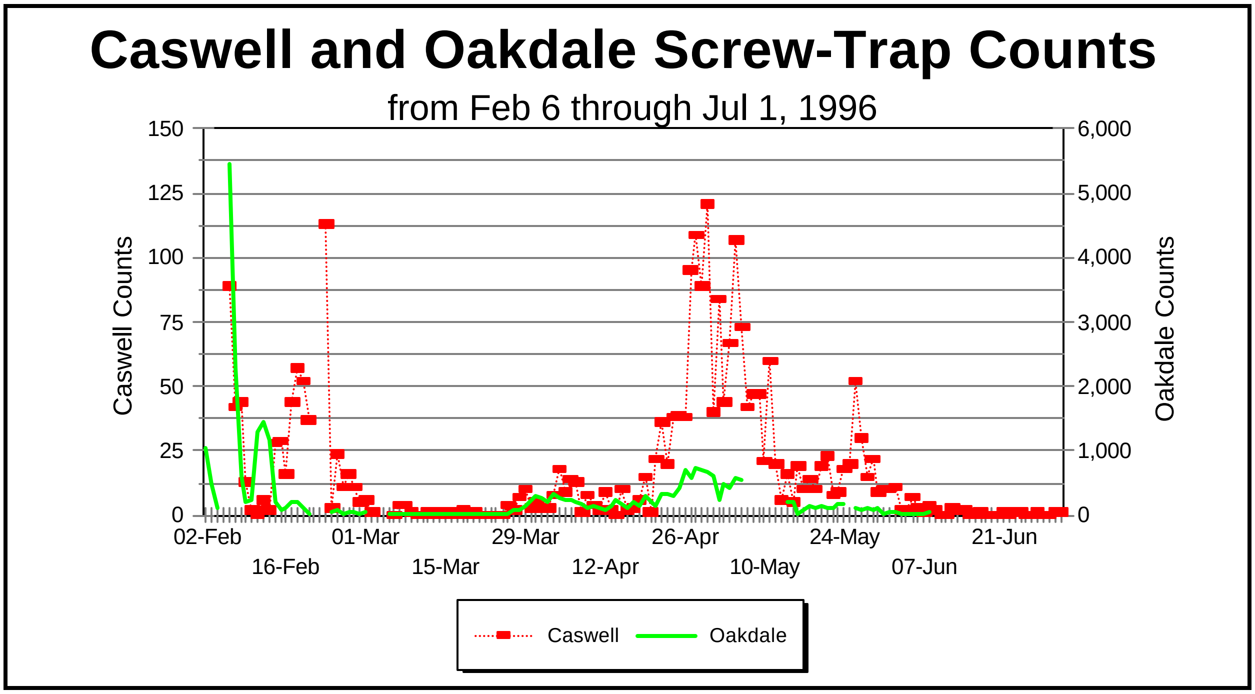


Figure A.11. Plots of actual 1996 Caswell and Oakdale screw-trap counts over evaluated passage time.

8 *Even though lag correlations between the Caswell and Oakdale values are maximum near or at Lag = 0, this does not mean that the same fish are passing both points on the same days. It may be that the river conditions tend to trigger peaks and valleys on the same days for the two locations.*

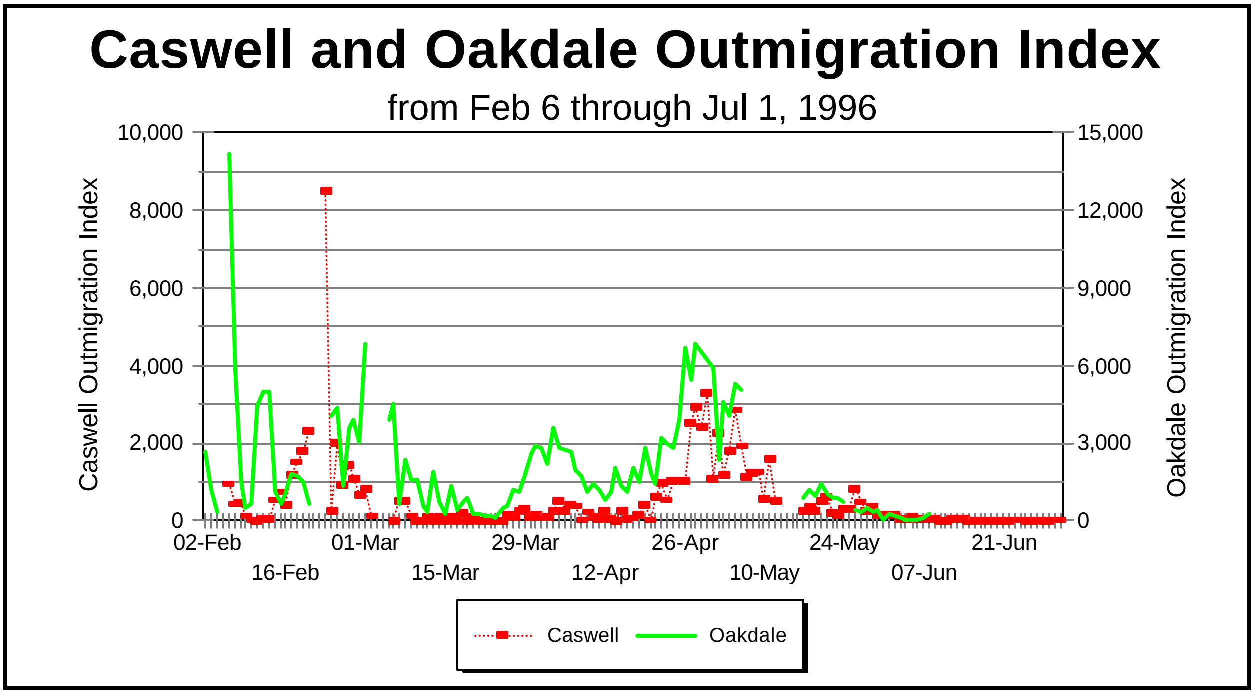


Figure A.12. Plots of efficiency-to-flow predicted 1996 Caswell and Oakdale outmigration indices over evaluated passage time.

Table A.5. Lag correlations between Caswell and Oakdale screw-trap counts and between Caswell and Oakdale outmigration indices.

		Correlations	
	Caswell Date:	Among	Among
Lag	Oakdale Date	Counts	Indices
-10	i; i-10	0.199	0.249
-9	i; i-9	0.168	0.174
-8	i; i-8	0.207	0.216
-7	i; i-7	0.166	0.221
-6	i; i-6	0.190	0.264
-5	i; i-5	0.155	0.248
-4	i; i-4	0.154	0.273
-3	i; i-3	0.153	0.249
-2	i; i-2	0.279	0.522
-1	i; i-1	0.322	0.513
0	i; i	0.426	0.529
1	i; i+1	0.450	0.498
2	i; i+2	0.340	0.467
3	i; i+3	0.359	0.323
4	i; i+4	0.390	0.385
5	i; i+5	0.439	0.423
6	i; i+6	0.430	0.309
7	i; i+7	0.363	0.483
8	i; i+8	0.214	0.345
9	i; i+9	0.048	0.214
10	i; i+10	-0.038	0.233

Appendix A1. Standard Error Estimation for Daily and Cumulative Outmigration Index

In the following discussion, I use upper case letters to represent parameter values and corresponding lower case letters to represent their estimates.

The population daily outmigration index is

$$O_i = \frac{C_i}{E_i}$$

wherein O_i is the true daily outmigration index on day i, C_i is that day's expected count, and E_i is the true trap efficiency for that day. The true cumulative outmigration index is simply the daily index added over days:

$$\Sigma_i O_i = \Sigma_i \frac{C_i}{E_i}$$

Substituting lower case letters for upper case letters gives the form of the estimated daily outmigration index

$$o_i = \frac{c_i}{e_i}$$

and the cumulative index

$$\Sigma_i o_i = \Sigma_i \frac{c_i}{e_i}$$

The variance of this cumulative passage is

$$S^2 [\Sigma_i o_i] = \Sigma_i Var[\frac{c_i}{e_i}] + \Sigma_i \Sigma_{i' \neq i} Cov [\frac{c_i}{e_i}, \frac{c_{i'}}{e_{i'}}]$$

Wherein Var is the variance of the daily outmigration index (day i) and Cov is the covariance between indices from different days (days i and i'). In developing $Var[G_i o_i]$, I first discuss $Var[c_i/e_i]$ followed by $Cov[c_i/e_i, c_{i'}/e_{i'}]$.

1. $Var[c_i/e_i]$

The variance of c_i/e_i can be approximated by variance of the ratio

$$Var[\frac{c_i}{e_i}] = \frac{C_i^2 Var[e_i]}{E_i^4} + \frac{Var[c_i]}{E_i^2} - 2*\frac{C_i Cov[c_i, e_i]}{E_i^3}]$$

The methods used to estimate the components in the above equation are now discussed.

1.a. Estimates of C_i and E_i.

C_i and E_i, the actual parametric (population) values, are estimated by c_i and e_i, respectively. The substitution of c_i and e_i raised to powers 2, 3, and 4 for the corresponding powers of C_i and E_i lead to biases. No attempt was made to adjust for those biases or to assess the relative magnitude or direction of those biases.

1.b. Estimate of $Var[e_i]$

Recalling from the main appendix, the efficiency predictor is

$$e_i = \frac{1}{1 + \exp(a + b\, x_i)}$$

The asymptotic form of the estimated variance of e_i can be developed by multiplying the variance-covariance matrix of a and b by the vector of the first derivatives of e_i above with respect to a and b and post multiplying by the transpose of that vector (delta method), giving:

$$Var[e_i] =$$
$$E_i^4 exp^2(-a-b*x_i)*[Var(a) + x_i^2*Var(b_i) + 2*x_i*Cov(a,b)]$$

1.c. Estimate of Var[c_i]

The count would be the total daily outmigration multiplied by the efficiency; therefore the estimated count would be

$$c_i = O_i * e_{2,i}$$

where $e_{2,i}$ is the efficiency for that day, which is not directly estimable. The variance of c_i is

$$Var[c_i] = O_i^2 * Var(e_{2,i})$$

I used $o_i^2 = [c_i/e_i]^2$ as an estimate of O_i^2. I used Var[e_i] presented in 1.a. in Var($e_{2,i}$) above; however Var[e_i] isn't the appropriate variance since e_i is based on a predicted estimate of the efficiency using that day's flow for the predictor variable rather than on a direct estimate of efficiency for that specific day.

1.d. Estimate of Cov[c_i, e_i]

The count and the predicted efficiency can be regarded as independent since they were based on different fish entrainments and since there is no reason to believe that the fact a given released fish used to estimate efficiency was captured affected the probability that a river-run fish used to estimate c_i was captured. Therefore

$$Cov[c_i,e_i] = 0$$

Substituting the estimates of C_i, E_i, Var[e_i], Var[c_i}, and Cov[c_i,e_i] presented in 1.a through 1.d into

$$Var[\frac{c_i}{e_i}] = \frac{C_i^2 Var[e_i]}{E_i^4} + \frac{Var[c_2]}{E_i^2} - 2*\frac{C_i Cov[c_i,e_i]}{E_i^3}]$$

gives

$$Var[\frac{c_i}{e_i}] = 2*[\frac{(c_i)^2}{(e_i)^4}]*Var[e_i]$$

Var[e_i] being given under **1.b. Estimate of Var[e_i]**.

2. Cov[(c_i/e_i),($c_{i'}$/$e_{i'}$)]

There is a covariance between outmigration indices from different days because the equations for predicting e_i and $e_{i'}$ used the same estimates of the intercept (a) and slope (b) parameters. The covariance was developed in a method analogous to that used for Var[e_i] (the delta method), the asymptotic covariance being

$$Cov[\frac{c_i}{e_i},\frac{c_{i'}}{e_{i'}}] = (c_i c_{i'})(e_i e_{i'})*[Var(a) + fx_i*fx_{i'}*Var(b) + (fx_i+fx_{i'})*Cov(a,b)]$$

3. Estimating Var(a), Var(b), and Cov(a,b)

Logistic regression was used to obtain the estimates of a and b and their variances and covariance. However, the variances and covariance so generated assumes that the distribution of the data points around the model is actually a binomial, meaning the expected ratio of the deviance to degrees of freedom (Dev/d.f.) is 1. When this is not the case, the variances and covariance estimates presented in logistic regression packages are underestimated. When Dev/d.f. significantly differed from 1 ($P < 0.1$), the variance-covariance output was expanded (multiplied) by Dev/d.f. to obtain the estimates of Var(a), Var(b), and Cov(a,b). The only case in which such an expansion did not occur was for the 1996 Oakdale outmigration.

4. Confidence Intervals

The 100*(1- ") confidence intervals of estimates were approximated using

estimate ± z(")*SE(estimate)

wherein z(") is the two-sided standardized normal deviate associated with confidence probability 1- " and SE is the standard error or square root of the variance of the estimate.

Appendix A2 Flow, screw-trap count, and predicted screw-trap efficiency and daily and cumulative outmigration index values, Caswell, 1996.

Date	Orange Blossom Bridge Flow (cfs)	Adjusted Count		Efficiency	Daily Passage	SE Passage	Cumulative Passage	SE
06-Feb	355	89		0.09	959	575	959	575
07-Feb	320	42		0.10	442	272	1,401	749
08-Feb	306	44		0.10	459	285	1,860	940
09-Feb	300	13		0.10	135	84	1,995	993
10-Feb	516	2		0.08	24	13	2,019	1,001
11-Feb	678	0		0.07	0	0	2,019	1,001
12-Feb	681	6		0.07	81	36	2,100	1,023
13-Feb	913	2		0.06	32	11	2,132	1,030
14-Feb	1,179	28		0.05	532	139	2,664	1,102
15-Feb	1,595	29		0.04	739	192	3,403	1,119
16-Feb	1,648	16		0.04	423	116	3,826	1,128
17-Feb	1,652	44		0.04	1,168	322	4,994	1,196
18-Feb	1,650	57		0.04	1,511	416	6,505	1,345
19-Feb	2,014	52		0.03	1,788	759	8,293	1,602
20-Feb	2,841	37		0.02	2,316	2,014	10,609	2,742
21-Feb	3,223	25	*	0.01	2,046	2,226	12,656	4,207
22-Feb	2,797	9	*	0.02	570	481	13,225	4,493
23-Feb	3,093	113		0.01	8,501	8,612	21,726	11,755
24-Feb	3,245	3		0.01	252	278	21,978	11,918
25-Feb	3,232	24		0.01	1,999	2,185	23,977	13,314
26-Feb	3,271	11		0.01	943	1,051	24,919	13,976
27-Feb	3,341	16		0.01	1,443	1,668	26,362	15,057
28-Feb	3,481	11		0.01	1,099	1,360	27,461	15,940
29-Feb	3,894	5		0.01	677	1,000	28,138	16,587
01-Mar	3,897	6		0.01	814	1,204	28,951	17,376
02-Mar	3,866	1		0.01	133	194	29,084	17,500
03-Mar	3,856	3	*	0.01	413	601	29,497	17,892

Date	Orange Blossom Bridge Flow (cfs)	Adjusted Count		Efficiency	Daily Passage	SE Passage	Cumulative Passage	SE
04-Mar	3,836	2	*	0.01	216	311	29,712	18,094
05-Mar	3,975	2	*	0.01	261	398	29,973	18,353
06-Mar	3,850	0		0.01	0	0	29,973	18,353
07-Mar	3,847	4		0.01	523	758	30,496	18,852
08-Mar	3,842	4		0.01	521	754	31,017	19,351
09-Mar	3,849	1		0.01	131	190	31,148	19,476
10-Mar	3,782	0		0.01	0	0	31,148	19,476
11-Mar	3,641	0		0.01	0	0	31,148	19,476
12-Mar	3,584	1		0.01	108	140	31,256	19,568
13-Mar	3,552	0		0.01	0	0	31,256	19,568
14-Mar	3,489	1		0.01	101	125	31,356	19,650
15-Mar	3,529	0		0.01	0	0	31,356	19,650
16-Mar	3,524	1		0.01	103	130	31,459	19,736
17-Mar	3,519	0		0.01	0	0	31,459	19,736
18-Mar	3,530	2		0.01	207	262	31,666	19,909
19-Mar	3,522	0		0.01	0	0	31,666	19,909
20-Mar	3,503	1		0.01	102	127	31,768	19,993
21-Mar	3,509	0		0.01	0	0	31,768	19,993
22-Mar	3,413	0		0.01	0	0	31,768	19,993
23-Mar	3,010	0		0.01	0	0	31,768	19,993
24-Mar	2,761	0		0.02	0	0	31,768	19,993
25-Mar	2,539	0		0.02	0	0	31,768	19,993
26-Mar	2,226	4		0.03	160	85	31,928	20,048
27-Mar	2,125	2		0.03	75	36	32,003	20,071
28-Mar	2,024	7		0.03	242	104	32,245	20,137
29-Mar	1,896	10		0.03	316	117	32,561	20,209
30-Mar	1,790	3		0.03	88	29	32,649	20,225
31-Mar	1,748	5		0.04	142	44	32,791	20,250
01-Apr	1,794	3		0.03	88	29	32,879	20,266
02-Apr	1,791	3		0.03	88	29	32,967	20,283
03-Apr	1,794	8		0.03	235	77	33,202	20,327
04-Apr	1,788	18		0.03	526	171	33,729	20,426
05-Apr	1,809	9		0.03	267	89	33,996	20,478
06-Apr	1,791	14		0.03	410	133	34,406	20,556
07-Apr	1,780	13		0.03	378	121	34,784	20,626
08-Apr	1,779	1		0.03	29	9	34,813	20,631
09-Apr	1,775	8		0.03	232	74	35,045	20,674
10-Apr	1,776	4		0.03	116	37	35,161	20,695
11-Apr	1,791	2		0.03	59	19	35,220	20,706
12-Apr	1,731	9		0.04	253	76	35,473	20,749
13-Apr	1,598	2		0.04	51	13	35,524	20,755

Date	Orange Blossom Bridge Flow (cfs)	Adjusted Count	Efficiency	Daily Passage	SE Passage	Cumulative Passage	SE
14-Apr	1,595	0	0.04	0	0	35,524	20,755
15-Apr	1,599	10	0.04	256	67	35,779	20,785
16-Apr	1,656	2	0.04	53	15	35,833	20,793
17-Apr	1,706	3	0.04	83	24	35,915	20,806
18-Apr	1,711	6	0.04	166	49	36,081	20,833
19-Apr	1,679	15	0.04	406	115	36,487	20,894
20-Apr	1,670	1	0.04	27	8	36,514	20,898
21-Apr	1,675	22	0.04	594	168	37,108	20,986
22-Apr	1,673	36	0.04	970	274	38,078	21,131
23-Apr	1,668	20	0.04	537	151	38,615	21,211
24-Apr	1,673	38	0.04	1,024	289	39,638	21,365
25-Apr	1,676	39	0.04	1,053	299	40,691	21,526
26-Apr	1,676	38	0.04	1,026	291	41,718	21,684
27-Apr	1,662	95	0.04	2,540	709	44,257	22,068
28-Apr	1,668	109	0.04	2,926	822	47,183	22,523
29-Apr	1,684	89	0.04	2,417	691	49,600	22,917
30-Apr	1,683	121	0.04	3,283	938	52,884	23,458
01-May	1,684	40	0.04	1,086	311	53,970	23,637
02-May	1,680	84	0.04	2,275	648	56,244	24,013
03-May	1,659	44	0.04	1,174	326	57,418	24,198
04-May	1,674	67	0.04	1,806	511	59,225	24,495
05-May	1,662	107	0.04	2,860	798	62,085	24,959
06-May	1,640	73	0.04	1,921	523	64,006	25,257
07-May	1,664	42	0.04	1,124	314	65,131	25,441
08-May	1,650	47	0.04	1,246	343	66,376	25,639
09-May	1,663	47	0.04	1,257	351	67,634	25,846
10-May	1,667	21	0.04	563	158	68,197	25,939
11-May	1,653	60	0.04	1,594	440	69,791	26,198
12-May	1,644	20	0.04	528	144	70,319	26,281
13-May	1,662	* 6	0.04	160	45	70,479	26,308
14-May	1,668	* 16	0.04	430	121	70,908	26,380
15-May	1,673	* 5	0.04	135	38	71,043	26,402
16-May	1,673	* 19	0.04	512	145	71,555	26,489
17-May	1,698	10	0.04	274	80	71,829	26,538
18-May	1,658	14	0.04	373	104	72,203	26,599
19-May	1,693	10	0.04	273	79	72,476	26,648
20-May	1,697	19	0.04	521	151	72,997	26,740
21-May	1,670	23	0.04	618	174	73,615	26,845
22-May	1,525	8	0.04	194	48	73,809	26,868
23-May	1,151	9	0.05	168	45	73,977	26,867
24-May	936	18	0.06	289	99	74,265	26,845

Date	Orange Blossom Bridge Flow (cfs)	Adjusted Count	Efficiency	Daily Passage	SE Passage	Cumulative Passage	SE
25-May	901	20	0.06	313	112	74,578	26,818
26-May	921	52	0.06	825	288	75,403	26,752
27-May	955	30	0.06	487	163	75,891	26,720
28-May	958	15	0.06	244	82	76,135	26,704
29-May	935	22	0.06	352	121	76,488	26,678
30-May	935	9	0.06	144	49	76,632	26,668
31-May	939	10	0.06	161	55	76,792	26,656
01-Jun	945	10	0.06	161	55	76,954	26,645
02-Jun	939	11	0.06	177	60	77,130	26,633
03-Jun	933	2	0.06	32	11	77,162	26,631
04-Jun	936	2	0.06	32	11	77,195	26,628
05-Jun	933	7	0.06	112	39	77,307	26,620
06-Jun	929	3	0.06	48	17	77,354	26,617
07-Jun	976	1	0.06	16	5	77,371	26,616
08-Jun	1,281	4	0.05	82	20	77,453	26,619
09-Jun	1,275	2	0.05	41	10	77,493	26,621
10-Jun	1,279	0	0.05	0	0	77,493	26,621
11-Jun	1,300	0	0.05	0	0	77,493	26,621
12-Jun	1,308	3	0.05	62	15	77,556	26,624
13-Jun	1,292	2	0.05	41	10	77,597	26,626
14-Jun	1,200	2	0.05	39	10	77,635	26,627
15-Jun	1,077	0	0.06	0	0	77,635	26,627
16-Jun	928	0	0.06	0	0	77,635	26,627
17-Jun	848	1	0.07	15	6	77,650	26,625
18-Jun	850	0	0.07	0	0	77,650	26,625
19-Jun	844	0	0.07	0	0	77,650	26,625
20-Jun	829	0	0.07	0	0	77,650	26,625
21-Jun	821	1	0.07	15	6	77,665	26,624
22-Jun	833	0	0.07	0	0	77,665	26,624
23-Jun	811	1	0.07	15	6	77,680	26,622
24-Jun	825	1	0.07	15	6	77,695	26,620
25-Jun	842	0	0.07	0	0	77,695	26,620
26-Jun	852	0	0.07	0	0	77,695	26,620
27-Jun	831	1	0.07	15	6	77,710	26,619
28-Jun	815	0	0.07	0	0	77,710	26,619
29-Jun	776	0	0.07	0	0	77,710	26,619
30-Jun	757	1	0.07	14	6	77,724	26,617
01-Jul	752	1	0.07	14	6	77,738	26,615

* Missing value substitutions

Appendix A3 Turbidity, screw-trap count, and predicted screw-trap efficiency and daily and cumulative outmigration index values, Caswell, 1996.

