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Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2002-2004.

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Summary

This report presents the results from three seasons of the Feather River Chinook Salmon (*Oncorhynchus tshawytscha*) emigration survey (2002-2004). The 2004 season was the seventh year Rotary Screw Traps were fished throughout the entire emigration period (December through June).

Two rotary screw trap locations were used to assess the timing and general abundance of juvenile Chinook salmon, steelhead and other fishes emigrating the Feather River. One RST (Thermalito) was stationed at river mile (RM) 60.1, approximately one mile above the Thermalito Afterbay Outlet. The second RST (Live Oak) was stationed at river mile 46, approximately 4.3 river miles upstream of the City of Live Oak Recreation Area boat ramp.

Although Chinook salmon and steelhead were the primary targets of trapping efforts, records were kept on all fish species caught. Twenty-nine species were caught over the three seasons of trapping. Chinook salmon was the dominant species, comprising over 99% of the catch. Of the total salmon catch, 1,791,730 (62%) were caught at the Live Oak RST and 1,117,946 (38%) were caught at the Thermalito RST.

Of the salmon trapped at Thermalito and Live Oak, 93.9 and 77.3%, respectively, were less than 50 mm, demonstrating that most Feather River salmon emigrate from the spawning grounds well before smolting. Salmon ranged from 26 to 210 mm fork length. Salmon emigration was observed as soon as the traps were installed in December, typically peaked in February, and continued through June at very low levels. Separate Fall-run Chinook emigration estimates were developed for the Low Flow Channel (LFC) and High Flow Channel (HFC). Over the three years, estimates ranged from 6.6 to 13.8 million Fall-run-size Chinook in the LFC and 8.9 to 29.2 million Fall-run-size Chinook for the HFC (entire river).

In general, environmental variables such as river flow (cfs), turbidity and temperature did not influence Fall-run emigration timing or magnitude between December and April. However, during one short period of elevated turbidity in the LFC, turbidity was shown to be a significant variable influencing emigration (Thermalito RST 2004). However, the onset of spawning the previous fall probably plays a larger role in determining when juvenile salmon emigrate the Feather River. Although no stream-type life-history strategies are still evident in the Feather, alternative patterns to an ocean-type model still probably exist.

Based on adult escapement, average fecundity and the emigration estimate the egg-to-fry survival rate for Fall-run Chinook juveniles for the entire river ranged from 5.9% to 15.4%. The emigration index (per capita production) of juveniles ranged from a low of 137 in 2002 to a high of 566 in 2004.

A total of 1026 young-of-the-year steelhead were captured at the Thermalito RST during the three-year period. However, only 4 wild yearlings were collected over the same time period (>150 mm fork length). Only 46 young-of-the-year and one wild yearling steelhead were captured at Live Oak throughout the entire sampling period.

Introduction

In 1996 DWR began to monitor salmon and steelhead in support of the Federal Energy Regulatory Commission (FERC) relicensing of the State Water Project's Oroville Facilities and to address issues raised by the Central Valley Project Improvement Act's (CVPIA) Anadromous Fish Restoration Program (USFWS 1997a). To this end, DWR initiated a study to identify the timing and magnitude of emigration of naturally produced salmon relative to different physical conditions and spawning population size. Although the main focus of the study is salmon and steelhead, other fish species were also recorded.

This study is the first on the emigration of salmonids and other fish species in the Feather River since the 1970's (Painter et al. 1977). The salmon emigration study has the following objectives:

(1) Document general salmonid emigration attributes, such as timing, abundance and composition by species, race, and life stage.
(2) Investigate the influence of factors thought to initiate emigration, such as flow, turbidity, and water temperature.
(3) Develop annual indices of juvenile salmon production by relating information on spawning intensity and emigration. Use the indices to examine the effects of physical and biological factors on Feather River salmon production.

Salmon emigration is monitored primarily using rotary screw traps (RSTs). Two RST locations are used, one at the lower end of each of the two study reaches. The traps are operated for approximately seven months (December through June). Two trap locations are necessary because flow is strictly regulated above the Thermalito Outlet and therefore emigration cues and species composition may be different for the two reaches. Furthermore, two traps were used in the HFC in 2004 to increase capture of salmonids for trap efficiency trials.

The following report is a summary of salmon emigration between December 2001 and June 2004, representing three consecutive seasons of trapping efforts. Although the trapping season begins at the end of one calendar year and continues into the middle of the next (i.e. December through June), trapping years will be referenced by the spring season. For example, the 2001/2002 trapping period that progressed from December 2001 through June 2002 will be referenced as the 2002 season.

Methods

Study Area

The Fish Barrier Dam, just downstream of the Thermalito Diversion Dam, is the upper limit for upstream migrating fish. The base of the Fish Barrier Dam is where the fish ladder begins, guiding fish into the Feather River Hatchery. The hatchery was built by DWR to mitigate for the loss of Chinook salmon and steelhead spawning and rearing habitat resulting from the construction of Oroville Dam and ancillary facilities.

The lower Feather River (Figure 1) is located within the Central Valley of California, draining an extensive area of the western slope of the Sierra Nevada. Lake Oroville, created by the completion of Oroville Dam in 1967, has a capacity of approximately 3.5 million acre-feet (maf) of water and provides flood control, water supply, power generation, and recreation. Flow in the lower Feather River below the reservoir is regulated through releases from Oroville Dam, Thermalito Diversion Dam, and the Thermalito Afterbay Outlet. Under normal operations, the majority of water released from Lake Oroville is diverted at Thermalito Diversion Dam into the Power Canal and Thermalito Forebay. Water released from the Forebay is used to generate power as it is discharged into Thermalito Afterbay. Water is returned to the Feather River through the Thermalito Afterbay Outlet, and then flows southward to the confluence with the Sacramento River at Verona. This section is generally referred to as the High Flow Channel (HFC). The remainder of the flow, typically 620-650 cubic feet per second (cfs), flows through the Low Flow Channel (LFC). The reach between Oroville Dam and the confluence with the Sacramento River is generally of low gradient.

The salmonid emigration study area (Figure 2) is 21 river miles long and consists of the Low Flow Channel and the upper 13 miles of the High Flow Channel. The LFC extends from the Fish Barrier Dam at river mile 67.25 to the Thermalito Outlet (RM 59). The HFC extends from the Thermalito Outlet to the confluence with the Sacramento River. The Yuba River (RM 27.5) is 16.5 river miles further downstream from Honcut Creek. The study is focused on the upper 21 river miles (RM 46 to 67) of the lower river because it is (1) the portion of the river where most Chinook salmon and steelhead spawn and initially rear, making them more affected by project operations and, (2) sampling in this reach provides the greatest opportunity to enumerate emigrating salmon and steelhead fry. River miles 0 to 42 are comprised mostly of flat-water habitat and fine substrates generally unsuitable for salmonid spawning.

Field Collection Methods

Eight-foot rotary screw traps (RSTs) are the main sampling devices used for the emigration survey. RSTs are sturdy, relatively easy to move within the stream, easy to operate and maintain, are able to capture fish without harm in fast-moving water, and can be used to sample continuously. A RST operates in the following manner to capture fish: with the trapping cone lowered into flowing water, water strikes the baffles on the inside of the trapping

cone, causing the cone to rotate. Fish enter the upstream end of the rotating trapping cone, become trapped inside the trapping cone, and are carried rearward into a live box.

One RST was placed at RM 60.1 to provide a sampling point near the end of the LFC. One RST was also placed in the HFC between the Cities of Live Oak and Gridley (RM 46, Figure 2). Two trap locations are needed because operation of the Oroville Complex results in two substantially different flow regimes: flow in the Low Flow Channel is strictly regulated (generally about 600-650 cfs), while the High Flow Channel is subject to flow fluctuations from 1050 to 40,000+ cfs during emigration. Therefore, emigration cues and species composition may differ between the two reaches. The RST sites were selected based on the following criteria for RST installation, operation, and maintenance: (1) depth greater than six feet at minimum flow; (2) velocity greater than two feet per second at minimum flow; (3) suitable anchoring point(s); (4) limited public access; and (5) general ability to capture juvenile salmonids. An additional trap was placed at the HFC location in 2004 to provide increased capture of Fall-run Chinook for trap efficiency evaluations.

The RSTs were fished continuously for approximately seven months (December through June), except for short periods when river conditions became unsafe or when heavy debris loads occurred due to high river flows. When serviced, trapped fish were removed from the live box, identified to species and counted. All fish were counted by hand if numbers permitted. When juvenile salmon were highly abundant, a simple volume displacement method was used to count them in increments of 1000. Fork length (to the nearest millimeter) was measured for up to 50 individuals of each salmonid species. Up to 25 non-salmonids were also measured and counted during processing. All fish were then released back to the river, except for salmon retained for coded-wire tagging and trap efficiency evaluations.

All Chinook salmon individuals were assigned to a race based on the length/date criterion set forth in the Sacramento River Daily Length Table (Greene 1992). All live salmon and steelhead that were measured were also inspected for characters such as presence of parr marks, silvery appearance, and deciduous scales to determine life stage. A simple designation was used for each salmon measured:

(1) yolk sac fry/parr: yolk sac is clearly visible.
(2) fry: may have parr marks but yolk sac is not fully absorbed
(3) parr: clearly parr, a darkly pigmented fish with characteristic dark, oval-to round-shaped parr marks on its sides and yolk sac is fully absorbed.
(4) intermediate: between parr and smolt. Usually has fading parr marks and some scale loss.
(5) smolt: highly faded or completely lacking parr marks, bright silver or nearly white color and heavy scale loss.

A salmon tagging station was set up at the Thermalito Afterbay Outlet to coded-wire tag (CWT) in-channel produced juvenile salmon. Juvenile salmon captured in the RSTs

were transported to the tagging station and implanted with a CWT half-tag (Northwest Marine Technology, Inc., Washington) by a contractor, Big Eagle and Associates. The tagged salmon were held overnight while a sub-sample was checked for tag shedding and survival. Tagged salmon were released immediately downstream of the Live Oak RST.

Other measurements collected daily at each RST included: water clarity (turbidity, measured in NTUs), water temperature, sample period, average trapping cone revolutions per minute, and the total number of trapping cone revolutions during the sample period. Additionally, overall trap performance was evaluated by determining whether the trap was fishing was good, fair or poor during the trapping period. Simply put, a "good" code meant the trap was fishing normally; a "fair" code was assigned when the trap was spinning very slowly or was partially blocked with debris and "poor" code was assigned when the trap was not spinning or operating properly. Daily mean river flow (cfs) for the Thermalito trap was obtained by adding the Thermalito Diversion Dam flow (CA Department of Water Resources gauge AO 5191) to the Feather River Fish Hatchery Outflow (CA Department of Water Resources gauge AO 5990). River flow for the Live Oak trap was obtained by adding the Thermalito trap flow to the Feather River Outlet-Thermalito Afterbay flow (CA Department of Water Resources gauge AO 5975).

Trap Efficiency and Emigration Estimate

Trap efficiency was evaluated using fish collected in the RSTs. Eighty-eight evaluations (over the three year period) were conducted using salmon captured in their respective traps (i.e. salmon trapped at Live Oak were generally used for Live Oak trap efficiency evaluations). Evaluations were performed between mid-December and mid-March, the period when nearly all emigration occurred. For each evaluation, approximately 1000 marked fish were transported roughly two kilometers upstream of each RST. Fish were released in equal proportions along the river margin (i.e. if 1000 fish were tagged, approximately 500 were released on river right and 500 on river left). Because holding trials revealed insignificant losses of fish held for 24 hours after marking, fish were generally released within an hour of marking. However, when elastomer tags were applied in addition to Bismarck Brown, fish were generally held for 24 hours prior to release. Furthermore, previous diel sampling (DWR 2002) revealed that nearly all salmon were captured at night and therefore time of release was unlikely to influence recapture rates. Only healthy fish (based on visual observations) were released and time of release was recorded (i.e. time of day). Although most recaptures occurred within the first day of release, catch was monitored for recaptures for at least seven days based on previous observations that nearly all recaptures occurred in that time-period. However, because the traps were searched daily for marked fish, individuals could be recovered several weeks after release. Mortality between the release point and the trap was assumed to be negligible.

All salmon were marked with Bismarck Brown (Spectrum Chemical, Gardena, California) dye at a concentration of 2.8 grams to 115 L of water for 30 minutes. Most released fish were also tagged with colored latex elastomer in the nose (Northwest Marine Technology, Shaw Island, Washington). The secondary tag served two purposes; (1) it allowed multiple release groups to be identified separately, and (2) it provided long-term identification of marked individuals (tags often lasted several months).

Trap efficiency was defined as the proportion of the total number of emigrants that were captured as they moved past the trap. The approximate estimate of trap efficiency (*TE*) for each sampling period is similar to that given by Roper and Scarnecchia (2000):

$$TE = \frac{\sum_{i=1}^{n} R_{ji}}{M_j}$$

Where R_{ji} is the number of recaptured fish from the j^{th} release group on the i^{th} day, and M_j is the number of marked fish released. This estimate of efficiency assumes that (1) all released fish continue downstream after release, (2) handling does not affect fish behavior, (3) mortality rates are zero, and (4) marked fish mix randomly with unmarked fish.

Efficiency values were only applied to data for their respective year and location. Although efficiency tests were performed separately (usually 2x/week), two adjoining trials were averaged to calculate daily trap efficiency and daily emigration past each trap for the respective time-period. This was done to avoid bias associated with few recaptures (less than 7; Roper and Scarnecchia, 1999) and to moderate against an unusually high or low value. For weeks between 1 December and 15 April without efficiency tests, the average efficiency value for the year was used to calculate daily passage. Efficiency values were only applied to RST catch between 1 December and 15 April. For periods when the trap was set for less than seven consecutive days, daily catch for the un-sampled period (*DCU*) was estimated by the following formula, where CS1 = total catch in the sample days before the un-sampled period; CS2 = the total catch after the un-sampled period; D_1 = the number of days in sample period one and D_2 = the number of days in sample period two.

$$DCU = \frac{\sum(C_{S1}) + \sum(C_{S2})}{D_1 + D_2}$$

Daily passage estimates (DPE) were not made for periods when the trap was set for less than seven consecutive days, so as to avoid making unreasonable inferences about longer un-sampled periods (Roper and Scarnecchia, 2000). Daily passage estimates and 95% confidence intervals were calculated by Chapman's (1951) expression:

$$DPE = [(Mj+1)(Cj+1)/(Rj+1)] - 1$$

Whereby *Mj* is the number of marked salmon released for the trap efficiency during time period j, Cj is the number of unmarked salmon captured in the trap during the time period j and Rj is the total number of recaptures during period j. Daily confidence intervals (95%) for the period are calculated as

$$C.I. = DPE + Z_{\alpha(2)}[(VarDPE)]^{1/2}$$

where

$$Var(DPE) = DPE^2(Cj - Rj)/[(Cj+1)(Rj+2)]$$

The annual emigration estimate (EE) is the sum of Daily Passage Estimates plus the sum of raw daily catch (DC) for periods without DPEs.

$$EE = \sum_{d=dec.1}^{Apr.15}(DPE) + \sum_{d=Apr.15}^{July1}(DC)$$

The resulting emigration estimate is inherently low for two reasons. First, it uses only raw catch before December 1 and after 15 April and in periods when the trap is fished for less than seven consecutive days. Second, and more importantly, the trap is not always fished during high flows (> 15,000 cfs) and heavy debris loads.

The emigration estimate for the river can then be used to calculate an emigration index (EI) using the spawning escapement estimate from the previous fall. The emigration

index is a per-capita production estimate that may be used to compare production from year to year. The index is calculated by dividing the emigration estimate (EE) for the river by the estimated number of adult/grilse females (F) determined by the fall escapement survey.

$$EI = \frac{EE}{F}$$

Juvenile salmon survival rate (SR) for the Low Flow Channel is computed as follows

$$SR = \frac{EE}{SF \times 5522}$$

Where SF is the number of successfully spawned females in the Low Flow Channel, 5522 is the expected average fecundity of Feather River Chinook salmon females (personal communication with Armando Quinones, California Department of Fish and Game) and EE is the total juvenile Fall-run salmon emigration estimate for the Low Flow Channel.

Due to unequal sampling effort among years, trapping effort (in hours per month) and number of salmon captured per hour (CPH) is reported for each year. Effort calculations were only performed for days when trapping performance was good or fair. The effects of river flow, temperature and turbidity on emigration timing were examined with simple linear regression. In general, each variable (e.g. river flow) was reduced to a weekly average and plotted against the corresponding passage estimate for the respective week. However, unusual periods of elevated turbidity and flow were also analyzed to investigate the relationship that either may play in stimulating passage.

Results

RST Catch and Species Composition

Twenty-nine species were caught during the three survey years, 13 native and 16 non-native (Table 1). This is similar to the number of species caught in the three previous years of trapping (DWR 2002). Chinook salmon was the dominant species, comprising over 99% of the total catch for all three years combined. Of the total catch, 1,121,978 (39%) were caught at the Thermalito RST and 1,786,833 (61%) were caught at the Live Oak RST (Table 2 and 3).

The large numbers of salmon resulted in a high proportion of native fish (99.7%) in the total catch. Although Chinook Salmon were by far the dominant species, non-natives were prevalent; 54.8% of all non-salmonids were non-native (Table 1). Although the proportion of native fish did not differ between the two traps (99.9% of the fish captured at Thermalito were native species, while 99.7% of the fish captured at Live Oak were native), during high flow events more non-natives are captured at the Live Oak RST.

Salmon Emigration

Salmon were caught in both RSTs as soon as they were deployed. Monthly salmon catch at each RST is reported in Tables 2 and 3. The highest daily catch at Thermalito was 59,415 on 19 February 2004. The highest daily catch at Live Oak was 65,667 on 18 February 2004. Catch was always highest in January, February and March of each year. January, February and March averaged 97.3% and 92.0% of the total Chinook catch at Live Oak and Thermalito, respectively. Salmon catch declined rapidly at both traps starting in April each year (Figures 3-8; Tables 2-3). The Thermalito trap averaged 0.02 % of the total catch for the months of April, May and June combined for all three years while the Live Oak trap averaged 0.28% of the total catch for the same time period.

Salmon size ranged from 26 to 104 mm FL at Thermalito and 28 to 210 mm at Live Oak. Weekly mean fork length ranged from 31 to 86 mm at Thermalito and 32 to 82 mm at Live Oak. Mean fork length at each RST changed little until late April, then steadily increased until the end of trapping (Figures 10 and 11).

Trap Efficiency and Emigration Estimates

Eighty-eight efficiency evaluations were conducted during the three-year study period (Tables 4 and 5). Recapture rates in the Thermalito RST ranged from 0.6% to 13.5% and averaged 3.63% ($\pm$ 2.43 SD) over the three-year period. The Live Oak RST efficiency ranged from 0% to 14.3% and averaged 4.02% ($\pm$ 2.92 SD) over the same

three-year period. Emigration estimates for Fall-run size fish from 2002-2004 are presented in Tables 2 and 3.