Date	Adjusted Turbidity		Adjusted Count		Efficiency	Daily Passage	SE Passage	Cumulative Passage	SE
06-Feb	3.7	*	89		0.02	5,163	2,790	5,163	2,790
07-Feb	3.7		42		0.02	2,436	1,316.64	7,599	3,632
08-Feb	7.6		44		0.03	1,293	344.10	8,892	3,811
09-Feb	10.8		13		0.06	221	53.53	9,114	3,810
10-Feb	14.0		2		0.10	20	8.39	9,134	3,808
11-Feb	12.0		0		0.07	0	0.00	9,134	3,808
12-Feb	13.5		6		0.09	65	25.26	9,199	3,800
13-Feb	14.8		2		0.11	18	8.25	9,217	3,797
14-Feb	14.7		28		0.11	252	115.83	9,468	3,759
15-Feb	15.7		29		0.13	223	115.91	9,691	3,719
16-Feb	11.7		16		0.07	234	66.16	9,925	3,712
17-Feb	9.4		44		0.05	950	204.12	10,875	3,776
18-Feb	6.0		57		0.03	2,211	806.85	13,086	4,290
19-Feb	10.5		52		0.06	931	215.73	14,017	4,319
20-Feb	10.5	*	37		0.06	663	153.50	14,680	4,342
21-Feb	6.1	*	25	*	0.03	943	337.54	15,623	4,553
22-Feb	6.1		9	*	0.03	358	128.20	15,981	4,633
23-Feb	13.8		113		0.10	1,172	474.85	17,154	4,547
24-Feb	13.6		3		0.09	32	12.62	17,186	4,545
25-Feb	12.4		24		0.08	313	100.35	17,499	4,539
26-Feb	12.1		11		0.07	151	45.78	17,649	4,538
27-Feb	10.8		16		0.06	272	65.88	17,922	4,549
28-Feb	9.9		11		0.05	218	47.55	18,140	4,565
29-Feb	7.8		5		0.04	142	36.40	18,282	4,587
01-Mar	8.1		6		0.04	162	39.37	18,444	4,610
02-Mar	6.1	*	1		0.03	38	13.64	18,482	4,618
03-Mar	3.9	*	3	*	0.02	177	93.66	18,659	4,672
04-Mar	1.6	*	2	*	0.01	140	99.67	18,799	4,727
05-Mar	1.6		2	*	0.01	152	108.87	18,951	4,788
06-Mar	5.9		0		0.03	0	0.00	18,951	4,788
07-Mar	9.0		4		0.04	92	20.17	19,044	4,798
08-Mar	4.5		4		0.02	202	96.16	19,245	4,856
09-Mar	5.7		1		0.02	41	15.79	19,286	4,866
10-Mar	7.0		0		0.03	0	0.00	19,286	4,866
11-Mar	5.1		0		0.02	0	0.00	19,286	4,866
12-Mar	10.5		1		0.06	18	4.15	19,304	4,866
13-Mar	8.0		0		0.04	0	0.00	19,304	4,866
14-Mar	5.4		1		0.02	43	17.58	19,347	4,877
15-Mar	5.6		0		0.02	0	0.00	19,347	4,877
16-Mar	6.0		1		0.03	39	14.16	19,386	4,886
17-Mar	5.6		0		0.02	0	0.00	19,386	4,886
18-Mar	7.6		2		0.03	59	15.64	19,445	4,895

Date	Adjusted Turbidity	Adjusted Count	Efficiency	Daily Passage	SE Passage	Cumulative Passage	SE
19-Mar	6.5	0	0.03	0	0.00	19,445	4,895
20-Mar	5.8	1	0.02	40	15.23	19,485	4,905
21-Mar	5.5	0	0.02	0	0.00	19,485	4,905
22-Mar	7.3	0	0.03	0	0.00	19,485	4,905
23-Mar	5.7	0	0.02	0	0.00	19,485	4,905
24-Mar	4.5	0	0.02	0	0.00	19,485	4,905
25-Mar	6.0	0	0.03	0	0.00	19,485	4,905
26-Mar	5.1	4	0.02	182	78.19	19,666	4,953
27-Mar	5.7	2	0.02	82	31.58	19,748	4,972
28-Mar	5.3	7	0.02	307	127.53	20,055	5,051
29-Mar	8.0	10	0.04	274	67.89	20,329	5,092
30-Mar	7.7	3	0.03	87	22.63	20,416	5,106
31-Mar	7.4	5	0.03	152	42.07	20,568	5,132
01-Apr	6.5	3	0.03	107	35.30	20,675	5,154
02-Apr	3.0	3	0.02	197	117.57	20,872	5,224
03-Apr	6.5	8	0.03	284	94.13	21,156	5,284
04-Apr	6.0	18	0.03	698	254.79	21,854	5,448
05-Apr	6.2	9	0.03	337	118.36	22,192	5,524
06-Apr	5.9	14	0.03	553	205.55	22,744	5,657
07-Apr	5.1	13	0.02	590	254.13	23,334	5,821
08-Apr	4.2	1	0.02	53	26.59	23,387	5,837
09-Apr	6.5	8	0.03	284	94.13	23,672	5,898
10-Apr	4.2	4	0.02	213	106.37	23,884	5,965
11-Apr	4.6	2	0.02	99	46.47	23,983	5,995
12-Apr	9.9	9	0.05	178	38.91	24,162	6,008
13-Apr	5.2	2	0.02	89	37.75	24,251	6,032
14-Apr	9.7	0	0.05	0	0.00	24,251	6,032
15-Apr	5.7	10	0.02	409	157.89	24,660	6,135
16-Apr	9.3	2	0.05	44	9.45	24,704	6,139
17-Apr	7.2	3	0.03	94	27.18	24,798	6,157
18-Apr	6.3	6	0.03	221	76.04	25,019	6,207
19-Apr	5.2	15	0.02	669	283.11	25,688	6,392
20-Apr	5.6	1	0.02	42	16.37	25,730	6,403
21-Apr	4.7	22	0.02	1,071	494.03	26,801	6,730
22-Apr	6.0	36	0.03	1,397	509.59	28,197	7,076
23-Apr	6.4	20	0.03	724	244.24	28,921	7,241
24-Apr	7.8	38	0.04	1,079	276.61	30,000	7,420
25-Apr	5.7	39	0.02	1,594	615.75	31,594	7,842
26-Apr	5.1	38	0.02	1,725	742.85	33,319	8,351
27-Apr	5.9	95	0.03	3,750	1,394.82	37,069	9,346
28-Apr	6.9	109	0.03	3,616	1,104.48	40,685	10,122
29-Apr	9.1	89	0.04	2,022	438.57	42,707	10,347
30-Apr	9.4	121	0.05	2,612	561.32	45,318	10,611
01-May	9.8	* 40	0.05	807	174.87	46,125	10,680
02-May	10.2	84	0.05	1,583	353.92	47,708	10,792
03-May	9.8	44	0.05	887	192.36	48,595	10,870

Date	Adjusted Turbidity		Adjusted Count	Efficiency	Daily Passage	SE Passage	Cumulative Passage	SE
04-May	9.9		67	0.05	1,328	289.64	49,923	10,985
05-May	9.2		107	0.04	2,390	515.98	52,312	11,267
06-May	8.4		73	0.04	1,870	434.62	54,182	11,549
07-May	9.2		42	0.04	938	202.54	55,120	11,660
08-May	9.0		47	0.04	1,086	237.01	56,206	11,799
09-May	8.8		47	0.04	1,124	249.26	57,330	11,952
10-May	8.7		21	0.04	511	114.44	57,841	12,023
11-May	9.0		60	0.04	1,386	302.57	59,227	12,202
12-May	8.8		20	0.04	478	106.07	59,706	12,268
13-May	6.8		6	0.03	203	63.11	59,908	12,311
14-May	7.1		16	0.03	513	150.46	60,421	12,415
15-May	6.9		5	0.03	166	50.66	60,587	12,449
16-May	7.3		19	0.03	588	165.87	61,175	12,564
17-May	7.1		10	0.03	320	94.03	61,495	12,629
18-May	6.1		14	0.03	534	191.03	62,029	12,757
19-May	6.2		10	0.03	375	131.51	62,404	12,846
20-May	5.8		19	0.02	763	289.31	63,167	13,041
21-May	5.4		23	0.02	991	404.41	64,158	13,310
22-May	6.4		8	0.03	289	97.70	64,447	13,377
23-May	7.9		9	0.04	251	63.25	64,698	13,420
24-May	9.8		18	0.05	363	78.69	65,061	13,455
25-May	8.9		20	0.04	470	103.36	65,531	13,518
26-May	6.8		52	0.03	1,755	546.99	67,287	13,899
27-May	6.6		30	0.03	1,048	340.06	68,335	14,134
28-May	7.4		15	0.03	456	126.20	68,792	14,221
29-May	8.3		22	0.04	573	135.18	69,365	14,311
30-May	7.9		9	0.04	251	63.25	69,616	14,354
31-May	8.6		10	0.04	247	56.06	69,863	14,390
01-Jun	9.8		10	0.05	202	43.72	70,065	14,410
02-Jun	7.7		11	0.03	318	82.98	70,383	14,467
03-Jun	6.8		2	0.03	68	21.04	70,450	14,481
04-Jun	6.6		2	0.03	70	22.67	70,520	14,497
05-Jun	8.3		7	0.04	182	43.01	70,703	14,525
06-Jun	7.4		3	0.03	91	25.24	70,794	14,543
07-Jun	7.9		1	0.04	28	7.03	70,822	14,548
08-Jun	8.6		4	0.04	99	22.43	70,921	14,562
09-Jun	8.6	*	2	0.04	49	11.21	70,970	14,569
10-Jun	8.6	*	0	0.04	0	0.00	70,970	14,569
11-Jun	9.2	*	0	0.04	0	0.00	70,970	14,569
12-Jun	9.7	*	3	0.05	62	13.28	71,032	14,575
13-Jun	9.7	*	2	0.05	41	8.85	71,073	14,580
14-Jun	9.7		2	0.05	41	8.85	71,114	14,584
15-Jun	8.8		0	0.04	0	0.00	71,114	14,584
16-Jun	8.3		0	0.04	0	0.00	71,114	14,584
17-Jun	7.5		1	0.03	30	8.11	71,144	14,589
18-Jun	4.9		0	0.02	0	0.00	71,144	14,589

Date	Adjusted Turbidity		Adjusted Count	Efficiency	Daily Passage	SE Passage	Cumulative Passage	SE
19-Jun	5.3		0	0.02	0	0.00	71,144	14,589
20-Jun	6.7		0	0.03	0	0.00	71,144	14,589
21-Jun	6.0		1	0.03	39	14.16	71,183	14,599
22-Jun	5.6		0	0.02	0	0.00	71,183	14,599
23-Jun	5.7		1	0.02	41	15.79	71,223	14,609
24-Jun	5.3		1	0.02	44	18.22	71,267	14,621
25-Jun	5.0		0	0.02	0	0.00	71,267	14,621
26-Jun	4.8		0	0.02	0	0.00	71,267	14,621
27-Jun	5.4		1	0.02	43	17.58	71,310	14,633
28-Jun	5.6		0	0.02	0	0.00	71,310	14,633
29-Jun	6.4		0	0.03	0	0.00	71,310	14,633
30-Jun	6.7		1	0.03	34	10.92	71,345	14,641
01-Jul	6.7	*	1	0.03	34	10.92	71,379	14,648

* Missing value substitutions

Appendix 1. Modifications made to the Caswell traps during 1996.

Modifications to Caswell screw traps during 1996

April 11 Traps moved out into current about 5-6 ft (away from north bank)

April 12 Traps moved back to original position (towards north bank)

April 14 Traps moved out into current about 5 ft (away from north bank)

April 15 Traps moved back to original position (towards north bank)

April 20 Traps moved upstream 50 - 100 ft

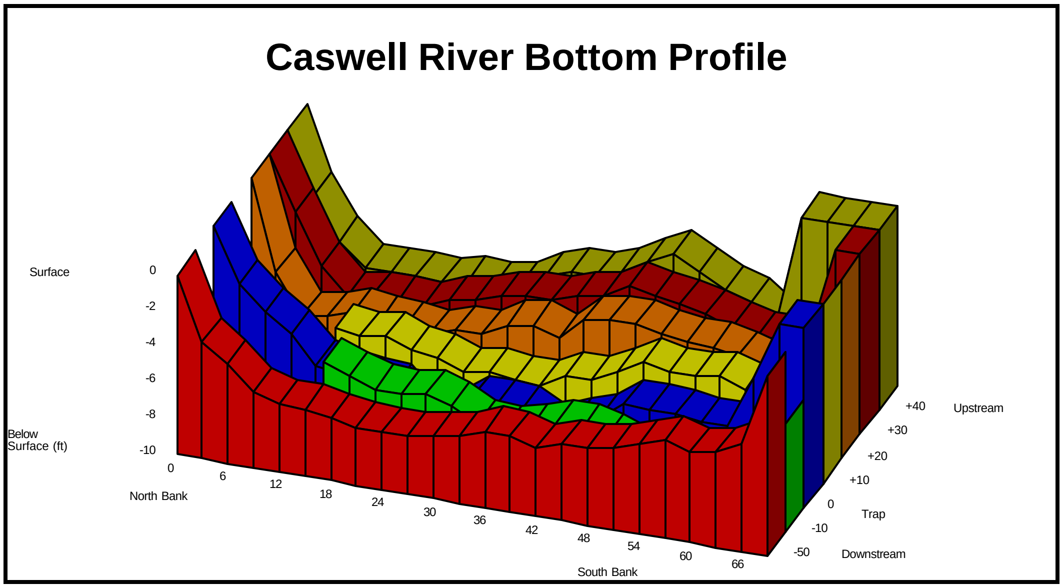
April 24&25 About 750 sandbags added to north bank upstream from traps. Wall extends out about 5 ft into river to guide fish and flow into traps

April 25 Traps moved 5-6 ft closer to north bank (near sandbags)

April 26 Traps moved back out 5-6 ft

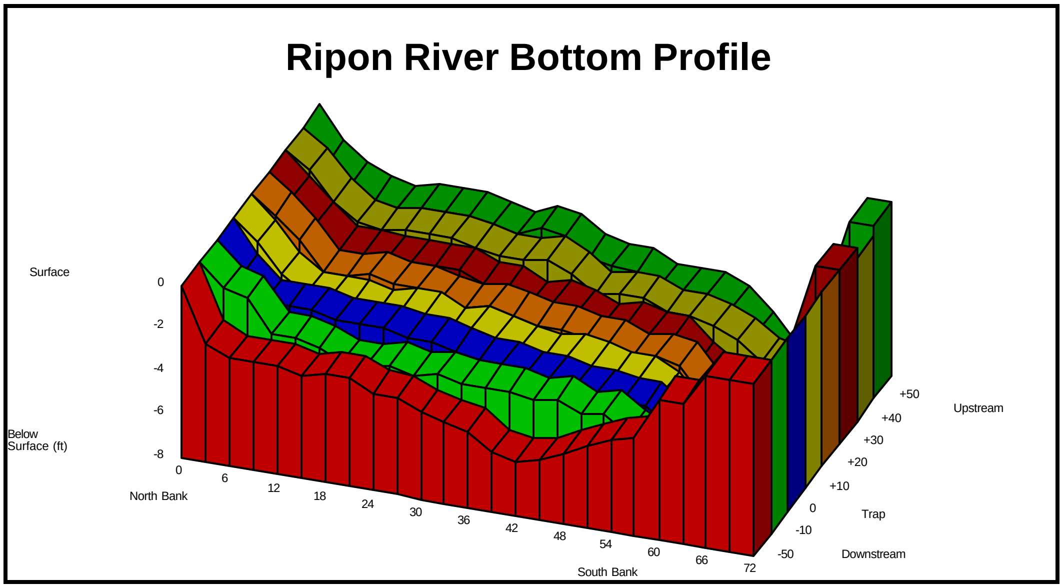
Appendix 2. Depth measurements made at Caswell and Ripon during 1996. Caswell measurements made in front of, upstream and downstream from traps on July 31, 1996. River flow at OBB was 805 cfs. Ripon measurements were made on August 1, 1996 at the proposed trapping location. River flow at OBB on August 1 was 826 cfs.

Distance From North Bank (ft)	Downstream -50	Downstream -10	At Traps 0	Upstream +10	Upstream +20	Upstream +30	Upstream +40	Upstream +50
0	0	0	0	-	-	0	0	0
3	-3.5	-	-3	-	-	-5	-3	-3.5
6	-4.5	-	-4.25	-	-	-7.25	-5.75	-5.75
9	-5.75	-	-5.25	-	-	-7	-7.25	-7
12	-6.25	-	-6.75	-	-6	-6.5	-7	-7
15	-6.25	-5	-7	-	-6.25	-6.75	-7	-7
18	-6.5	-5.5	-7.25	-	-6	-6.75	-7	-7
21	-6.75	-6	-7.25	-	-6.5	-7	-6.5	-6.75
24	-6.75	-6	-8.75	-	-6.75	-6.5	-6.25	-6.75
27	-6.75	-5.75	-8.25	-	-7.25	-6.5	-5.75	-6.5
30	-6.5	-6.25	-7.25	-	-7	-5.75	-5.5	-5.75
33	-6.25	-7	-7.25	-	-7.25	-5.5	-5.5	-5.25
36	-5.75	-7	-7.25	-	-7.25	-6	-5	-5.25
39	-5.75	-6.75	-8	-	-6.5	-4.75	-4.75	-4.75
42	-6.25	-6.25	-7.5	-	-6.5	-4.5	-4	-4
45	-5.75	-6.25	-7	-	-5.75	-4.5	-4.25	-3.25
48	-5.75	-6.5	-6	-	-5	-4.75	-4.5	-4
51	-5.5	-7	-6	-	-5.25	-5	-4.75	-4.75
54	-5	-7.25	-6	-	-5.25	-5	-5.25	-5.25
57	-4.5	-7.75	-6.25	-	-5	-5.25	-5.5	-6.25
60	-5	-7	-6.25	-	-5.5	-5.75	-5.5	0
63	-4.75	-6.5	-3.25	-	-5.75	-5.5	-5	0
66	-4	-7	0	-	-4	-4	0	0
69	0	-4	0	-	0	0	0	0



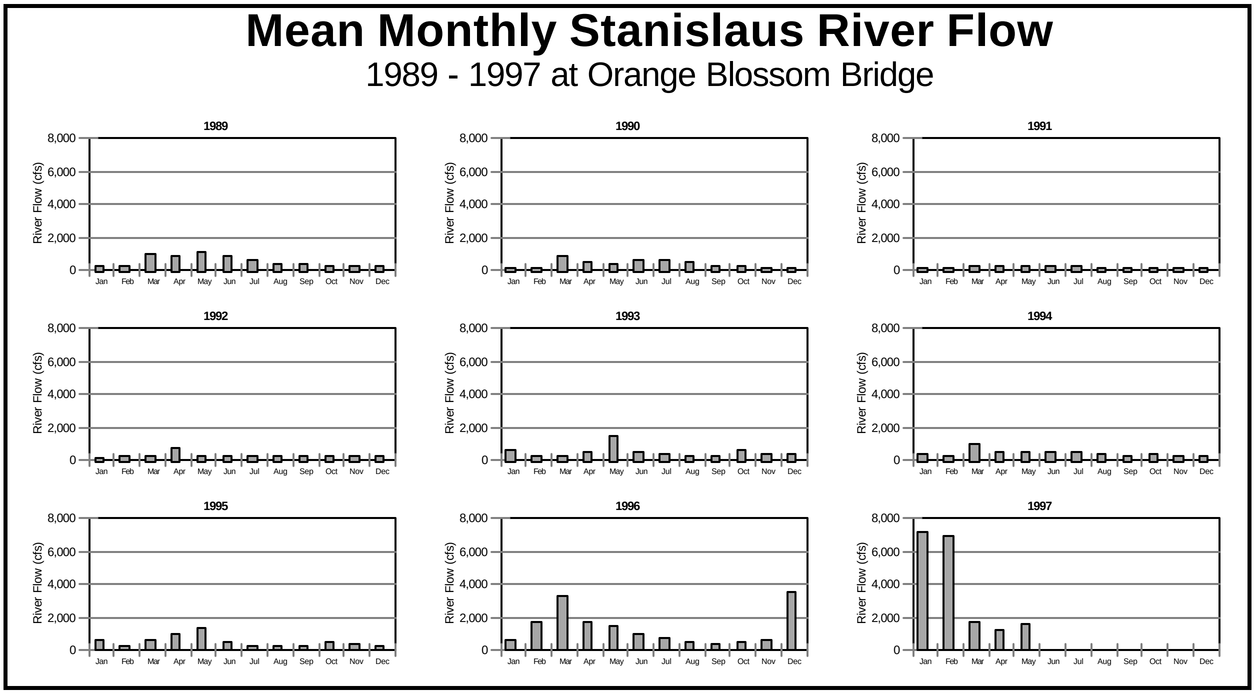
App endi x 2. Continued.

Distance From North Bank (ft)	Downstream -50	Downstream -10	At Trap 0	Upstream +10	Upstream +20	Upstream +30	Upstream +40	Upstream +50
0	0	0	0	0	0	0	0	0
3	-2.5	-1	-1.5	-1	-0.75	-1	-0.75	-1.5
6	-3	-1.25	-2.5	-2.25	-1.75	-2	-2	-2.25
9	-3	-2.75	-2.5	-3	-3	-3	-2.75	-2.75
12	-3	-2.75	-2.5	-3	-3	-3	-3	-3
15	-3.25	-3	-2.75	-3	-2.75	-3	-2.75	-2.75
18	-3	-3.5	-2.75	-3.25	-3	-3	-2.75	-2.75
21	-3	-3.5	-2.75	-3	-3	-3	-2.75	-2.75
24	-3.5	-3.25	-3	-3	-3.25	-3	-3	-3
27	-3.5	-3.5	-3	-3.5	-3.5	-3.5	-3.25	-3.25
30	-4	-3.25	-3.25	-3.25	-3.25	-3.5	-3.25	-2.75
33	-4.25	-3.5	-3.5	-3.5	-3.5	-4	-3	-3
36	-4.5	-3.5	-3.5	-3.75	-3.75	-3.75	-3.5	-3.75
39	-5.25	-3.5	-3.75	-4	-3.75	-4	-4.25	-4
42	-5.5	-3.75	-3.75	-3.75	-4	-4.5	-4	-4
45	-5.25	-3.5	-4	-4	-4	-4.25	-4	-4.5
48	-4.75	-4	-4	-4.25	-4.5	-4.5	-4.5	-4.5
51	-4.25	-3.75	-4.25	-4.25	-4.25	-4.5	-4.5	-4.5
54	-3.75	-4.5	-4.25	-4.75	-4.5	-5.5	-4.75	-5
57	-3.5	-5	-5	-6	-5.75	-6.25	-5.25	-6
60	-1.5	-5.75	-6.25	-6.5	-6.25	-7.25	-6	-7.25
63	-1.5	-6.5	-6.75	-6	-7	-6	-6.25	-6
66	0	-4.5	-7	-5.25	-5.75	-3.5	-6.75	-3.25
69	0	-3.75	-4	-3	-3.75	0	-4	0
72	0	0	0	0	0	0	-0.5	0



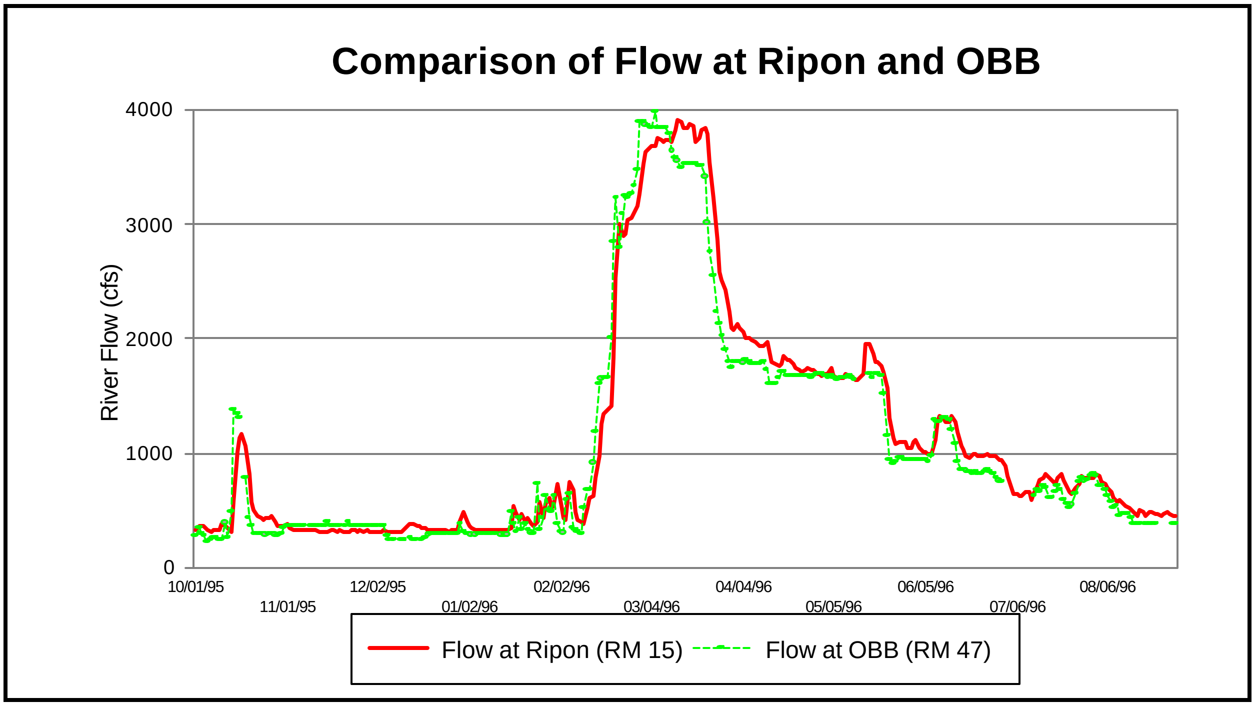
Appendix 3. Stanislaus River flow at Orange blossom Bridge (OBB) and Ripon. Data obtained from CDEC (OBB) and USGS (Ripon) Internet sites.

Appendix 3. Continued.



Appendix 3. Continued.

Appendix 3. Continued.



Appendix 4. Hourly Stanislaus River flow at Orange Blossom Bridge (OBB) one day prior to

and one day following trap efficiency releases. Flow data from CDEC.

Release C 1

Date	Release Group	Time (Hours)	OBB Flow (cfs)
Feb 13	-	0	677
Feb 13	-	1	681
Feb 13	-	2	681
Feb 13	-	3	681
Feb 13	-	4	686
Feb 13	-	5	725
Feb 13	-	6	792
Feb 13	-	7	877
Feb 13	-	8	940
Feb 13	-	9	969
Feb 13	-	10	989
Feb 13	-	11	999
Feb 13	-	12	1015
Feb 13	-	13	1025
Feb 13	-	14	1020
Feb 13	-	15	1020
Feb 13	-	16	1020
Feb 13	-	17	1015
Feb 13	-	18	1015
Feb 13	-	19	1015
Feb 13	-	20	1020
Feb 13	-	21	1020
Feb 13	-	22	1020
Feb 13	-	23	1020
Feb 14	-	0	1020
Feb 14	-	1	1025
Feb 14	-	2	1025
Feb 14	-	3	1020
Feb 14	-	4	1015
Feb 14	-	5	1020
Feb 14	-	6	1015
Feb 14	-	7	1015
Feb 14	-	8	1015
Feb 14	-	9	1015
Feb 14	-	10	1015
Feb 14	-	11	1015
Feb 14	-	12	1020
Feb 14	-	13	1015
Feb 14	-	14	1050
Feb 14	-	15	1140
Feb 14	-	16	1260
Feb 14	-	17	1397
Feb 14	-	18	1491
Feb 14	-	19	1522
Feb 14	-	20	1528
Feb 14	C1 Released	21	1540
Feb 14	-	22	1558
Feb 14	-	23	1558
Feb 15	-	0	1564
Feb 15	-	1	1558
Feb 15	-	2	1558
Feb 15	-	3	1558
Feb 15	-	4	1570
Feb 15	-	5	1558
Feb 15	-	6	1570
Feb 15	-	7	1558
Feb 15	-	8	1564
Feb 15	-	9	1558
Feb 15	-	10	1564
Feb 15	-	11	1552
Feb 15	-	12	1540
Feb 15	-	13	1552
Feb 15	-	14	1564
Feb 15	-	15	1605
Feb 15	-	16	1646
Feb 15	-	17	1657
Feb 15	-	18	1651
Feb 15	-	19	1663
Feb 15	-	20	1669
Feb 15	-	21	1663
Feb 15	-	22	1663
Feb 15	-	23	1669

Release C2

Date	Release Group	Time (Hours)	OBB Flow (cfs)
Feb 18	-	0	1657
Feb 18	-	1	1651
Feb 18	-	2	1651
Feb 18	-	3	1651
Feb 18	-	4	1651
Feb 18	-	5	1657
Feb 18	-	6	1646
Feb 18	-	7	1651
Feb 18	-	8	1651
Feb 18	-	9	1651
Feb 18	-	10	1640
Feb 18	-	11	1651
Feb 18	-	12	1651
Feb 18	-	13	1651
Feb 18	-	14	1646
Feb 18	-	15	1640
Feb 18	-	16	1640
Feb 18	-	17	1646
Feb 18	-	18	1646
Feb 18	-	19	1646
Feb 18	-	20	1646
Feb 18	-	21	1657
Feb 18	-	22	1651
Feb 18	-	23	1657
Feb 19	-	0	1663
Feb 19	-	1	1651
Feb 19	-	2	1651
Feb 19	-	3	1657
Feb 19	-	4	1657
Feb 19	-	5	1680
Feb 19	-	6	1704
Feb 19	-	7	1721
Feb 19	-	8	1757
Feb 19	-	9	1763
Feb 19	-	10	1757
Feb 19	-	11	1768
Feb 19	-	12	1828
Feb 19	-	13	1937
Feb 19	-	14	1968
Feb 19	-	15	1956
Feb 19	-	16	1993
Feb 19	-	17	1925
Feb 19	-	18	2144
Feb 19	-	19	2415
Feb 19	-	20	2693
Feb 19	C2 Released	21	2901
Feb 19	-	22	3034
Feb 19	-	23	3108
Feb 20	-	0	3081
Feb 20	-	1	2994
Feb 20	-	2	2915
Feb 20	-	3	2829
Feb 20	-	4	2796
Feb 20	-	5	2744
Feb 20	-	6	2699
Feb 20	-	7	2674
Feb 20	-	8	2648
Feb 20	-	9	2622
Feb 20	-	10	2635
Feb 20	-	11	2654
Feb 20	-	12	2699
Feb 20	-	13	2744
Feb 20	-	14	2803
Feb 20	-	15	2842
Feb 20	-	16	2914
Feb 20	-	17	3001
Feb 20	-	18	3021
Feb 20	-	19	3041
Feb 20	-	20	3014
Feb 20	-	21	2974
Feb 20	-	22	2941
Feb 20	-	23	2895

Appendix 4. Continued.

Release C3

Date	Release Group	Time	OBB Flow (cfs)
Mar 21		0	3508
Mar 21		1	3522
Mar 21		2	3529
Mar 21		3	3515

Releases C4 through C7

Date	Release Group	Time	OBB Flow (cfs)
Apr 5		0	1822
Apr 5		1	1828
Apr 5		2	1834
Apr 5		3	1834

Mar 21		4	3522	Apr 5		4	1834
Mar 21		5	3508	Apr 5		5	1828
Mar 21		6	3522	Apr 5		6	1822
Mar 21		7	3508	Apr 5		7	1816
Mar 21		8	3494	Apr 5		8	1810
Mar 21		9	3501	Apr 5		9	1792
Mar 21		10	3494	Apr 5		10	1792
Mar 21		11	3501	Apr 5		11	1786
Mar 21		12	3494	Apr 5		12	1786
Mar 21		13	3501	Apr 5		13	1786
Mar 21		14	3501	Apr 5		14	1792
Mar 21		15	3501	Apr 5		15	1792
Mar 21		16	3501	Apr 5		16	1792
Mar 21		17	3494	Apr 5		17	1804
Mar 21		18	3515	Apr 5		18	1798
Mar 21		19	3515	Apr 5		19	1804
Mar 21		20	3522	Apr 5		20	1810
Mar 21		21	3508	Apr 5		21	1816
Mar 21		22	3508	Apr 5		22	1816
Mar 21		23	3515	Apr 5		23	1810
Mar 22		0	3522	Apr 6		0	1822
Mar 22		1	3529	Apr 6		1	1834
Mar 22		2	3537	Apr 6		2	1834
Mar 22		3	3529	Apr 6		3	1840
Mar 22		4	3515	Apr 6		4	1834
Mar 22		5	3522	Apr 6		5	1828
Mar 22		6	3515	Apr 6		6	1822
Mar 22		7	3501	Apr 6		7	1804
Mar 22		8	3508	Apr 6		8	1804
Mar 22		9	3494	Apr 6		9	1798
Mar 22		10	3494	Apr 6		10	1780
Mar 22		11	3494	Apr 6		11	1780
Mar 22		12	3487	Apr 6		12	1768
Mar 22		13	3494	Apr 6		13	1751
Mar 22		14	3494	Apr 6	C6 Released	14	1751
Mar 22		15	3494	Apr 6	C7 Released	15	1757
Mar 22		16	3480	Apr 6		16	1751
Mar 22		17	3403	Apr 6		17	1768
Mar 22		18	3272	Apr 6		18	1763
Mar 22		19	3176	Apr 6		19	1768
Mar 22		20	3122	Apr 6		20	1768
Mar 22		21	3108	Apr 6	C5 Released	21	1774
Mar 22	C3 Released	22	3108	Apr 6	C4 Released	22	1774
Mar 22		23	3102	Apr 6		23	1786
Mar 23		0	3115	Apr 7		0	1786
Mar 23		1	3115	Apr 7		1	1798
Mar 23		2	3115	Apr 7		2	1798
Mar 23		3	3129	Apr 7		3	1804
Mar 23		4	3122	Apr 7		4	1804
Mar 23		5	3122	Apr 7		5	1792
Mar 23		6	3108	Apr 7		6	1786
Mar 23		7	3122	Apr 7		7	1774
Mar 23		8	3122	Apr 7		8	1768
Mar 23		9	3115	Apr 7		9	1763
Mar 23		10	3115	Apr 7		10	1757
Mar 23		11	3115	Apr 7		11	1751
Mar 23		12	3108	Apr 7		12	1751
Mar 23		13	3041	Apr 7		13	1757
Mar 23		14	2941	Apr 7		14	1757
Mar 23		15	2868	Apr 7		15	1763
Mar 23		16	2849	Apr 7		16	1774
Mar 23		17	2849	Apr 7		17	1780
Mar 23		18	2855	Apr 7		18	1786
Mar 23		19	2842	Apr 7		19	1792
Mar 23		20	2855	Apr 7		20	1798
Mar 23		21	2862	Apr 7		21	1798
Mar 23		22	2875	Apr 7		22	1804
Mar 23		23	2868	Apr 7		23	1804

Appendix 4. Continued.

Releases C8 and C9

Date	Release Group	Time	OBB Flow (cfs)
May 1		0	1699
May 1		1	1704
May 1		2	1704
May 1		3	1704
May 1		4	1698
May 1		5	1698
May 1		6	1686
May 1		7	1686
May 1		8	1675
May 1		9	1669

Release C10

Date	Release Group	Time	OBB Flow (cfs)
May 3		0	1680
May 3		1	1675
May 3		2	1680
May 3		3	1680
May 3		4	1680
May 3		5	1669
May 3		6	1669
May 3		7	1663
May 3		8	1651
May 3		9	1646

May 1		10	1675
May 1		11	1675
May 1		12	1669
May 1		13	1663
May 1		14	1663
May 1		15	1663
May 1		16	1675
May 1		17	1675
May 1		18	1680
May 1		19	1686
May 1		20	1686
May 1		21	1686
May 1		22	1692
May 1		23	1692
May 2	C8 Released	0	1698
May 2		1	1704
May 2	C9 Released	2	1704
May 2		3	1704
May 2		4	1698
May 2		5	1692
May 2		6	1686
May 2		7	1675
May 2		8	1680
May 2		9	1669
May 2		10	1669
May 2		11	1675
May 2		12	1686
May 2		13	1680
May 2		14	1675
May 2		15	1675
May 2		16	1669
May 2		17	1663
May 2		18	1663
May 2		19	1663
May 2		20	1669
May 2		21	1669
May 2		22	1669
May 2		23	1680
May 3		0	1680
May 3		1	1675
May 3		2	1680
May 3		3	1680
May 3		4	1680
May 3		5	1669
May 3		6	1669
May 3		7	1663
May 3		8	1651
May 3		9	1646
May 3		10	1646
May 3		11	1640
May 3		12	1640
May 3		13	1640
May 3		14	1640
May 3		15	1640
May 3		16	1646
May 3		17	1646
May 3		18	1651
May 3		19	1657
May 3		20	1663
May 3		21	1669
May 3		22	1675
May 3		23	1686
May 3		10	1646
May 3		11	1640
May 3		12	1640
May 3		13	1640
May 3		14	1640
May 3		15	1640
May 3		16	1646
May 3		17	1646
May 3		18	1651
May 3		19	1657
May 3		20	1663
May 3		21	1669
May 3		22	1675
May 3		23	1686
May 4		0	1686
May 4		1	1692
May 4		2	1692
May 4		3	1686
May 4		4	1686
May 4		5	1686
May 4		6	1675
May 4		7	1675
May 4		8	1663
May 4		9	1657
May 4		10	1663
May 4		11	1651
May 4		12	1640
May 4		13	1640
May 4		14	1640
May 4		15	1640
May 4		16	1640
May 4		17	1640
May 4		18	1651
May 4		19	1646
May 4	C10 Released	20	1646
May 4		21	1651
May 4		22	1651
May 4		23	1651
May 5		0	1651
May 5		1	1651
May 5		2	1663
May 5		3	1663
May 5		4	1669
May 5		5	1657
May 5		6	1651
May 5		7	1651
May 5		8	1646
May 5		9	1640
May 5		10	1628
May 5		11	1617
May 5		12	1605
May 5		13	1600
May 5		14	1600
May 5		15	1611
May 5		16	1617
May 5		17	1628
May 5		18	1634
May 5		19	1640
May 5		20	1651
May 5		21	1651
May 5		22	1663
May 5		23	1663

Appendix 4. Continued.

Releases C11 and C12

Date	Release Group	Time	OBB Flow (cfs)
May 9		0	1669
May 9		1	1686
May 9		2	1692
May 9		3	1692
May 9		4	1698
May 9		5	1692
May 9		6	1686
May 9		7	1675
May 9		8	1675
May 9		9	1669
May 9		10	1680
May 9		11	1640
May 9		12	1611
May 9		13	1623
May 9		14	1640
May 9		15	1651

Releases C13 and C14

Date	Release Group	Time	OBB Flow (cfs)
May 25		0	901
May 25		1	901
May 25		2	901
May 25		3	896
May 25		4	896
May 25		5	891
May 25		6	891
May 25		7	886
May 25		8	886
May 25		9	886
May 25		10	891
May 25		11	896
May 25		12	896
May 25		13	896
May 25		14	896
May 25		15	896

May 9		16	1651	May 25		16	905
May 9		17	1657	May 25		17	915
May 9		18	1669	May 25		18	920
May 9		19	1663	May 25		19	920
May 9		20	1680	May 25		20	920
May 9		21	1675	May 25		21	920
May 9		22	1669	May 25		22	920
May 9		23	1663	May 25		23	925
May 10		0	1663	May 26		0	925
May 10		1	1663	May 26		1	930
May 10		2	1669	May 26		2	930
May 10		3	1663	May 26		3	930
May 10		4	1669	May 26		4	930
May 10		5	1663	May 26		5	925
May 10		6	1640	May 26		6	920
May 10		7	1640	May 26		7	920
May 10		8	1640	May 26		8	915
May 10		9	1628	May 26		9	915
May 10		10	1634	May 26		10	910
May 10		11	1640	May 26		11	905
May 10		12	1640	May 26		12	901
May 10		13	1646	May 26		13	901
May 10		14	1651	May 26		14	901
May 10		15	1651	May 26		15	910
May 10		16	1651	May 26		16	925
May 10		17	1663	May 26		17	930
May 10		18	1657	May 26		18	935
May 10		19	1663	May 26		19	935
May 10		20	1651	May 26		20	940
May 10	C11 Released	21	1651	May 26	C13 released	21	940
May 10		22	1663	May 26		22	945
May 10	C12 Released	23	1657	May 26	C14 released	23	950
May 11		0	1663	May 27		0	950
May 11		1	1663	May 27		1	954
May 11		2	1657	May 27		2	959
May 11		3	1669	May 27		3	964
May 11		4	1663	May 27		4	959
May 11		5	1651	May 27		5	959
May 11		6	1646	May 27		6	959
May 11		7	1640	May 27		7	954
May 11		8	1628	May 27		8	954
May 11		9	1623	May 27		9	954
May 11		10	1623	May 27		10	954
May 11		11	1623	May 27		11	949
May 11		12	1628	May 27		12	949
May 11		13	1623	May 27		13	949
May 11		14	1623	May 27		14	949
May 11		15	1634	May 27		15	949
May 11		16	1646	May 27		16	949
May 11		17	1646	May 27		17	954
May 11		18	1634	May 27		18	954
May 11		19	1646	May 27		19	959
May 11		20	1651	May 27		20	959
May 11		21	1657	May 27		21	964
May 11		22	1663	May 27		22	964
May 11		23	1663	May 27		23	969

Appendix 4. Continued.

Releases C15 and C16

Date	Release Group	Time	OBB Flow (cfs)
Jun 9		0	1294
Jun 9		1	1294
Jun 9		2	1299
Jun 9		3	1294
Jun 9		4	1294
Jun 9		5	1299
Jun 9		6	1288
Jun 9		7	1288
Jun 9		8	1282
Jun 9		9	1271
Jun 9		10	1266
Jun 9		11	1260
Jun 9		12	1254
Jun 9		13	1254
Jun 9		14	1254
Jun 9		15	1266
Jun 9		16	1266
Jun 9		17	1271
Jun 9		18	1266
Jun 9		19	1271
Jun 9		20	1271
Jun 9		21	1260
Jun 9		22	1266
Jun 9		23	1266

Jun 10		0	1277
Jun 10		1	1282
Jun 10		2	1288
Jun 10		3	1294
Jun 10		4	1288
Jun 10		5	1294
Jun 10		6	1277
Jun 10		7	1282
Jun 10		8	1282
Jun 10		9	1271
Jun 10		10	1260
Jun 10		11	1260
Jun 10		12	1249
Jun 10		13	1249
Jun 10		14	1260
Jun 10		15	1266
Jun 10		16	1277
Jun 10		17	1288
Jun 10		18	1288
Jun 10		19	1288
Jun 10		20	1299
Jun 10		21	1305
Jun 10	C15 released	22	1305
Jun 10	C16 released	23	1299
Jun 11		0	1311
Jun 11		1	1311
Jun 11		2	1316
Jun 11		3	1316
Jun 11		4	1311
Jun 11		5	1305
Jun 11		6	1305
Jun 11		7	1299
Jun 11		8	1288
Jun 11		9	1271
Jun 11		10	1254
Jun 11		11	1266
Jun 11		12	1277
Jun 11		13	1288
Jun 11		14	1299
Jun 11		15	1299
Jun 11		16	1305
Jun 11		17	1305
Jun 11		18	1311
Jun 11		19	1311
Jun 11		20	1305
Jun 11		21	1316
Jun 11		22	1322
Jun 11		23	1328

Appendix 5. Cross-section measurements of depth and velocity at the Caswell trap site during 1996.

	02/08/96 306 cfs	02/08/96 306 cfs	02/08/96 306 cfs	02/11/96 678 cfs	02/11/96 678 cfs	02/11/96 678 cfs
Distance From North Bank (ft)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)
3	2	0.22	0.22	2	0.1	0.15
6	6	0.4	0.2	7	0.5	0.2
9	6	0.15	0.2	6.5	0.19	0.23
12	5.8	0.5	0.55	7	0.5	0.77
15	6	0.7	0.78	7.25	2.1	2.35
18	6	2	2.44	6.75	2.11	2.96
21	7	2.49	2.92	8	2.56	2.88
24	6.25	2.58	2.83	7.75	2.55	2.9

27	7	2.39	2.7	7.5	2.46	2.79
30	6.75	2.46	2.84	8	2.44	2.81
33	6	2	1.88	7	2.33	2.36
36	6.75	2.41	2.04	7	2.12	2.44
39	7.25	2.21	2.06	7.25	2.05	2.33
42	7.75	2.17	1.88	8	2.27	2.01
45	6.75	2	1.92	7	1.19	1.88
48	6.25	1.55	1.72	6	1.59	1.72
51	6	1.54	1.36	6	1.76	1.41
54	6.5	1.99	1.66	6.75	2.39	1.79
57	6.75	1.81	1.54	7	1.71	1.44
60	7.25	1.68	2.22	7	1.72	2.39
63	7	2.12	1.54	7.25	2	1.77
66	6.75	1.99	1	7	1.86	1.5
69	7	1.01	0.15	7.25	1.22	0.3
72	8	0	0	7.5	0.5	0
75	3	0	0	3.25	0	0
78	-	-	-	-	-	-
81	-	-	-	-	-	-
84	-	-	-	-	-	-
87	-	-	-	-	-	-
90	-	-	-	-	-	-
93	-	-	-	-	-	-
96	-	-	-	-	-	-
99	-	-	-	-	-	-

Appendix 5. Continued.

	06/19/96 844 cfs	06/19/96 844 cfs	06/19/96 844 cfs	06/17/96 848 cfs	06/17/96 848 cfs	06/17/96 848 cfs
Distance From North Bank (ft)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)
3	4.5	0.15	0.2	4.5	0.2	0.2
6	7.25	0.4	0.29	7.25	0.45	0.4
9	6.75	0.18	0.19	7	0.53	0.23
12	7.5	0.67	0.82	7.5	0.95	1.11
15	7.25	2.13	2.18	5.75	2.14	1.42

18	7	2.77	2.87	7.75	2.32	1.29
21	8.5	2.76	2.93	7.75	2.48	2.49
24	7.75	2.6	2.83	7.5	2.57	2.4
27	7.5	2.67	2.73	7.75	1.93	1.68
30	7.75	2.45	2.87	7.75	1.4	1.59
33	8	2.45	2.45	8.75	1.6	1.46
36	8	2.52	2.5	8.75	2.1	2.16
39	7.75	2.11	2.36	8.5	2.15	2.4
42	8	2.33	2.07	8.75	2.61	2.7
45	7.5	1.7	1.82	8.5	2.84	2.83
48	7	1.78	1.8	8	2.7	2.77
51	7	1.73	1.4	8.25	2.6	2.58
54	7	2.54	1.85	6.75	2.45	2.54
57	7.5	1.82	1.5	8	0.54	0.53
60	7	1.75	2.33	9	0.18	0.19
63	7.25	2.07	1.92	7	2	1.99
66	7.25	1.85	1.42	5.5	1.79	1.5
69	7.25	1.14	0.33	7	1.44	0.27
72	7.25	0.37	0	7.5	0.41	0.15
75	3	0	0	3	0	0
78	-	-	-	-	-	-
81	-	-	-	-	-	-
84	-	-	-	-	-	-
87	-	-	-	-	-	-
90	-	-	-	-	-	-
93	-	-	-	-	-	-
96	-	-	-	-	-	-
99	-	-	-	-	-	-

Appendix 5. Continued.

	05/25/96 925 cfs	05/25/96 925 cfs	05/25/96 925 cfs	05/28/96 958 cfs	05/28/96 958 cfs	05/28/96 958 cfs
Distance From North Bank (ft)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)

3	3	0.2	0.2	3	0.2	0.2
6	5	0.46	0.5	5	0.45	0.45
9	7.25	0.74	0.24	6.25	0.56	0.41
12	8	0.51	0.62	7.75	0.88	0.86
15	8	2.64	2.38	9	2.15	2.15
18	9.25	2.33	2.39	8.75	2.26	1.52
21	8.5	2.23	2.23	9.25	1.73	2
24	8.5	2.29	2.33	10.25	2.84	2.72
27	9.25	2.6	2.65	8	2.64	2.4
30	9	2.22	2.33	7.75	2.65	2.74
33	8.75	2.64	2.53	8.25	2.68	2.6
36	8.75	2.16	2.14	8.5	2.57	2.52
39	8	1.77	1.52	8	2.5	2.44
42	7.75	1.61	1.68	8.25	2.16	2.45
45	7.25	1.63	1.73	8.75	2.09	1.87
48	7.5	2.87	2.16	8	1.58	1.49
51	8	2.15	2.1	7.75	1.7	1.34
54	8.25	0.27	0.6	7.5	1.88	1.67
57	7.5	2.11	1.75	7.5	1.7	1.88
60	7	2.05	1.81	7.5	1.93	1.39
63	8	2.06	2.17	7.5	2.25	2.23
66	7.5	1.86	1.87	7.5	1.71	1.66
69	7.25	0.29	0.2	7	0.68	0.2
72	7	0.44	0.1	7	0.25	0.2
75	3	0.1	0.1	4.5	0.1	0.1
78	-	-	-	3	0.1	0.1
81	-	-	-	-	-	-
84	-	-	-	-	-	-
87	-	-	-	-	-	-
90	-	-	-	-	-	-
93	-	-	-	-	-	-
96	-	-	-	-	-	-
99	-	-	-	-	-	-

Appendix 5. Continued.

Distance From North Bank (ft)	05/23/96 1151 cfs Max Depth (ft)	05/23/96 1151 cfs Vel. at 20% of Depth (ft/sec)	05/23/96 1151 cfs Vel at 80% of Depth (ft/sec)	04/14/96 1595 cfs Max Depth (ft)	04/14/96 1595 cfs Vel. at 20% of Depth (ft/sec)	04/14/96 1595 cfs Vel at 80% of Depth (ft/sec)
3	3	0.84	0.84	3	0	0
6	4.5	0.34	0.5	4.5	0.2	0.25
9	5	0.44	0.62	4.75	0.27	0.25
12	6	0.55	0.37	10	0.25	0.23
15	9.5	1.1	0.9	11	1.2	0.85
18	9	2.33	2.16	12.5	0.5	1.46
21	10.5	2.65	2.06	12.25	1.1	1.03
24	9	2.42	1.7	12	1.45	1.53
27	11	2.5	2.14	12	1.2	1.55
30	10.25	2.7	2.53	11	2.08	2.34
33	9	2.54	2.23	11	2.53	2.43
36	8.75	2.51	2.33	10.5	2.03	1.99
39	9.5	2.41	2.27	11	1.43	1.87
42	10	2.57	2.5	11.25	2.08	2.53
45	9	2.67	2.6	11	2.01	2.74
48	9.25	2.51	2.58	10	1.93	2.81
51	8	2.67	2.31	9.75	3.05	2.91
54	7	2.9	2.39	10	2.44	2.74
57	8	2.8	2.3	11	1.72	2.8
60	6.5	2.65	2.59	10	2.79	2.66
63	6.25	2.67	2.32	9	2.47	2.46
66	7	2.72	2.45	7	2.66	3.01
69	7.75	2.58	2.69	8	2.73	3
72	8.5	2.66	2.4	8	2.68	2.74
75	9.25	2.72	2.67	9.5	2.43	2.87
78	6	2.65	2.33	9.25	2.96	2.94
81	4.5	2.6	2.44	8	2.42	2.19
84	5	2.27	2.01	8	1.44	1.66
87	3	1.69	1.47	7	0.6	0.55
90	2	1.04	0.7	2.75	0.45	0.6
93	-	-	-	-	-	-
96	-	-	-	-	-	-
99	-	-	-	-	-	-

Appendix 5. Continued.

	04/04/96 1788 cfs	04/04/96 1788 cfs	04/04/96 1788 cfs	03/29/96 1896 cfs	03/29/96 1896 cfs	03/29/96 1896 cfs
Distance From North Bank (ft)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)
3	3			2	0.1	0.1
6	5	0.3	0.3	4	0.33	0.21
9	5	0.33	0.33	5.5	0.35	0.31
12	10.25	0.27	0.29	5.75	0.27	0.38
15	11.5	0.69	0.85	10.5	0.6	0.72
18	12.25	0.56	1.5	12	0.97	1.02
21	12.25	1.11	0.89	12.5	0.6	1.59
24	12	1.68	1.62	12.25	1.13	1.12
27	12	1.22	1.51	12.5	1.71	1.66
30	11	2.15	2.6	12.25	1.19	1.64
33	12	2.67	2.44	12	2.18	2.64
36	11	1.9	2.11	12.5	2.83	2.51
39	11.25	1.55	2.04	11.5	2	2.07
42	11.5	2.18	2.87	11.5	1.77	2.15
45	11.25	2.7	2.98	11.5	2.22	2.97
48	10	2.4	2.88	11.5	2.67	3.01
51	10	2.88	2.93	11	1.92	3.12
54	10.25	2.76	2.84	10.75	3.1	3.13
57	10.75	1.89	2.78	10.5	2.95	2.94
60	10	2.77	2.6	10.75	1.81	2.81
63	9	2.56	2.61	10.5	2.7	2.68
66	8	2.71	2.66	10.25	2.63	2.53
69	9.5	2.8	3.27	10.25	2.85	2.92
72	8.75	2.76	2.6	10	2.88	3.16
75	9.75	2.51	2.72	9	2.83	2.64
78	9	2.89	2.98	9.75	2.44	2.8
81	8	2.5	2.21	9.25	3.08	3.07
84	8.25	1.41	1.57	8.75	2.25	2.14
87	7	0.8	0.6	8.5	1.6	1.69
90	3	0.51	0.6	7	0.82	0.68
93	-	-	-	3.25	0.67	0.67
96	-	-	-	-	-	-
99	-	-	-	-	-	-

Appendix 5. Continued.

Distance From North Bank (ft)	03/27/96 2125 cfs Max Depth (ft)	03/27/96 2125 cfs Vel. at 20% of Depth (ft/sec)	03/27/96 2125 cfs Vel at 80% of Depth (ft/sec)	03/25/96 2539 cfs Max Depth (ft)	03/25/96 2539 cfs Vel. at 20% of Depth (ft/sec)	03/25/96 2539 cfs Vel at 80% of Depth (ft/sec)
3	2.25	0.05	0.1	2	0.1	0.1
6	4.75	0.19	0.21	4	0.2	0.27
9	6	0.32	0.33	6	0.45	0.15
12	10	0.4	0.5	7.25	0.7	0.81
15	10.75	0.92	1.1	8.25	0.56	0.41
18	12	1.83	1.1	13.5	0.29	0.54
21	13.25	1.27	1.5	14	1.4	1.02
24	13.25	1.54	1.87	14.75	2.24	1.8
27	13	1.39	1.78	15	1.11	2.24
30	12.25	1.08	2	14.75	1.96	2
33	12.5	1.98	2.31	14.75	1.3	2.3
36	12.5	1.47	1.57	14	0.18	0.44
39	12.25	1.96	1.75	14.5	1.64	1.73
42	12.25	2.1	2.13	15	1.96	2.2
45	12.5	3	2.98	14	2.75	2.89
48	12.75	3.59	3.21	13.75	3.43	3.33
51	12.25	3.14	3.16	14.5	3.79	3.68
54	11.75	3.32	2.85	15+	4.34	3.87
57	11.75	2.72	2.77	15+	3.94	3.33
60	11.75	2.83	2.52	15+	3.53	3.58
63	11	2.95	2.58	14	3.42	2.81
66	10.5	3.05	2.83	13	3.76	3.21
69	10	2.87	2.97	12.25	3.9	3.87
72	9.25	2.87	2.86	12	3.16	3.38
75	9	2.8	2.86	12	3.57	3.36
78	8.75	2.31	1.93	11.25	3	2.83
81	8.75	1.31	1.24	11.25	2.33	2.22
84	9	2.21	1.84	10.25	1.38	1.28
87	9	1.5	1.66	10	1.02	1.28
90	7	0.94	1.12	13	1	0.62
93	4	0.5	0.5	10	0.37	0.24

96	-	-	-	8	0.22	0.2
99	-	-	-	6	0.15	0.2

Appendix 5. Continued.