Emigration index values increased over the three year period, however, survival rates fluctuated (Table 6). From Table 6, we can conclude that for every adult female salmon that spawned in the river in fall 2001, 137 juvenile Chinook salmon passed the RST at Thermalito in the winter and spring of 2002. This corresponds to a survival of 6.3% from the time of egg deposition to capture at the Thermalito trap (2002 only).

Coded-wire Tagging of Naturally Spawned Salmon

A summary of DWR tagging efforts of naturally produced Fall-run Chinook salmon is presented in Table 8. To this point, low return rates of naturally produced Chinook have precluded formal analysis of the data. A recent increase in tagging effort should provide greater returns allowing us to evaluate the return success of naturally produced fish compared to hatchery stock.

Spring-run-Size Chinook

Figure 12 illustrates that the majority of Spring-run-sized fish caught at the traps are small. They are nearly identical in size to the Fall-run emigrating at the same time, clearly illustrating the uncertainties of using the Daily Length Table alone as an indicator of race.

Figure 12 also illustrates the emigration patterns and catch distribution for Spring-run-sized fish. In all three years, the highest catch was in December. Spring-run were caught at both traps throughout most of the sampling period, with a steady decline from December to March—a typical Fall-run or Ocean-type emigration pattern. After rearing in the river to a larger size, a very small group of Spring-run-sized fish passed Live Oak in April.

Late-fall-Size Chinook

Very few Late-fall-run Chinook were present in the Feather River. Immediately after emergence, Late-fall Chinook were captured at both RSTs (Figure 13). Catch at both traps peaked between March and May, then quickly dropped. The highest number of Late-fall-run Chinook were caught at Live Oak in April 2002 (Table 3.). Sixty-percent of all the Late-fall-run Chinook were caught at Thermalito and nearly all were captured as fry (Tables 2 and 3 and Figure 13).

Steelhead

Over the three years, a total of 1464 steelhead were caught at both locations. Of those, 1071 were naturally produced (wild) YOY steelhead (<150 mm) captured at Thermalito and Live Oak (Figure 14; Tables 2 and 3). Only five wild yearlings have been captured during the past three trapping seasons. One adult wild steelhead (>250 mm) was caught on 6 January 2004 at the Live Oak RST.

Steelhead catch predominantly occurs in March and April at both locations, with much smaller catch in May and June (Figure 15). Average fork length was 26.3 mm (± 7.9 SD) at Thermalito and 24.5 mm (± 7.2 SD) at Live Oak (Figure 16). Steelhead catch has decreased every year since 2002 at Thermalito (Table 1). Nearly 96% of all wild steelhead trapped were caught at the Thermalito RST (Figure 14 and Table 1).

Influence of Flow, Temperature and Turbidity on Emigration

Except for two brief events in 2004, LFC flows were approximately 600 cfs year round (Figure 3). High Flow Channel flows ranged from a low of 1047 cfs in March 2003 to a high of 19,000 cfs in February 2004 (Figure 4). There is no evidence of a connection between flow and Chinook catch at Thermalito or Live Oak (Table 7). Fry passage at Thermalito varies considerably through time, while flows remain nearly constant. Furthermore, although flows fluctuate at Live Oak, salmon catch rarely responds accordingly (Figure 4).

Water was normally clearer in the Low Flow Channel than in the High Flow Channel (Figures 7 and 8). No general relationship between turbidity and passage was observed for the HFC or LFC. However, a strong and significant relationship was observed for one elevated turbidity event in the LFC in 2004 (r^2=.554, P<0.05, Table 7).

Although temperature was often statistically significant for predicting passage, it was not deemed to be biologically significant in influencing winter or early spring emigration because the average daily temperature at both traps never exceeded 14.0° C (57.2° F) until 90% of the population had already emigrated (Figures 5 and 6). Average daily water temperature ranged from 6.1 to 19.5 °C (43 to 67 °F) at the Thermalito RST and 7 to 24 °C (44.6 to 75 °F) at the Live Oak RST (Figures 5 and 6). Water temperature was low during winter, then steadily increased from March until the end of the sampling period at both locations.

Effort

Effort was generally consistent at Thermalito in all months except June 2003 (Table 9). Effort also doubled at Live Oak in 2004 with the addition of the second RST. Catch

rates were generally greatest in January and February, although in March 2002 and 2004, Live Oak catch rates exceeded 168 salmon per hour (Table 9). Low effort in 2003 at Live Oak (419 hours in February) likely caused an underestimate of the number of salmon emigrating through the High Flow Channel (Table 9).

Discussion

Salmon Emigration: Trap Efficiency, Estimates and Timing

The accuracy of the emigration estimate is affected by several factors, the most important being trap efficiency. Searching for marked fish among thousands can be problematic. However, Bismarck Brown has consistently proven to be a safe, easy, and reliable method of mass marking individuals. Marked fish can be easily identified as many as five days after marking. Furthermore, salmon were often given an additional elastomer mark, making positive identification reliable for several weeks. Additionally, over 90% of the recaptures occurred within the first two days of release, the time when positive identification of marked fish is greatest.

Another factor affecting the emigration estimate at Live Oak is the lack of trapping during sustained high flow conditions. For example, six days of trapping were missed in February of 2004 at Live Oak near the probable peak of emigration. There is no reliable method to estimate passage during such long periods when the trap is not fishing. Roper and Scarnecchia (1999) used regression analysis of flow and catch to predict passage when traps could not be fished, but only for shorter periods of time (a few days). However, this requires a reliable relationship between flow and passage that has been problematic to develop on the Feather River. Furthermore, this method is only acceptable for short periods of trap inactivity. We investigated the relationship between river flow and trap efficiency in 2004 at both Thermalito and Live Oak and found no significant relationship ($P>0.9$ and $P>0.6$, respectively). In previous years, the relationship between the onset of adult spawning the previous fall and the onset of emigration has proved more valuable for predicting passage at the traps (DWR, 2002). Future work will continue to focus on all variables thought to predict passage when the traps are not fishing. Continuous efforts are in place to measure trap efficiency under varying flow conditions, release locations and turbidity levels in both the LFC and HFC. Although sustained high flows can be problematic for sampling with RSTs, the Feather River RSTs sample the majority of available days with trap efficiencies regularly performed throughout the emigration period.

The emigration pattern of Fall-run Chinook was similar in all three years at Thermalito. At Live Oak, however, a noteworthy change in the timing and magnitude of passage was observed in 2003. On average (dating back to 1999), 13 million more Fall-run Chinook pass the Live Oak location than Thermalito. In 2003, only 1.5 million more Fall-run passed Live Oak. The magnitude of the variation changes from year to year, but the unusually small passage difference observed in 2003 was alarming. A brief analysis of the 2002 adult escapement data for the LFC and HFC provided no clues as to the cause of the decline in passage. Because emigration estimates rely so heavily on trap efficiency trials, we investigated the likelihood of a problem with trap efficiencies performed at both locations. No obvious problems were found. We then investigated the likelihood of a large predation problem occurring between the Live Oak and

Thermalito traps. In the fall of 2002, hatchery releases of steelhead smolts into the Feather River at Live Oak and Gridley totaled over 500,000. Observations of these fish by Feather River Program staff and anglers indicated that many were residualizing in both the LFC and HFC. Subsequent angling surveys conducted in the LFC in February revealed numerous salmon fry in the stomachs of steelhead smolts. One-hundred and one smolts were analyzed for stomach contents. The analysis revealed that each steelhead smolt had, on average, 1.38 (± 3.98 SD) salmon fry in its stomach. This was likely the large predation problem that was most responsible for the unexpectedly low passage estimate at Live Oak. If only 10% of the smolts stayed and consumed only two Chinook fry per day they would consume 6,000,000 fry in just 60 days. Observations of these smolts continued into spring, indicating a rearing period potentially longer than 60 days. Rates of consumption would likely be even greater for the HFC (the release locations are both in the HFC) but increased flows in February prevented the collection of specimens for stomach analysis. It is possible that the increase in flow and turbidity in the HFC allowed many salmon fry to escape predation. However, it is likely that millions of fry were consumed during the winter and spring emigration period. The results of this limited predation study reveals the potential significance of releasing predator sized hatchery fish into the wild. Future studies should focus on the emigration strategies employed by hatchery reared steelhead so potential conflicts can be minimized.

Emigration Variables and Timing

This study confirmed all previous survey results (DWR 1999a, DWR 2002) that the bulk of the emigrating salmon are pre-smolt. The percentage of salmon that was clearly smolt or intermediate between parr and smolt was less than 2% at Thermalito and 15% at Live Oak. Most were smaller than 50 mm fork length (97% at Thermalito and 81% at Live Oak). The high percentages of pre-smolt fish and fish smaller than 50 mm indicate that most salmon smolt downstream of Live Oak.

In all years, 97% or more juvenile salmon had already passed the Live Oak screw trap by 1 April, probably ruling out temperature as a major driving force for the winter emigration pattern often observed. Environmental variables such as flow and turbidity (when muted or stabilized) appear to have a very small role in salmon emigration in the Feather River. However, the ability to monitor changes in turbidity and catch at both traps has been difficult. In the HFC, large increases in turbidity are usually accompanied by large increases in flow, preventing the traps from fishing continuously.

It is typical for LFC water clarity to remain high because flows are usually constant and low. However, in mid February 2004 the LFC experienced an unusually high turbidity event in the absence of a large flow increase (Figures 3 and 7). Initial analysis of the data (using weekly averages) revealed no significant relationship between turbidity and passage. However, isolating this single turbidity and corresponding passage event revealed a significant positive relationship between salmon passage and turbidity

(Figure 9, Figure 15 and Table 7). This demonstrates that when turbidity is elevated and large numbers of parr are present, salmon probably emigrate at a greater rate, probably moving both during the day and night. For example, 31% percent of the LFC emigrant population passed during these two weeks. Approximately 12% of the entire LFC emigrant population passed the Thermalito trap in one 24-hour period during this two week event. Furthermore, more than 50% of the salmon passed the Thermalito trap in February, the month when turbidity is generally elevated (although not statistically significant). It is unknown, however, if the large number of passing fry in the month of February was caused by subtle changes in turbidity or simply because the fry had recently emerged from the gravel. It is likely that increased turbidity will stimulate emigration but, Chinook fry and parr still emigrate the Feather River in the absence of strong environmental cues. A combination of increased flows and highly elevated turbidity probably allows fry and parr the greatest opportunity for survival as they emigrate the Feather River. However, if flow pulses cannot be generated, increasing turbidity alone could still provide greatly increased survival for salmon smolts and fry.

Although it appears that flow, turbidity and temperature have little effect on emigration, it is possible that the altered flow regime on the Feather River mutes these historical emigration signals. Snider and Titus (1995) found that the timing of both fry and fingerling emigration was substantially different from that before construction of Folsom Dam on the American River. Additionally, measuring emigration during larger flow events (>15,000 cfs) is nearly impossible due to high debris loads. This creates bias toward more easily measured variables. It is also possible that warmer water on the valley floor (as compared to historical spawning grounds at higher elevations) causes fry to develop and emerge sooner than the river is capable of supporting them. The result is immediate and massive emigration due to a lack of food base in the winter/early spring. Historically, salmon may have emerged a month later and exploited the spring and summer food web. Perhaps salmon emigrate soon after emergence because competition for food in the LFC is so great that fry must disperse downstream to find adequate rearing habitat. Unwin (1986) found that the initial mass migration of Chinook fry in Glenariffe stream, New Zealand, was most likely a result of competition for rearing habitat. Healey (1991) reported that a large downstream movement of Chinook fry immediately after emergence is typical of most populations. He further reports that “the downstream migration of stream- and ocean-type Chinook fry, when spawning grounds are well upstream, is probably a dispersal mechanism that helps distribute fry among the suitable rearing habitats.” Salmon might also emigrate early to avoid high temperatures on the Sacramento Valley floor in the spring and summer. Unfortunately, the history of emigration in the Feather River is poorly known. Even the extensive sampling performed by Painter et al. (1977) between 1968 and 1973 provides little insight into the reasons for early emigration of fry.

The end of emigration in all three years was similar to previous years (DWR 1999a and DWR 2002). Painter and others (1977) found that, in 1968 through 1975, emigration could occur at least through the end of June in some years. Warner (1955) found that emigration ended around 1 June (in 1955). Snorkel surveys (DWR, unpublished data)

and the rapid increase in fork-length at both traps between 23 March and the end of trapping implies that some Chinook use the upper river as a nursery area in the spring. Changing photoperiod and temperature together might create a migration cue for these fish. Roper and Scarnecchia (1999) found that photoperiod, or a correlated variable, was a migratory cue in the South Umpqua River, Oregon. However, the emigration peak in the South Umpqua is in summer, when long days might provide a strong cue. Furthermore, fish remaining in the river for several months grow larger and may have an advantage during emigration. They may be more adept at avoiding predators and finding food and be more physically prepared to smolt. However, fish emigrating in late spring may encounter much warmer conditions. Flain (in Unwin, 1986) reported that Chinook juveniles that reared in fresh water for several months to a year comprised 76% of the adult angler catch in the Rakaia River, although they comprised only 5% of the juvenile population. It is possible that a similar pattern of prolonged stream residence is successful on the Feather River and other Central Valley streams. Salmon rearing into the spring and summer could emigrate in the fall when temperatures are more suitable for passing the lower river and estuary. It is unknown if these late emigrants contribute substantially to the adult population. Current and future work focusing on otolith microstructure of Feather River Chinook will hopefully provide answers to questions circulating about various rearing strategies.

Spring-run Size Chinook

Although catch numbers were modest, the 2003 trapping season provided the highest catch of Spring-run size fish at both trapping locations (Table 2 and 3). During the last three trapping seasons emigration timing was similar to all previous years (DWR 2002). Spring-run size salmon were caught as soon as the RSTs were deployed (December), indicating that emigration began immediately after emergence.

The size difference between supposed Fall and Spring-run emigrants was typically only a few millimeters, demonstrating the difficulty of using the Daily Length Table alone as an indicator of race (Greene, 1992). As previously mentioned, most Spring-run sized salmon were small upon capture. Although probability of catch decreases as fish get larger, there is no reason to expect that great numbers of larger (>75 mm) Spring-run sized salmon were actively avoiding the traps at either location. Throughout spring, many Fall-run salmon are captured in the 60-100 mm range. This data, along with previous RST sampling, snorkel surveys and electrofishing implies that a true stream-type life-history no longer exists for Spring-run in the Feather River (assuming it ever existed). This would suggest an ocean-type life-history pattern typical of Fall-run Chinook in the Feather River and many other central valley rivers. While some larger fish of presumably all races (Fall, Spring and Late-fall) do persist throughout the summer (DWR unpublished data), there is no data to support the

current existence of a true stream-type life-history for any race of salmon in the Feather River. Variations to the ocean-type life-history probably still exist in the Feather, however distinct populations that use these strategies exclusively are not apparent. Due to very low catch and the uncertainty of race designations, no estimate was generated for the population of “Spring-run” or Late-fall Chinook juveniles in the Feather River.

Late-fall-Size Chinook

Late-fall Chinook abundance and emigration timing was nearly identical to previous years. Catches at both Live Oak and Thermalito suggest little production of Late-fall-size Chinook in the Feather River. Most Late-fall-size Chinook appear to emigrate soon after emergence. Essentially all Late-fall-size salmon that were captured passed the traps within a month of emergence. This implies an emigration pattern similar to Fall-run-size fish. However, dive surveys (DWR, unpublished data) indicate that many Late-fall-size Chinook rear in the Feather River well into the summer. The recent capture of smolt size (>150 mm) Late-fall-run further supports the potential for an alternative life history strategy. Patterns of occurrence of Late-fall-size fish are subject to the same caution as for Spring-run-size fish. Their identification is based on the Daily Length Table, which provides little separation from Fall-run-size fish. However, the observations of adults spawning as late as March and the capture of smolt sized fish indicate that a true Late-fall-run may still exist. The small number of Late-fall juveniles captured and emigration pattern variability prohibit any firm conclusions about the status of this run.

Steelhead

Steelhead catch has declined every year since 2002 at both locations. The capture of wild juveniles at the Thermalito trap indicates a modest number of steelhead continue to spawn in the LFC.

Very few yearling steelhead were caught during this study. This is probably attributable to three factors: 1) the scarcity of adults; 2) the ability of the larger fish to avoid capture; and 3) their lack of movement. Unlike most emigrating salmon, few juvenile steelhead appear to emigrate the Feather River when they are susceptible to capture (immediately after emergence). Emigration typically peaks in March and continues through April in most years. Most steelhead probably set up a “home-range” and rear until they reach or surpass a size at which capture by screw trap is unlikely. Dive surveys confirm that even 60 mm salmon and steelhead can avoid the RSTs under some conditions of location and water velocity, making it difficult to gather information on steelhead emigration patterns (DWR, unpublished data).

These observations further support the need for other methods (mark-recapture and diver surveys) to understand the basic life history of fry, juvenile and adult steelhead in the Feather River.

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References

Chapman, D.G. 1951. Some properties of the hypergeometric distribution with applications to zoological census. University of California Publications in Statistics 1:131-160.

[DWR] California Department of Water Resources. 1999a. Feather River Study, Chinook Salmon Emigration Survey, March through June 1996. Sacramento (CA): California Department of Water Resources. 24 p.

[DWR] California Department of Water Resources. 2002. River Flow Effects on Emigrating Juvenile Salmonids in the Lower Feather River, SP F-10 Task 4A. Sacramento (CA): California Department of Water Resources. 41 p.

Greene, S. 1992. Daily fork-length table from data by Frank Fisher, California Department of Fish and Game. California Department of Water Resources, Environmental Services Department, Sacramento.

Healey, M.C. 1991. Life History of Chinook Salmon (Oncorhynchus tshawytscha). Pages 311-393 in C Groot and Margolis, editors. Pacific Salmon Life Histories. UBC Press, Vancouver, B.C.

Painter R.E., L.H. Wixom, and S.N. Taylor. 1977. An Evaluation of Fish Populations and Fisheries in the Post-Oroville Project Feather River. Department of Fish and Game, Anadromous Fisheries Branch. Report submitted to the Department of Water Resources in accordance with Federal Power Commission License No. 2100. Interagency Agreement No. 456705. Sacramento (CA): California Department of Fish and Game. 56 p.

Roper, B.B. and D.L. Scarnecchia. 1999. Emigration of age-0 chinook salmon (Oncorhynchus tshawytscha) smolts from the upper South Umpqua River basin, Oregon, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences. 56: 939-46.

Roper B.B. and D.L. Scarnecchia. 2000. Key Strategies for Estimating Population Sizes of Emigrating Salmon Smolts with a Single Trap. Rivers 7(2):77-88.