	03/18/96 3530 cfs	03/18/96 3530 cfs	03/18/96 3530 cfs	03/10/96 3782 cfs	03/10/96 3782 cfs	03/10/96 3782 cfs
Distance From North Bank (ft)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)
3	3	0.18	0.24	3	0	0
6	4	0.31	0.47	5.5	0.44	0.44
9	7.75	0.26	0.18	8.75	0.3	0.05
12	8.25	0.32	0.45	9.75	0.23	0.05
15	10.5	0.28	0.26	13.25	0.24	0.44
18	13.25	0.34	1	14	1.26	1.02
21	14	0.36	1.36	15	1.12	0.86
24	15	0.74	0.44	15	1.38	0.68
27	16+	1.52	1.62	15.25	1.55	1.28
30	16	0.42	1.73	15.5	2.24	2.74
33	16+	2.32	2.14	15.5	1.66	3.01
36	16+	2.12	2.51	15.25	2.49	1.68
39	15.75	1.87	1.5	14	1.57	2.93
42	16+	1.26	2.44	15	2.26	0.56
45	16+	1.76	2.46	14.5	2.33	3.33
48	15	2.76	3.87	14	4.13	3.78
51	15	3.46	3.65	15	4.16	4
54	16+	3.98	4.29	14.25	4.26	4.11
57	16+	3.87	4.02	14.5	4.16	3.58
60	16+	4.03	3.95	14.75	4.05	4.2
63	15.5	3.93	3.26	16	3.75	3.1
66	15.5	3.8	3.93	14.75	3.45	3.28
69	16+	3.93	3.8	14	3.55	3.65
72	15.5	3.39	3.44	15	3.84	3.59
75	14.5	5.54	3.35	12.5	3.64	3.59
78	15.5	3.21	3.32	13.75	3.63	3.36

81	14.5	3.06	2.96	12.5	2.2	2.57
84	14.25	2.18	1.83	105	1.68	1.96
87	14.5	1.33	1.46	8.5	0.9	1.01
90	15	0.9	1.6	14	0.26	0.4
93	13	0.4	0.47	12	0.39	0.45
96	10	0.36	0.28	9	0.29	0.42
99	7	0.2	0.25	8	0.2	0.25

Appendix 5. Continued.

	03/08/96 3842 cfs	03/08/96 3842 cfs	03/08/96 3842 cfs
Distance From North Bank (ft)	Max Depth (ft)	Vel. at 20% of Depth (ft/sec)	Vel at 80% of Depth (ft/sec)
3	3	0	0
6	6	0.48	0.45
9	8.75	0.37	0.33
12	9.75	0.28	0.22
15	13.25	0.32	0.44
18	14	1.42	0.97
21	15.25	1.07	1.1
24	15	1.44	0.88
27	15	1.43	1.44
30	16	2.43	2.49
33	16	1.71	2.82
36	15.5	2.66	1.87
39	15	1.42	2.55
42	15	2.26	0.56
45	14	2.14	3.02
48	-	4.04	3.84
51	-	4.2	3.94
54	-	4.33	4.21
57	-	4.07	3.59
60	-	4.12	4.2
63	-	3.02	3.83
66	-	4.68	3.74

69	-	3.77	3.4
72	-	3.92	3.11
75	-	3.74	3.55
78	-	3.66	3.52
81	-	2.8	2.75
84	-	1.75	1.88
87	-	1.2	1.07
90	-	0.26	0.26
93	-	0.4	0.54
96	-	0.36	0.5
99	-	0.1	0.21

Appendix 6. Number of natural chinook captured in north and south Caswell traps during 1996. Data includes the number captured for each trap check, not the number captured during 24 hour sampling periods.

		Number of Natural Chinook Captured		
Date	Time trap Checked	North Trap	South Trap	Total
06-Feb	900	21	68	89
07-Feb	900	11	31	42
08-Feb	900	0	44	44
09-Feb	900	0	13	13
10-Feb	930	1	0	1
	945	0	1	1
11-Feb	900	0	0	0
12-Feb	1000	2	4	6
13-Feb	900	0	2	2
14-Feb	930	2	26	28
	2300	0	0	0
	2330	0	25	25
15-Feb	1030	0	13	13
	1045	1	0	1
16-Feb	830	5	11	16
17-Feb	1030	11	33	44
18-Feb	900	4	53	57
19-Feb	1030	7	45	52
	2245	0	1	1
	2300	4	0	4
	2330	0	1	1
	2400	3	0	3
20-Feb	830	2	26	28

		Number of Natural Chinook Captured		
Date	Time trap Checked	North Trap	South Trap	Total
21-Mar	900	0	0	0
22-Mar	800	0	0	0
23-Mar	45	0	0	0
	100	0	0	0
	145	0	0	0
	200	0	0	0
	845	0	0	0
24-Mar	830	0	0	0
25-Mar	830	0	0	0
	900	0	0	0
26-Mar	930	2	2	4
27-Mar	900	0	2	2
28-Mar	1000	5	2	7
29-Mar	900	0	10	10
30-Mar	1000	0	3	3
31-Mar	1000	0	5	5
01-Apr	900	1	2	3
02-Apr	930	0	3	3
03-Apr	900	2	6	8
04-Apr	900	4	14	18
05-Apr	1000	2	7	9
06-Apr	900	5	9	14
	1430	0	1	1

23-Feb	800	0	97	97		1500	0	2	2
	930	16	0	16		1530	0	0	0
24-Feb	900	2	1	3		1600	0	0	0
25-Feb	930	1	23	24		1630	0	0	0
26-Feb	1030	0	0	0		1730	0	1	1
	1100	0	11	11		1830	0	0	0
27-Feb	900	0	16	16		1900	0	0	0
28-Feb	900	0	11	11		1930	0	0	0
29-Feb	1000	0	5	5		2000	0	2	2
01-Mar	1000	0	6	6		2030	0	1	1
02-Mar	930	0	1	1		2100	0	0	0
06-Mar	945	0	0	0		2130	0	0	0
	1000	0	0	0		2200	0	0	0
07-Mar	1000	0	4	4		2230	0	0	0
	1100	0	0	0		2300	0	0	0
08-Mar	1000	4	0	4		2330	1	0	1
09-Mar	915	0	1	1	07-Apr	100	0	0	0
	945	0	0	0		930	0	5	5
10-Mar	915	0	0	0		2400	0	0	0
	930	0	0	0	08-Apr	900	1	0	1
11-Mar	900	0	0	0	09-Apr	900	3	5	8
12-Mar	930	0	1	1	10-Apr	900	0	4	4
13-Mar	900	0	0	0	11-Apr	900	1	1	2
14-Mar	900	1	0	1	12-Apr	730	2	7	9
15-Mar	900	0	0	0	13-Apr	900	2	0	2
16-Mar	945	0	1	1	14-Apr	1030	0	0	0
17-Mar	900	0	0	0	15-Apr	900	2	8	10
18-Mar	900	0	2	2	16-Apr	900	0	2	2
19-Mar	830	0	0	0	17-Apr	900	2	1	3
20-Mar	1000	0	1	1	18-Apr	900	3	3	6
	1015	0	0	0	19-Apr	1030	3	12	15

Appendix 6. Continued.

		Number of Natural Chinook Captured					Number of Natural Chinook Captured		
	Time trap	North	South			Time trap	North	South	
Date	Checked	Trap	Trap	Total	Date	Checked	Trap	Trap	Total
20-Apr	930	0	1	1	26-May	1045	0	24	24
21-Apr	1045	11	11	22		1115	28	0	28
22-Apr	1015	15	21	36		2230	6	9	15
23-Apr	1000	20	0	20	27-May	30	0	7	7
24-Apr	1000	17	21	38		100	4	0	4
25-Apr	1030	18	21	39		900	3	1	4
26-Apr	900	12	26	38	28-May	900	10	5	15
27-Apr	900	36	59	95	29-May	1000	10	12	22
28-Apr	1030	34	75	109	30-May	900	3	6	9
29-Apr	1100	26	63	89	31-May	1000	5	5	10
30-Apr	1000	44	77	121	01-Jun	1000	7	3	10
01-May	930	36	4	40	02-Jun	1000	5	6	11
02-May	200	14	24	38	03-Jun	800	1	1	2
	400	11	31	42	04-Jun	900	2	0	2
	500	0	4	4	05-Jun	830	3	4	7
	1815	0	3	3	06-Jun	900	2	1	3
	1845	1	0	1	07-Jun	900	1	0	1
03-May	1045	10	30	40	08-Jun	1000	2	2	4
04-May	900	21	46	67	09-Jun	1000	1	1	2
05-May	1100	0	75	75	10-Jun	830	0	0	0

	1130	32	0	32	11-Jun	100	0	0	0
06-May	900	35	38	73		200	0	0	0
07-May	1200	0	22	22		930	0	0	0
	1230	20	0	20	12-Jun	900	0	3	3
08-May	930	0	22	22	13-Jun	1000	1	0	1
	1015	25	0	25		1030	0	1	1
09-May	800	19	28	47	14-Jun	900	0	0	0
10-May	1200	20	1	21		1000	0	2	2
	2030	0	6	6		2000	0	0	0
	2300	6		6	15-Jun	930	0	0	0
11-May	30	0	17	17		1900	0	0	0
	100	12	0	12	16-Jun	715	0	0	0
	130	0	5	5		730	0	0	0
	200	0	0	0	17-Jun	1015	0	0	0
	1200	6	8	14		1045	0	1	1
12-May	1000	8	12	20	18-Jun	800	0	0	0
13-May	1300	0	6	6		1500	0	0	0
14-May	900	13	3	16	19-Jun	800	0	0	0
15-May	930	5	0	5		830	0	0	0
16-May	900	3	16	19	20-Jun	800	0	0	0
17-May	900	6	4	10	21-Jun	800	0	1	1
18-May	1030	0	14	14	22-Jun	830	0	0	0
19-May	1045	1	0	1		900	0	0	0
	1115	0	9	9	23-Jun	815	0	0	0
	1845	0	0	0		845	0	1	1
	1915	0	0	0	24-Jun	800	0	1	1
20-May	1000	6	13	19	25-Jun	915	0	0	0
	1900	0	1	1		930	0	0	0
21-May	900	3	19	22	26-Jun	800	0	0	0
22-May	900	4	4	8	27-Jun	800	0	1	1
23-May	900	6	3	9	28-Jun	800	0	0	0
24-May	1115	0	12	12	29-Jun	800	0	0	0
	1200	6	0	6	30-Jun	1015	0	1	1
25-May	915	0	0	0	01-Jul	815	0	1	1
	1000	0	20	20		Totals	795	1673	2,468

Appendix 7. Number of natural chinook measured and mean length for north trap, south trap and combined traps for each day chinook were measured.

	ST004N		ST004S		Combined	
Date	Mean Length (mm)	# Measured	Mean Length (mm)	# Measured	Mean Length (mm)	# Measured
02/06/96	35.61	18	34.50	30	34.92	48
02/07/96	-	-	-	-	-	-
02/08/96	-	-	34.10	30	34.10	30
02/09/96	-	-	-	-	-	-
02/10/96	-	-	-	-	-	-
02/11/96	-	-	-	-	-	-
02/12/96	34.50	2	35.50	4	35.17	6
02/13/96	-	-	-	-	-	-
02/14/96	-	-	-	-	-	-
02/15/96	35.00	1	34.76	37	34.76	38
02/16/96	-	-	-	-	-	-
02/17/96	-	-	-	-	-	-
02/18/96	-	-	-	-	-	-
02/19/96	33.43	7	35.10	30	34.78	37
02/20/96	-	-	-	-	-	-
02/21/96	-	-	-	-	-	-

	ST004N		ST004S		Combined	
Date	Mean Length (mm)	# Measured	Mean Length (mm)	# Measured	Mean Length (mm)	# Measured
02/22/96	-	-	-	-	-	-
02/23/96	35.19	16	34.90	30	35.00	46
02/24/96	-	-	-	-	-	-
02/25/96	-	-	-	-	-	-
02/26/96	-	-	35.55	11	35.55	11
02/27/96	-	-	-	-	-	-
02/28/96	-	-	-	-	-	-
02/29/96	-	-	40.40	5	40.40	5
03/01/96	-	-	34.83	6	34.83	6
03/02/96	-	-	-	-	-	-
03/03/96	-	-	-	-	-	-
03/04/96	-	-	-	-	-	-
03/05/96	-	-	-	-	-	-
03/06/96	-	-	-	-	-	-
03/07/96	-	-	44.00	4	44.00	4
03/08/96	-	-	-	-	-	-
03/09/96	-	-	-	-	-	-
03/10/96	-	-	-	-	-	-
03/11/96	-	-	-	-	-	-
03/12/96	-	-	38.00	1	38.00	1
03/13/96	-	-	-	-	-	-
03/14/96	44.00	1	-	-	44.00	1
03/15/96	-	-	-	-	-	-
03/16/96	-	-	51.00	1	51.00	1
03/17/96	-	-	-	-	-	-
03/18/96	-	-	38.00	2	38.00	2
03/19/96	-	-	-	-	-	-
03/20/96	-	-	45.00	1	45.00	1
03/21/96	-	-	-	-	-	-
03/22/96	-	-	-	-	-	-
03/23/96	-	-	-	-	-	-
03/24/96	-	-	-	-	-	-
03/25/96	-	-	-	-	-	-
03/26/96	80.00	2	75.00	2	77.50	4
03/27/96			76.50	2	76.50	2
03/28/96	82.20	5	76.00	2	80.43	7
03/29/96	-	-	81.70	10	81.70	10
03/30/96	-	-	74.00	3	74.00	3
03/31/96	-	-	74.80	5	74.80	5
04/01/96	80.00	1	92.00	2	88.00	3
04/02/96	-	-	90.00	3	90.00	3
04/03/96	87.50	2	82.83	6	84.00	8
04/04/96	75.75	4	85.33	12	82.94	16
04/05/96	71.50	2	86.00	7	82.78	9
04/06/96	92.00	5	85.00	9	87.50	14
04/07/96	85.00	1	76.25	12	76.92	13
04/08/96	81.00	1	-	-	81.00	1
04/09/96	85.67	3	86.67	3	86.17	6
04/10/96	-	-	80.75	4	80.75	4
04/11/96	95.00	1	75.00	1	85.00	2
04/12/96	83.00	2	82.43	7	82.56	9
04/13/96	80.50	2	-	-	80.50	2
04/14/96	-	-	-	-	-	-
04/15/96	79.50	2	87.00	8	85.50	10
04/16/96	-	-	97.50	2	97.50	2

	ST004N		ST004S		Combined	
Date	Mean Length (mm)	# Measured	Mean Length (mm)	# Measured	Mean Length (mm)	# Measured
04/17/96	86.50	2	101.00	1	91.33	3
04/18/96	87.67	3	81.67	3	84.67	6
04/19/96	92.33	3	84.67	12	86.20	15
04/20/96	-	-	89.00	1	89.00	1
04/21/96	88.18	11	91.36	11	89.77	22
04/22/96	91.87	15	90.52	21	91.08	36
04/23/96	89.65	20	-	-	89.65	20
04/24/96	88.65	17	90.48	21	89.66	38
04/25/96	91.17	18	93.14	21	92.23	39
04/26/96	91.08	12	91.24	25	91.19	37
04/27/96	91.80	30	90.13	30	90.97	60
04/28/96	90.73	30	92.63	30	91.68	60
04/29/96	91.12	26	92.57	30	91.89	56
04/30/96	91.63	30	90.40	30	91.02	60
05/01/96	91.73	30	87.25	4	91.21	34
05/02/96	90.33	6	94.17	24	93.40	30
05/03/96	91.60	10	93.30	30	92.88	40
05/04/96	90.57	21	90.40	30	90.47	51
05/05/96	94.40	30	92.57	30	93.48	60
05/06/96	90.03	30	91.57	30	90.80	60
05/07/96	92.00	20	92.19	21	92.10	41
05/08/96	90.68	25	93.32	22	91.91	47
05/09/96	92.58	19	90.54	28	91.36	47
05/10/96	89.60	20	110.00	1	90.57	21
05/11/96	91.25	24	92.86	14	91.84	38
05/12/96	92.25	8	90.76	29	91.08	37
05/13/96	-	-	-	-	-	-
05/14/96	93.62	13	92.00	9	92.95	22
05/15/96	98.20	5	-	-	98.20	5
05/16/96	101.67	3	89.25	16	91.21	19
05/17/96	92.17	6	96.00	4	93.70	10
05/18/96	-	-	95.79	14	95.79	14
05/19/96	94.00	1	100.11	9	99.50	10
05/20/96	93.83	6	95.54	13	95.00	19
05/21/96	99.67	3	94.79	19	95.45	22
05/22/96	93.25	4	95.00	4	94.12	8
05/23/96	98.33	6	91.00	3	95.89	9
05/24/96	90.67	6	96.58	12	94.61	18
05/25/96	-	-	95.10	20	95.10	20
05/26/96	94.71	28	95.38	24	95.02	52
05/27/96	95.00	13	91.00	10	93.26	23
05/28/96	93.11	9	95.67	12	94.57	21
05/29/96	93.60	10	92.42	12	92.95	22
05/30/96	98.67	3	90.67	6	93.33	9
05/31/96	95.80	5	96.00	5	95.90	10
06/01/96	97.14	7	100.00	3	98.00	10
06/02/96	98.40	5	96.33	6	97.27	11
06/03/96	86.00	1	98.00	1	92.00	2
06/04/96	99.00	2	-	-	99.00	2
06/05/96	-	-	102.00	4	102.00	4
06/06/96	98.00	2	104.00	1	100.00	3
06/07/96	91.00	1	-	-	91.00	1
06/08/96	96.50	2	102.00	2	99.25	4
06/09/96	98.00	1	88.00	1	93.00	2
06/10/96	-	-	-	-	-	-

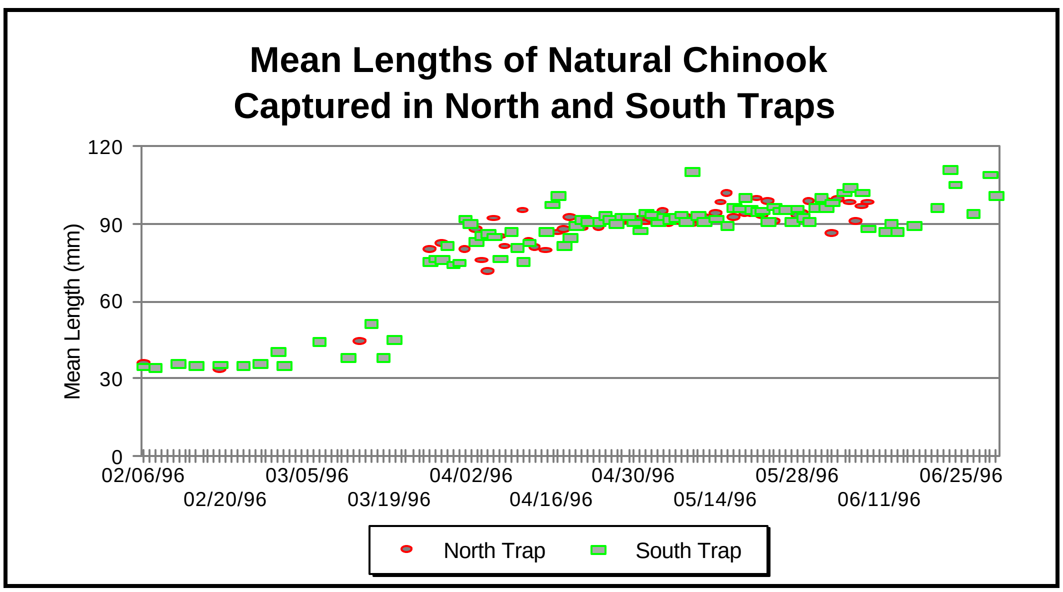
	ST004N		ST004S		Combined	
Date	Mean Length (mm)	# Measured	Mean Length (mm)	# Measured	Mean Length (mm)	# Measured
06/11/96	-	-	-	-	-	-
06/12/96	-	-	87.00	3	87.00	3
06/13/96	-	-	90.00	1	90.00	1
06/14/96	-	-	87.00	2	87.00	2
06/15/96	-	-	-	-	-	-
06/16/96	-	-	-	-	-	-
06/17/96	-	-	89.00	1	89.00	1
06/18/96	-	-	-	-	-	-
06/19/96	-	-	-	-	-	-
06/20/96	-	-	-	-	-	-
06/21/96	-	-	96.00	1	96.00	1
06/22/96	-	-	-	-	-	-
06/23/96	-	-	111.00	1	111.00	1
06/24/96	-	-	105.00	1	105.00	1
06/25/96	-	-	-	-	-	-
06/26/96	-	-	-	-	-	-
06/27/96	-	-	94.00	1	94.00	1
06/28/96	-	-	-	-	-	-
06/29/96	-	-	-	-	-	-
06/30/96	-	-	109.00	1	109.00	1
07/01/96	-	-	101.00	1	101.00	1

Data was queried from 12:01 the previous day to 12:00 of the date shown.

Data derived from "caswel96" computer file.

The number "measured" should not be interpreted as the number captured.

A "-" represents periods no chinook were captured and periods no chinook were measured.



Appendix 8. Mark-recapture data for all chinook released for juvenile chinook studies at Oakdale and Caswell.

Appendix 8. Continued.

Appendix 8. Continued.

Appendix 9. Mean lengths at release and recapture for all groups of marked fish recovered at Caswell.

Group Code	Release Groups Mean Length (mm)	Release Groups # Measured	Recapture Groups Mean Length (mm)	Recapture Groups # Measured	Recapture Minus Release (mm)
C 1	34.3	30	35.2	62	0.9
C 2	33.8	30	35.5	56	1.7
C 3	42.7	30	41.8	15	-0.9
C 4	67.4	30	71.6	22	4.2
C 5	70.2	30	72.9	8	2.7
C 6	73.2	30	-	-	-
C 7	69.7	30	-	-	-
C 8	76.1	30	76.7	30	0.6
C 9	75.5	30	75.9	30	0.4
C 10	89.5	30	102.5	2	13.0
C 11	74.2	30	73.4	50	-0.8
C 12	76.1	30	72.9	55	-3.2
C 13	71.7	30	69.9	60	-1.8
C 14	72.7	30	68.2	65	-4.5
C 15	91.6	30	85.5	43	-6.1
C 16	90.5	30	86.8	56	-3.7
CDFG 1	-	30	87.9	14	-
CDFG 2	-	30	86.0	2	-
O 1	34	30	35.0	1	1.0
O 3	43.9	30	100.0	1	56.1
O 4	70.6	30	76.5	2	5.9
O 9	86.1	30	88.3	3	2.2
O 10	75.5	30	80.0	1	4.5
O 12	72.2	30	80.0	1	7.8

Thirty chinook were measured from each release group prior to release. Recapture mean lengths were queried from the "caswel96" file.

*Although it seems unlikely that we could recapture a 100 mm fish when the mean at release is 43.9 mm, the daily data sheets support the 100 mm catch. A measuring or recording mistake could have been made in the field.

Appendix 10 Trap revolution data for south Caswell trap.

Summary of South Trap Operation

Date	Counter Revolutions	Time Trap Checked	Time Counter Last Reset	Elapsed Time	Revolutions Per Hour	Time per Revolution	Trap Op. Code
06-Feb	3589	900	1400	18	199	18.89	1
07-Feb	1581	900	900	24	66	22.49	2
08-Feb	3912	900	900	24	163	25.10	1
09-Feb	3171	900	900	24	132	24.10	1
10-Feb	3411	945	900	24.75	138	25.90	1
11-Feb	3298	900	945	23.25	142	24.98	1
12-Feb	3766	1000	900	25	151	20.65	1
13-Feb	4020	900	1000	23	175	22.10	1
14-Feb	4440	930	900	24.5	181	19.80	1
15-Feb	4367	1030	930	25	175	17.98	1
16-Feb	2598	830	1030	22	118	17.75	2
17-Feb	1246	1030	1715	12.25	102	18.00	2
18-Feb	3579	900	1700	16	224	15.69	1
19-Feb	3765	1030	1700	17.5	215	17.63	1
20-Feb	2621	830	2100	11.5	228	17.42	1
21-Feb	-	-	-	-	-	-	-
22-Feb	-	-	-	-	-	-	-
23-Feb	3303	800	1700	15	220	17.40	1
24-Feb	2875	900	1830	14.5	198	14.05	2
25-Feb	3960	930	1800	15.5	255	13.27	1
26-Feb	4378	1100	1700	1800	2	13.05	1
27-Feb	4431	900	1830	14.5	306	13.82	1
28-Feb	6119	900	900	24	255	15.39	1
29-Feb	6323	1000	900	25	253	16.33	1
01-Mar	6311	1000	1000	24	263	15.40	1
02-Mar	4789	930	1000	23.5	204	15.35	2
03-Mar	-	-	-	-	-	-	-
04-Mar	-	-	-	-	-	-	-
05-Mar	-	-	-	-	-	-	-
06-Mar	1358	945	1800	15.75	86	12.50	2
07-Mar	4945	1000	945	24.25	204	14.10	2
08-Mar	4576	1000	1000	24	191	13.13	1
09-Mar	6210	915	1000	23.25	267	11.90	1
10-Mar	6365	915	915	24	265	13.60	1
11-Mar	1202	900	915	23.75	51	17.15	2
12-Mar	6214	930	900	24.5	254	15.37	1
13-Mar	5972	900	930	23.5	254	13.71	1
14-Mar	6391	900	900	24	266	13.29	1
15-Mar	5997	900	900	24	250	11.68	1
16-Mar	6463	945	900	24.75	261	14.20	1
17-Mar	4614	900	945	23.25	198	13.80	1
18-Mar	4762	900	900	24	198	16.44	1
19-Mar	6245	830	900	23.5	266	15.76	1
20-Mar	6617	1000	830	25.5	259	13.30	1
21-Mar	6066	900	1000	23	264	13.76	1

Date	Counter Revolutions	Time Trap Checked	Time Counter Last Reset	Elapsed Time	Revolutions Per Hour	Time per Revolution	Trap Op. Code
22-Mar	6362	900	900	24	265	12.12	1
23-Mar	6220	845	900	23.75	262	13.50	1
24-Mar	6074	830	845	23.75	256	15.29	1
25-Mar	5985	830	830	24	249	13.89	1
26-Mar	5975	930	830	25	239	13.85	1
27-Mar	5725	900	930	23.5	244	15.04	1
28-Mar	5591	1000	900	25	224	14.11	1
29-Mar	5310	900	1000	23	231	16.71	1
30-Mar	5422	1000	900	25	217	16.90	1
31-Mar	4460	1000	1000	24	186	16.03	2
01-Apr	4968	900	1000	23	216	16.13	1
02-Apr	4301	930	900	24.5	176	16.07	2
03-Apr	5223	900	930	23.5	222	16.55	1
04-Apr	4982	900	900	24	208	16.80	1
05-Apr	4704	1000	900	25	188	18.48	2
06-Apr	4718	900	1000	23	205	16.43	1
07-Apr	5360	930	900	24.5	219	17.00	1
08-Apr	3909	900	930	23.5	166	17.60	1
09-Apr	4804	900	900	24	200	18.74	1
10-Apr	4144	900	900	2400	2	15.99	1
11-Apr	4838	900	900	2400	2	16.88	1
12-Apr	2399	730	1715	14.25	168	16.72	2
13-Apr	5003	900	900	24	208	18.59	1
14-Apr	4994	1030	900	25.5	196	19.50	1
15-Apr	4525	900	1030	22.5	201	16.73	1
16-Apr	4831	900	1000	23	210	18.33	1
17-Apr	3916	900	900	24	163	17.52	2
18-Apr	4973	900	900	24	207	17.13	1
19-Apr	5139	1030	900	25.5	202	18.19	2
20-Apr	2677	930	1030	23	116	16.61	2
21-Apr	4562	1045	1400	20.45	223	16.49	1
22-Apr	5207	1015	1045	23.5	222	15.50	1
23-Apr	260	1000	1015	23.75	11	17.35	2
24-Apr	5033	1000	1000	24	210	17.13	1
25-Apr	5288	1030	1000	24.5	216	15.63	1
26-Apr	4113	900	1630	16.5	249	15.67	1
27-Apr	5587	900	1900	14	399	16.64	1
28-Apr	4293	1030	900	25.5	168	16.25	2
29-Apr	3688	1100	1030	24.5	151	17.16	1
30-Apr	5284	1000	1100	23	230	15.89	1
01-May	1980	930	1000	23.5	84	17.16	2
02-May	3553	1815	930	32.75	108	nd	1
03-May	1789	1045	1815	1600	1	17.20	2
04-May	3294	900	1045	22.25	148	15.06	1
05-May	5764	1100	900	26	222	17.00	1
06-May	4200	900	1100	22	191	17.30	1
07-May	3765	1200	900	27	139	22.79	1

Date	Counter Revolutions	Time Trap Checked	Time Counter Last Reset	Elapsed Time	Revolutions Per Hour	Time per Revolution	Trap Op. Code
08-May	2682	930	1200	21.5	125	23.77	1
09-May	4897	800	930	22.5	218	15.98	1
10-May	858	1200	800	28	31	15.82	2
11-May	6505	1200	1200	24	271	17.15	1
12-May	3850	1000	1200	22	175	21.93	1
13-May	2323	1300	1000	27	86	17.47	2
14-May	1566	900	1300	20	78	16.75	2
15-May	1201	930	900	24.5	49	16.65	2
16-May	4291	900	930	23.5	183	17.59	2
17-May	1964	900	900	24	82	17.24	2
18-May	1621	1030	900	25.5	64	15.46	2
19-May	4119	1115	1030	24.75	166	15.07	2
20-May	3641	1000	1915	14.75	247	15.25	1
21-May	4539	900	1900	15	303	17.07	1
22-May	2758	900	900	24	115	16.06	2
23-May	4550	900	900	24	190	16.52	1
24-May	2966	1115	900	26.25	113	16.63	1
25-May	3066	1000	1115	22.75	135	19.17	1
26-May	3493	1045	1000	24.75	141	24.66	1
27-May	3665	900	1045	21.25	172	20.29	1
28-May	3280	900	900	24	137	26.68	1
29-May	3981	1000	900	25	159	23.47	1
30-May	3696	900	1000	23	161	26.59	1
31-May	4092	1000	900	25	164	29.77	1
01-Jun	2589	1000	1000	24	108	29.44	1
02-Jun	3804	1000	1000	24	159	26.24	1
03-Jun	3907	800	1000	22	178	24.09	1
04-Jun	2415	900	800	25	97	18.31	2
05-Jun	3869	830	900	23.5	165	18.58	1
06-Jun	4043	900	830	24.5	165	18.00	1
07-Jun	-	-	-	-	-	-	-
08-Jun	8249	1000	900	25	330	19.61	1
09-Jun	1943	1000	1000	24	81	16.54	2
10-Jun	821	830	1730	15	55	20.40	2
11-Jun	4625	930	830	25	185	23.01	1
12-Jun	4528	900	930	23.5	193	23.56	1
13-Jun	4902	1030	900	25.5	192	24.41	1
14-Jun	4505	1000	1030	23.5	192	19.01	1
15-Jun	3308	930	2000	13.5	245	18.64	1
16-Jun	4470	730	930	22	203	18.89	1
17-Jun	4713	1045	730	27.75	170	25.20	1
18-Jun	3949	800	1045	21.25	186	21.59	1
19-Jun	4295	830	800	24.5	175	22.38	1
20-Jun	4081	800	830	23.5	174	24.18	1
21-Jun	3984	800	800	24	166	25.97	1
22-Jun	4162	900	800	25	166	25.32	1
23-Jun	4023	845	900	23.75	169	23.80	1

Date	Counter Revolutions	Time Trap Checked	Time Counter Last Reset	Elapsed Time	Revolutions Per Hour	Time per Revolution	Trap Op. Code
24-Jun	3537	800	845	23.25	152	28.48	1
25-Jun	3489	930	800	25.5	137	35.88	1
26-Jun	3912	800	930	22.5	174	20.87	1
27-Jun	4069	800	800	24	170	nd	1
28-Jun	4322	800	800	24	180	18.78	1
29-Jun	4407	800	800	24	184	19.30	1
30-Jun	4399	1015	800	26.25	168	24.09	1
01-Jul	3765	815	1015	22	171	25.32	1

Trap Code: 1 = operating; 2 = stopped.

Appendix 11 Trap revolution data for north Caswell trap.

Summary of North trap Operation

Date	Counter Revolutions	Time Trap Checked	Time Counter Last Reset	Elapsed Time	Revolutions Per Hour	Time per Revolution	Trap Op. Code
06-Feb	1057	900	1400	18	59	74.00	2
07-Feb	909	900	900	24	38	68.00	1
08-Feb	1325	900	900	24	55	85.00	2
09-Feb	1123	900	900	24	47	76.00	1
10-Feb	962	930	900	24.5	39	113.00	1
11-Feb	817	900	930	23.5	35	64.00	1
12-Feb	1809	1000	900	25	72	52.09	1
13-Feb	2103	900	1000	23	91	58.50	1
14-Feb	2309	930	900	24.5	94	61.20	1
15-Feb	2328	1045	930	25.25	92	41.16	1
16-Feb	1296	830	1045	22.25	58	40.33	2
17-Feb	1292	1030	1715	17.25	75	39.00	2
18-Feb	1730	900	1700	16	108	37.98	1
19-Feb	1765	1030	1700	20.5	86	40.72	1
20-Feb	772	830	2400	8.5	91	39.30	1
21-Feb	-	-	-	-	-	-	-
22-Feb	-	-	-	-	-	-	-
23-Feb	2658	930	1700	16.5	161	26.10	1
24-Feb	1973	900	1830	14.5	136	17.13	1
25-Feb	1602	930	1800	15.5	103	17.82	1
26-Feb	221	1030	1700	17.5	13	18.03	1
27-Feb	2994	900	1830	14.5	206	22.03	1
28-Feb	4633	900	900	24	193	18.49	1
29-Feb	4573	1000	900	25	183	27.17	1

Date	Counter Revolutions	Time Trap Checked	Time Counter Last Reset	Elapsed Time	Revolutions Per Hour	Time per Revolution	Trap Op. Code
01-Mar	4527	1000	1000	24	189	18.73	1
02-Mar	3600	930	1000	23.5	153	19.20	2
03-Mar	-	-	-	-	-	-	-
04-Mar	-	-	-	-	-	-	-
05-Mar	-	-	-	-	-	-	-
06-Mar	106	1000	1800	16	7	18.07	1
07-Mar	5085	1100	1000	25	203	17.32	1
08-Mar	2240	1000	1100	23	97	19.13	1
09-Mar	4638	945	1000	23.75	195	20.00	1
10-Mar	4757	930	945	23.75	200	23.50	1
11-Mar	4154	900	930	23.5	177	21.13	1
12-Mar	2699	930	900	24.5	110	20.45	1
13-Mar	4347	900	930	23.5	185	34.78	1
14-Mar	4396	900	900	24	183	21.76	1
15-Mar	4154	900	900	24	173	25.94	1
16-Mar	4210	945	900	24.75	170	21.10	1
17-Mar	4164	900	945	23.25	179	16.70	1
18-Mar	4513	900	900	24	188	20.75	1
19-Mar	4095	830	900	23.5	174	23.77	1
20-Mar	4490	1015	830	25.75	174	19.50	1
21-Mar	4029	900	1015	22.75	177	24.69	1
22-Mar	4388	800	900	23	191	21.89	1
23-Mar	1330	845	200	6.75	197	20.57	1
24-Mar	4505	830	845	23.75	190	21.63	1
25-Mar	4665	900	830	24.5	190	22.84	1
26-Mar	4384	930	900	24.5	179	20.47	1
27-Mar	4368	900	930	23.5	186	27.19	1
28-Mar	4332	1000	900	25	173	24.87	1
29-Mar	3645	900	1000	23	158	22.98	1
30-Mar	4139	1000	900	25	166	26.31	1
31-Mar	3902	1000	1000	24	163	28.01	1
01-Apr	3750	900	1000	23	163	35.13	1
02-Apr	3725	930	900	24.5	152	23.07	1
03-Apr	3536	900	930	23.5	150	23.92	1
04-Apr	3770	900	900	24	157	25.63	1
05-Apr	3663	1000	900	25	147	27.46	1
06-Apr	3206	900	1000	23	139	30.65	1
07-Apr	1761	930	1530	18	98	27.00	1
08-Apr	2929	900	930	23.5	125	28.6	1
09-Apr	2872	900	900	24	120	32.09	1
10-Apr	3314	900	900	24	138	34.56	1
11-Apr	3111	900	900	24	130	31.09	1
12-Apr	3473	730	1715	13.25	262	19.41	1
13-Apr	3831	900	900	24	160	32.73	1
14-Apr	835	1030	900	25.5	33	26.10	2
15-Apr	2727	900	1030	22.5	121	20.30	1
16-Apr	3493	900	1000	23	152	29.29	1

Date	Counter Revolutions	Time Trap Checked	Time Counter Last Reset	Elapsed Time	Revolutions Per Hour	Time per Revolution	Trap Op. Code
17-Apr	3272	900	900	24	136	26.63	1
18-Apr	3468	900	900	24	145	28.27	1
19-Apr	3476	1030	900	25.5	136	25.85	1
20-Apr	2695	930	1030	23	117	32.76	1
21-Apr	4367	1045	930	25.25	173	18.59	1
22-Apr	4975	1015	1045	23.5	212	17.99	1
23-Apr	4885	1000	1015	23.5	208	19.33	1
24-Apr	4778	1000	1000	23.75	201	18.29	1
25-Apr	4558	1030	1000	24	190	15.88	1
26-Apr	4587	900	1030	24.5	187	17.74	1
27-Apr	5170	900	900	24	215	17.47	1
28-Apr	5730	1030	900	25.5	225	16.67	1
29-Apr	5153	1100	1030	24.5	210	17.72	1
30-Apr	4459	1000	1100	23	194	16.26	2
01-May	4422	930	1000	23.5	188	15.54	1
02-May	-	-	-	-	-	-	1
03-May	1883	1045	1845	16	118	16.20	2
04-May	-	-	-	-	-	-	1
05-May	-	-	-	-	-	-	1
06-May	-	-	-	-	-	-	1
07-May	-	-	-	-	-	-	1
08-May	-	-	-	-	-	-	1
09-May	4950	800	1015	21.75	228	16.67	1
10-May	6585	1200	800	28	235	16.57	1
11-May	5060	1200	1200	24	211	16.18	1
12-May	4383	1000	12	22	199	20.33	1
13-May	1183	1300	1000	27	44	20.16	2
14-May	2248	900	1300	20	112	15.97	1
15-May	4486	930	900	24.5	183	17.11	2
16-May	2291	900	930	23.5	97	17.34	2
17-May	2421	900	900	24	101	16.24	2
18-May	-	-	-	-	-	-	2
19-May	-	-	-	-	-	-	2
20-May	-	-	-	-	-	-	2
21-May	-	-	-	-	-	-	2
22-May	-	-	-	-	-	-	1
23-May	3048	900	900	24	127	16.63	1
24-May	4401	1200	900	27	163	21.03	1
25-May	1266	915	1200	21.25	60	20.50	2
26-May	4275	1115	915	26	164	24.00	1
27-May	3906	900	1115	21.75	180	19.88	1
28-May	3784	900	900	24	158	19.76	1
29-May	4151	1000	900	25	166	24.34	1
30-May	3908	900	1000	23	170	18.67	1
31-May	4560	1000	900	25	182	21.84	1
01-Jun	3654	1000	1000	24	152	30.18	1
02-Jun	4258	1000	1000	24	177	23.61	1

Date	Counter Revolutions	Time Trap Checked	Time Counter Last Reset	Elapsed Time	Revolutions Per Hour	Time per Revolution	Trap Op. Code
03-Jun	3845	800	1000	22	175	27.49	1
04-Jun	2632	900	800	25	105	26.73	1
05-Jun	3902	830	900	23.5	166	24.00	2
06-Jun	4000	900	830	24.5	163	19.05	1
07-Jun	4335	900	900	24	181	18.93	1
08-Jun	4545	1000	900	25	182	20.44	1
09-Jun	2470	1000	1000	24	103	16.86	2
10-Jun	3164	830	1000	22.5	141	20.81	2
11-Jun	4824	930	830	25	193	17.14	1
12-Jun	4546	900	930	23.5	193	18.75	1
13-Jun	4981	1000	900	25	199	18.22	1
14-Jun	4308	900	1000	23	187	19.43	2
15-Jun	4755	930	900	24.5	194	20.02	1
16-Jun	2494	715	1900	12.25	204	18.10	1
17-Jun	4974	1015	715	27	184	19.54	1
18-Jun	4101	800	1015	21.75	189	20.30	1
19-Jun	4435	800	800	24	185	22.30	1
20-Jun	4107	800	800	24	171	25.57	1
21-Jun	4733	800	800	24	197	21.87	1
22-Jun	4363	830	800	24.5	178	24.44	1
23-Jun	4395	815	830	23.75	185	21.53	1
24-Jun	3772	800	815	23.75	159	27.60	1
25-Jun	4008	915	800	25.25	159	24.70	1
26-Jun	3987	800	915	22.75	175	22.71	1
27-Jun	3998	800	800	24	167	nd	1
28-Jun	4542	800	800	24	189	22.30	1
29-Jun	4527	800	800	24	189	18.33	1
30-Jun	4643	1015	800	26.25	177	19.89	1
01-Jul	3925	815	1015	22	178	22.54	1

Trap Code: 1 = operating; 2 = stopped.

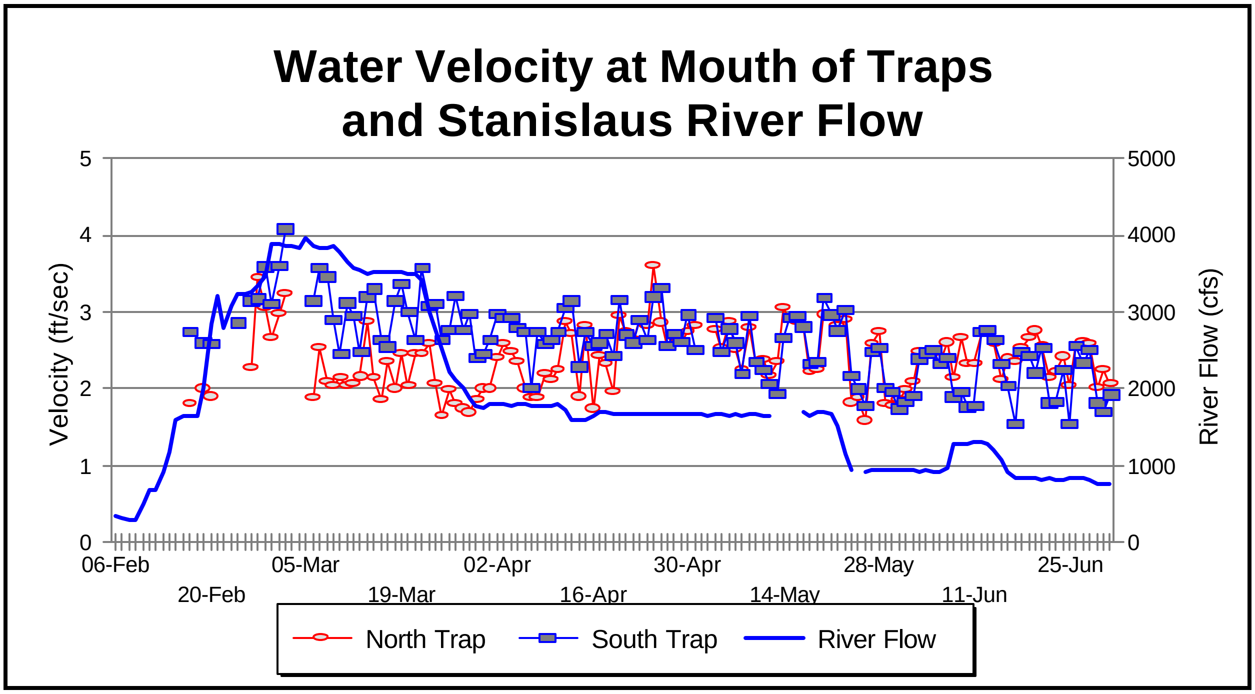
Appendix 12 Physical data at Caswell during 1996. Water temperature is hand-held thermometer measurement recorded each morning on data sheets.

Date	Time Trap Checked	Flow at OBB (cfs)	North Trap Water Velocity (ft/sec)	South Trap Water Velocity (ft/sec)	Turbidity (NTU's)	Stream Gage (ft)	Water Temp (C)
06-Feb	900	355	nd	nd	nd	nd	nd
07-Feb	900	320	nd	nd	nd	nd	nd
08-Feb	900	306	nd	nd	3.7	nd	14.0
09-Feb	900	300	nd	nd	7.6	0.10	12.5
10-Feb	930	516	nd	nd	10.8	0.00	13.5

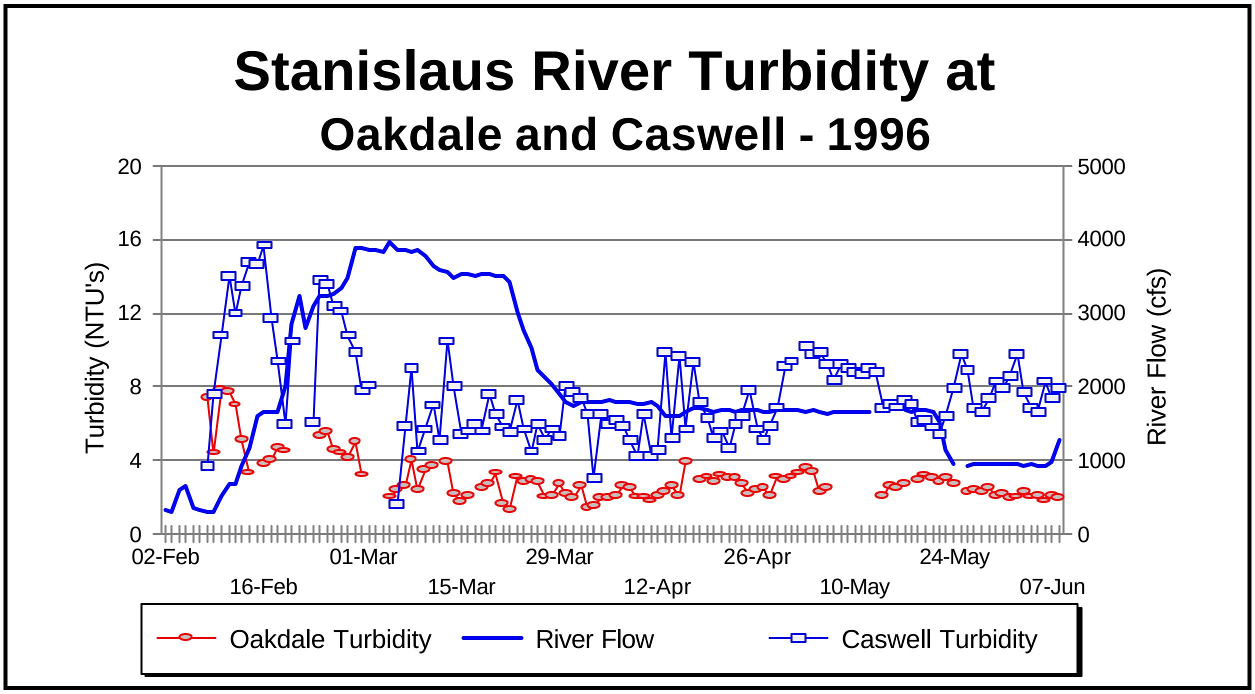
Date	Time Trap Checked	Flow at OBB (cfs)	North Trap Water Velocity (ft/sec)	South Trap Water Velocity (ft/sec)	Turbidity (NTU's)	Stream Gage (ft)	Water Temp (C)
11-Feb	900	678	nd	nd	14.0	0.30	13.0
12-Feb	1000	681	nd	nd	12.0	1.20	12.0
13-Feb	900	913	nd	nd	13.5	1.35	12.0
14-Feb	930	1179	nd	nd	14.8	1.90	14.0
15-Feb	1045	1595	nd	nd	14.7	nd	11.6
16-Feb	830	1648	nd	nd	15.7	3.66	11.0
17-Feb	1030	1652	1.80	2.74	11.7	4.20	12.0
18-Feb	900	1650	nd	nd	9.4	4.30	11.5
19-Feb	1030	2014	2.00	2.60	6.0	4.50	11.5
20-Feb	830	2841	1.90	2.59	10.5	4.85	11.0
21-Feb	nd	3223	nd	nd	nd	nd	nd
22-Feb	1700	2797	nd	nd	nd	nd	nd
23-Feb	930	3093	nd	nd	6.1	5+	12.5
24-Feb	900	3245	2.87	2.86	13.8	5+	10.0
25-Feb	930	3232	nd	nd	13.6	5+	10.2
26-Feb	1030	3271	2.28	3.15	12.4	5+	10.0
27-Feb	900	3341	3.45	3.17	12.1	5+	10.0
28-Feb	900	3481	3.06	3.59	10.8	5+	10.0
29-Feb	1000	3894	2.66	3.11	9.9	5+	10.0
01-Mar	1000	3897	2.98	3.61	7.8	5+	9.0
02-Mar	930	3866	3.24	4.08	8.1	5+	10.5
03-Mar	nd	3856	nd	nd	nd	nd	nd
04-Mar	nd	3836	nd	nd	nd	nd	nd
05-Mar	nd	3975	nd	nd	nd	nd	nd
06-Mar	1000	3850	1.88	3.15	1.6	5+	9.7
07-Mar	1100	3847	2.53	3.57	5.9	5+	10.0
08-Mar	1000	3842	2.10	3.46	9.0	5+	10.0
09-Mar	945	3849	2.05	2.90	4.5	5+	10.1
10-Mar	930	3782	2.15	2.45	5.7	5+	10.5
11-Mar	900	3641	2.03	3.12	7.0	5+	10.0
12-Mar	930	3584	2.06	2.96	5.1	5+	10.8
13-Mar	900	3552	2.16	2.49	10.5	5+	10.0
14-Mar	900	3489	2.87	3.20	8.0	5+	10.8
15-Mar	900	3529	2.15	3.30	5.4	5+	11.0
16-Mar	945	3524	1.85	2.65	5.6	5+	11.0
17-Mar	900	3519	2.35	2.55	6.0	5+	10.8
18-Mar	900	3530	2.00	3.15	5.6	5+	11.1
19-Mar	830	3522	2.46	3.37	7.6	5+	11.0
20-Mar	1015	3503	2.05	3.01	6.5	5+	11.5
21-Mar	900	3509	2.46	2.65	5.8	5+	11.5
22-Mar	800	3413	2.45	3.57	5.5	5+	11.0
23-Mar	845	3010	2.59	3.09	7.3	5+	10.5
24-Mar	830	2761	2.06	3.10	5.7	5+	10.1
25-Mar	900	2539	1.65	2.65	4.5	5+	10.5
26-Mar	930	2226	1.99	2.77	6.0	5+	10.8
27-Mar	900	2125	1.80	3.21	5.1	5+	11.1
28-Mar	1000	2024	1.74	2.77	5.7	5+	11.4
29-Mar	900	1896	1.69	2.98	5.3	5+	11.0