Snider, B., and R.G. Titus. 1995. Lower American River Emigration Survey. November 1993-July 1994. California Department of Fish and Game, Environmental Services Division. Unpublished report. 28 p.

Unwin, M.J. 1986. Stream residence time, size characteristics, and migration patterns of juvenile chinook salmon (*Oncorhynchus tshawytscha*) from a tributary of the Rakaia River, New Zealand. New Zealand Journal of Marine and Freshwater Research. 20:231-252.

[USFWS] US Fish and Wildlife Service. 1997a. Revised Draft Restoration Plan for the Anadromous Fish Restoration Program. Revised Draft, May 30, 1997. Sacramento (CA): US Fish and Wildlife Service. 112 p.

Warner, G,H. 1955. Studies on the downstream migration of young salmon in the Feather River. California Department of Fish and Game. Unpublished report. 15 p.

Table 1. Summary of non-Chinook fishes caught at both screw trap locations all three years.

			Thermalito			Live Oak			
Common Name	Scientific Name	Origin*	2002	2003	2004	2002	2003	2004	**Total**
American Shad	*Alosa sapidissima*	I	0	0	0	1	0	2	**3**
Bluegill	*Lepomis macrochirus*	I	0	0	1	15	11	20	**47**
Black Bullhead	*Ameiurus melas*	I	1	0	0	0	1	0	**2**
Black Crappie	*Pomoxis nigromaculatus*	I	0	0	1	0	0	2	**3**
Channel Catfish	*Ictalurus punctatus*	I	0	0	1	0	1	1	**3**
Brown Bullhead	*Ameiurus nebulosus*	I	0	0	0	1	0	0	**1**
Common Carp	*Cyprinus carpio*	I	1	0	0	1	0	0	**2**
Golden Shiner	*Notemigonus crysoleucas*	I	1	1	3	2	7	10	**24**
Green Sunfish	*Lepomis cyanellus*	I	0	0	0	0	3	10	**13**
Hard Head	*Mylopharadon conocephalus*	N	2	9	4	43	198	31	**287**
Hitch	*Lavinia exilicauda*	N	1	0	2	0	0	0	**3**
Largemouth Bass	*Micropterus salmoides*	I	8	3	9	36	28	3	**87**
Pacific Lamprey	*Lampetra tridentata*	N	493	112	2103	163	122	140	**3133**
Prickly Sculpin	*Cottus asper*	N	66	27	27	0	32	8	**160**
Steelhead (Clipped)	*Oncorhynchus mykiss mykiss*	N	2	11	0	334	35	6	**388**
Steelhead (Wild)	*Oncorhynchus mykiss mykiss*	N	470	378	182	18	10	18	**1076**
Redear Sunfish	*Lepomis microlophus*	I	0	0	0	6	3	7	**16**
Riffle Sculpin	*Cottus gulosus*	N	4	1	22	0	0	1	**28**
River Lamprey	*Lampetra ayresi*	N	10	25	39	111	301	485	**971**
Sacramento Pikeminnow	*Ptychocheilus grandis*	N	15	14	22	93	101	86	**331**
Sacramento Splittail	*Pogonichthys macrolepidotus*	N	0	0	0	0	0	1	**1**
Sacramento Sucker	*Catostomus occidentalis*	N	13	9	20	18	139	30	**229**
Smallmouth Bass	*Micropterus dolomieu*	I	0	0	0	6	0	3	**9**
Speckled Dace	*Rhinichthys osculus*	N	0	0	2	8	12	7	**29**
Tule perch	*Hysterocarpus traski*	N	0	7	5	222	21	25	**280**
Wakasagi	*Hypomesus nipponensis*	I	144	124	565	1587	1226	3367	**7013**
Warmouth	*Lepomis gulosus*	I	0	0	1	17	0	26	**44**
Western Mosquitofish	*Gambusia affinis*	I	28	7	8	28	8	8	**87**
White Crappie	*Pomoxis annularis*	I	0	0	1	0	0	9	**10**
Unidentified Bass	*Micropterus sp.*	I	22	0	1	11	0	2	**36**
Unidentified Lamprey	*Lampetra sp.*	N	103	71	208	134	349	501	**1366**
Unidentified Minnow	Cyprinidae	N	2	1	0	26	0	0	**29**
Unidentified Sculpin	*Cottus sp.*	I	260	55	0	123	49	74	**561**
Unidentified Sunfish	*Lepomis sp.*	I	0	0	0	0	1	3	**4**
Total			**1646**	**855**	**3227**	**3004**	**2658**	**4886**	

* N = Native, I = Introduced

Table 2. Monthly catch for three race of Chinook salmon caught from 2001-2004 at Thermalito. Monthly estimates were included for fall Chinook only.

	2001		2002						
	Nov.	Dec.	Jan	Feb	Mar	Apr	May	Jun	**Total**
Fall Chinook (caught)	---	8753	140998	106281	17161	167	122	8	273490
Fall Chinook (estimate)	---	291524	3176581	2466434	725535	2252	122	8	6662456
% of Estimate	---	4%	48%	37%	11%	0.03%	0.002%	0.0001%	100%
Spring Chinook	83	68	3	8	6	1	---	---	169
Late Fall Chinook	---	---	---	---	---	80	61	---	141

	2002		2003						
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
Fall Chinook (caught)	---	51384	199495	71612	4087	336	66	21	327001
Fall Chinook (estimate)	---	1147813	4075062	2050333	170899	3679	66	21	7447872
% of Estimate	---	15%	55%	28%	2%	0.05%	0.001%	0.0003%	100%
Spring Chinook	---	5658	10	7	9	9	1	---	5694
Late Fall Chinook	---	---	---	---	---	34	60	---	94

	2003		2004						
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
Fall Chinook (caught)	---	27689	173919	296290	22874	461	231	23	521487
Fall Chinook (estimate)	---	571777	4627763	7079212	1554807	9698	231	23	13843511
% of Estimate	---	4%	33%	51%	11%	0.07%	0.002%	0.0002%	100%
Spring Chinook	---	1297	764	8	3	2	1	---	2075
Late Fall Chinook	---	---	---	---	---	76	6	---	82

Table 3. Monthly catch for three race of Chinook salmon caught from 2001-2004 at Live Oak. Monthly estimates were included for fall Chinook only. Two rotary screwtraps were used in the 2003-2004 trapping year.

	2001		2002						
	Nov.	Dec.	Jan	Feb	Mar	Apr	May	Jun	**Total**
Fall Chinook (caught)	---	79	127792	300715	119317	1501	254	6	549664
Fall Chinook (estimate)	---	2844	2555454	9752959	3464567	25990	254	6	15802074
% of Estimate	---	0.02%	16%	62%	22%	0.2%	0.002%	0.00004%	100%
Spring Chinook	---	1	2	10	23	26	2	---	64
Late Fall Chinook	---	2	---	---	---	84	---	---	86

	2002		2003						
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
Fall Chinook (caught)	---	18033	177705	116908	19118	852	223	4	332843
Fall Chinook (estimate)	---	514205	5053937	2835676	543360	13263	223	4	8960669
% of Estimate	---	6%	56%	32%	6%	0.1%	0.002%	0.00004%	100%
Spring Chinook	---	3254	50	6	27	103	20	---	3460
Late Fall Chinook	---	---	---	---	55	17	2	---	74

	2003		2004						
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
Fall Chinook (caught)	---	10020	137636	488983	250735	8252	8079	621	904326
Fall Chinook (estimate)	---	246133	2965321	8024689	17389138	641108	7159	621	29274170
% of Estimate	---	1%	10%	27%	59%	2%	0.02%	0.002%	100%
Spring Chinook	---	344	31	41	27	55	14	---	512
Late Fall Chinook	---	---	1	---	---	49	3	1	54

Table 4. Trap efficiency data for the Feather River Thermalito RSTR, 2002-2004.

	Mark Type	Release Date	Recovery Period	# Marked	# Recaptured	% Efficiency
2002	BB	1/4/02	1/04/02 - 1/07/02	996	31	3.11
	BB	1/8/02	1/08/02 - 1/11/02	1000	31	3.10
	BB	1/14/02	1/14/02 - 1/22/02	1495	40	2.68
	BB	1/22/02	1/22/02 - 1/27/02	1000	49	4.90
	BB	1/28/02	1/28/02 - 2/02/02	998	80	8.02
	BB	2/4/02	2/04/02 - 2/10/02	1000	34	3.40
	BB	2/11/02	2/11/02 - 2/17/02	996	25	2.51
	BB	2/19/02	2/19/02 - 2/23/02	998	44	4.41
	BB	2/26/02	2/26/02 - 3/01/02	996	62	6.22
	BB	3/4/02	3/04/02 - 3/06/02	998	23	2.30
	BB	3/7/02	3/07/02 - 3/10/02	1000	11	1.10
	BB	3/11/02	3/11/02 - 3/13/02	896	18	2.01
	BB	3/19/02	3/19/02 - 3/22/02	178	1	0.56
2003						
	BB	12/30/2002	12/30/02 - 1/07/03	1000	79	7.90
	BB/ Orange Nose	1/7/2003	1/07/03 - 1/10/03	692	32	4.62
	BB/ Green Nose	1/10/2003	1/10/03 - 1/15/03	980	9	0.92
	BB/ Orange Nose	1/15/2003	1/15/03 - 1/18/03	1178	91	7.72
	BB	1/18/2003	1/18/03 - 1/21/03	975	30	3.08
	BB/ Yellow Nose	1/21/2003	1/21/03 - 1/23/03	1020	48	4.71
	BB/ Orange Nose	1/23/2003	1/23/03 -1/29/03	1923	96	4.99
	BB/ Red Nose	1/29/2003	1/29/03 - 2/04/03	1482	56	3.78
	Orange Nose Only	2/4/2003	2/04/03 - 2/11/03	992	14	1.41
	BB	2/11/2003	2/11/03 - 2/21/03	1000	55	5.50
	BB/ Yellow Nose	2/21/2003	2/21/03 - 2/27/03	1084	21	1.94
	BB	2/27/2003	2/27/03 - 3/08/03	994	23	2.31
	BB	3/8/2003	3/08/03 - 3/12/03	572	10	1.75
2004						
	BB/ Orange Nose	12/23/2003	12/23/03 - 12/27/03	693	29	4.18
	BB/ Green Nose	12/27/2003	12/27/03 - 01/02/04	738	46	6.23
	BB/ Orange Nose	1/2/2004	1/03/04 - 1/08/04	1074	29	2.70
	BB/ Yellow Nose	1/8/2004	1/09/04 - 1/14/04	925	50	5.41
	BB/ Blue Nose	1/14/2004	1/15/04 - 1/23/04	1012	57	5.63
	BB/ Orange Nose	1/23/2004	1/24/04 - 1/29/04	1059	52	4.91
	BB	1/29/2004	1/30/04 - 2/01/04	982	22	2.24
	BB	2/1/2004	2/02/04 - 2/05/04	1000	15	1.50
	BB	2/5/2004	2/06/04 - 2/09/04	999	135	13.51
	BB	2/9/2004	2/10/04 - 2/12/04	995	39	3.92
	BB/ Red Nose	2/12/2004	2/13/04 - 2/16/04	1291	42	3.25
	BB	2/16/2004	2/17/04 - 2/19/04	1188	56	4.71
	BB	2/19/2004	2/20/04 - 2/23/04	1134	51	4.50
	BB	2/23/2004	2/23/04 - 2/24/04	997	28	2.81
	BB/ Orange Nose	2/28/2004	2/29/04 - 3/03/04	1085	8	0.74
	BB/ Yellow Nose	3/3/2004	3/04/04 - 3/06/04	1601	20	1.25
	BB/ Red Nose	3/6/2004	3/07/04 - 3/10/04	1030	21	2.04
	BB	3/10/2004	3/10/04 - 3/15/04	1191	18	1.51
	BB	3/15/2004	3/15/04 - 3/19/04	725	10	1.38
	BB/ Pink Nose	3/19/2004	3/19/04 - 3/25/04	850	15	1.76
	BB/ Red Nose	3/25/2004	3/25/04 - 3/31/04	492	7	1.42

Table 5. Trap efficiency data for the Feather River Live Oak RSTR, 2002-2004.

2002	Mark Type	Release Date	Recovery Period	# Marked	# Recaptured	% Efficiency
	BB	1/17/02	1/17/02 - 1/22/02	4000	136	3.40
	BB	1/22/02	1/22/02 - 1/27/02	998	143	14.33
	BB	1/28/02	1/28/02 - 2/02/02	1000	68	6.80
	BB	2/5/02	2/05/02 - 2/10/02	997	20	2.01
	BB	2/11/02	2/11/02 - 2/17/02	998	21	2.10
	BB	2/19/02	2/19/02 - 2/23/02	998	42	4.21
	BB	2/26/02	2/26/02 - 2/28/02	992	55	5.54
	BB	3/4/02	3/04/02 - 3/06/02	998	21	2.10
	BB	3/7/02	3/07/02 - 3/10/02	984	34	3.46
	BB	3/11/02	3/11/02 - 3/13/02	999	35	3.50
	BB	3/15/02	3/15/02 - 3/19/02	230	2	0.87
	BB	3/19/02	3/19/02 - 3/22/02	766	16	2.09
2003						
	BB	12/30/2002	12/30/02 - 1/09/03	995	65	6.53
	Pink/ Yellow Nose	1/9/2003	1/09/03 - 1/14/03	1052	0	0
	BB/ Blue Nose	1/14/2003	1/14/03 - 1/17/03	922	7	0.76
	BB/ Red Nose	1/17/2003	1/17/03 - 1/22/03	758	31	4.09
	BB	1/22/2003	1/22/03 - 1/25/03	1000	43	4.30
	BB/ Green Nose	1/25/2003	1/25/03 - 1/30/03	1015	39	3.84
	BB/ Green Nose	1/30/2003	1/30/03 - 2/05/03	1245	38	3.05
	BB/ Red Nose	2/5/2003	2/05/03 - 2/20/03	993	56	5.64
	BB	2/20/2003	2/20/03 - 3/04/03	486	6	1.23
	BB	3/4/2003	3/04/03 - 3/11/03	998	33	3.51
	BB	3/11/2003	3/11/03 - 3/15/03	819	39	4.76
2004						
	BB	12/30/2003	12/30/04 - 1/07/04	686	21	3.06
	BB	1/7/2004	1/07/04 - 1/12/04	540	28	5.19
	BB	1/12/2004	1/12/04 - 1/17/04	1995	80	4.01
	BB	1/17/2004	1/17/04 - 1/24/04	1309	64	4.89
	BB	1/24/2004	1/24/04 - 1/29/04	995	86	8.64
	BB	1/29/2004	1/29/04 - 2/02/04	1000	62	6.20
	BB	2/2/2004	2/02/04 - 2/05/04	988	54	5.47
	BB	2/5/2004	2/05/04 - 2/09/04	991	92	9.28
	BB	2/9/2004	2/09/04 - 2/12/04	1000	65	6.50
	BB	2/12/2004	2/12/04 - 2/16/04	992	63	6.35
	BB	2/16/2004	2/16/04 - 2/22/04	1000	89	8.90
	BB	2/22/2004	2/22/04 - 2/23/04	997	11	1.10
	BB	3/2/2004	3/02/04 - 3/08/04	992	21	2.12
	BB	3/8/2004	3/08/04 - 3/14/04	999	18	1.80
	BB	3/14/2004	3/14/04 - 3/24/04	1000	22	2.20
	BB	3/24/2004	3/24/04 - 3/30/04	995	4	0.40
	BB	3/30/2004	3/30/04 - 4/17/04	1089	5	0.46
	BB	4/17/2004	4/17/04 - 4/21/04	629	2	0.32

Table 6. Emigration index and egg-to-fry survival rates for the Feather River, calculated from emigration estimates and prior year's escapement data. Data from 2001 included as reference.

	2001 Trap Year		Emigration Index	Survival Rate
	Emigration Estimate ('01)	33839990	465	
	Total Escapement ('00)	116941		0.133053
Sampled (*n*=6246)	% Females	56%		
	% Females Spent	63%		
Estimated	Total Females	72700		
	Total Females Spent	46059		

	2002 Trap Year		Emigration Index	Survival Rate
	Emigration Estimate ('02)	15802074	137	
	Total Escapement ('01)	160672		0.063125
Sampled (*n*=4845)	% Females	72%		
	% Females Spent	39%		
Estimated	Total Females	114974		
	Total Females Spent	45333		

	2003 Trap Year		Emigration Index	Survival Rate
	Emigration Estimate ('03)	8960669	184	
	Total Escapement ('02)	83346		0.059066
Sampled (*n*=4942)	% Females	59%		
	% Females Spent	56%		
Estimated	Total Females	48773		
	Total Females Spent	27473		

	2004 Trap Year		Emigration Index	Survival Rate
	Emigration Estimate ('04)	29274115	566	
	Total Escapement ('03)	88830		0.153728
Sampled (*n*=6128)	% Females	66%		
	% Females Spent	59%		
Estimated	Total Females	58853		
	Total Females Spent	34485		

Table 7. Regression values for salmon passage on the Feather River, 2002-2004; for 2004 (a) corresponds to weekly averages for the entire trapping season and (b) corresponds to the week of 2/16/04-2/22/04.

		Thermalito		Live Oak	
		P-value	R^2 (adj.)	*P*-value	R^2 (adj.)
2002	Turbidity	0.268	3.8%	0.098	17.5%
	Flow	0.351	0.0%	0.078	20.6%
	Temperature	0.022	33.9%	0.492	0.0%
2003	Turbidity	0.445	0.0%	0.537	0.0%
	Flow	0.054	31.2%	0.395	0.0%
	Temperature	0.042	35.1%	0.455	0.0%
2004	Turbidity (a)	0.111	15.7%	0.340	0.0%
	Turbidity (b)	0.001	55.4%	---	---
	Flow (a)	0.925	0.0%	0.469	0.0%
	Flow (b)	0.445	0.0%		
	Temperature	0.781	0.0%	0.000	62.1%

Table 8. Naturally spawned coded-wire-tagged Feather River Fall-run Chinook salmon release totals, 1998-2004.

Year	Total Release
1998	63,989
1999	136,470
2000	147,156
2001	213,961
2002	202,796
2003	164,929
2004	168,612

Table 9. Monthly trap effort and catch per hour at both trapping locations, 2002-2004.