Date	Time Trap Checked	Flow at OBB (cfs)	North Trap Water Velocity (ft/sec)	South Trap Water Velocity (ft/sec)	Turbidity (NTU's)	Stream Gage (ft)	Water Temp (C)
30-Mar	1000	1790	1.87	2.40	8.0	5+	10.8
31-Mar	1000	1748	2.00	2.45	7.7	5+	11.2
01-Apr	900	1794	2.00	2.65	7.4	5+	11.5
02-Apr	930	1791	2.41	2.98	6.5	5+	11.0
03-Apr	900	1794	2.59	2.93	3.0	5+	11.5
04-Apr	900	1788	2.48	2.93	6.5	5+	12.0
05-Apr	1000	1809	2.36	2.79	6.0	4.50	11.8
06-Apr	900	1791	2.00	2.74	6.2	4.50	12.1
07-Apr	930	1780	1.89	2.01	5.9	4.45	12.1
08-Apr	900	1779	1.88	2.75	5.1	4.46	13.0
09-Apr	900	1775	2.20	2.59	4.2	4.36	12.8
10-Apr	900	1776	2.12	2.63	6.5	4.36	12.0
11-Apr	900	1791	2.26	2.75	4.2	4.34	12.1
12-Apr	730	1731	2.88	3.06	4.6	4.35	12.1
13-Apr	900	1598	2.71	3.15	9.9	4.30	nd
14-Apr	1030	1595	1.90	2.29	5.2	3.81	nd
15-Apr	900	1599	2.83	2.74	9.7	3.90	nd
16-Apr	900	1656	1.74	2.56	5.7	3.80	nd
17-Apr	900	1706	2.43	2.60	9.3	3.86	nd
18-Apr	900	1711	2.33	2.72	7.2	3.86	nd
19-Apr	1030	1679	1.96	2.44	6.3	3.95	nd
20-Apr	930	1670	2.96	3.16	5.2	4.00	nd
21-Apr	1045	1675	2.75	2.70	5.6	3.95	nd
22-Apr	1015	1673	2.65	2.60	4.7	3.80	nd
23-Apr	1000	1668	2.90	2.90	6.0	3.50	nd
24-Apr	1000	1673	2.82	2.65	6.4	3.50	13.3
25-Apr	1030	1676	3.60	3.20	7.8	3.55	13.3
26-Apr	900	1676	2.86	3.31	5.7	3.46	13.3
27-Apr	900	1662	2.54	2.57	5.1	3.40	13.4
28-Apr	1030	1668	2.68	2.71	5.9	3.40	13.9
29-Apr	1100	1684	2.62	2.62	6.9	3.25	13.9
30-Apr	1000	1683	2.75	2.97	9.1	3.30	13.9
01-May	930	1684	2.82	2.50	9.4	3.30	14.4
02-May	1845	1680	nd	nd	nd	nd	nd
03-May	1045	1659	nd	nd	10.2	3.30	14.4
04-May	900	1674	2.77	2.93	9.8	3.52	14.4
05-May	1130	1662	2.52	2.49	9.9	3.35	13.9
06-May	900	1640	2.88	2.78	9.2	3.40	13.3
07-May	1230	1664	2.52	2.60	8.4	3.30	13.9
08-May	1015	1650	2.26	2.20	9.2	3.35	13.3
09-May	800	1663	2.79	2.95	9.0	3.40	12.2
10-May	1200	1667	2.36	2.35	8.8	3.45	13.9
11-May	1200	1653	2.38	2.24	8.7	3.42	13.9
12-May	1000	1644	2.18	2.06	9.0	3.20	13.9
13-May	1300	-	2.36	1.94	8.8	3.20	13.9
14-May	900	-	3.06	2.67	6.8	3.20	15.6
15-May	930	-	2.90	2.92	7.1	3.35	14.5
16-May	900	-	2.87	2.95	6.9	4.20	13.9

Date	Time Trap Checked	Flow at OBB (cfs)	North Trap Water Velocity (ft/sec)	South Trap Water Velocity (ft/sec)	Turbidity (NTU's)	Stream Gage (ft)	Water Temp (C)
17-May	900	1698	2.78	2.81	7.3	nd	13.9
18-May	1030	1658	2.23	2.33	7.1	4.20	13.3
19-May	1045	1693	2.24	2.36	6.1	3.78	13.3
20-May	1000	1697	2.97	3.19	6.2	3.72	13.9
21-May	900	1670	2.95	2.97	5.8	3.60	13.4
22-May	900	1525	2.83	2.76	5.4	3.50	14.4
23-May	900	1151	2.90	3.03	6.4	3.40	12.7
24-May	1200	936	1.82	2.18	7.9	2.42	13.9
25-May	915	-	1.88	2.00	9.8	1.82	14.4
26-May	1115	921	1.59	1.79	8.9	1.38	13.9
27-May	900	955	2.58	2.49	6.8	1.58	15.7
28-May	900	958	2.74	2.54	6.6	1.30	15.0
29-May	1000	935	1.80	2.01	7.4	1.52	15.0
30-May	900	935	1.78	1.96	8.3	1.30	15.0
31-May	1000	939	1.86	1.74	7.9	1.30	15.6
01-Jun	1000	945	1.99	1.83	8.6	1.30	16.1
02-Jun	1000	939	2.10	1.91	9.8	1.52	17.2
03-Jun	800	933	2.49	2.39	7.7	1.10	17.8
04-Jun	900	936	2.45	2.47	6.8	0.98	17.7
05-Jun	830	933	2.47	2.51	6.6	0.08	13.2
06-Jun	900	929	2.33	2.33	8.3	0.08	19.4
07-Jun	900	976	2.60	2.41	7.4	0.86	17.8
08-Jun	1000	1281	2.14	1.90	7.9	1.17	16.9
09-Jun	1000	1275	2.67	1.96	8.6	2.00	16.9
10-Jun	830	1279	2.32	1.77	nd	2.17	16.9
11-Jun	930	1300	2.33	1.78	nd	2.09	16.7
12-Jun	900	1308	2.72	2.74	nd	2.00	17.2
13-Jun	1000	1292	2.77	2.77	nd	2.00	15.6
14-Jun	900	1200	2.60	2.65	nd	2.20	15.5
15-Jun	930	1077	2.11	2.33	9.7	2.12	16.9
16-Jun	715	928	2.39	2.03	8.8	1.97	16.9
17-Jun	1015	848	2.36	1.55	8.3	1.56	16.9
18-Jun	800	850	2.54	2.49	7.5	1.24	16.9
19-Jun	800	844	2.67	2.44	4.9	1.00	16.9
20-Jun	800	829	2.76	2.21	5.3	0.90	16.9
21-Jun	800	821	2.55	2.53	6.7	1.08	16.5
22-Jun	830	833	2.14	1.82	6.0	1.00	16.9
23-Jun	815	811	2.22	1.84	5.6	1.02	17.2
24-Jun	800	825	2.42	2.26	5.7	0.98	17.2
25-Jun	915	842	2.03	1.55	5.3	0.88	17.2
26-Jun	800	852	2.57	2.57	5.0	0.98	16.1
27-Jun	800	831	2.62	2.34	4.8	1.00	nd
28-Jun	800	815	2.59	2.51	5.4	0.90	15.6
29-Jun	800	776	2.01	1.82	5.6	1.00	16.9
30-Jun	1015	757	2.26	1.70	6.4	0.85	17.2
01-Jul	815	752	2.06	1.92	6.7	0.71	17.2



Water Velocity at Mouth of Traps
and Stanislaus River Flow
Velocity (ft/sec)
River Flow (cfs)
0
1
2
3
4
5
0
1000
2000
3000
4000
5000
06-Feb
20-Feb
05-Mar
19-Mar
02-Apr
16-Apr
30-Apr
14-May
28-May
11-Jun
25-Jun
North Trap
South Trap
River Flow



Appendix 13 Velocity data collected from June 9 through June 30, 1996 at the Caswell traps. Data collected using an Oceanic flow meter installed on the north trap.

Date	Start Time	Begin Flow Meter	End Flow Meter	Total Meter Revolutions	Begin Trap Counter	End Trap Counter	Total Counter Revolutions	Elapsed Time hr:min:sec:100/sec
09-Jun	1125	409206	459743	50537	140	243	103	00:30:07:99
10-Jun	925	459728	509673	49945	5	108	103	00:30:11:15
11-Jun	217	511000	556570	45570	3330	3431	101	00:30:00:13
11-Jun	1045	607790	708056	100266	201	414	213	00:59:55:15
12-Jun	-	-	-	-	-	-	-	-
13-Jun	1022	759000	810327	51327	70	172	102	00:30:00:00
14-Jun	955	810000	862107	52107	75	179	104	00:30:00:27
15-Jun	945	862100	911719	49619	75	179	104	00:29:59:73
16-Jun	740	911688	961881	50193	66	168	102	00:30:00:05
17-Jun	1055	961885	12267	50382	116	218	102	00:30:00:11
18-Jun	835	13000	595080	582080	90	1318	1228	06:22:45:00
19-Jun	820	595000	643979	48979	34	130	96	00:30:00:25
20-Jun	830	700000	226356	526356	95	1226	1131	05:36:00:00

21-Jun	819	225000	774398	549398	72	1269	1197	06:19:59:00
22-Jun	900	774403	823668	49265	75	183	108	00:30:00:77
23-Jun	840	823672	873164	49492	76	175	99	00:30:00:28
24-Jun	826	875000	466467	591467	47	1349	1302	07:26:00:51
25-Jun	940	466000	30747	564747	102	1464	1362	07:24:00:34
26-Jun	805	30000	75656	45656	53	150	97	00:30:01:80
27-Jun	814	75600	123775	48175	64	168	104	00:30:02:00
28-Jun	805	124000	173798	49798	41	136	95	00:30:00:19
29-Jun	820	175997	131758	955760	15	2306	2291	12:00:04:57
30-Jun	1005	137160	186852	49692	70	167	97	00:29:59:33

Appendix 14 Common and scientific names of fished captured at Caswell during 1996. All common and scientific names of fish species are from Freshwater Fished of California, except rainbow trout, for which the more current Native Trout of Western North America is cited.

Salmonidae

Chinook Salmon	*Onchorhyncus tshawytscha*
Rainbow Trout	*Onchorhyncus mykiss*

Cyprinidae

Sacramento Squawfish	*Ptychocheilus grandis*
Hardhead	*Mylopharodon conocephalus*
Golden Shiner	*Notemigonus crysoleucas*
Carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Hitch	*Lavinia exilicauda*

Petromyzontidae

Pacific Lamprey	*Lampetra tridentata*

Ictaluridae

Black Bullhead	*Ictalurus melas*

Yellow Bullhead	*Ictalurus natalis*
Brown Bullhead	*Ictalurus nebulosus*
White Catfish	*Ictalurus catus*
Channel Catfish	*Ictalurus puncatus*
Poeciliidae	
Mosquitofish	*Gambusia affinis*
Atherinidae	
Silverside	*Menidia beryllina*
Embiotocidae	
Tuleperch	*Hysterocarpus traski*
Cottidae	
Sculpin	*Cottus spp.*
Centrarchidae	
Largemouth Bass	*Micropterus salmoides*
Smallmouth Bass	*Micropterus dolomieui*
White Crappie	*Pomoxis annularis*
Black Crappie	*Pomoxis nigromaculatus*
Bluegill	*Lepomis microlophus*
Sacramento Perch	*Archoplites interruptus*
Clupeidae	
Threadfin Shad	*Dorosoma petenense*
Catostomidae	
Sacramento Sucker	*Catostomus occidentalis*

McGinnis, Samuel M. 1984.
Freshwater Fished of California. University of California Press.

Behnke, Robert J. 1992.
Native Trout of Western North America. American Fisheries Society Monograph 6.

Appendix 15 Anatomical characteristics used to identify fish species captured in the Stanislaus River. All fish were identified to species level when possible. The condition of fish (i.e. live, dead, partial, destroyed) sometimes prevented proper identification. In these instances fish were identified to the lowest taxonomical group possible. Parentheses indicate codes used to identify fish in computer database.

Bass spp.	(bas)	species not identified
Brown bullhead	(bbl)	caudal fin straight; body yellow-brown; belly white or yellow
Black crappie	(bcrp)	7-8 dorsal spines, random spots on body
Bluegill	(blg)	blue-black opercular flap; bars on side; large black spot posterior base of rayed dorsal
Rainbow/steelhead	(bow)	similar to chinook but with numerous dark spots on body and dorsal fin (pre-smolts); rounded anal fin and less sharply forked tail than chinook
Carp	(car)	bronze color; large scales; two barbels on posterior edge of upper jaw

Catfish	(cat)	species not identified
Channel catfish	(chcat)	deeply forked tail; body color dark green or blue with black spots
Chinook	(chn)	tall par marks (pre-smolts); dorsal fin clear; sharp anal fin; no random spots as seen on rainbow/steelhead
Crappie	(crp)	species not identified
Crawdad	(crw)	species not identified
Goldfish	(gld)	deep-bodied large cyprinid; long dorsal fin; no barbels on jaw
Golden shiner	(gshn)	sharp keel present between anal and caudal fins; golden back; golden-silver sides; dorsal fin 8 rays
Hardhead	(hhd)	long pointed snout; jaw does not extend beyond anterior margin of eyes; fold of skin connects upper jaw to side of head
Hitch	(hit)	no sharp keel present between anal and caudal fins; 10+ rays
Pacific lamprey	(lam)	eel like
Largemouth bass	(lgb)	jaw extends past posterior margin of the eye; continuous black lateral stripe
Mosquitofish	(mqf)	small dorsal fin; no heavy spotting; drab green-gray color; upturned mouth
Sacramento perch	(sap)	12-14 dorsal spines; brown body with dark vertical stripes; 6-7 anal spines
Sacramento sucker	(sck)	5-6 rows of papillae on upper lip, 1 row across low lip; lower lip deeply cleft; 11-12 dorsal rays
Sculpin	(scp)	species not identified
Silverside	(sls)	transparent body with silver line from head to tail along lateral line
Smallmouth bass	(smb)	jaw does not extend to posterior margin of eye; no black lateral stripe
Sac. squawfish	(sqf)	long pointed snout; jaw extends beyond anterior margin of eye; jaw without teeth; frenulum not attached as on hard head
Sunfish		(sun) unidentified centrarchid
Threadfin shad	(thf)	small silvery fish with thin, deep body; long thread-like projection from posterior dorsal fin; single spot behind head
Tuleperch	(tlp)	sunfish-like build; very long dorsal fin; row of large scales at base of dorsal fin; dorsal fin 15-19 spines
White catfish	(wcat)	anal fin base short with 18-24 rays; tail forked; large adult body color pale grey-blue; juveniles black body color; adult and juveniles white belly
White crappie	(wcrp)	5-6 dorsal spines; silver body with spotted verticalbands
Yellow Bullhead	(ybl)	white chin barbels; rounded caudal fin; body yellow-brown to black; white belly

Appendix 16 Number and date of non-salmonids captured in screw traps at Caswell during 1996.

Date	bas	bbl	bcrp	blg	bow	car	cat	chcat	crp	crw	gld	gshn	hhd	hit	lam	lgb	mqf	sap	sck	scp	sls	smb	sqf	sun	thf	tlp	wcat	wcrp	ybl
02/06/96					2											1				1			2	1	2		2		
02/07/96															501	2	4				1						3		
02/08/96			2	1		1			2			2				2	2			1			1	2		1	3		
02/09/96			4												100	1											5		
02/10/96			4												18								1		1				
02/11/96			5				1			2					10								2				4		
02/12/96			1							2						2	2		2		3		1				4		
02/13/96									2			2															4		

Date	bas	bbl	bcrp	blg	bow	car	cat	chcat	crp	crw	gld	gshn	hhd	hit	lam	lgb	mqf	sap	sck	scp	sls	smb	sqf	sun	thf	tlp	wcat	wcrp	ybl
02/14/96			1													3	5										2		
02/15/96			4												1	1			1		1		1				6		
02/16/96			1														1										4		
02/17/96			1													1	2			1									
02/18/96			2								1					1	5		3				1				2		
02/19/96					1						1						1		1				2				1		
02/20/96																	4						3				1		
02/23/96			1											1	95		1		10	1			24				2		
02/24/96															100				2		1						2		
02/25/96												1			20		2	1	1				8				1		
02/26/96																	2		2				15	1					
02/27/96																	1						17						
02/28/96																	3						4						
02/29/96											1						2		1				22						
03/01/96																	2						2				1		
03/02/96																	8		1				15						
03/07/96																	3		1				13						
03/08/96				1													1		1				24						
03/09/96								1									3						8						
03/10/96																			2				13						
03/11/96																							2						
03/12/96																							6		1				
03/13/96																	1						18						
03/14/96						1											4						21					1	
03/15/96																	2		1				6			1		2	
03/16/96			1														3						4		2				
03/17/96																	1						5		1				
03/18/96								1									1		1				4		2	1	1		
03/19/96																	2		1				1		1	1			
03/20/96																	1						2						
03/21/96																							5						
03/22/96																	4		1				3					1	
03/23/96																							1						
03/24/96																			1				2				1		
03/25/96				1																			2					1	
03/26/96															1				1				7						
03/27/96																	1		1				10					2	
03/28/96																	3						7					3	
03/29/96																	4		1				21		1		1	3	
03/30/96																	2						29					1	
03/31/96																	2						25					2	
04/01/96																	9						17					2	
04/02/96																	1					1	24			1		3	
04/03/96																	4						21					5	
04/04/96														1			6						35					4	
04/05/96																	2		1				2			4		4	
04/06/96																	6		1				6					4	
04/07/96																1	9		2				11				1	2	
04/08/96		1															2						2						
04/09/96																	1		1				6			5		1	
04/10/96																	2		1				2			5	1		
04/11/96																	7						1			2			
04/12/96																	1						1			2			
04/13/96																	1		1				1			1	1		
04/14/96																	4						2					1	
04/15/96																	6						1			1			
04/16/96																	1						2						
04/17/96							1							1									4						

Date	bas	bbl	bcrp	blg	bow	car	cat	chcat	crp	crw	gld	gshn	hhd	hit	lam	lgb	mqf	sap	sck	scp	sls	smb	sqf	sun	thf	tlp	wcat	wcrp	ybl
04/18/96																							2						
04/19/96																	2		1				6						
04/21/96											1						1											1	
04/22/96			1														2		1								1		
04/23/96			1														1												
04/24/96			1														6						6			1	1	3	
04/25/96														1			1					1	6				2	2	
04/26/96																							4				1		
04/27/96																							3			3			
04/28/96																	1						2		1	1	1		
04/29/96																1	1						5						
04/30/96																	1						8		1	1	1		
05/01/96											1	1					1										1	1	
05/02/96																	1											1	
05/03/96																	2						4		1		1		
05/04/96													1										7		1	1			1
05/05/96																										1			
05/06/96															2														
05/08/96																1													
05/09/96																	3		2								1	1	
05/10/96																1													
05/11/96																	2						1				1	1	
05/12/96																1	1						1						
05/14/96																							1						
05/15/96																											1		
05/16/96																							1						
05/17/96		1																									1		
05/18/96																1	2					1	1					1	
05/19/96																2	6		3				2						
05/20/96																14	3		2	1						1	2		
05/21/96	2															3	10		4										
05/22/96												2				1	4		1										
05/23/96																1							1						
05/24/96																3			1				2				1		
05/25/96																3							1		1		2	5	
05/26/96			4												1	5		1				2	2				2	4	
05/27/96								1					1			16	6						4			6	2	8	
05/28/96													1		2	2	1						3			4	2	4	
05/29/96																6	1						1				1	1	
05/30/96																3										1	1	1	
05/31/96													1		2	1		1					1					1	
06/01/96		1											3										1					1	
06/02/96		1											1									1				1	1	1	
06/03/96		1																									4	5	
06/04/96		1		1								1																1	
06/05/96				1																							1	2	
06/06/96					1											2							1				2	6	
06/07/96																2			1				1				1	3	
06/08/96		1														2	1						2				1	1	
06/09/96																1										1	1		
06/10/96			1												1	1													
06/11/96															1												1		
06/12/96																													
06/13/96															1	2	1								1		1		
06/14/96		1		1												5							1				1		
06/15/96		2																					2				1		
06/16/96																										2		1	
06/17/96		1														1										3			

Date	bas	bbl	bcrp	blg	bow	car	cat	chcat	crp	crw	gld	gshn	hhd	hit	lam	lgb	mgf	sap	sck	scp	sls	smb	sgf	sun	thf	tlp	wcat	wcrp	ybl
06/18/96									4							2										2			
06/19/96		2														3													
06/20/96		1														4							1						
06/21/96																3							1				1	2	
06/22/96		1														1							1			1		1	
06/23/96																							1				1		
06/24/96																3											1		
06/25/96			1																							1	1		
06/26/96		1	1																1			1							
06/27/96																1									1		2		
06/28/96						1										1							2				3	1	
06/29/96			1																				1		1	1	3		
06/30/96															1	2							1				1		
07/01/96		1															1		1										
Totals	2	17	38	6	4	3	2	3	8	4	5	9	8	4	857	116	209	3	61	5	6	7	589	4	19	57	107	102	1

Appendix 17 Number measured and mean lengths of non-salmonids captured in screw traps at Caswell during 1996.

	bbl		bcrp		blg		bow		car		chcat		crp		gld		gshn		hhd		hit		lgb	
Date	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len	# Meas.	Mean Len
02/06/96							2	268															1	95
02/08/96			2	58	1	118			1	87			2	48			2	75					2	49
02/10/96			4	53																				
02/12/96			1	48																			2	74
02/15/96																							1	76
02/18/96																								
02/19/96							1	34							1	120								
02/20/96																								
02/23/96			1	170																	1	78		
02/26/96																								
02/29/96															1	146								
03/07/96																								
03/11/96																								
03/14/96									1	74														
03/18/96											1	34												
03/21/96																								
03/23/96																								
03/25/96					1	140																		
03/28/96																								
04/01/96																								
04/04/96																					1	57		
04/07/96																								
04/08/96	1	35																						
04/09/96																								
04/11/96																								
04/15/96																								
04/18/96																								
04/22/96			1	67																				
04/25/96																					1	55		
04/27/96																								
04/28/96																								
04/29/96																							1	50
04/30/96																								
05/02/96																								
05/06/96																								
05/09/96																								
05/11/96																								
05/16/96																								
05/18/96																								
05/20/96																							14	26
05/23/96																							1	22
05/27/96																			1	116			7	23
05/28/96																								
05/30/96																							3	24
05/31/96																								
06/03/96	1	148																						
06/06/96							1	94															2	26
06/11/96																								
06/12/96																								
06/13/96																							2	41
06/14/96																								
06/17/96	1	199																					1	31
06/20/96	1	190																					4	31
06/23/96																								
06/24/96																							3	38
06/27/96																							1	49

	bbl		bcrp		blg		bow		car		chcat		crp		gld		gshn		hhd		hit		lgb	
	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean
Date	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len
07/01/96	1	205																						

	mqf		sck		scp		sls		smb		sqf		sun		thf		tlp		wcat		wcrp	
	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean
Date	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len
02/06/96					1	80					2	74	1	126	2	80			2	208		
02/08/96	2	31			1	97					1	47	2	116			1	70	3	91		
02/10/96											1	122			1	86						
02/12/96	2	34	2	54			3	75			1	30							4	34		
02/15/96			1	52			1	81			1	47							5	71		
02/18/96																						
02/19/96	1	26	1	30							2	30							1	42		
02/20/96																						
02/23/96	1	30	10	50	1	98					24	44							2	43		
02/26/96	2	29	2	40							15	43	1	133								
02/29/96	2	30	1	38							22	48										
03/07/96	3	30	1	43							13	41										
03/11/96											2	61										
03/14/96	4	28									20	47									1	46
03/18/96	1	32	1	35							4	54			2	52	1	66				
03/21/96											5	39										
03/23/96																						
03/25/96											2	39									1	42
03/28/96	3	31									7	55									3	57
04/01/96	9	29									17	55									2	60
04/04/96	6	30									34	53									4	35
04/07/96																						
04/08/96	2	31									1	39										
04/09/96																						
04/11/96	7	30									1	83					2	52				
04/15/96	6	29															1	36				
04/18/96											2	54										
04/22/96	2	43	1	23															1	42		
04/25/96	1	50							1	350	6	74							2	45	2	47
04/27/96																						
04/28/96																						
04/29/96	1	40									5	53										
04/30/96																						
05/02/96																						
05/06/96																						
05/09/96	3	30	2	42															1	41	1	72
05/11/96																						
05/16/96											1	34										
05/18/96																						
05/20/96	3	38	2	38	1	19											1	31	2	117		
05/23/96											1	32										
05/27/96	1	22																	1	230		
05/28/96																						
05/30/96																	1	51	1	34	1	74
05/31/96																						
06/03/96																			4	80	5	39

	mqf		sck		scp		sls		smb		sqf		sun		thf		tlp		wcat		wcrp	
	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean	#	Mean
Date	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len	Meas.	Len
06/06/96											1	63							2	111	6	67
06/11/96																						
06/12/96																						
06/13/96	1	27													1	90			1	41		
06/14/96																						
06/17/96																	3	75				
06/20/96											1	27										
06/23/96																						
06/24/96																			1	174		
06/27/96															1	96			2	150		
07/01/96	1	47	1	32																		

Appendix 18 Number of natural chinook measured, minimum, maximum and mean lengths for combined traps each day chinook were measured. Extreme lengths are chinook that are considerably larger or smaller than the daily catch. No chinook of "extreme" lengths were captured at Caswell in 1996.