	Thermalito		Live Oak	
2002	Effort (hours)	Catch/hour	Effort (hours)	Catch/hour
December	717	12.22	695	0.11
January	729	193.41	553	230.98
February	666	159.70	621	484.63
March	711	24.14	708	168.47
April	718	0.23	712	2.11
May	617	0.20	460	0.55
June	191	0.04	186	0.03
Totals	**4348**		**3935**	

2003	Effort (hours)	Catch/hour	Effort (hours)	Catch/hour
December	501	102.56	471	38.29
January	708	281.77	734	242.10
February	644	111.20	419	279.02
March	797	5.13	744	25.70
April	765	0.44	719	1.18
May	620	0.11	686	0.32
June	617	0.03	96	0.04
Totals	**4653**		**3869**	

2004	Effort (hours)	Catch/hour	Effort (hours)	Catch/hour
December	520	53.28	1039	9.65
January	730	238.25	1476	93.25
February	647	458.30	1036	471.88
March	729	31.39	1226	204.47
April	636	0.73	766	10.77
May	753	0.31	1512	5.35
June	286	0.08	239	2.60
Totals	**4300**		**7294**	

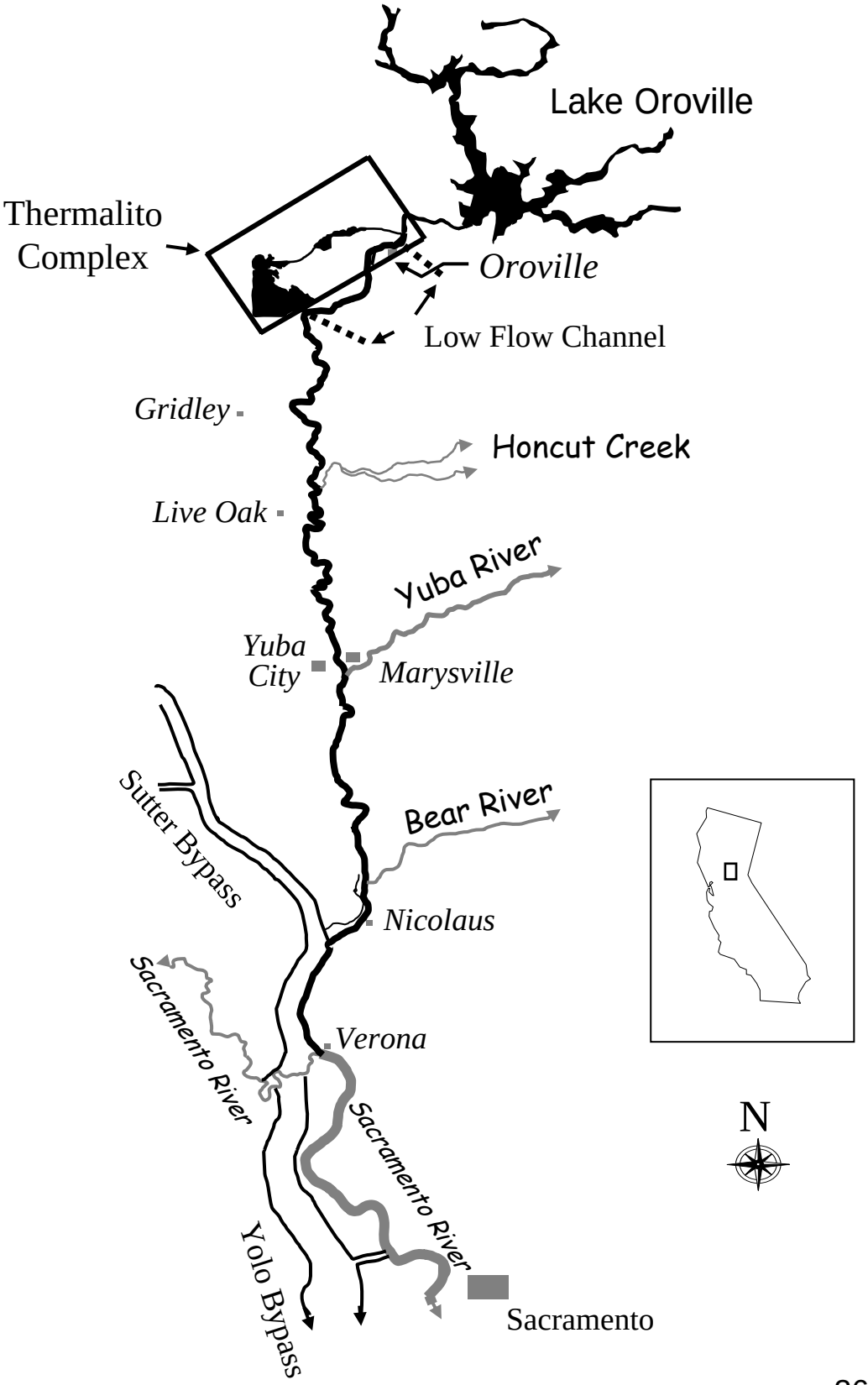

Figure 1: Lower Feather River (Feather River below Oroville Dam) and associated tributaries between Oroville Dam and the confluence with the Sacramento River.

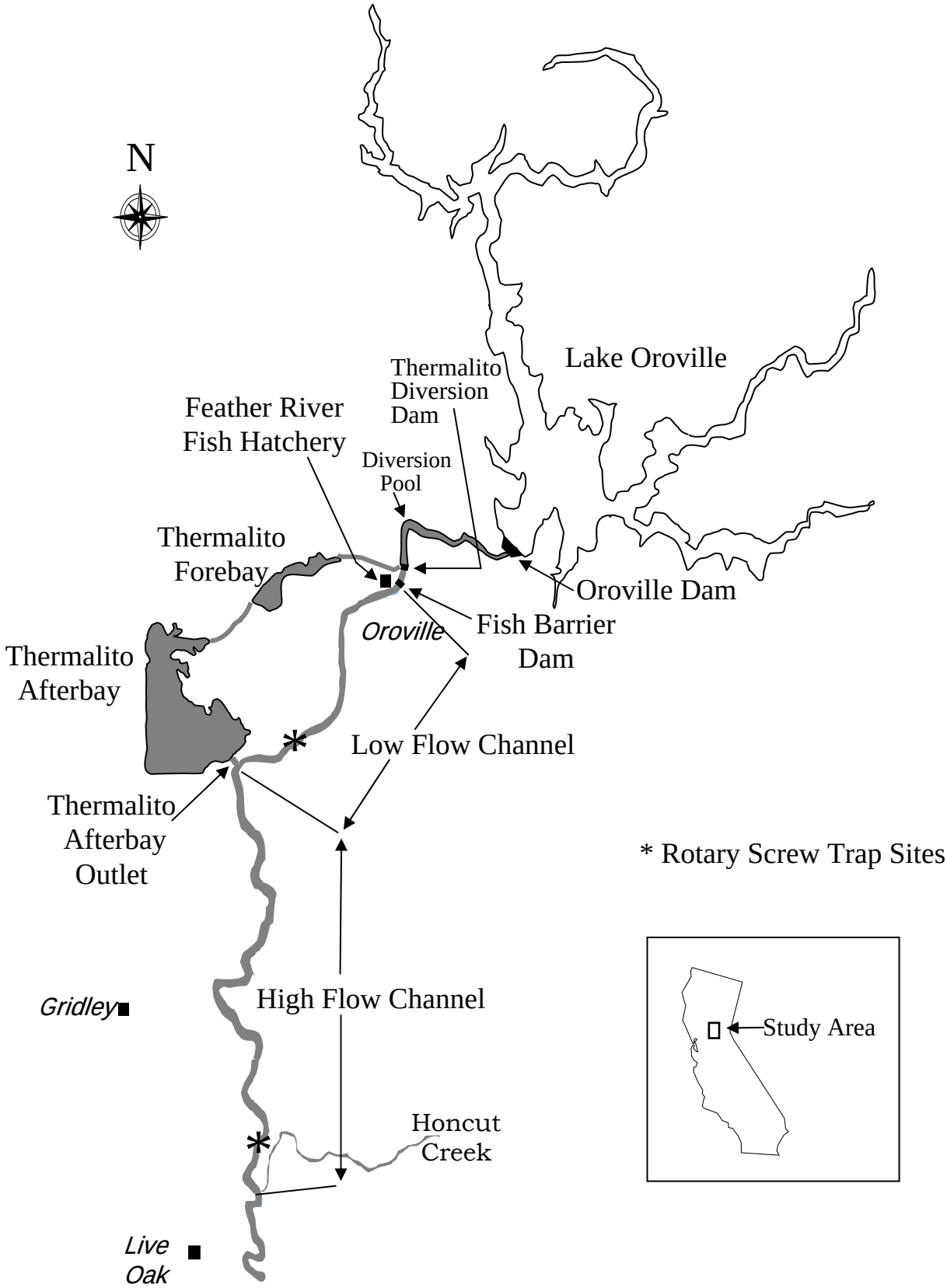

Figure 2: Lower Feather River Study Area.

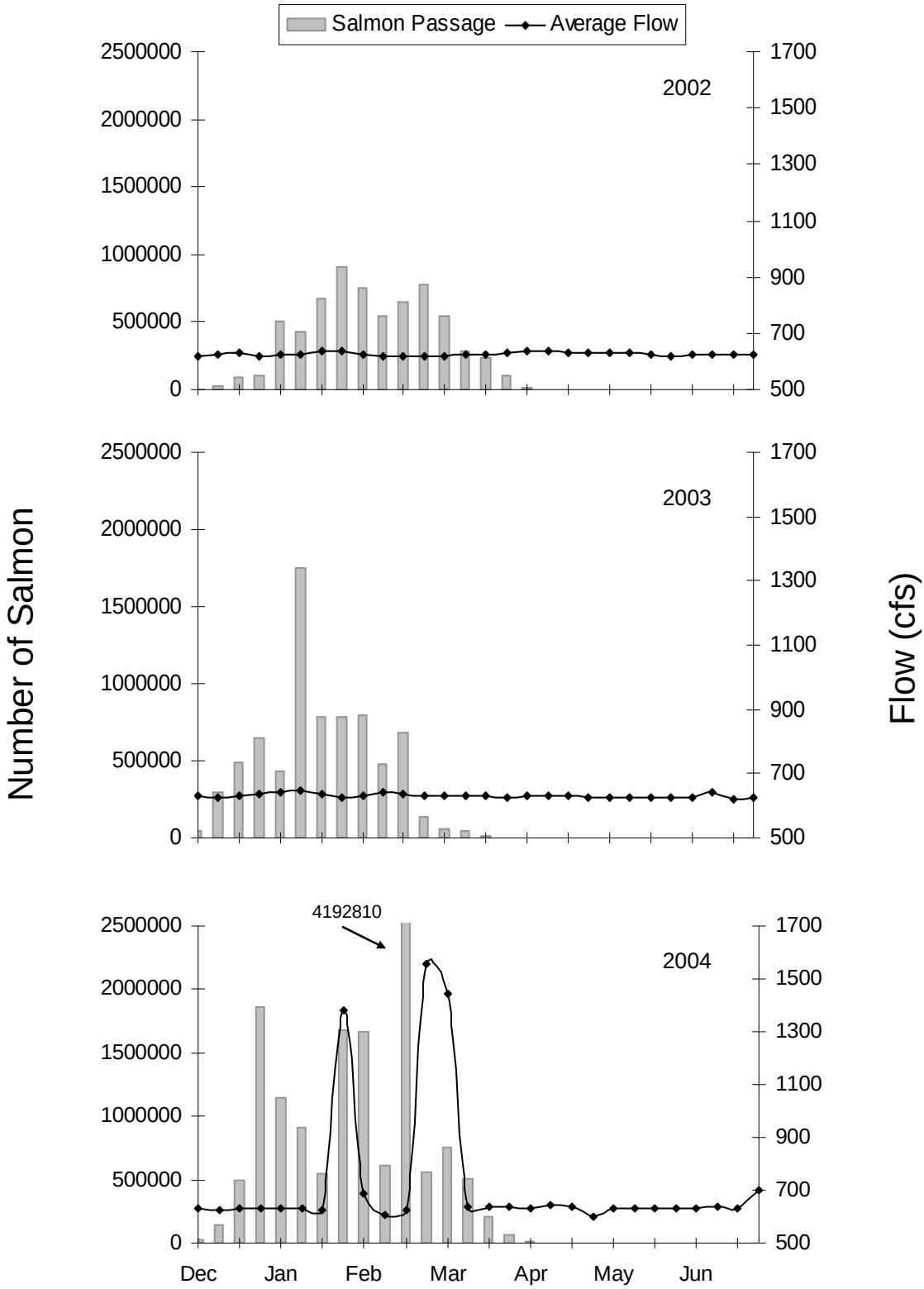

Figure 3. Estimated weekly passage and weekly average flow associated with catch of Fall-run-sized Chinook at the Thermalito RST during all three years of trapping.

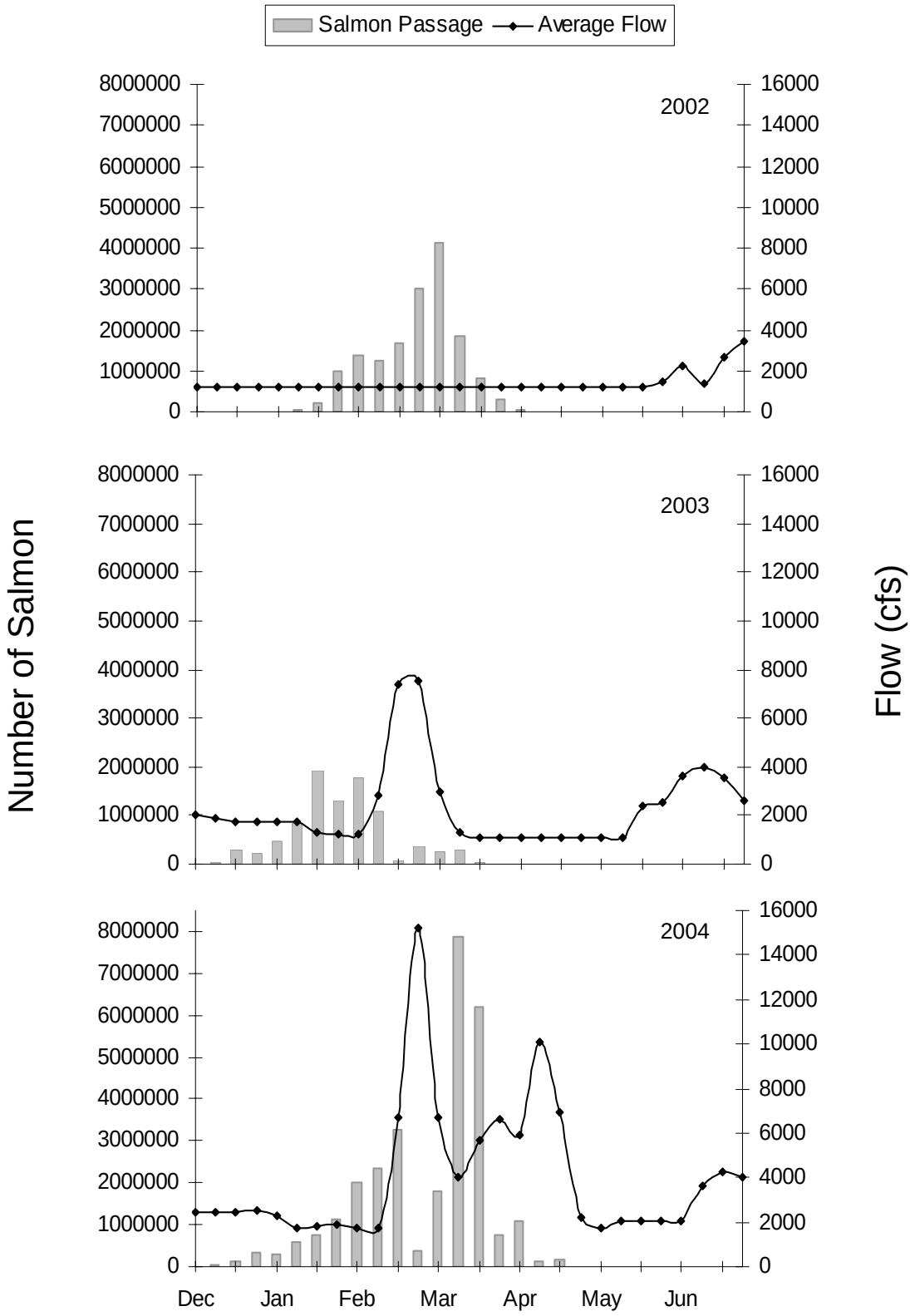

Figure 4. Estimated weekly passage and weekly average flow associated with catch of Fall-run-sized Chinook at the Live Oak RST during all three years of trapping.

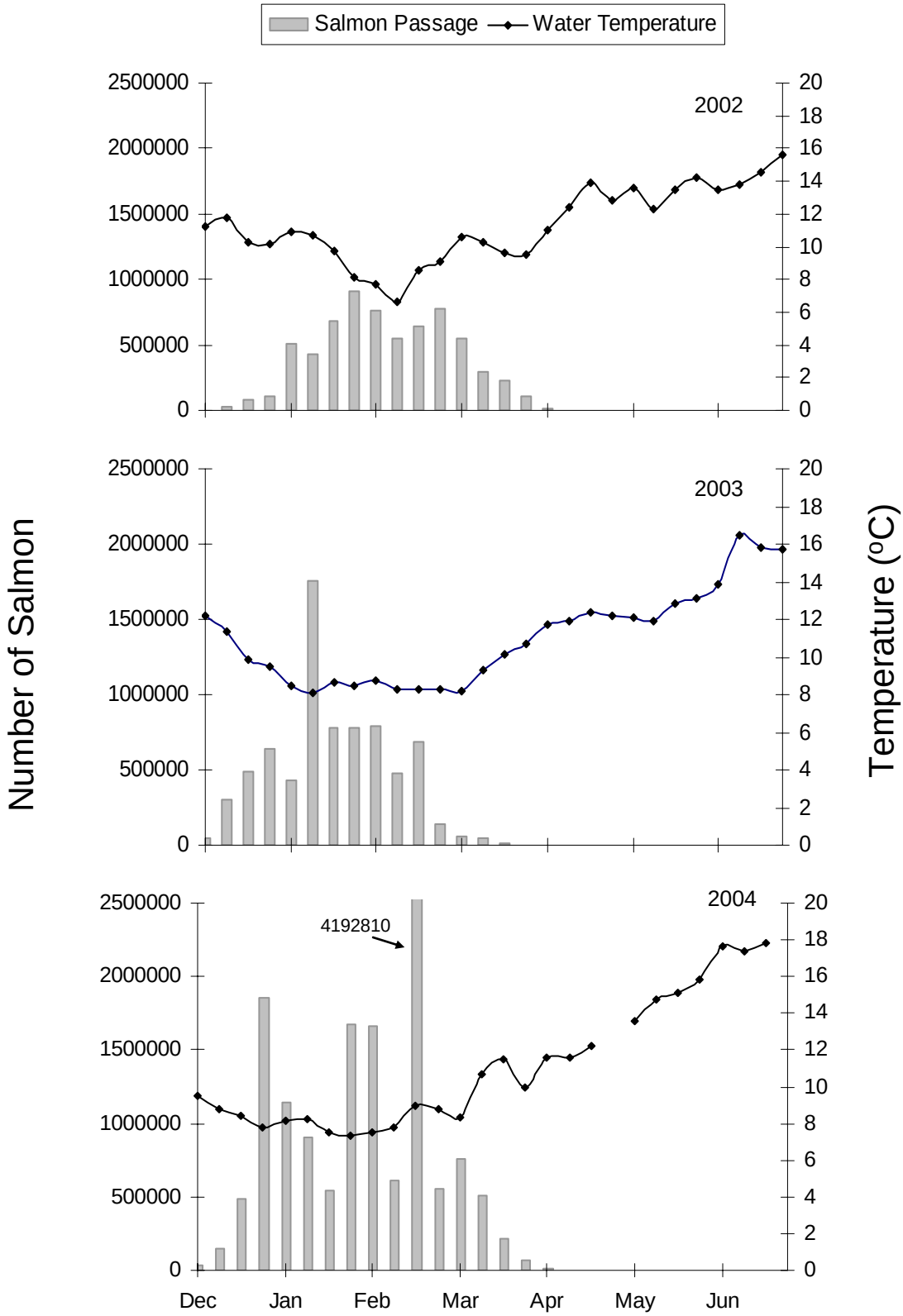

Figure 5. Estimated weekly passage and weekly average water temperature associated with catch of Fall-run-sized Chinook at the Thermalito RST during all three years of trapping.

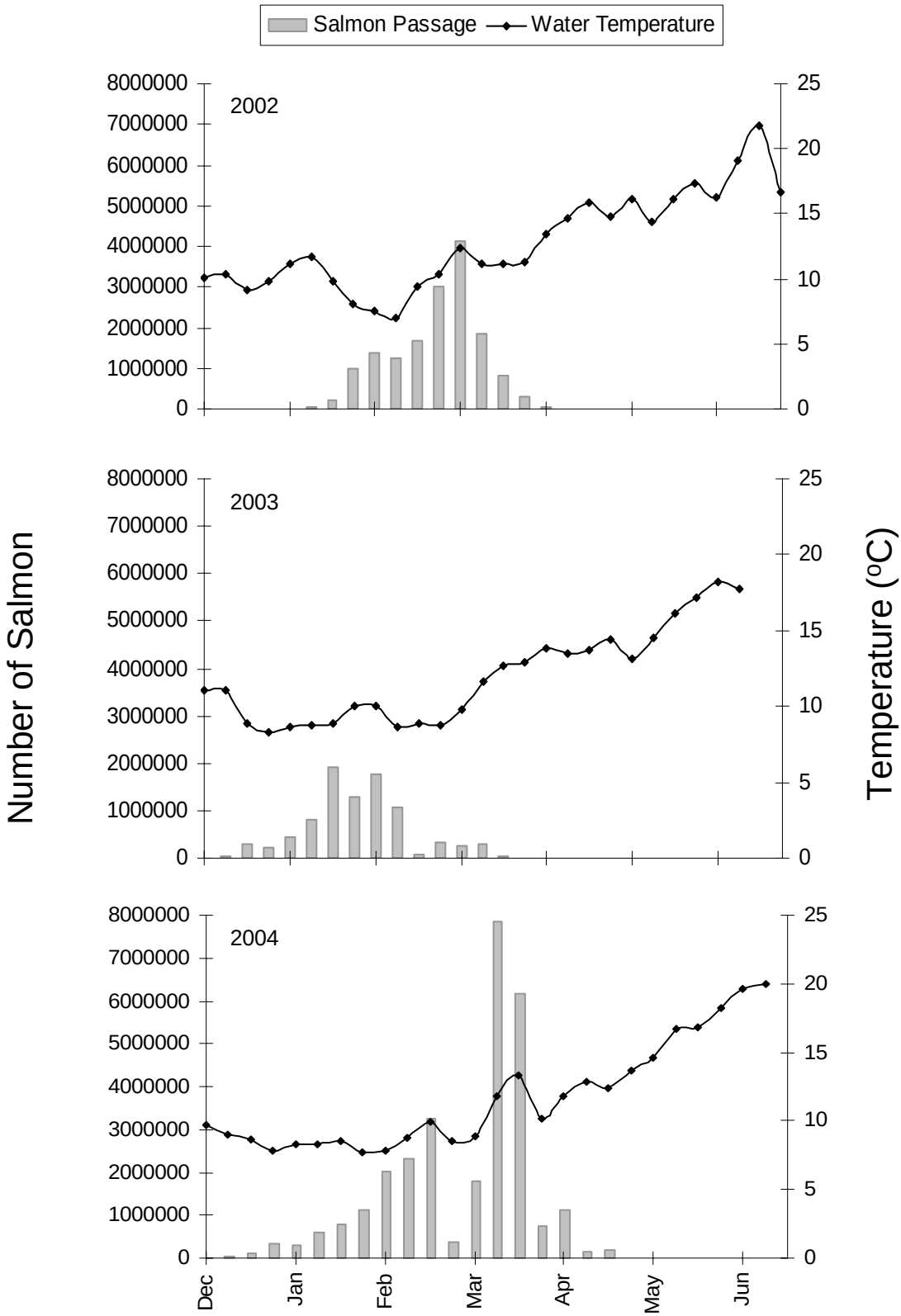

Figure 6. Estimated weekly passage and weekly average water temperature associated with catch of Fall-run-sized Chinook at the Live Oak RST during all three years of trapping.

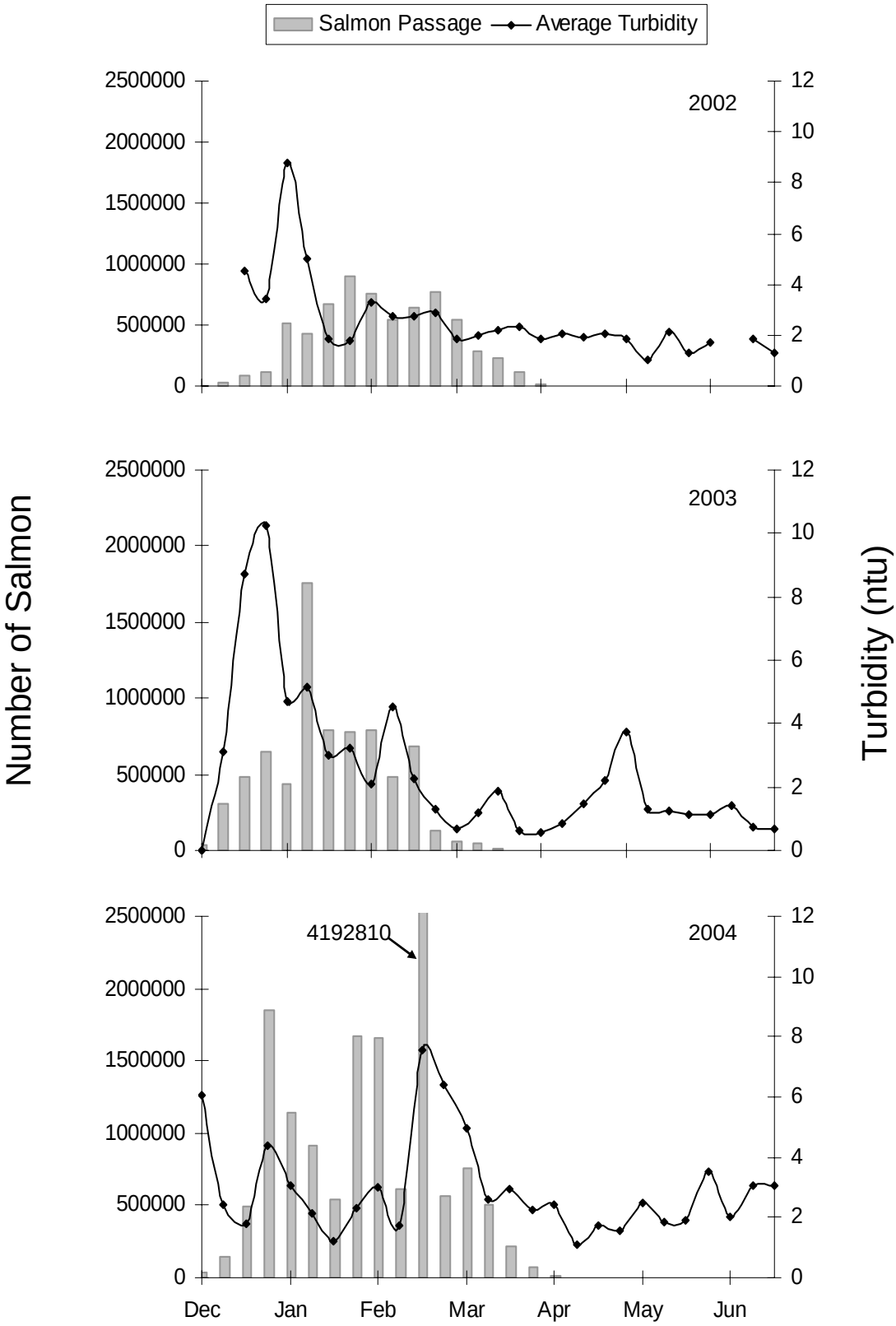

Figure 7. Estimated weekly passage and weekly average turbidity associated with catch of Fall-run-sized Chinook at the Thermalito RST during all three years of trapping.

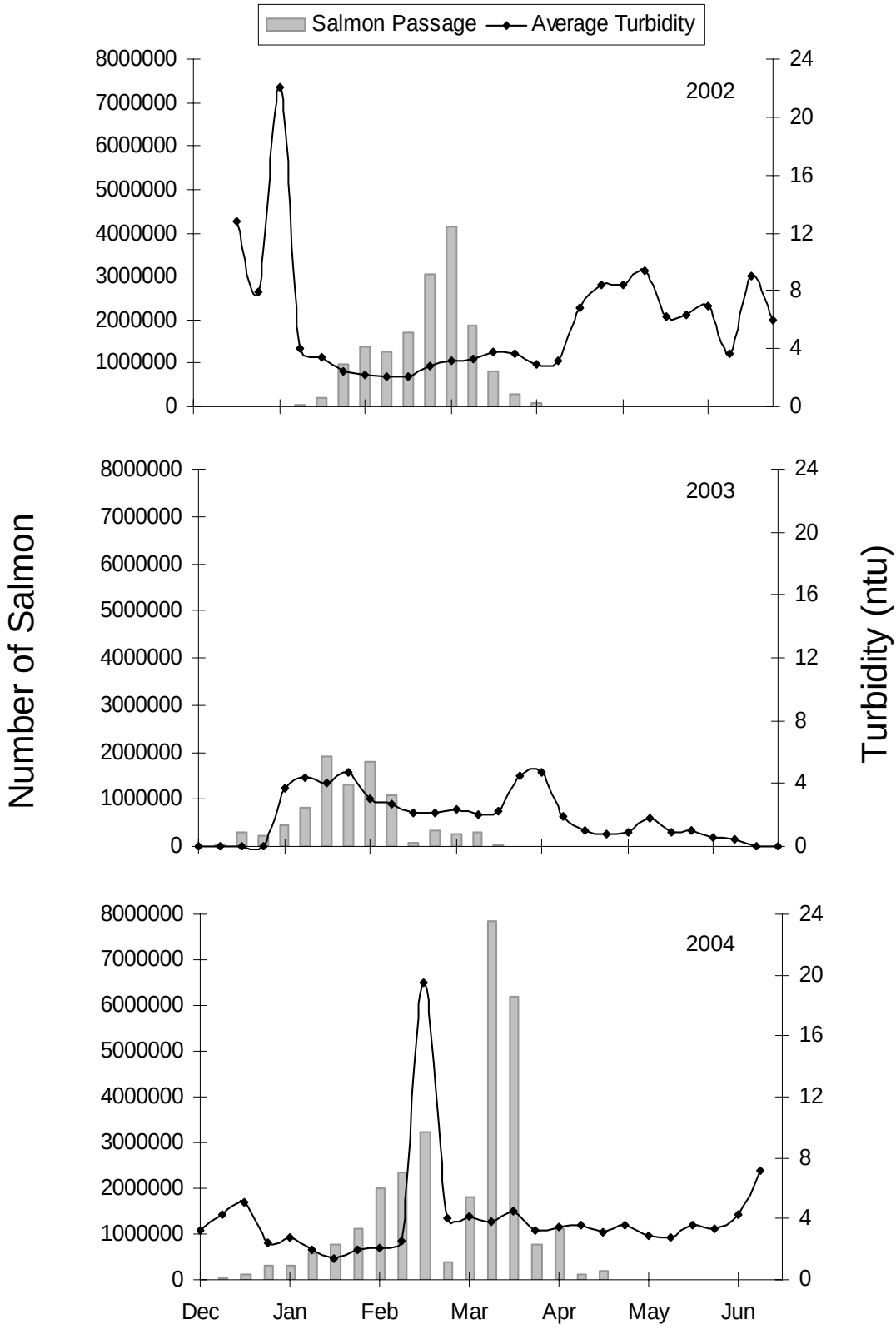

Figure 8. Estimated weekly passage and weekly average turbidity associated with catch of Fall-run-sized Chinook at the Live Oak RST during all three years of trapping.

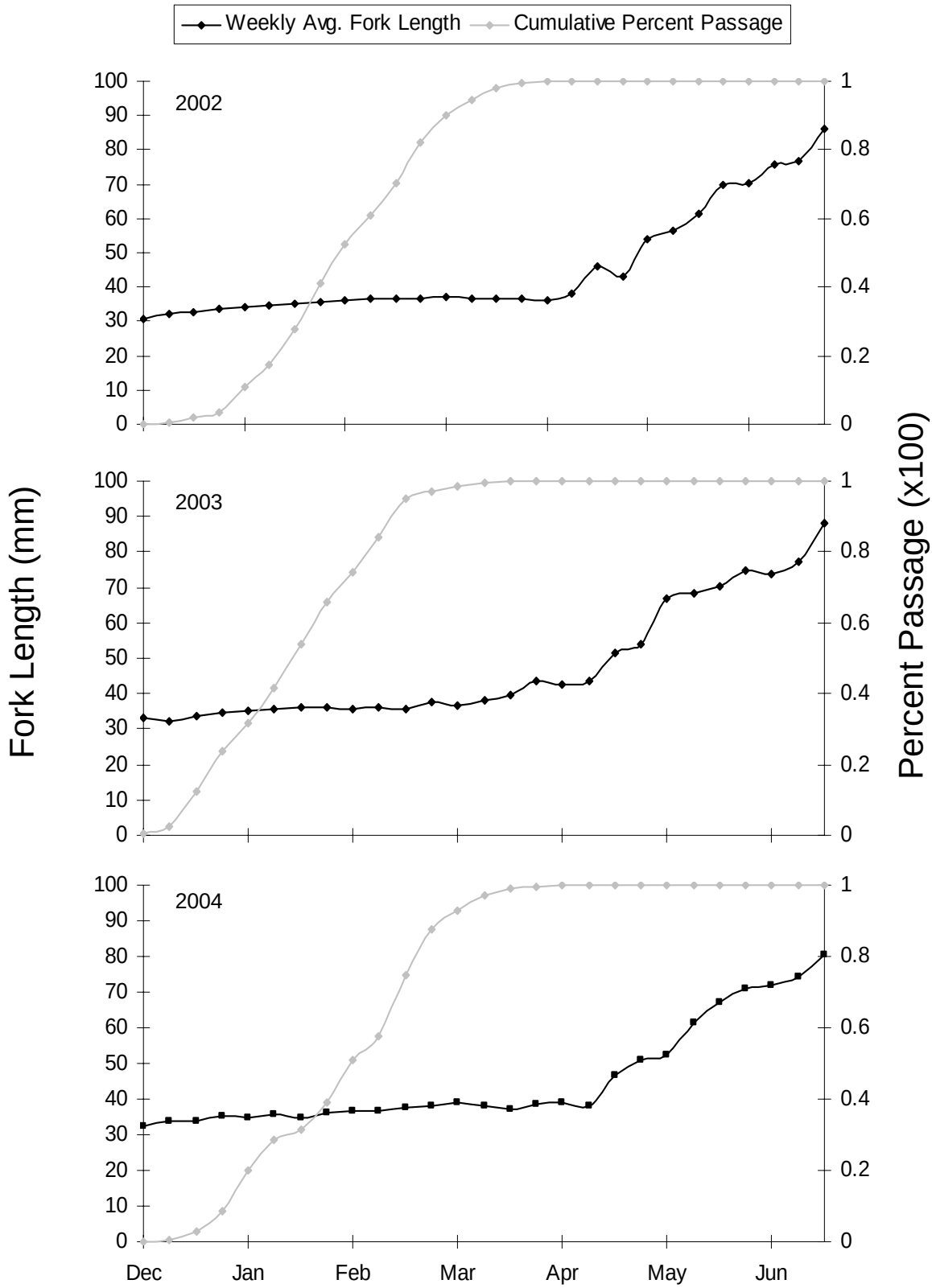

Figure 9. Average weekly fork length and cumulative percent observed Fall-run-sized Chinook salmon at Thermalito during all three years of trapping.