Date	# Measured	Mean Length	Minimum Length	Maximum Length	Extreme Length
06-Feb	48	34.92	29	44	-
07-Feb	-	-	-	-	-
08-Feb	30	34.10	29	41	-
09-Feb	-	-	-	-	-
10-Feb	-	-	-	-	-
11-Feb	-	-	-	-	-
12-Feb	6	35.17	33	38	-
13-Feb	-	-	-	-	-
14-Feb	-	-	-	-	-
15-Feb	38	34.76	32	39	-
16-Feb	-	-	-	-	-
17-Feb	-	-	-	-	-
18-Feb	-	-	-	-	-
19-Feb	37	34.78	30	38	-
20-Feb	-	-	-	-	-
21-Feb	-	-	-	-	-
22-Feb	-	-	-	-	-
23-Feb	46	35.00	30	42	-
24-Feb	-	-	-	-	-
25-Feb	-	-	-	-	-
26-Feb	11	35.55	32	38	-
27-Feb	-	-	-	-	-
28-Feb	-	-	-	-	-
29-Feb	5	40.40	32	52	-
01-Mar	6	34.83	33	36	-
02-Mar	-	-	-	-	-
03-Mar	-	-	-	-	-
04-Mar	-	-	-	-	-
05-Mar	-	-	-	-	-
06-Mar	-	-	-	-	-
07-Mar	4	44.00	39	52	-
08-Mar	-	-	-	-	-
09-Mar	-	-	-	-	-
10-Mar	-	-	-	-	-
11-Mar	-	-	-	-	-
12-Mar	1	38.00	38	38	-
13-Mar	-	-	-	-	-
14-Mar	1	44.00	44	44	-
15-Mar	-	-	-	-	-
16-Mar	1	51.00	51	51	-

Date	# Measured	Mean Length	Minimum Length	Maximum Length	Extreme Length
17-Mar	-	-	-	-	-
18-Mar	2	38.00	35	41	-
19-Mar	-	-	-	-	-
20-Mar	1	45.00	45	45	-
21-Mar	-	-	-	-	-
22-Mar	-	-	-	-	-
23-Mar	-	-	-	-	-
24-Mar	-	-	-	-	-
25-Mar	-	-	-	-	-
26-Mar	4	77.50	67	93	-
27-Mar	2	76.50	67	86	-
28-Mar	7	80.43	68	87	-
29-Mar	10	81.70	70	93	-
30-Mar	3	74.00	69	79	-
31-Mar	5	74.80	59	91	-
01-Apr	3	88.00	80	92	-
02-Apr	3	90.00	88	91	-
03-Apr	8	84.00	69	97	-
04-Apr	16	82.94	65	99	-
05-Apr	9	82.78	69	91	-
06-Apr	14	87.50	77	101	-
07-Apr	13	76.92	59	87	-
08-Apr	1	81.00	81	81	-
09-Apr	6	86.17	75	97	-
10-Apr	4	80.75	75	90	-
11-Apr	2	85.00	75	95	-
12-Apr	9	82.56	46	98	-
13-Apr	2	80.50	79	82	-
14-Apr	-	-	-	-	-
15-Apr	10	85.50	62	99	-
16-Apr	2	97.50	95	100	-
17-Apr	3	91.33	78	101	-
18-Apr	6	84.67	77	93	-
19-Apr	15	86.20	60	101	-
20-Apr	1	89.00	89	89	-
21-Apr	22	89.77	75	103	-
22-Apr	36	91.08	72	106	-
23-Apr	20	89.65	75	100	-
24-Apr	38	89.66	71	105	-
25-Apr	39	92.23	72	104	-
26-Apr	37	91.19	79	109	-
27-Apr	60	90.97	75	104	-
28-Apr	60	91.68	74	105	-
29-Apr	56	91.89	57	112	-
30-Apr	60	91.02	78	105	-
01-May	34	91.21	79	108	-
02-May	30	93.40	82	115	-
03-May	40	92.88	81	107	-
04-May	51	90.47	75	109	-

Date	# Measured	Mean Length	Minimum Length	Maximum Length	Extreme Length
05-May	60	93.48	79	110	-
06-May	60	90.80	71	114	-
07-May	41	92.10	85	108	-
08-May	47	91.91	78	107	-
09-May	47	91.36	76	109	-
10-May	21	90.57	78	110	-
11-May	38	91.84	74	105	-
12-May	37	91.08	70	104	-
13-May	-	-	-	-	-
14-May	22	92.95	77	105	-
15-May	5	98.20	92	104	-
16-May	19	91.21	76	110	-
17-May	10	93.70	85	104	-
18-May	14	95.79	86	106	-
19-May	10	99.50	85	111	-
20-May	19	95.00	86	110	-
21-May	22	95.45	85	112	-
22-May	8	94.12	80	102	-
23-May	9	95.89	87	109	-
24-May	18	94.61	85	112	-
25-May	20	95.10	83	105	-
26-May	52	95.02	69	106	-
27-May	23	93.26	70	107	-
28-May	21	94.57	82	108	-
29-May	22	92.95	82	110	-
30-May	9	93.33	80	102	-
31-May	10	95.90	86	104	-
01-Jun	10	98.00	91	107	-
02-Jun	11	97.27	91	104	-
03-Jun	2	92.00	86	98	-
04-Jun	2	99.00	99	99	-
05-Jun	4	102.00	98	108	-
06-Jun	3	100.00	94	104	-
07-Jun	1	91.00	91	91	-
08-Jun	4	99.25	92	102	-
09-Jun	2	93.00	88	98	-
10-Jun	-	-	-	-	-
11-Jun	-	-	-	-	-
12-Jun	3	87.00	83	90	-
13-Jun	1	90.00	90	90	-
14-Jun	2	87.00	82	92	-
15-Jun	-	-	-	-	-
16-Jun	-	-	-	-	-
17-Jun	1	89.00	89	89	-
18-Jun	-	-	-	-	-
19-Jun	-	-	-	-	-
20-Jun	-	-	-	-	-
21-Jun	1	96.00	96	96	-
22-Jun	-	-	-	-	-

Date	# Measured	Mean Length	Minimum Length	Maximum Length	Extreme Length
23-Jun	1	111.00	111	111	-
24-Jun	1	105.00	105	105	-
25-Jun	-	-	-	-	-
26-Jun	-	-	-	-	-
27-Jun	1	94.00	94	94	-
28-Jun	-	-	-	-	-
29-Jun	-	-	-	-	-
30-Jun	1	109.00	109	109	-
01-Jul	1	101.00	101	101	-

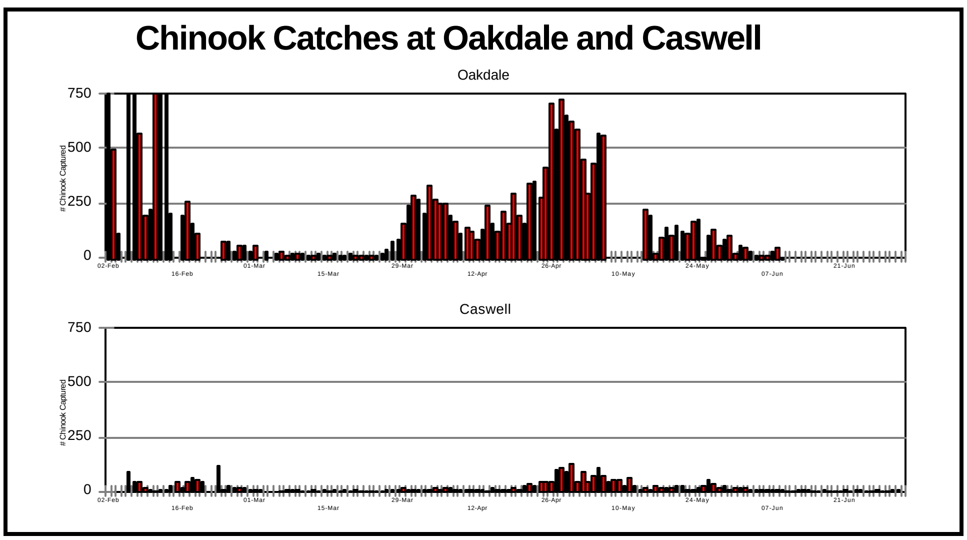
Appendix 19 Stanislaus River flow, number and mean lengths of chinook captured at Caswell and Oakdale during 1996. "Extreme" lengths at Oakdale are chinook that were significantly larger or smaller than the daily average.

		Oakdale			Caswell	
Date	OBB Flow (cfs)	# Chinook Captured	Mean Length (mm)	Extreme Length (mm)	# Chinook Captured	Mean Length (mm)
02-Feb	317	1046	35.9		-	-
03-Feb	302	493	34.7		-	-
04-Feb	591	104	36.3		-	-
05-Feb	642	ND	-		-	-
06-Feb	355	5452	35.4		89	34.9
07-Feb	320	2289	-		42	-
08-Feb	306	565	35.5		44	34.1
09-Feb	300	194	37.2		13	-
10-Feb	516	222	37.5		2	-
11-Feb	678	1454	-	169	0	-
12-Feb	681	1449	35.4		6	35.2
13-Feb	913	1179	-		2	-
14-Feb	1179	200	-		28	-
15-Feb	1595	ND	-		39	34.8
16-Feb	1648	187	-		16	-
17-Feb	1652	257	-		44	-
18-Feb	1650	149	-		57	-
19-Feb	2014	109	36.2		52	34.8
20-Feb	2841	ND	-		37	-
21-Feb	3223	ND	-		-	-
22-Feb	2797	ND	-		-	-
23-Feb	3093	ND	-		113	35
24-Feb	3245	65	-		3	-
25-Feb	3232	71	-		24	-
26-Feb	3271	21	34.9		11	35.5
27-Feb	3341	51	-		16	-
28-Feb	3481	47	-		11	-

		Oakdale			Caswell	
	OBB Flow	# Chinook	Mean	Extreme	# Chinook	Mean
Date	(cfs)	Captured	Length (mm)	Length (mm)	Captured	Length (mm)
29-Feb	3894	22	37.6		5	40.4
01-Mar	3897	49	-		6	34.8
02-Mar	3866	ND	-		1	-
03-Mar	3856	26	-		-	-
04-Mar	3836	ND	-		-	-
05-Mar	3975	16	37.3		-	-
06-Mar	3850	24	-		0	-
07-Mar	3847	5	41.8		4	44
08-Mar	3842	18	41.6		4	-
09-Mar	3849	11	45.8		1	-
10-Mar	3782	13	41.8		0	-
11-Mar	3641	6	49.3		0	-
12-Mar	3584	4	42.5		1	38
13-Mar	3552	16	40.9		0	-
14-Mar	3489	9	55.5		1	44
15-Mar	3529	3	41.7		0	-
16-Mar	3524	15	42.5		1	51
17-Mar	3519	5	47.0		0	-
18-Mar	3530	8	65.9		2	38
19-Mar	3522	10	45.4		0	-
20-Mar	3503	3	47.5		1	45
21-Mar	3509	3	45.7		0	-
22-Mar	3413	3	67.0		0	-
23-Mar	3010	4	90.0	160	0	-
24-Mar	2761	4	72.5		0	-
25-Mar	2539	18	73.6		0	-
26-Mar	2226	30	75.5		4	77.5
27-Mar	2125	74	79.2		2	76.5
28-Mar	2024	82	76.7		7	80.4
29-Mar	1896	149	71.6		10	81.7
30-Mar	1790	238	76.9		3	74
31-Mar	1748	284	82.4	151	5	74.8
01-Apr	1794	262	78.5		3	88
02-Apr	1791	200	81.1		3	90
03-Apr	1794	332	77.5		8	84
04-Apr	1788	265	80.5	233	18	82.9
05-Apr	1809	249	79.5		9	82.8
06-Apr	1791	249	79.4		14	87.5
07-Apr	1780	188	80.3		13	76.9
08-Apr	1779	160	81.9		1	81
09-Apr	1775	104	82.9		8	86.2
10-Apr	1776	135	80.7		4	80.8
11-Apr	1791	114	82.7		2	79.7
12-Apr	1731	79	84.9		9	87.1
13-Apr	1598	129	83.3		2	80.5
14-Apr	1595	239	84.0		0	-
15-Apr	1599	158	86.5		10	85.5
16-Apr	1656	118	90.2		2	97.5
17-Apr	1706	212	83.8		3	91.3
18-Apr	1711	155	87.7		6	84.7
19-Apr	1679	295	84.3		15	86.2
20-Apr	1670	194	86.4		1	84
21-Apr	1675	152	84.2		22	89.8
22-Apr	1673	340	88.6		36	91.1
23-Apr	1668	343	89.3		20	89.7

		Oakdale			Caswell	
	OBB Flow	# Chinook	Mean	Extreme	# Chinook	Mean
Date	(cfs)	Captured	Length (mm)	Length (mm)	Captured	Length (mm)
24-Apr	1673	269	89.5		38	89.7
25-Apr	1676	415	87.2		39	92.2
26-Apr	1676	704	89.1		38	91.2
27-Apr	1662	584	89.8		95	91
28-Apr	1668	727	91.8		109	91.6
29-Apr	1684	655	91.3		89	91.9
30-Apr	1683	625	92.7		121	90.9
01-May	1684	589	91.0		40	91.2
02-May	1680	448	92.6		84	93.4
03-May	1659	296	90.3		44	92.8
04-May	1674	435	89.1		67	90.5
05-May	1662	566	92.1		107	93.5
06-May	1640	556	91.1		73	91
07-May	1664	-	-		42	92.1
08-May	1650	-	-		47	91.9
09-May	1663	-	-		47	90.6
10-May	1667	-	-		21	90.6
11-May	1653	-	-		60	91.5
12-May	1644	-	-		20	91.2
13-May	-	-	-		6	94.8
14-May	-	219	92.2		16	92.4
15-May	-	191	97.8		5	98.2
16-May	-	14	95.7		19	91.2
17-May	1698	92	94.2		10	93.7
18-May	1658	132	95.6		14	95.8
19-May	1693	101	96.4		10	99.5
20-May	1697	148	95.2		19	95
21-May	1670	113	97.7		23	95.5
22-May	1525	108	92.8		8	94.1
23-May	1151	164	94.3		9	95.9
24-May	936	176	93.5		18	94.6
25-May		0	-		20	95.1
26-May	921	94	95.0		52	95
27-May	955	130	92.9		30	94.6
28-May	958	51	94.6		15	92.4
29-May	935	81	96.0		22	93
30-May	935	99	96.5		9	93.3
31-May	939	15	96.1		10	95.9
01-Jun	945	56	96.5		10	98
02-Jun	939	37	96.0		11	97.3
03-Jun	933	23	93.8		2	92
04-Jun	936	8	95.0		2	99
05-Jun	933	9	96.7		7	98
06-Jun	929	4	101.5		3	100
07-Jun	976	27	96.1		1	91
08-Jun	1281	38	97.1		4	99.3
09-Jun	1275	0	-		2	93
10-Jun	1279	-	-		0	-
11-Jun	1300	-	-		0	-
12-Jun	1308	-	-		3	87
13-Jun	1292	-	-		2	90
14-Jun	1200	-	-		2	87
15-Jun	1077	-	-		0	-
16-Jun	928	-	-		0	-
17-Jun	848	-	-		1	89

		Oakdale			Caswell	
Date	OBB Flow (cfs)	# Chinook Captured	Mean Length (mm)	Extreme Length (mm)	# Chinook Captured	Mean Length (mm)
18-Jun	850	-	-		0	-
19-Jun	844	-	-		0	-
20-Jun	829	-	-		0	-
21-Jun	821	-	-		1	96
22-Jun	833	-	-		0	-
23-Jun	811	-	-		1	111
24-Jun	825	-	-		1	105
25-Jun	842	-	-		0	-
26-Jun	852	-	-		0	-
27-Jun	831	-	-		1	94
28-Jun	815	-	-		0	-
29-Jun	776	-	-		0	-
30-Jun	757	-	-		1	109
01-Jul	752	-	-		1	101
02-Jul	763	-	-		-	-



Appendix 20 Date, number and smolt index rating of all rainbow/steelhead captured at Oakdale and Caswell in 1996. (Note: All rainbow/steelhead captured at both locations were identified, measured and rated.)

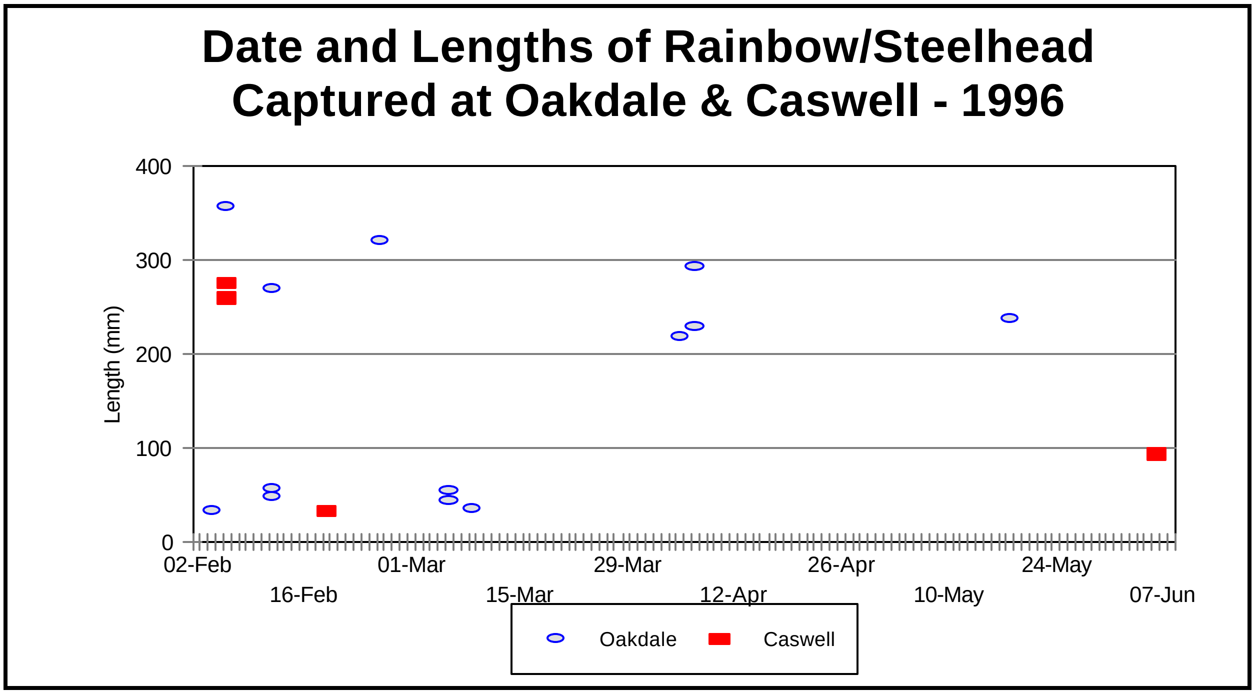
Oakdale Screw Trap

Date	Length (mm)	Smolt Index
04-Feb-96	34	1
06-Feb-96	356	3
12-Feb-96	270	3
12-Feb-96	49	1

Caswell Screw Traps

Date	Length (mm)	Smolt Index
06-Feb-96	275	3
06-Feb-96	260	3
19-Feb-96	34	1
06-Jun-96	94	2

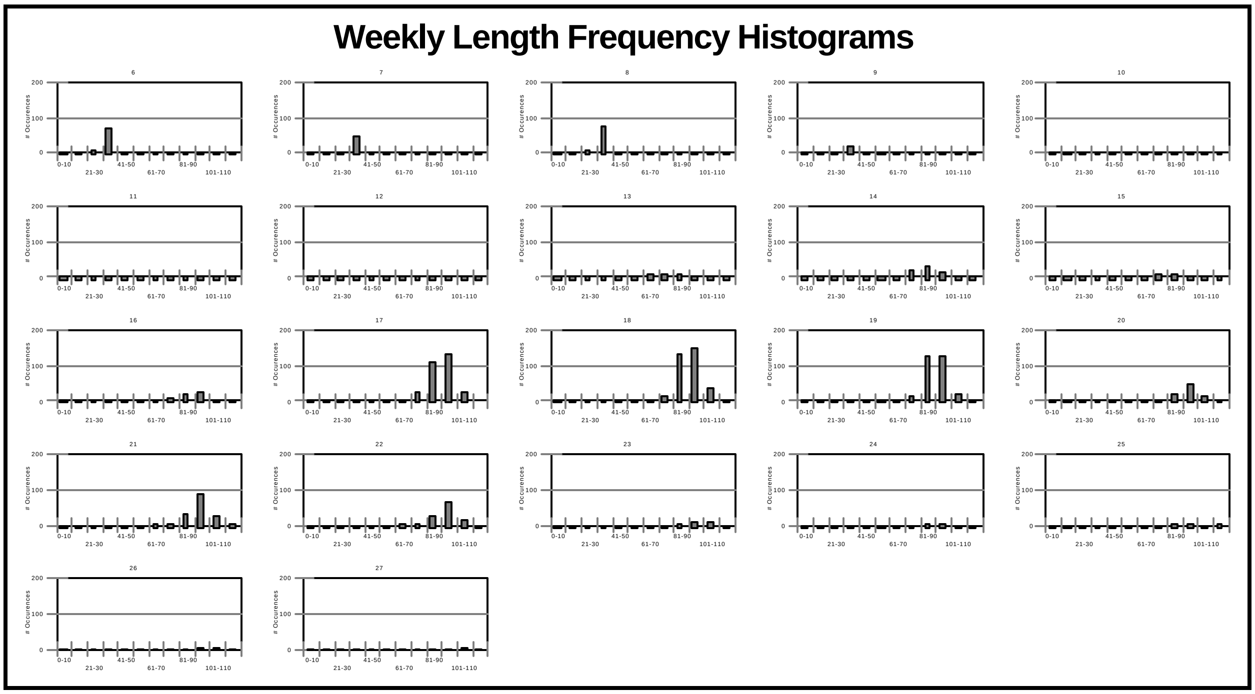
12-Feb-96	58	1
26-Feb-96	320	1
06-Mar-96	45	1
06-Mar-96	55	1
09-Mar-96	35	1
05-Apr-96	218	3
07-Apr-96	230	3
07-Apr-96	292	3
18-May-96	238	3



Appendix 21 Length frequencies of all measured fish by Julian week captured at Caswell during 1996.

Length Interval (mm)	Julian Week 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Weeks 6-27	% of Total Measured
0-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
11-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
21-30	6	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0.6

31-40	69	44	77	20	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	213	12.6
41-50	3	0	1	1	2	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	11	0.6
51-60	0	0	0	1	1	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	7	0.4
61-70	0	0	0	0	0	0	0	7	4	0	1	0	0	1	0	1	1	0	0	0	0	0	15	0.9
71-80	0	0	0	0	0	0	0	10	16	7	11	26	14	14	3	1	1	0	0	0	0	0	103	6.1
81-90	0	0	0	0	0	0	0	9	31	11	18	107	133	126	17	33	23	2	5	1	0	0	516	30.5
91-100	0	0	0	0	0	0	0	4	12	5	25	134	146	128	46	84	65	9	1	1	1	0	661	39.0
101-110	0	0	0	0	0	0	0	0	2	0	3	23	35	21	13	27	16	7	0	0	2	1	150	8.9
111-120	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	2	0	0	0	1	0	0	7	0.4
	78	44	83	22	4	3	3	31	66	24	59	290	331	291	80	148	106	18	6	3	3	1	1694	



Appendix 22 Stanislaus River flow, total number of chinook captured and total number chinook rated for smolt index each day. An average smolting index for each day chinook were rated was completed by the expression:

daily chinook smolting index = {1 * (# chinook SI 1) + 2 * (# chinook SI 2) + 3 * (#

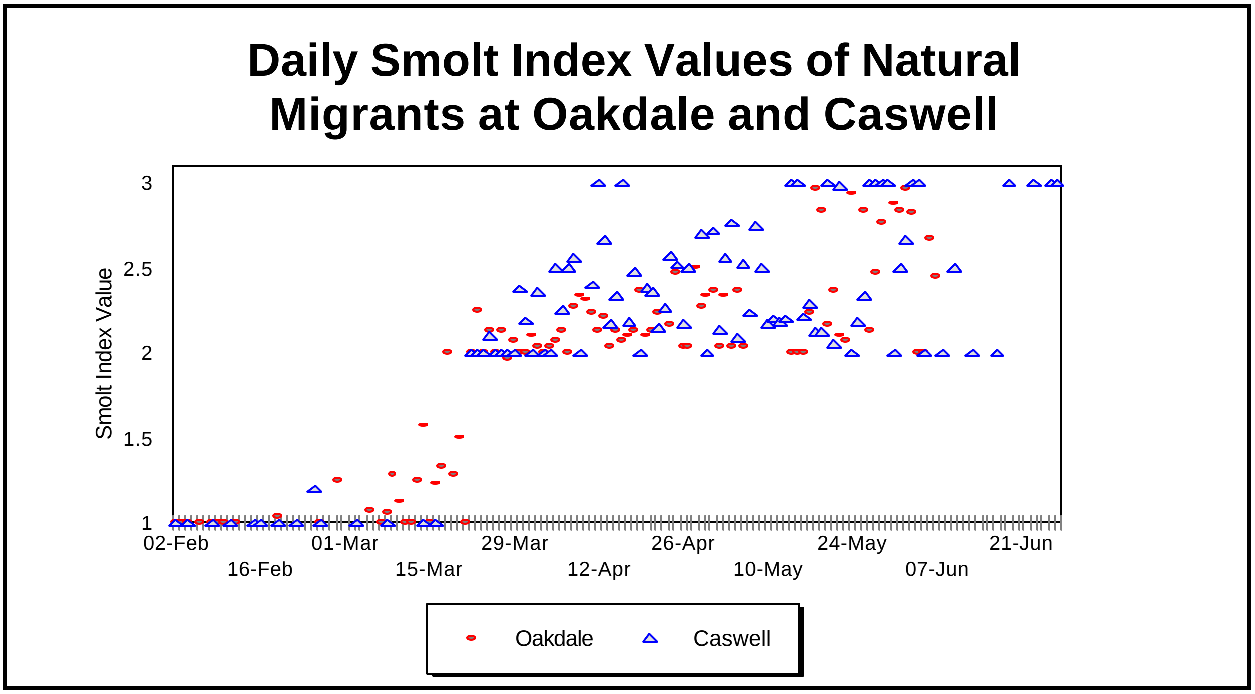
chinook SI 3)} / number of chinook rated each day.