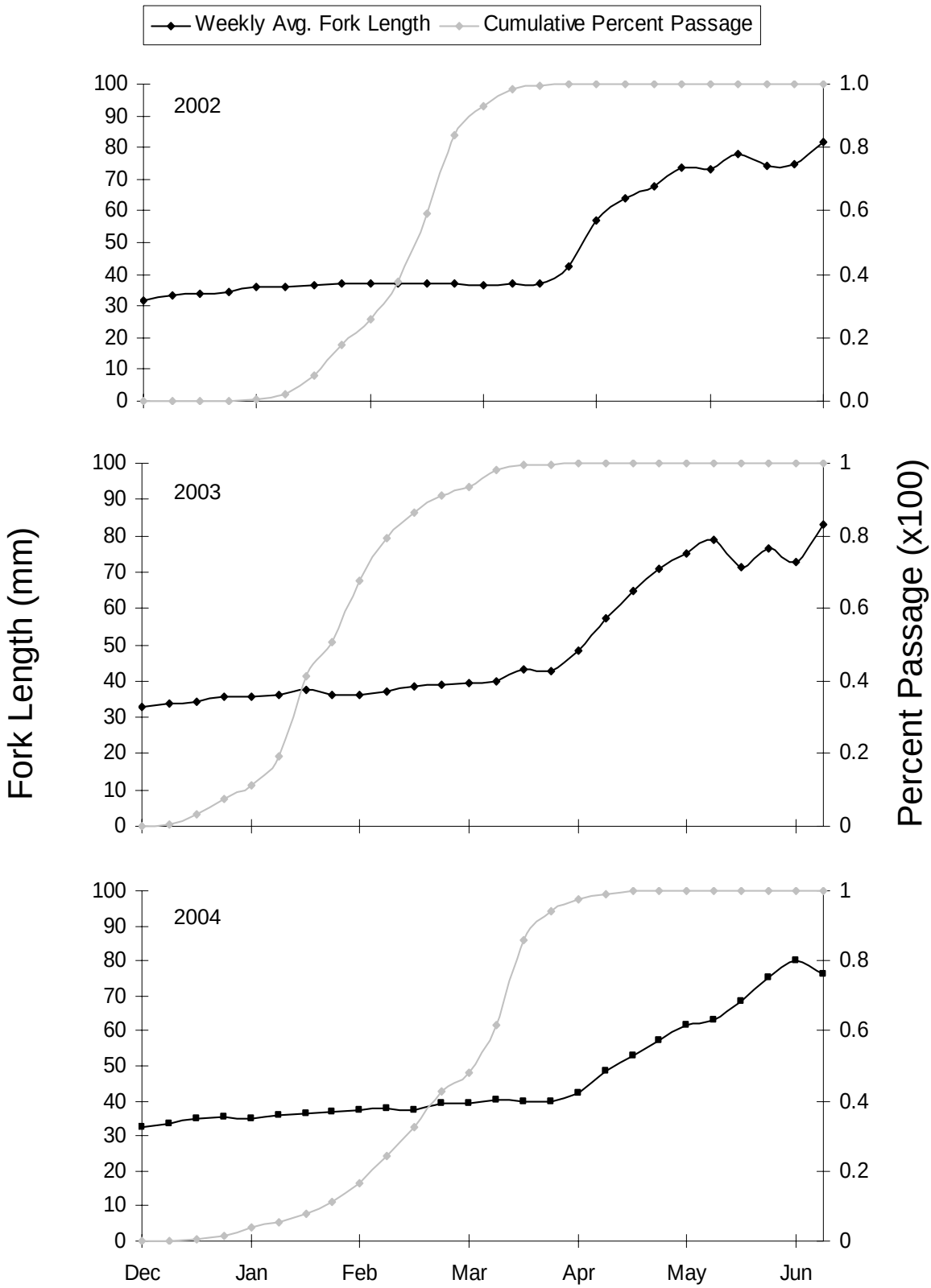

Figure 10. Average weekly fork length and cumulative percent observed Fall-run-sized Chinook salmon at Live Oak during all three years of trapping.

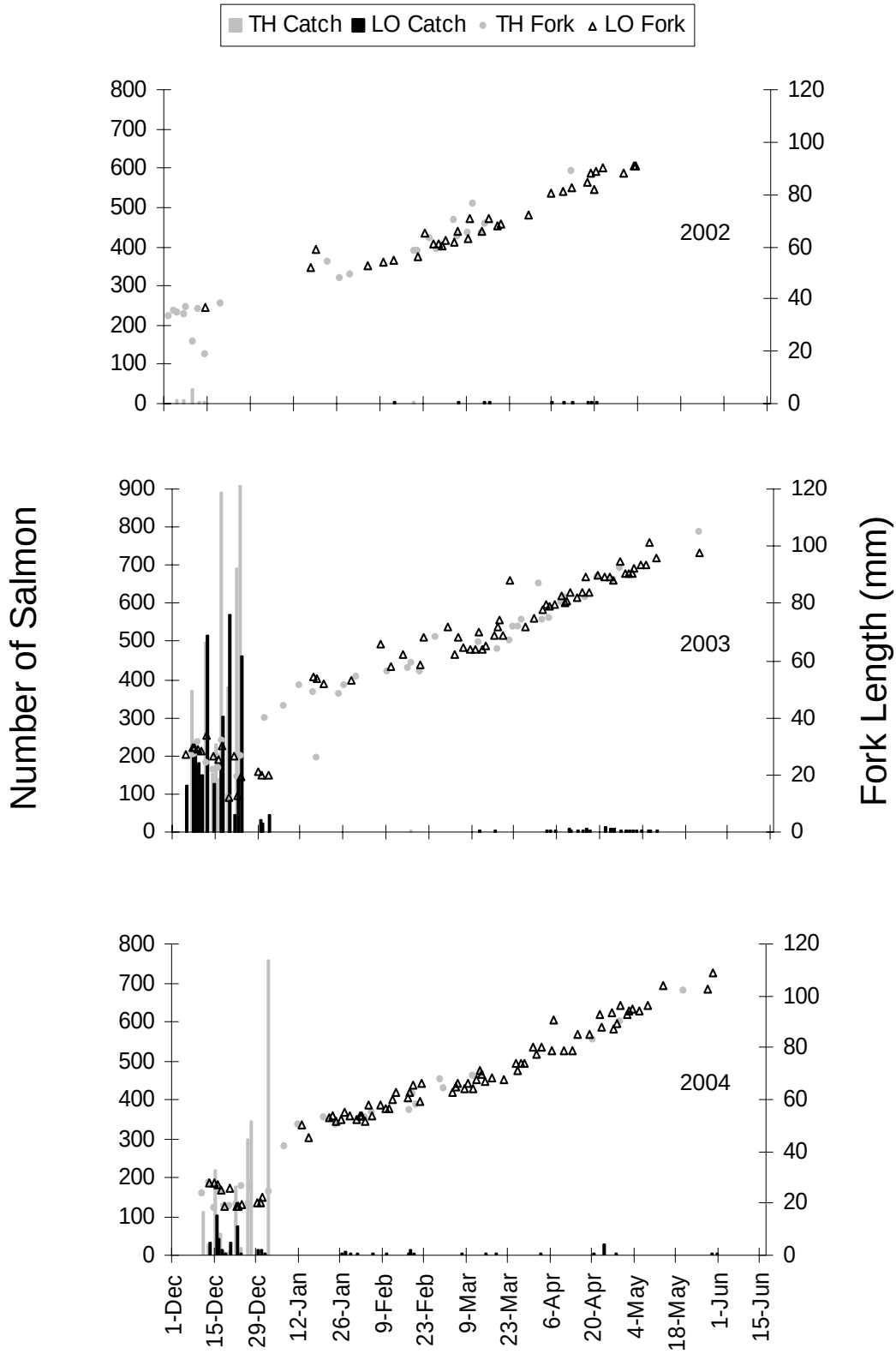

Figure 11. Daily catch distribution and daily average fork length for Spring-run-sized Chinook caught at Thermalito and Live Oak during all three years of trapping. Note y-axis scale change for 2003.

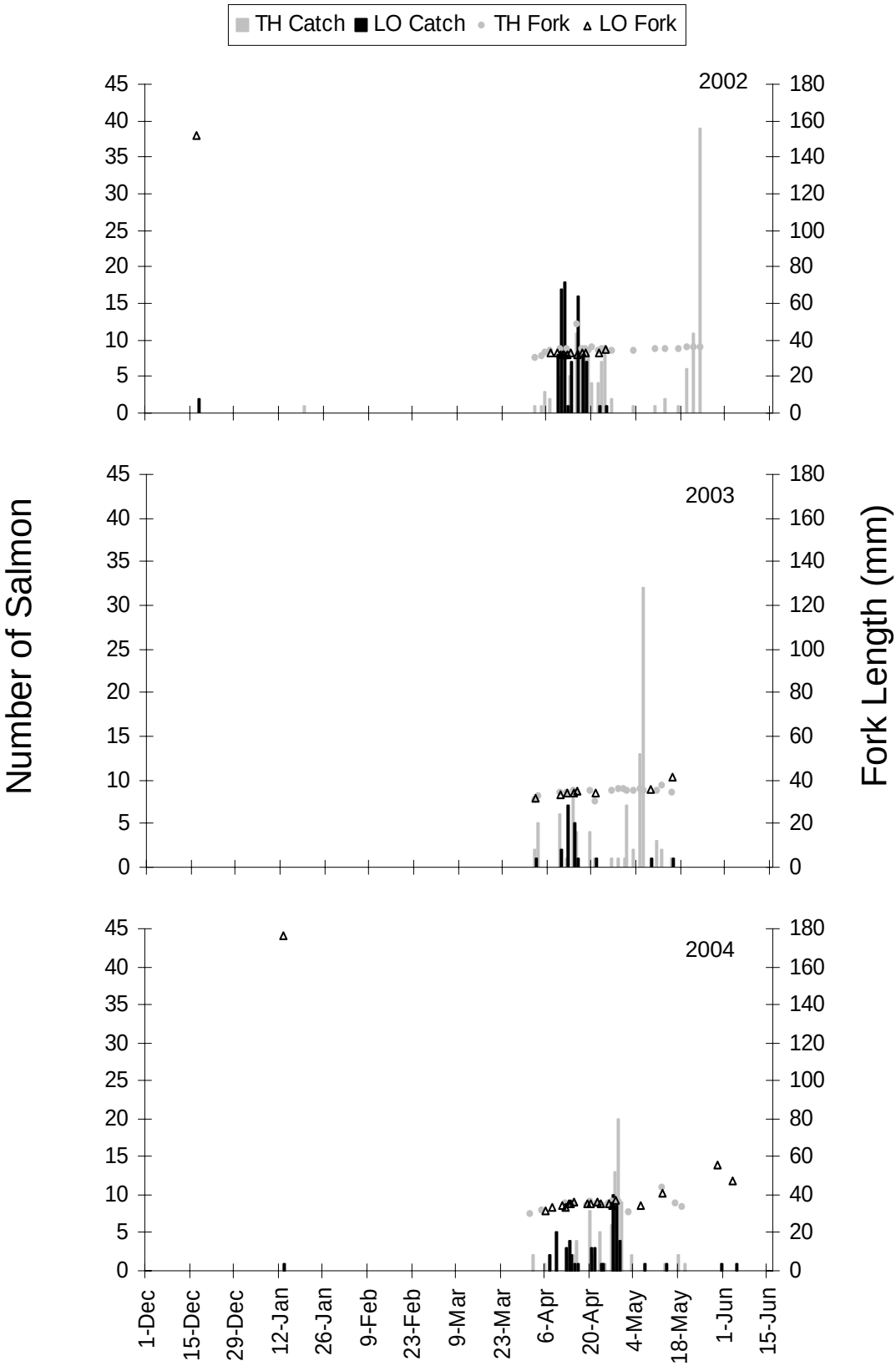

Figure 12. Daily catch distribution and daily average fork length for Late-fall-run-sized Chinook caught at Thermalito and Live Oak during all three years of trapping.

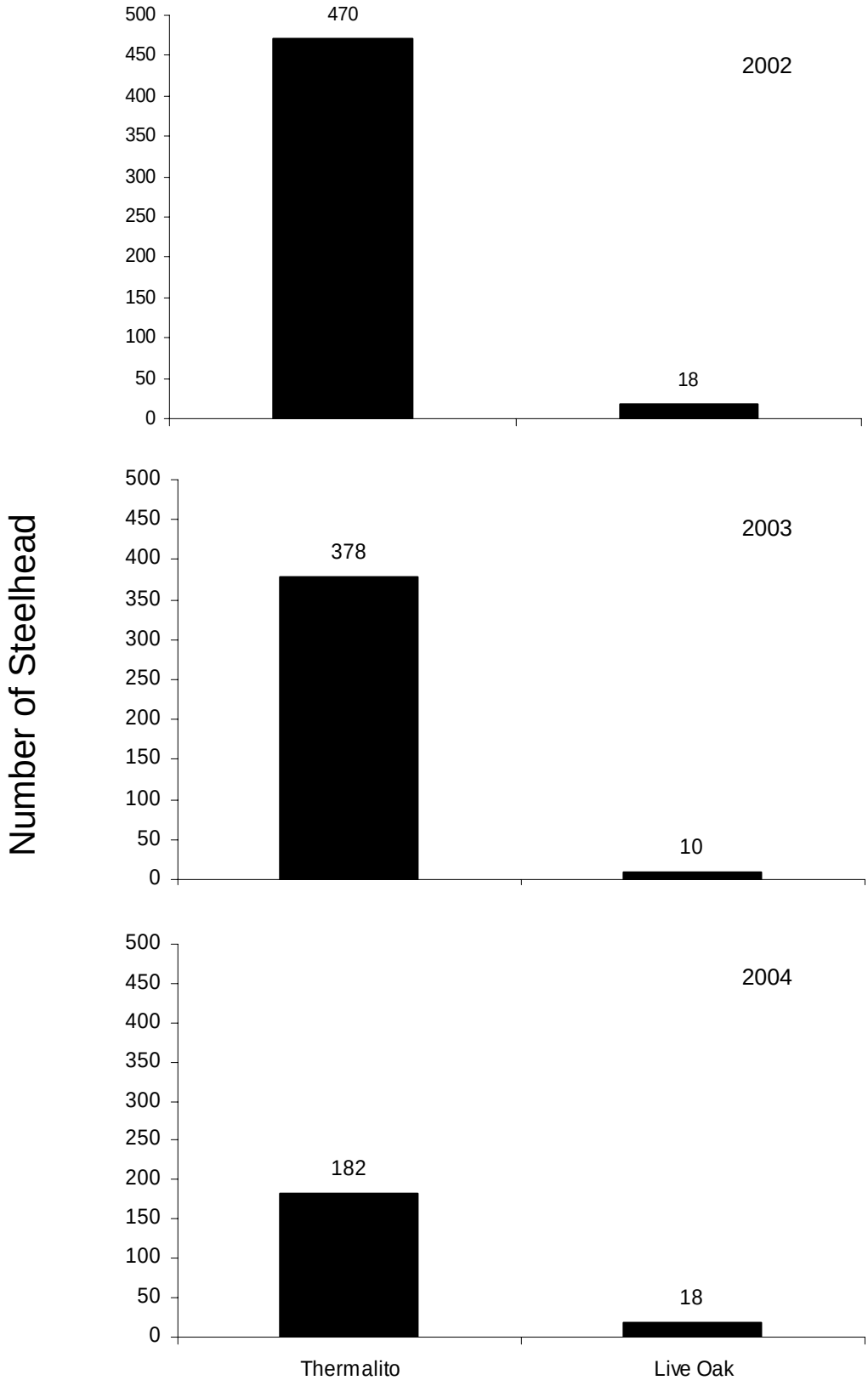

Figure 13. Total catch of wild steelhead at both trapping locations during all three years of trapping.

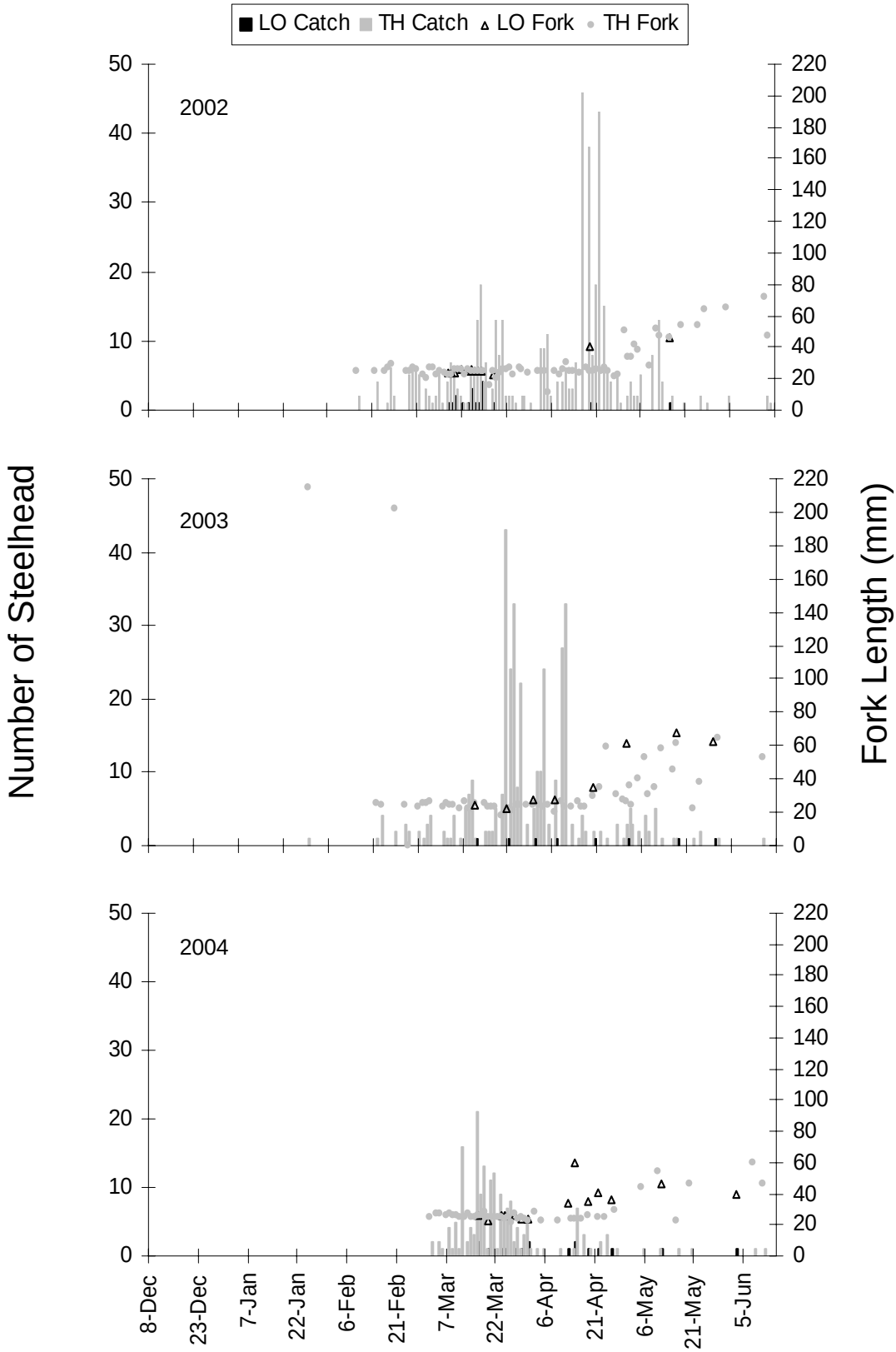

Figure 14. Daily catch distribution and daily average fork length for steelhead caught at Thermalito and Live Oak during all three years of trapping.

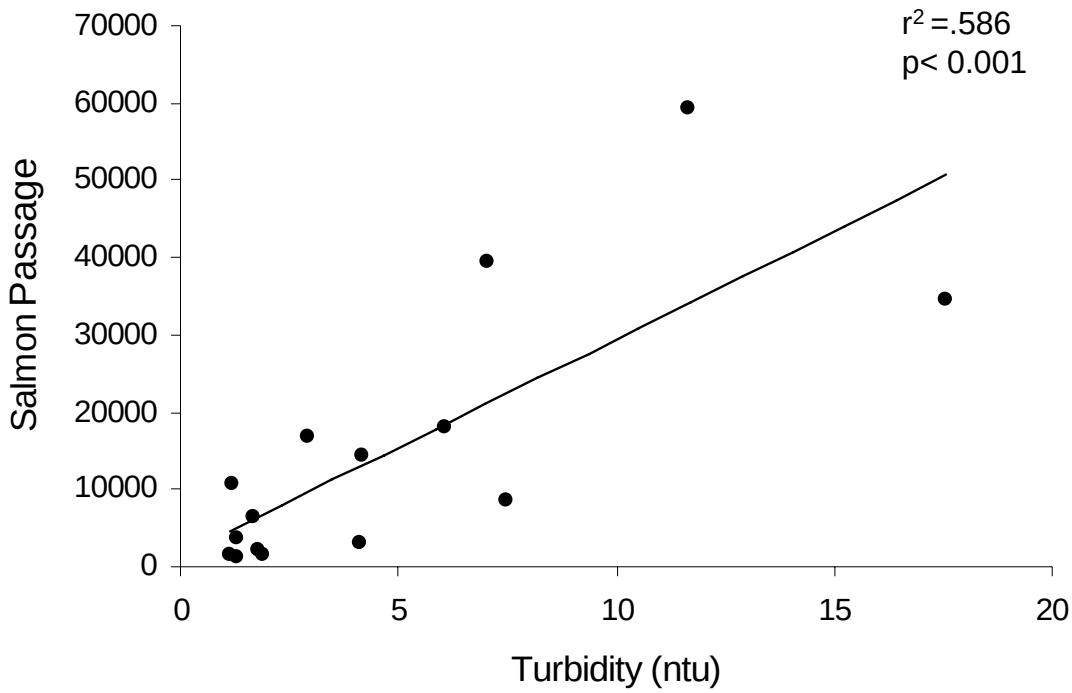

Figure 15. Regression plot of Fall-run-sized Chinook salmon estimated passage and turbidity at Thermalito between 2/8/2004 and 2/22/2004.

Appendices

Appendix 1A. Thermalito 2004 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.	Date	Min Fork	Max Fork	Avg Fork	S.D.
12/11/03	32	34	33.3	0.96	2/13/04	33	39	36.0	2.16
12/13/03	29	35	32.3	1.79	2/14/04	33	38	35.5	1.87
12/15/03	32	35	33.7	1.11	2/15/04	34	43	37.8	2.92
12/16/03	30	36	33.0	2.16	2/16/04	32	40	36.0	2.74
12/17/03	32	36	34.3	1.49	2/17/04	33	40	36.5	2.45
12/18/03	32	37	34.5	1.87	2/18/04	34	40	37.0	2.16
12/20/03	30	37	33.3	2.21	2/19/04	30	55	39.4	7.69
12/22/03	31	37	33.9	2.03	2/20/04	34	40	37.0	2.16
12/23/03	31	37	34.0	2.16	2/21/04	33	49	38.8	5.83
12/24/03	29	38	34.3	2.92	2/22/04	33	50	38.0	5.05
12/26/03	27	37	33.9	2.89	2/23/04	30	40	36.1	3.18
12/27/03	31	38	34.6	2.30	2/24/04	31	40	35.9	2.93
12/29/03	31	38	34.8	2.44	2/25/04	34	46	38.4	3.64
12/30/03	32	38	35.1	2.03	2/28/04	33	54	37.7	6.48
12/31/03	33	39	35.9	2.03	2/29/04	31	58	40.7	9.07
1/2/04	32	39	34.8	2.40	3/1/04	33	44	38.1	3.48
1/3/04	32	38	34.9	2.03	3/2/04	30	55	38.3	6.69
1/5/04	30	39	34.9	2.93	3/3/04	34	42	38.0	2.74
1/6/04	32	39	35.5	2.45	3/4/04	33	44	38.5	3.63
1/7/04	29	39	34.2	2.79	3/5/04	34	59	40.1	7.02
1/8/04	30	40	34.9	2.75	3/6/04	35	60	40.8	8.03
1/10/04	33	38	35.3	1.80	3/7/04	34	42	37.6	2.67
1/12/04	32	39	35.9	2.41	3/8/04	35	42	38.5	2.45
1/13/04	31	40	35.9	2.93	3/9/04	33	51	39.2	5.51
1/14/04	32	38	35.0	2.16	3/10/04	33	53	39.5	6.23
1/15/04	31	39	35.0	2.74	3/11/04	30	55	38.0	7.41
1/16/04	32	40	35.6	2.70	3/12/04	31	44	37.1	3.39
1/17/04	32	40	35.8	2.82	3/13/04	33	40	36.3	2.35
1/19/04	32	39	35.2	2.44	3/14/04	34	43	37.8	2.92
1/20/04	32	39	35.3	2.35	3/15/04	34	40	37.0	2.16
1/21/04	31	38	34.9	2.41	3/16/04	31	42	37.3	3.40
1/22/04	30	38	34.4	2.67	3/17/04	30	39	34.5	3.03
1/23/04	31	39	35.2	2.44	3/18/04	32	41	36.9	2.93
1/24/04	30	38	34.4	2.51	3/19/04	31	44	36.8	4.03
1/26/04	32	40	35.6	2.62	3/20/04	33	54	37.8	5.79
1/27/04	33	39	36.0	2.16	3/21/04	32	46	38.4	4.43
1/28/04	34	39	36.5	1.87	3/22/04	32	50	38.9	4.87
1/30/04	35	41	38.0	2.00	3/23/04	31	43	37.4	3.57
1/31/04	33	39	36.3	2.12	3/24/04	32	67	39.8	9.07
2/1/04	32	39	35.3	2.20	3/25/04	29	55	42.1	7.31
2/2/04	33	40	36.5	2.45	3/26/04	28	50	36.6	6.30
2/3/04	26	40	35.0	3.87	3/27/04	31	44	36.7	3.77
2/4/04	29	44	36.1	4.16	3/28/04	32	57	38.9	6.85
2/5/04	34	42	37.6	2.51	3/29/04	30	61	39.4	8.01
2/6/04	33	47	38.3	4.72	3/30/04	32	48	39.2	4.86
2/7/04	32	40	36.4	2.67	3/31/04	31	63	40.1	9.18
2/8/04	35	41	38.0	2.16	4/1/04	33	48	38.7	5.12
2/9/04	32	40	36.0	2.74	4/3/04	32	59	39.5	7.97
2/10/04	33	39	36.0	2.16	4/4/04	33	43	36.9	3.18
2/11/04	32	41	36.9	2.93	4/5/04	34	50	39.9	5.17
2/12/04	33	41	37.3	2.82	4/6/04	34	62	41.3	9.12

Appendix 1A. Thermalito 2004 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/7/04	34	37	35.5	1.29
4/10/04	35	38	36.5	2.12
4/11/04	35	38	36.5	1.29
4/12/04	36	67	46.7	12.08
4/13/04	36	60	45.6	8.90
4/14/04	36	53	44.0	5.76
4/15/04	39	77	54.1	10.80
4/17/04	33	50	43.6	7.02
4/19/04	38	72	52.1	10.06
4/20/04	38	80	57.9	10.88
4/22/04	37	67	50.6	8.84
4/24/04	39	47	42.8	3.19
4/26/04	38	42	40.0	2.00
4/27/04	46	83	61.4	15.30
4/28/04	46	60	53.3	7.02
4/29/04	60	60	60.0	
5/2/04	45	47	46.0	1.41
5/3/04	41	77	56.0	10.93
5/4/04	56	76	65.9	8.23
5/5/04	50	75	64.4	9.26
5/6/04	60	60	60.0	
5/10/04	61	61	61.0	
5/11/04	56	85	72.6	10.23
5/12/04	56	83	71.6	7.76
5/13/04	59	85	72.6	7.41
5/16/04	43	79	56.6	8.57
5/17/04	63	78	72.0	5.45
5/19/04	54	81	67.8	8.58
5/20/04	51	98	71.0	11.72
5/23/04	57	96	73.3	8.99
5/24/04	62	72	67.4	3.62
5/26/04	55	92	77.6	10.21
5/30/04	58	82	71.3	9.87
5/31/04	60	90	73.8	9.95
6/2/04	77	93	83.3	6.62
6/3/04	72	94	81.0	9.54
6/4/04	65	72	68.3	3.51
6/5/04	63	68	66.0	2.65
6/8/04	67	70	68.5	2.12
6/11/04	90	90	90.0	
6/12/04	81	85	83.0	2.83

Appendix 1B. Live Oak West trap 2004 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.	Date	Min Fork	Max Fork	Avg Fork	S.D.
12/11/03	30	35	32.5	1.87	2/16/04	34	43	38.1	2.93
12/13/03	30	35	32.7	1.68	2/17/04	34	40	37.0	2.16
12/15/03	31	35	33.0	1.41	2/18/04	34	43	37.8	2.92
12/16/03	32	35	33.5	1.29	2/19/04	34	43	38.5	3.03
12/17/03	30	36	33.5	1.97	2/28/04	33	40	36.2	2.44
12/18/03	31	36	33.5	1.87	3/2/04	33	40	36.3	2.35
12/20/03	30	37	33.8	2.25	3/3/04	35	42	38.1	2.41
12/22/03	31	37	33.7	2.00	3/4/04	35	47	40.4	3.91
12/23/03	32	37	34.5	1.87	3/5/04	34	46	38.5	3.44
12/24/03	32	38	35.1	1.90	3/6/04	35	51	39.9	4.76
12/26/03	32	37	34.9	1.81	3/7/04	34	61	41.2	7.27
12/27/03	32	38	35.4	2.26	3/8/04	36	62	44.4	8.28
12/29/03	32	39	35.9	2.41	3/9/04	35	60	41.7	7.07
12/30/03	33	39	35.7	2.00	3/10/04	35	42	38.1	2.41
12/31/03	30	38	34.0	2.74	3/11/04	33	61	39.9	7.35
1/3/04	34	39	36.5	1.87	3/12/04	33	63	40.4	7.62
1/6/04	32	38	35.0	2.16	3/13/04	36	50	42.1	4.48
1/7/04	31	38	34.5	2.45	3/14/04	35	44	39.5	3.03
1/8/04	32	38	35.0	2.16	3/15/04	35	52	41.1	4.78
1/10/04	31	38	34.6	2.30	3/16/04	33	45	39.1	3.75
1/12/04	34	39	36.5	1.87	3/17/04	34	43	38.0	3.12
1/13/04	34	39	36.5	1.87	3/18/04	35	49	42.0	4.64
1/14/04	32	38	35.0	2.16	3/19/04	35	47	39.8	3.61
1/15/04	32	39	35.5	2.45	3/20/04	31	47	39.7	4.68
1/16/04	33	38	35.5	1.87	3/21/04	34	42	37.7	2.53
1/17/04	32	41	35.8	2.94	3/22/04	35	45	40.0	3.32
1/19/04	35	42	38.5	2.45	3/24/04	32	44	38.8	3.66
1/20/04	32	39	35.1	2.33	3/25/04	35	44	39.5	2.88
1/21/04	31	39	35.0	2.74	3/26/04	31	58	41.0	7.30
1/22/04	35	40	37.1	1.95	3/27/04	36	45	40.5	3.03
1/23/04	32	39	35.9	2.41	3/28/04	33	45	38.5	3.98
1/24/04	32	40	36.9	2.19	3/29/04	35	49	40.5	4.16
1/26/04	35	41	38.0	2.16	3/30/04	33	50	40.6	5.33
1/27/04	30	40	37.2	2.86	3/31/04	33	72	41.6	9.76
1/29/04	32	38	35.3	2.16	4/1/04	34	60	41.5	7.31
1/31/04	34	41	37.5	2.45	4/3/04	34	65	45.3	8.79
2/1/04	33	41	36.3	2.65	4/28/04	48	84	62.8	9.77
2/2/04	32	49	37.3	4.85	4/29/04	42	72	54.9	8.07
2/3/04	34	40	36.7	2.16	5/1/04	51	84	63.6	8.09
2/4/04	32	42	37.4	3.17	5/2/04	41	88	62.4	9.98
2/5/04	34	39	36.5	1.87	5/3/04	45	79	59.3	8.73
2/6/04	35	43	38.3	2.42	5/4/04	45	87	62.3	10.26
2/7/04	33	48	39.0	4.32	5/5/04	42	72	54.1	8.92
2/8/04	33	40	36.5	2.45	5/6/04	43	83	62.8	10.33
2/9/04	35	39	37.0	1.58	5/8/04	53	89	66.7	8.80
2/10/04	35	45	39.2	3.15	5/9/04	48	76	62.3	7.82
2/11/04	31	40	36.6	2.99	5/10/04	47	81	65.4	8.48
2/12/04	35	43	39.0	2.74	5/11/04	53	85	67.9	9.36
2/13/04	34	41	37.5	2.45	5/12/04	58	81	68.5	7.43
2/14/04	30	52	37.4	5.93	5/13/04	52	85	70.2	9.54
2/15/04	34	42	38.0	2.74	5/15/04	48	87	68.9	10.32

Appendix 1B. Live Oak West trap 2004 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
5/16/04	51	88	68.1	11.70
5/17/04	54	86	72.2	9.16
5/19/04	49	90	74.4	9.90
5/22/04	67	91	77.5	7.11
5/23/04	60	87	74.3	7.47
5/24/04	53	86	72.8	10.27
5/26/04	59	91	76.5	8.15
5/28/04	57	90	72.4	8.13
5/30/04	68	106	91.0	10.44
5/31/04	63	107	85.7	14.59
6/2/04	54	82	71.5	8.21
6/3/04	59	99	69.7	10.35
6/4/04	59	92	72.9	9.78

Appendix 1C. Live Oak East trap 2004 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.	Date	Min Fork	Max Fork	Avg Fork	S.D.
12/13/03	31	35	33.0	1.49	2/17/04	35	40	37.5	1.87
12/15/03	30	37	33.7	2.21	2/18/04	34	40	37.0	2.16
12/16/03	32	36	34.0	1.58	2/19/04	31	42	37.3	3.40
12/17/03	29	36	33.3	2.21	2/21/04	33	48	37.9	4.79
12/18/03	31	36	33.3	1.67	2/22/04	31	42	36.5	3.34
12/20/03	31	37	34.2	1.96	2/23/04	34	55	41.6	6.40
12/22/03	32	37	34.3	1.67	2/28/04	33	43	37.2	3.15
12/23/03	32	37	34.5	1.87	3/2/04	34	59	40.4	6.82
12/24/03	32	38	35.0	1.73	3/3/04	34	42	38.0	2.74
12/26/03	33	38	35.4	1.72	3/4/04	34	43	38.1	2.93
12/27/03	32	38	35.1	2.03	3/5/04	34	40	37.0	2.16
12/29/03	31	39	34.8	2.66	3/6/04	35	58	41.4	6.39
12/30/03	32	39	35.4	2.37	3/9/04	34	52	39.2	4.71
12/31/03	31	39	35.7	2.69	3/10/04	35	42	38.5	2.45
1/3/04	32	39	35.5	2.45	3/11/04	34	41	37.6	2.30
1/6/04	32	39	35.1	2.41	3/12/04	35	43	39.0	2.74
1/7/04	29	38	33.8	3.07	3/13/04	34	43	38.5	3.03
1/8/04	31	40	35.5	3.03	3/14/04	34	49	40.4	4.56
1/10/04	33	39	36.0	2.16	3/15/04	34	46	39.9	3.69
1/12/04	31	39	35.4	2.67	3/16/04	34	47	38.7	4.00
1/13/04	32	39	35.9	2.41	3/17/04	33	45	39.4	3.75
1/14/04	34	39	36.5	1.87	3/18/04	32	45	38.5	3.76
1/15/04	32	40	36.0	2.74	3/19/04	34	62	41.4	9.29
1/16/04	34	39	36.5	1.87	3/20/04	33	46	38.5	3.99
1/17/04	32	39	35.5	2.45	3/21/04	35	57	42.3	7.16
1/19/04	33	39	36.0	2.16	3/22/04	34	47	39.3	3.85
1/20/04	34	42	38.0	2.74	3/24/04	35	45	39.6	3.20
1/21/04	32	39	35.5	2.45	3/25/04	34	49	39.5	4.37
1/22/04	35	41	37.4	2.07	3/30/04	34	43	38.9	2.70
1/23/04	34	39	36.5	1.87	3/31/04	32	64	41.1	7.64
1/24/04	30	45	35.9	4.23	4/1/04	34	53	41.5	5.63
1/26/04	35	41	38.0	2.16	4/3/04	35	70	48.8	9.09
1/27/04	34	43	37.8	2.94	4/6/04	37	68	46.0	7.81
1/29/04	30	39	34.6	2.77	4/7/04	34	67	47.1	8.92
1/31/04	34	41	37.6	2.30	4/8/04	34	68	45.5	8.80
2/1/04	34	40	37.0	2.16	4/10/04	35	72	49.0	9.78
2/2/04	34	48	38.7	4.18	4/11/04	39	74	54.3	9.53
2/3/04	31	40	36.3	2.92	4/12/04	36	73	53.5	10.83
2/4/04	35	42	38.5	2.45	4/13/04	37	75	50.7	8.84
2/5/04	33	40	36.9	2.41	4/14/04	38	79	53.1	10.83
2/6/04	30	42	37.8	3.52	4/15/04	36	64	50.4	7.95
2/7/04	35	42	38.5	2.45	4/17/04	42	77	57.4	9.72
2/8/04	33	39	36.0	2.16	4/19/04	45	79	58.3	9.56
2/9/04	31	41	36.4	3.11	4/20/04	43	61	51.6	5.82
2/10/04	35	41	38.0	2.16	4/22/04	42	83	58.8	12.52
2/11/04	36	41	38.5	1.87	4/23/04	42	77	57.5	9.11
2/12/04	35	41	38.0	2.16	4/24/04	31	85	59.9	13.05
2/13/04	32	50	38.5	5.37	4/26/04	47	74	61.7	8.48
2/14/04	33	39	36.0	2.16	4/27/04	42	79	61.2	8.67
2/15/04	35	42	38.5	2.45	4/28/04	46	84	63.9	8.83
2/16/04	31	41	37.1	3.18	4/29/04	45	77	64.3	8.23

Appendix 1C. Live Oak East trap 2004 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
5/1/04	41	83	59.8	9.82
5/2/04	50	72	60.8	6.31
5/3/04	44	81	64.1	10.06
5/4/04	54	87	67.9	9.08
5/5/04	44	81	63.5	8.93
5/6/04	45	81	63.8	9.46
5/8/04	52	82	64.2	7.80
5/9/04	50	78	63.1	7.47
5/10/04	58	90	70.0	8.09
5/11/04	50	82	67.1	8.78
5/12/04	53	84	70.3	8.00
5/13/04	47	89	68.8	9.61
5/15/04	52	85	68.2	9.01
5/16/04	49	83	64.9	10.14
5/17/04	49	86	70.5	9.24
5/19/04	58	89	75.0	8.23
5/20/04	60	89	76.5	7.57
5/23/04	65	91	77.1	7.54
5/24/04	61	87	74.7	7.56
5/26/04	67	96	79.6	7.83
5/28/04	54	113	82.9	13.40
5/30/04	59	107	86.8	12.87
5/31/04	72	103	84.6	8.62
6/2/04	62	100	76.5	9.98
6/3/04	53	93	72.7	10.35
6/4/04	55	94	70.8	11.12
6/5/04	56	91	76.0	9.94