Date	OBB Flow (cfs)	Total Chn Captured	Total Chn Indexed	Smlt Index 1	(1 * #SI 1)	Smlt Index 2	(2 * #SI 2)	Smlt Index 3	(3 * #DI 3)	Sum / # Rated
06-Feb	355	89	48	48	48	0	0	0	0	1.0
07-Feb	320	42	-	-	0	-	0	-	0	-
08-Feb	306	44	30	30	30	-	0	-	0	1.0
09-Feb	300	13	-	-	0	-	0	-	0	-
10-Feb	516	2	-	-	0	-	0	-	0	-
11-Feb	678	0	-	-	0	-	0	-	0	-
12-Feb	681	6	6	6	6	-	0	-	0	1.0
13-Feb	913	2	-	-	0	-	0	-	0	-
14-Feb	1179	28	-	-	0	-	0	-	0	-
15-Feb	1595	39	38	38	38	-	0	-	0	1.0
16-Feb	1648	16	-	-	0	-	0	-	0	-
17-Feb	1652	44	-	-	0	-	0	-	0	-
18-Feb	1650	57	-	-	0	-	0	-	0	-
19-Feb	2014	52	37	37	37	0	0	0	0	1.0
20-Feb	2841	37	1	1	1	0	0	0	0	1.0
21-Feb	3223		-	-	0	-	0	-	0	-
22-Feb	2797		-	-	0	-	0	-	0	-
23-Feb	3093	113	46	46	46	0	0	0	0	1.0
24-Feb	3245	3	-	-	0	-	0	-	0	-
25-Feb	3232	24	-	-	0	-	0	-	0	-
26-Feb	3271	11	11	11	11	0	0	0	0	1.0
27-Feb	3341	16	-	-	0	-	0	-	0	-
28-Feb	3481	11	-	-	0	-	0	-	0	-
29-Feb	3894	5	5	4	4	1	2	0	0	1.2
01-Mar	3897	6	6	6	6	0	0	0	0	1.0
02-Mar	3866	1	-	-	0	-	0	-	0	-
03-Mar	3856		-	-	0	-	0	-	0	-
04-Mar	3836		-	-	0	-	0	-	0	-
05-Mar	3975		-	-	0	-	0	-	0	-
06-Mar	3850	0	-	-	0	-	0	-	0	-
07-Mar	3847	4	2	2	2	0	0	0	0	1.0
08-Mar	3842	4	-	-	0	-	0	-	0	-
09-Mar	3849	1	-	-	0	-	0	-	0	-
10-Mar	3782	0	-	-	0	-	0	-	0	-
11-Mar	3641	0	-	-	0	-	0	-	0	-
12-Mar	3584	1	1	1	1	0	0	0	0	1.0
13-Mar	3552	0	-	-	0	-	0	-	0	-
14-Mar	3489	1	-	-	0	-	0	-	0	-
15-Mar	3529	0	-	-	0	-	0	-	0	-

Date	OBB Flow (cfs)	Total Chn Captured	Total Chn Indexed	Smlt Index 1	(1 * #SI 1)	Smlt Index 2	(2 * #SI 2)	Smlt Index 3	(3 * #DI 3)	Sum / # Rated
16-Mar	3524	1	-	-	0	-	0	-	0	-
17-Mar	3519	0	-	-	0	-	0	-	0	-
18-Mar	3530	2	2	2	2	0	0	0	0	1.0
19-Mar	3522	0	-	-	0	-	0	-	0	-
20-Mar	3503	1	1	1	1	0	0	0	0	1.0
21-Mar	3509	0	-	-	0	-	0	-	0	-
22-Mar	3413	0	-	-	0	-	0	-	0	-
23-Mar	3010	0	-	-	0	-	0	-	0	-
24-Mar	2761	0	-	-	0	-	0	-	0	-
25-Mar	2539	0	-	-	0	-	0	-	0	-
26-Mar	2226	4	3	0	0	3	6	0	0	2.0
27-Mar	2125	2	2	0	0	2	4	0	0	2.0
28-Mar	2024	7	7	0	0	7	14	0	0	2.0
29-Mar	1896	10	10	0	0	9	18	1	3	2.1
30-Mar	1790	3	3	0	0	3	6	0	0	2.0
31-Mar	1748	5	5	0	0	5	10	0	0	2.0
01-Apr	1794	3	3	0	0	3	6	0	0	2.0
02-Apr	1791	3	3	0	0	3	6	0	0	2.0
03-Apr	1794	8	8	0	0	5	10	3	9	2.4
04-Apr	1788	18	16	0	0	13	26	3	9	2.2
05-Apr	1809	9	9	0	0	9	18	0	0	2.0
06-Apr	1791	14	14	0	0	9	18	5	15	2.4
07-Apr	1780	13	10	0	0	10	20	0	0	2.0
08-Apr	1779	1	1	0	0	1	2	0	0	2.0
09-Apr	1775	8	6	0	0	3	6	3	9	2.5
10-Apr	1776	4	4	0	0	3	6	1	3	2.3
11-Apr	1791	2	2	0	0	1	2	1	3	2.5
12-Apr	1731	9	9	1	1	2	4	6	18	2.6
13-Apr	1598	2	2	0	0	2	4	0	0	2.0
14-Apr	1595	0	-	-	0	-	0	-	0	-
15-Apr	1599	10	10	0	0	6	12	4	12	2.4
16-Apr	1656	2	2	0	0	0	0	2	6	3.0
17-Apr	1706	3	3	0	0	1	2	2	6	2.7
18-Apr	1711	6	6	0	0	5	10	1	3	2.2
19-Apr	1679	15	15	0	0	10	20	5	15	2.3
20-Apr	1670	1	1	0	0	0	0	1	3	3.0
21-Apr	1675	22	22	0	0	18	36	4	12	2.2
22-Apr	1673	36	36	0	0	19	38	17	51	2.5
23-Apr	1668	20	20	0	0	20	40	0	0	2.0
24-Apr	1673	38	37	0	0	23	46	14	42	2.4
25-Apr	1676	39	39	0	0	25	50	14	42	2.4
26-Apr	1676	38	34	0	0	29	58	5	15	2.1

Date	OBB Flow (cfs)	Total Chn Captured	Total Chn Indexed	Smlt Index 1	(1 * #SI 1)	Smlt Index 2	(2 * #SI 2)	Smlt Index 3	(3 * #DI 3)	Sum / # Rated
27-Apr	1662	95	60	0	0	44	88	16	48	2.3
28-Apr	1668	109	60	0	0	26	52	34	102	2.6
29-Apr	1684	89	56	0	0	27	54	29	87	2.5
30-Apr	1683	121	59	0	0	49	98	10	30	2.2
01-May	1684	40	34	0	0	17	34	17	51	2.5
02-May	1680	84	-	-	0	-	0	-	0	-
03-May	1659	44	40	0	0	12	24	28	84	2.7
04-May	1674	67	51	0	0	51	102	0	0	2.0
05-May	1662	107	60	0	0	17	34	43	129	2.7
06-May	1640	73	60	0	0	52	104	8	24	2.1
07-May	1664	42	41	0	0	18	36	23	69	2.6
08-May	1650	47	47	0	0	11	22	36	108	2.8
09-May	1663	47	47	0	0	43	86	4	12	2.1
10-May	1667	21	21	0	0	10	20	11	33	2.5
11-May	1653	60	55	0	0	42	84	13	39	2.2
12-May	1644	20	20	0	0	5	10	15	45	2.8
13-May	-	6	6	0	0	3	6	3	9	2.5
14-May	-	16	12	0	0	10	20	2	6	2.2
15-May	-	5	5	0	0	4	8	1	3	2.2
16-May	-	19	11	0	0	9	18	2	6	2.2
17-May	1698	10	5	0	0	4	8	1	3	2.2
18-May	1658	14	14	0	0	0	0	14	42	3.0
19-May	1693	10	10	0	0	0	0	10	30	3.0
20-May	1697	19	19	0	0	15	30	4	12	2.2
21-May	1670	23	21	0	0	15	30	6	18	2.3
22-May	1525	8	8	0	0	7	14	1	3	2.1
23-May	1151	9	8	0	0	7	14	1	3	2.1
24-May	936	18	18	0	0	0	0	18	54	3.0
25-May	-	20	20	0	0	19	38	1	3	2.1
26-May	921	52	52	0	0	1	2	51	153	3.0
27-May	955	30	-	-	0	-	0	-	0	-
28-May	958	15	14	0	0	14	28	0	0	2.0
29-May	935	22	22	0	0	18	36	4	12	2.2
30-May	935	9	9	0	0	6	12	3	9	2.3
31-May	939	10	10	0	0	0	0	10	30	3.0
01-Jun	945	10	10	0	0	0	0	10	30	3.0
02-Jun	939	11	11	0	0	0	0	11	33	3.0
03-Jun	933	2	1	0	0	0	0	1	3	3.0
04-Jun	936	2	2	0	0	2	4	0	0	2.0
05-Jun	933	7	4	0	0	2	4	2	6	2.5
06-Jun	929	3	3	0	0	1	2	2	6	2.7
07-Jun	976	1	1	0	0	0	0	1	3	3.0

Date	OBB Flow (cfs)	Total Chn Captured	Total Chn Indexed	Smlt Index 1	(1 * #SI 1)	Smlt Index 2	(2 * #SI 2)	Smlt Index 3	(3 * #DI 3)	Sum / # Rated
08-Jun	1281	4	4	0	0	0	0	4	12	3.0
09-Jun	1275	2	1	0	0	1	2	0	0	2.0
10-Jun	1279	0	-	-	0	-	0	-	0	-
11-Jun	1300	0	-	-	0	-	0	-	0	-
12-Jun	1308	3	3	0	0	3	6	0	0	2.0
13-Jun	1292	2	-	-	0	-	0	-	0	-
14-Jun	1200	2	2	0	0	1	2	1	3	2.5
15-Jun	1077	0	-	-	0	-	0	-	0	-
16-Jun	928	0	-	-	0	-	0	-	0	-
17-Jun	848	1	1	0	0	1	2	0	0	2.0
18-Jun	850	0	-	-	0	-	0	-	0	-
19-Jun	844	0	-	-	0	-	0	-	0	-
20-Jun	829	0	-	-	0	-	0	-	0	-
21-Jun	821	1	1	0	0	1	2	0	0	2.0
22-Jun	833	0	-	-	0	-	0	-	0	-
23-Jun	811	1	1	0	0	0	0	1	3	3.0
24-Jun	825	1	-	-	0	-	0	-	0	-
25-Jun	842	0	-	-	0	-	0	-	0	-
26-Jun	852	0	-	-	0	-	0	-	0	-
27-Jun	831	1	1	0	0	0	0	1	3	3.0
28-Jun	815	0	-	-	0	-	0	-	0	-
29-Jun	776	0	-	-	0	-	0	-	0	-
30-Jun	757	1	1	0	0	0	0	1	3	3.0
01-Jul	752	1	1	0	0	0	0	1	3	3.0
		2468		234		818		547		



Appendix 23 Daily minimum, maximum and mean water temperature in Celsius and Fahrenheit at Caswell. Data collected with Onset Optic StowAway recording water temperature once per hour. Daily mean was calculated by summing daily measurements and dividing by 24. "Min Time" and "Max Time" are the time of day that the minimum and maximum temperatures first occurred. "Min Count" and "Max Count" are the number of times the same minimum or same maximum temperatures occurred each day.

	Temperature (C)			Temperature (F)			Min	Min	Max	Max
Date	Average	Min	Max	Average	Min	Max	Time	Count	Time	Count
09-Feb	13.53	13.22	13.68	56.36	55.80	56.64	10:00	2	15:00	6
10-Feb	13.87	13.37	14.62	56.97	56.08	58.32	00:00	10	17:00	1
11-Feb	14.02	13.53	14.62	57.25	56.36	58.32	07:00	3	16:00	1
12-Feb	13.25	12.91	13.68	55.85	55.25	56.64	09:00	4	00:00	2
13-Feb	12.68	12.44	12.91	54.83	54.41	55.25	04:00	8	15:00	9
14-Feb	12.82	12.76	12.91	55.09	54.97	55.25	10:00	14	00:00	10
15-Feb	12.03	11.67	12.60	53.67	53.02	54.69	23:00	1	00:00	2
16-Feb	11.76	11.21	12.29	53.18	52.19	54.13	06:00	4	15:00	6

Date	Temperature (C) Average	Temperature (C) Min	Temperature (C) Max	Temperature (F) Average	Temperature (F) Min	Temperature (F) Max	Min Time	Min Count	Max Time	Max Count
17-Feb	12.26	11.98	12.60	54.08	53.58	54.69	01:00	10	16:00	7
18-Feb	12.13	11.83	12.29	53.84	53.30	54.13	07:00	3	00:00	8
19-Feb	11.87	11.83	11.98	53.38	53.30	53.58	04:00	17	00:00	7
20-Feb	11.63	11.52	11.83	52.95	52.74	53.30	03:00	11	17:00	5
21-Feb	11.54	11.52	11.67	52.78	52.74	53.02	03:00	21	00:00	3
22-Feb	11.27	11.06	11.52	52.29	51.91	52.74	07:00	5	00:00	1
23-Feb	10.91	10.59	11.21	51.64	51.07	52.19	08:00	2	14:00	1
24-Feb	11.06	10.74	11.36	51.92	51.35	52.46	00:00	4	14:00	4
25-Feb	10.87	10.59	11.06	51.57	51.07	51.91	09:00	2	00:00	6
26-Feb	10.50	10.12	10.90	50.92	50.23	51.63	07:00	3	14:00	1
27-Feb	10.33	10.12	10.43	50.60	50.23	50.79	22:00	2	00:00	10
28-Feb	10.08	9.81	10.43	50.15	49.67	50.79	04:00	7	20:00	1
29-Feb	10.38	10.12	10.74	50.70	50.23	51.35	03:00	7	18:00	1
01-Mar	10.48	10.12	10.74	50.87	50.23	51.35	05:00	5	14:00	10
02-Mar	10.72	10.28	11.06	51.30	50.51	51.91	07:00	1	15:00	7
03-Mar	10.65	10.43	10.90	51.18	50.79	51.63	07:00	2	00:00	1
04-Mar	10.49	10.28	10.74	50.90	50.51	51.35	04:00	7	17:00	4
05-Mar	10.64	10.43	10.90	51.16	50.79	51.63	07:00	3	15:00	3
06-Mar	10.23	9.97	10.43	50.43	49.95	50.79	05:00	5	00:00	7
07-Mar	10.55	10.12	11.06	51.00	50.23	51.91	04:00	5	17:00	4
08-Mar	10.88	10.43	11.21	51.60	50.79	52.19	07:00	2	16:00	7
09-Mar	11.01	10.59	11.36	51.84	51.07	52.46	06:00	4	15:00	8
10-Mar	11.05	10.74	11.36	51.90	51.35	52.46	06:00	4	17:00	3
11-Mar	11.03	10.74	11.36	51.87	51.35	52.46	05:00	6	16:00	4
12-Mar	10.99	10.90	11.06	51.78	51.63	51.91	02:00	11	00:00	13
13-Mar	10.93	10.59	11.21	51.68	51.07	52.19	03:00	6	15:00	9
14-Mar	11.28	11.06	11.52	52.31	51.91	52.74	01:00	9	14:00	8
15-Mar	11.31	10.90	11.67	52.36	51.63	53.02	06:00	4	15:00	6
16-Mar	11.44	11.06	11.83	52.60	51.91	53.30	06:00	4	15:00	5
17-Mar	11.55	11.06	11.98	52.80	51.91	53.58	07:00	2	17:00	4
18-Mar	11.70	11.21	12.13	53.08	52.19	53.85	06:00	3	16:00	5
19-Mar	11.85	11.36	12.29	53.33	52.46	54.13	07:00	3	16:00	6
20-Mar	12.11	11.67	12.60	53.81	53.02	54.69	04:00	6	16:00	4
21-Mar	12.04	11.67	12.44	53.69	53.02	54.41	05:00	6	16:00	4
22-Mar	11.73	11.36	11.98	53.12	52.46	53.58	07:00	3	00:00	7
23-Mar	11.14	10.90	11.67	52.06	51.63	53.02	06:00	6	00:00	1
24-Mar	10.93	10.59	11.21	51.69	51.07	52.19	06:00	5	15:00	7
25-Mar	11.10	10.74	11.67	51.99	51.35	53.02	03:00	7	17:00	1
26-Mar	10.98	10.43	11.36	51.77	50.79	52.46	08:00	1	16:00	6
27-Mar	11.30	10.74	11.98	52.35	51.35	53.58	06:00	4	18:00	2
28-Mar	11.84	11.21	12.44	53.32	52.19	54.41	07:00	2	16:00	4
29-Mar	11.68	11.36	11.98	53.03	52.46	53.58	06:00	5	00:00	6
30-Mar	11.43	10.90	12.13	52.59	51.63	53.85	05:00	6	19:00	1

	Temperature (C)			Temperature (F)			Min	Min	Max	Max
Date	Average	Min	Max	Average	Min	Max	Time	Count	Time	Count
31-Mar	12.09	11.52	12.76	53.76	52.74	54.97	08:00	3	18:00	2
01-Apr	12.19	11.98	12.44	53.96	53.58	54.41	09:00	4	00:00	1
02-Apr	11.84	11.21	12.29	53.32	52.19	54.13	08:00	1	16:00	5
03-Apr	12.26	11.67	12.91	54.08	53.02	55.25	08:00	2	17:00	4
04-Apr	12.64	12.13	13.22	54.76	53.85	55.80	06:00	5	17:00	3
05-Apr	12.83	12.29	13.37	55.10	54.13	56.08	06:00	4	16:00	4
06-Apr	13.07	12.44	13.68	55.54	54.41	56.64	07:00	2	17:00	4
07-Apr	13.51	12.91	14.14	56.33	55.25	57.47	06:00	5	16:00	7
08-Apr	13.77	13.37	14.14	56.80	56.08	57.47	06:00	6	15:00	6
09-Apr	13.27	12.91	13.68	55.90	55.25	56.64	09:00	2	00:00	1
10-Apr	12.88	12.29	13.37	55.20	54.13	56.08	07:00	2	17:00	4
11-Apr	12.94	12.60	13.37	55.29	54.69	56.08	04:00	8	16:00	5
12-Apr	12.94	12.60	13.37	55.31	54.69	56.08	06:00	5	16:00	3
13-Apr	12.74	12.13	13.22	54.95	53.85	55.80	08:00	2	16:00	4
14-Apr	12.91	12.29	13.53	55.25	54.13	56.36	07:00	3	18:00	4
15-Apr	12.99	12.76	13.37	55.39	54.97	56.08	09:00	3	00:00	1
16-Apr	12.83	12.44	13.07	55.11	54.41	55.53	10:00	1	00:00	7
17-Apr	12.30	12.13	12.44	54.15	53.85	54.41	05:00	8	00:00	10
18-Apr	12.17	11.52	12.91	53.92	52.74	55.25	06:00	4	15:00	5
19-Apr	12.24	11.83	12.60	54.04	53.30	54.69	08:00	2	16:00	2
20-Apr	12.39	11.83	14.46	54.32	53.30	58.03	06:00	4	11:00	1
21-Apr	12.22	11.52	12.76	54.01	52.74	54.97	07:00	1	16:00	8
22-Apr	13.07	12.44	13.68	55.54	54.41	56.64	04:00	4	16:00	5
23-Apr	13.51	13.07	13.99	56.33	55.53	57.19	06:00	2	16:00	4
24-Apr	13.40	13.22	13.53	56.14	55.80	56.36	06:00	2	00:00	4
25-Apr	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26-Apr	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27-Apr	14.38	14.14	14.62	57.89	57.47	58.32	23:11	1	18:11	1
28-Apr	13.97	13.37	14.46	57.16	56.08	58.03	08:11	2	16:11	4
29-Apr	14.04	13.37	14.62	57.29	56.08	58.32	07:11	3	15:11	6
30-Apr	14.50	13.83	15.09	58.12	56.91	59.17	07:11	3	16:11	5
01-May	14.91	14.30	15.57	58.85	57.75	60.03	05:11	5	16:11	5
02-May	15.13	14.46	15.72	59.24	58.03	60.31	06:11	1	17:11	3
03-May	14.82	14.30	15.25	58.68	57.75	59.46	07:11	4	00:11	4
04-May	14.46	13.83	14.93	58.04	56.91	58.88	08:11	1	17:11	3
05-May	14.06	13.53	14.46	57.31	56.36	58.03	07:11	4	00:11	6
06-May	13.97	13.37	14.46	57.16	56.08	58.03	07:11	3	17:11	2
07-May	14.02	13.37	14.62	57.25	56.08	58.32	08:11	2	17:11	4
08-May	13.77	13.37	14.14	56.80	56.08	57.47	08:11	3	00:11	2
09-May	13.47	12.91	13.99	56.25	55.25	57.19	04:11	6	15:11	8
10-May	14.06	13.37	14.77	57.33	56.08	58.60	06:11	4	16:11	4
11-May	14.63	13.99	15.25	58.34	57.19	59.46	08:11	2	16:11	4
12-May	14.99	14.14	15.88	59.00	57.47	60.60	07:11	4	17:11	5

Date	Temperature (C) Average	Temperature (C) Min	Temperature (C) Max	Temperature (F) Average	Temperature (F) Min	Temperature (F) Max	Min Time	Min Count	Max Time	Max Count
13-May	15.52	14.93	16.04	59.94	58.88	60.88	06:11	5	17:11	2
14-May	15.55	15.09	15.88	60.00	59.17	60.60	07:11	2	16:11	5
15-May	14.96	14.77	15.57	58.94	58.60	60.03	09:11	8	00:11	1
16-May	14.77	14.46	15.09	58.60	58.03	59.17	09:11	1	16:11	3
17-May	14.35	13.68	14.93	57.83	56.64	58.88	23:11	1	00:11	2
18-May	13.39	13.22	13.53	56.11	55.80	56.36	04:11	6	00:11	9
19-May	13.80	13.07	14.62	56.85	55.53	58.32	05:11	2	17:11	2
20-May	14.35	13.83	14.93	57.84	56.91	58.88	05:11	4	15:11	5
21-May	14.00	13.53	14.62	57.21	56.36	58.32	07:11	5	18:11	1
22-May	13.55	13.22	13.83	56.39	55.80	56.91	06:11	5	00:11	4
23-May	14.11	13.37	15.09	57.41	56.08	59.17	03:11	6	18:11	2
24-May	14.78	13.83	15.88	58.62	56.91	60.60	06:11	3	18:11	5
25-May	15.94	15.25	16.99	60.70	59.46	62.59	02:11	6	21:11	1
26-May	16.64	15.88	17.63	61.96	60.60	63.74	05:11	2	17:11	3
27-May	16.58	16.04	17.14	61.85	60.88	62.87	07:11	1	15:11	4
28-May	15.85	15.41	16.36	60.54	59.74	61.45	08:11	2	17:11	2
29-May	15.80	15.25	16.36	60.45	59.46	61.45	04:11	3	15:11	5
30-May	16.04	15.41	16.67	60.88	59.74	62.02	05:11	3	15:11	4
31-May	16.21	15.25	16.99	61.19	59.46	62.59	07:11	1	17:11	3
01-Jun	16.99	16.04	17.79	62.58	60.88	64.03	07:11	2	18:11	5
02-Jun	17.76	16.99	18.76	63.98	62.59	65.77	03:11	5	18:11	2
03-Jun	18.24	17.79	18.92	64.84	64.03	66.07	02:11	7	19:11	3
04-Jun	18.43	17.63	19.24	65.19	63.74	66.65	07:11	1	17:11	1
05-Jun	18.76	18.11	19.41	65.77	64.61	66.94	06:11	3	15:11	4
06-Jun	18.77	18.11	19.41	65.80	64.61	66.94	08:11	1	18:11	2
07-Jun	18.81	18.11	19.57	65.87	64.61	67.24	06:11	3	22:11	1
08-Jun	18.88	18.43	19.24	66.01	65.19	66.65	07:11	1	14:11	5
09-Jun	17.94	17.31	18.76	64.31	63.16	65.77	08:11	1	00:11	1
10-Jun	17.69	17.31	18.11	63.85	63.16	64.61	07:11	5	18:11	1
11-Jun	17.42	16.83	17.95	63.37	62.30	64.32	07:11	5	00:11	2
12-Jun	17.35	16.67	17.95	63.24	62.02	64.32	08:11	4	20:11	2
13-Jun	17.15	16.67	17.79	62.88	62.02	64.03	07:11	4	00:11	1
14-Jun	17.16	16.51	17.63	62.89	61.73	63.74	09:11	1	17:11	4
15-Jun	17.10	16.51	17.63	62.78	61.73	63.74	07:11	3	20:11	1
16-Jun	17.08	16.51	17.47	62.76	61.73	63.45	06:11	3	16:11	6
17-Jun	17.00	16.51	17.47	62.60	61.73	63.45	07:11	3	18:11	2
18-Jun	17.39	16.83	17.95	63.32	62.30	64.32	07:11	2	18:11	3
19-Jun	17.41	17.14	17.63	63.35	62.87	63.74	05:11	5	13:11	7
20-Jun	17.23	16.67	17.79	63.02	62.02	64.03	08:11	2	16:11	2
21-Jun	17.23	16.83	17.63	63.02	62.30	63.74	05:11	4	17:11	5
22-Jun	17.56	16.99	18.11	63.61	62.59	64.61	08:11	3	17:11	4
23-Jun	17.90	17.31	18.59	64.22	63.16	65.48	04:11	5	17:11	4
24-Jun	17.54	16.67	17.95	63.58	62.02	64.32	23:11	1	00:11	2

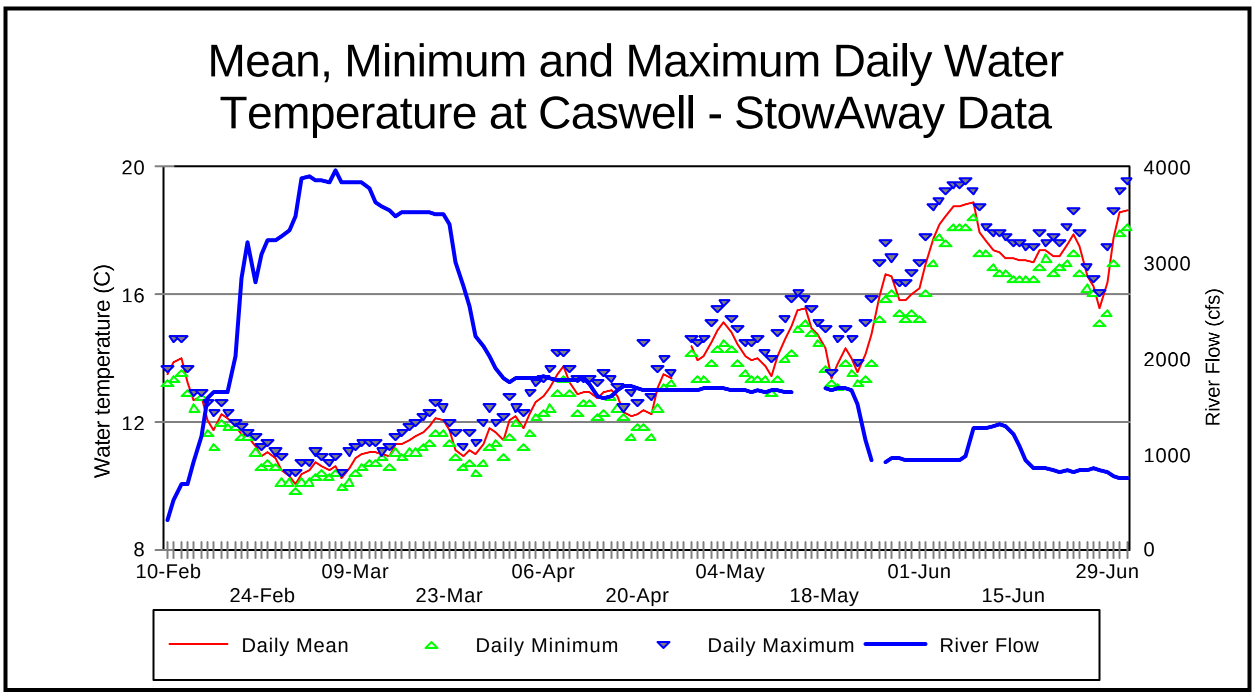
	Temperature (C)			Temperature (F)			Min	Min	Max	Max
Date	Average	Min	Max	Average	Min	Max	Time	Count	Time	Count
25-Jun	16.55	16.20	16.83	61.81	61.17	62.30	06:11	6	15:11	7
26-Jun	16.26	16.04	16.51	61.27	60.88	61.73	17:11	4	00:11	3
27-Jun	15.55	15.09	16.04	59.99	59.17	60.88	07:11	6	16:11	3
28-Jun	16.38	15.41	17.47	61.49	59.74	63.45	02:11	3	23:11	1
29-Jun	17.76	16.99	18.59	63.98	62.59	65.48	03:11	4	18:11	2
30-Jun	18.60	17.95	19.24	65.48	64.32	66.65	05:11	3	15:11	5
01-Jul	18.63	18.11	19.57	65.55	64.61	67.24	06:11	2	13:11	1

River temperature data collected at Caswell trapping station with Onset Optic StowAway recording data once per hour.

Daily average was calculated by summing the 24 separate hourly recordings and dividing by 24.

Min Time and Max Time are the time of day that the minimum and maximum temperatures first occured.

Min Count and Max Count are the number of times the same minimum or same maximum temperatures occured each day.



Appendix 24 Number and date of all recaptures at Caswell.