Appendix 1D . Thermalito 2003 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.	Date	Min Fork	Max Fork	Avg Fork	S.D.
12/7/02	32	34	32.8	0.96	2/5/03	29	40	35.2	3.27
12/8/02	32	34	33.0	0.89	2/6/03	33	39	36.0	2.16
12/9/02	29	34	32.0	1.73	2/7/03	33	40	36.7	2.35
12/10/02	30	34	32.4	1.43	2/8/03	34	40	36.8	2.12
12/12/02	30	35	33.3	1.68	2/9/03	33	39	36.3	2.16
12/14/02	30	35	32.9	1.76	2/10/03	30	40	35.1	3.18
12/15/02	30	35	33.1	1.62	2/11/03	31	39	35.0	2.74
12/16/02	32	36	34.1	1.64	2/12/03	29	42	36.0	3.67
12/17/02	29	36	33.2	2.40	2/16/03	33	41	36.6	2.62
12/19/02	32	36	33.9	1.35	2/17/03	31	53	41.4	6.29
12/20/02	32	40	36.0	2.74	2/18/03	30	55	37.9	6.86
12/21/02	30	37	33.7	2.10	2/19/03	31	43	36.2	3.39
12/22/02	32	37	34.6	1.67	2/20/03	31	40	35.5	3.03
12/23/02	31	37	34.6	1.86	2/21/03	35	42	38.1	2.41
12/29/02	32	39	35.2	2.30	2/22/03	32	41	36.5	3.03
12/30/02	30	39	34.3	2.77	2/23/03	30	40	35.0	3.32
12/31/02	33	39	36.0	2.16	2/25/03	32	43	36.8	3.43
1/1/03	31	39	35.3	2.57	2/26/03	30	50	37.6	5.90
1/2/03	32	40	35.7	2.75	2/27/03	34	41	37.1	2.41
1/3/03	31	39	35.4	2.73	3/1/03	31	43	35.8	3.61
1/5/03	31	40	35.3	2.58	3/2/03	34	40	37.0	2.16
1/6/03	31	40	35.8	2.54	3/3/03	33	56	40.1	6.14
1/7/03	33	40	36.2	2.44	3/4/03	32	40	36.0	2.74
1/8/03	32	40	36.0	2.58	3/5/03	29	50	37.9	5.70
1/9/03	31	40	35.9	2.93	3/6/03	30	56	39.4	6.84
1/10/03	30	40	35.8	2.97	3/8/03	33	47	38.5	4.74
1/11/03	28	39	35.0	3.24	3/10/03	30	39	34.8	3.07
1/12/03	30	39	35.6	2.77	3/11/03	31	58	38.8	7.50
1/13/03	30	39	34.9	2.77	3/12/03	30	59	40.1	8.92
1/14/03	34	40	37.0	2.16	3/13/03	31	56	41.4	7.82
1/15/03	34	43	37.8	2.92	3/15/03	32	65	42.0	9.07
1/16/03	32	40	36.4	2.67	3/16/03	32	50	41.1	5.42
1/17/03	32	39	35.6	2.33	3/17/03	33	59	44.1	7.96
1/18/03	31	41	35.4	3.14	3/18/03	32	56	42.8	8.84
1/19/03	32	40	36.0	2.74	3/19/03	29	64	44.2	10.72
1/20/03	28	39	34.3	3.40	3/21/03	32	63	44.4	8.98
1/21/03	31	40	35.5	2.88	3/22/03	33	62	45.2	8.77
1/22/03	32	40	36.0	2.74	3/24/03	33	60	44.7	8.90
1/23/03	34	42	38.0	2.74	3/25/03	32	62	44.6	10.13
1/24/03	29	39	35.1	3.18	3/26/03	33	58	45.8	8.68
1/25/03	34	40	37.0	2.16	3/27/03	34	48	38.4	5.59
1/26/03	31	41	36.3	3.07	3/29/03	35	40	37.5	3.54
1/27/03	32	40	36.0	2.74	3/31/03	33	56	39.3	7.70
1/28/03	30	40	35.0	3.16	4/1/03	36	39	37.3	1.53
1/29/03	32	40	35.8	2.66	4/3/03	34	61	47.3	9.75
1/30/03	30	41	35.9	3.53	4/5/03	34	72	49.5	15.71
1/31/03	31	40	35.8	3.07	4/7/03	35	72	55.2	12.43
2/1/03	31	40	35.9	2.93	4/9/03	31	66	50.0	13.27
2/2/03	31	40	36.1	3.04	4/10/03	37	68	51.4	10.47
2/3/03	31	39	34.8	2.66	4/12/03	43	56	49.5	9.19
2/4/03	33	39	36.0	2.16	4/14/03	35	63	50.3	8.39

Appendix 1D . Thermalito 2003 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/15/03	33	78	55.6	13.36
4/16/03	34	34	34.0	
4/17/03	34	65	55.3	11.47
4/18/03	40	88	71.7	27.43
4/19/03	38	72	57.6	12.86
4/21/03	52	80	65.3	9.87
4/23/03	49	78	70.2	12.03
4/24/03	51	81	67.8	9.85
4/26/03	46	87	64.2	11.84
4/28/03	46	77	62.9	9.89
4/29/03	44	81	66.0	12.14
4/30/03	50	85	67.1	11.54
5/1/03	50	84	68.5	11.64
5/3/03	66	82	76.3	8.96
5/5/03	58	75	66.5	12.02
5/6/03	48	80	67.1	10.20
5/10/03	57	88	77.6	9.53
5/12/03	61	85	72.8	12.01
5/13/03	67	79	73.0	8.49
5/14/03	81	82	81.5	0.71
5/15/03	49	90	72.0	15.52
5/19/03	60	66	63.0	4.24
5/20/03	78	78	78.0	
5/21/03	67	86	78.5	8.89
5/22/03	60	90	75.0	21.21
5/26/03	71	79	74.0	4.36
5/28/03	55	95	76.0	20.07
5/29/03	81	81	81.0	
6/9/03	78	105	90.4	11.55
6/11/03	78	92	86.2	4.37
6/18/03	87	92	90.0	2.16
6/21/03	70	90	80.0	14.14

Appendix 1E. Live Oak 2003 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.	Date	Min Fork	Max Fork	Avg Fork	S.D.
12/5/02	31	33	32.0	1.00	2/8/03	33	43	37.0	3.06
12/7/02	33	33	33.0	0.00	2/9/03	32	52	37.6	5.68
12/8/02	31	34	32.6	1.14	2/10/03	35	41	38.0	2.16
12/9/02	31	34	32.9	1.21	2/14/03	34	44	38.5	3.08
12/10/02	32	34	33.3	1.15	2/20/03	33	44	38.5	3.37
12/12/02	32	35	33.6	1.27	2/21/03	33	49	39.7	4.45
12/14/02	31	35	33.3	1.50	2/25/03	32	46	38.4	4.43
12/16/02	33	36	34.5	1.29	2/26/03	34	48	39.4	4.06
12/17/02	32	37	34.7	1.58	2/27/03	34	45	38.4	3.50
12/19/02	31	36	34.0	1.51	3/1/03	32	44	38.1	3.75
12/21/02	31	37	34.2	1.93	3/2/03	31	58	39.7	6.79
12/22/02	31	37	34.4	1.78	3/3/03	34	47	39.9	4.23
12/23/02	32	37	34.6	1.69	3/4/03	31	57	40.1	8.77
12/29/02	33	39	36.0	2.00	3/6/03	31	42	36.9	3.48
12/30/02	32	39	35.3	2.35	3/8/03	33	58	40.4	6.31
12/31/02	32	39	36.0	2.27	3/10/03	32	49	40.3	5.11
1/1/03	32	40	36.0	2.74	3/11/03	31	60	41.9	9.27
1/2/03	30	39	35.6	2.60	3/12/03	33	61	40.8	8.03
1/3/03	31	39	35.6	2.50	3/13/03	32	56	41.4	7.13
1/4/03	31	39	34.9	2.43	3/15/03	34	61	44.1	8.39
1/5/03	30	40	35.7	3.28	3/16/03	34	59	44.4	7.67
1/6/03	31	40	36.2	2.48	3/17/03	33	56	41.9	6.46
1/7/03	32	39	35.4	2.30	3/18/03	32	58	43.8	8.55
1/9/03	31	39	35.7	2.69	3/19/03	32	61	45.1	9.08
1/10/03	30	40	35.0	3.16	3/21/03	33	54	42.3	7.18
1/11/03	30	40	35.3	3.33	3/22/03	34	61	44.4	9.22
1/12/03	34	41	37.5	2.45	3/23/03	33	65	42.8	11.09
1/13/03	32	40	36.3	2.76	3/24/03	32	58	42.1	7.92
1/14/03	32	41	37.0	2.83	3/26/03	30	59	42.4	9.69
1/16/03	35	42	38.5	2.45	3/27/03	33	68	45.3	11.52
1/17/03	34	41	37.5	2.45	3/29/03	32	66	46.7	11.65
1/18/03	34	40	37.0	2.16	3/31/03	32	67	47.0	10.01
1/19/03	33	41	36.8	2.44	4/1/03	33	68	50.1	11.80
1/20/03	32	42	36.5	3.07	4/2/03	33	70	52.2	12.13
1/21/03	33	41	36.8	2.66	4/3/03	36	69	54.6	10.16
1/22/03	35	46	39.3	3.39	4/5/03	35	71	57.8	12.34
1/23/03	31	39	35.3	2.82	4/7/03	34	75	56.7	11.33
1/24/03	29	41	35.6	3.91	4/8/03	35	70	56.1	10.68
1/25/03	34	41	37.2	2.44	4/9/03	35	75	60.7	12.41
1/26/03	32	41	36.5	3.03	4/10/03	35	75	58.7	10.13
1/28/03	32	40	37.1	2.37	4/12/03	50	78	66.3	7.49
1/29/03	33	40	36.6	2.30	4/14/03	47	79	65.2	8.77
1/30/03	32	41	36.9	2.93	4/15/03	38	79	66.0	9.76
1/31/03	32	40	35.8	2.66	4/16/03	54	80	68.8	8.03
2/1/03	32	41	36.8	2.64	4/17/03	65	79	71.3	6.13
2/2/03	34	48	38.9	4.49	4/19/03	38	81	66.3	10.17
2/3/03	32	41	36.5	3.03	4/21/03	55	83	73.0	7.34
2/4/03	29	41	35.0	3.46	4/23/03	58	84	73.8	7.97
2/5/03	29	40	34.8	3.60	4/24/03	68	83	75.3	4.83
2/6/03	31	40	35.5	3.03	4/26/03	57	87	73.2	8.59
2/7/03	32	45	38.1	4.03	4/28/03	60	86	74.5	6.76

Appendix 1E. Live Oak 2003 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/29/03	58	87	75.6	8.10
4/30/03	60	88	76.2	7.60
5/1/03	69	85	77.3	4.77
5/3/03	45	89	77.1	10.96
5/5/03	61	90	80.4	7.03
5/6/03	71	91	80.4	6.01
5/8/03	65	92	81.2	7.51
5/12/03	58	58	58.0	
5/13/03	58	91	73.9	9.56
5/14/03	48	95	73.1	13.09
5/15/03	58	92	73.6	11.76
5/17/03	55	82	64.4	8.94
5/19/03	74	88	80.6	5.64
5/20/03	88	88	88.0	
5/21/03	64	88	75.3	9.84
5/22/03	73	73	73.0	
5/26/03	69	77	73.0	5.66
5/29/03	81	81	81.0	
6/2/03	80	90	85.0	5.00

Appendix 1F. Thermalito 2002 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.	Date	Min Fork	Max Fork	Avg Fork
12/2/01	26	32	29.2	2.17	2/4/02	33	39	36.0
12/4/01	28	33	31.0	1.83	2/5/02	32	40	35.9
12/5/01	27	33	30.5	1.84	2/6/02	33	40	36.5
12/7/01	26	33	30.4	2.29	2/7/02	33	40	36.1
12/8/01	27	34	31.1	2.22	2/8/02	33	43	37.2
12/10/01	30	34	31.7	1.34	2/9/02	33	39	35.9
12/12/01	30	35	32.5	1.58	2/10/02	34	40	37.0
12/14/01	29	35	32.2	1.75	2/11/02	32	40	36.4
12/15/01	30	35	32.5	1.60	2/13/02	34	48	38.1
12/17/01	28	36	32.1	2.24	2/14/02	33	39	36.0
12/18/01	30	36	32.8	1.69	2/15/02	34	39	36.3
12/19/01	29	36	32.6	2.15	2/16/02	33	40	36.5
12/20/01	31	36	33.1	1.73	2/17/02	32	39	35.8
12/21/01	30	35	32.6	1.71	2/19/02	32	40	36.4
12/22/01	31	37	33.8	1.83	2/20/02	34	40	36.9
12/23/01	30	36	33.0	1.86	2/21/02	34	39	36.5
12/27/01	31	36	33.0	1.68	2/22/02	34	40	37.0
12/28/01	31	38	34.3	2.02	2/23/02	31	40	36.1
12/29/01	32	37	34.4	1.80	2/25/02	33	40	36.5
12/30/01	31	37	34.2	1.83	2/26/02	35	40	37.5
12/31/01	29	37	33.8	2.21	2/27/02	33	55	40.3
1/2/02	31	38	34.4	2.11	2/28/02	35	40	37.0
1/3/02	31	38	34.4	2.18	3/1/02	32	41	36.6
1/4/02	32	37	34.4	1.72	3/2/02	32	41	36.4
1/5/02	32	38	35.0	2.16	3/3/02	33	39	36.0
1/6/02	31	37	33.9	1.90	3/4/02	29	40	35.7
1/7/02	32	38	34.9	2.03	3/5/02	33	44	37.7
1/9/02	31	38	34.4	2.22	3/6/02	34	50	39.2
1/10/02	31	39	35.1	2.50	3/7/02	34	50	39.7
1/11/02	31	38	34.2	2.12	3/8/02	32	58	39.9
1/12/02	30	39	34.6	2.95	3/9/02	33	45	37.6
1/13/02	32	38	34.4	2.07	3/10/02	33	44	38.1
1/14/02	32	38	35.0	2.16	3/11/02	34	56	40.1
1/16/02	31	38	34.5	2.07	3/12/02	33	47	39.0
1/17/02	32	38	34.6	2.26	3/13/02	31	58	37.9
1/18/02	34	40	37.0	2.16	3/14/02	32	40	35.5
1/19/02	31	38	34.5	2.45	3/15/02	34	59	40.6
1/20/02	33	39	36.0	2.16	3/16/02	30	56	38.8
1/22/02	30	41	37.0	3.46	3/17/02	32	40	35.6
1/23/02	33	39	35.4	2.19	3/18/02	33	65	41.4
1/24/02	32	38	34.9	2.03	3/19/02	32	55	40.3
1/25/02	32	39	35.3	2.21	3/20/02	33	54	39.5
1/26/02	32	38	35.0	2.00	3/21/02	33	43	36.6
1/27/02	33	38	35.5	1.87	3/22/02	30	42	36.0
1/28/02	33	40	36.5	2.45	3/23/02	32	48	36.1
1/29/02	34	38	36.0	1.58	3/24/02	32	43	36.1
1/30/02	34	39	36.5	1.87	3/25/02	33	39	36.0
1/31/02	33	38	35.5	1.87	3/27/02	32	44	36.0
2/1/02	33	40	36.5	2.45	3/28/02	31	54	38.3
2/2/02	32	40	36.1	2.62	3/29/02	32	55	41.4
2/3/02	33	39	36.0	2.16	3/30/02	34	42	37.3

Appendix 1F. Thermalito 2002 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/2/02	34	60	42.0	12.11
4/3/02	33	56	39.1	6.90
4/4/02	34	52	40.7	7.79
4/5/02	35	36	35.5	0.71
4/7/02	35	45	38.7	5.51
4/9/02	33	51	39.7	9.87
4/10/02	43	66	57.3	12.50
4/11/02	41	52	47.0	5.57
4/12/02	36	55	42.0	8.83
4/13/02	36	71	51.8	15.93
4/17/02	40	80	58.5	14.40
4/18/02	39	78	58.1	11.39
4/19/02	41	64	56.5	8.17
4/20/02	42	70	56.9	9.87
4/22/02	43	62	55.0	8.51
4/23/02	46	78	60.6	9.41
4/24/02	45	60	53.3	7.64
4/26/02	41	72	57.4	9.86
4/27/02	60	64	61.7	2.08
4/29/02	48	73	60.8	7.96
4/30/02	42	76	58.9	9.45
5/1/02	47	61	54.0	9.90
5/2/02	61	80	70.5	13.44
5/3/02	48	72	64.3	10.97
5/7/02	70	74	72.0	2.83
5/9/02	54	81	67.7	8.41
5/10/02	55	82	70.8	8.43
5/13/02	53	88	70.5	11.54
5/17/02	56	80	70.4	6.95
5/20/02	64	84	74.4	7.50
5/22/02	68	86	77.0	6.57
5/24/02	54	88	72.8	10.11
5/31/02	71	82	76.5	7.78
6/5/02	69	93	83.0	10.36
6/7/02	89	89	89.0	
6/12/02	82	82	82.0	
6/13/02	79	90	84.5	7.78
6/14/02	63	84	73.3	10.50

Appendix 1G. Live Oak 2002 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/10/2001	31	31	31.0	
12/12/2001	31	32	31.5	0.71
12/14/2001	33	33	33.0	
12/15/2001	31	34	32.7	1.53
12/17/2001	31	35	33.0	1.58
12/18/2001	32	34	33.0	1.00
12/19/2001	32	35	33.5	2.12
12/20/2001	34	36	35.0	1.41
12/22/2001	32	35	33.2	1.30
12/23/2001	31	35	33.0	1.58
12/27/2001	30	36	33.0	2.94
12/28/2001	33	38	35.5	1.87
12/29/2001	31	37	33.8	2.32
12/30/2001	32	32	32.0	0.00
12/31/2001	32	37	34.4	1.72
1/10/2002	33	38	35.0	1.85
1/11/2002	32	39	35.2	2.44
1/12/2002	33	39	35.8	2.12
1/13/2002	33	39	36.0	2.16
1/14/2002	33	40	36.5	2.45
1/17/2002	32	39	35.9	2.41
1/18/2002	35	41	38.0	2.16
1/19/2002	33	42	36.8	2.92
1/20/2002	33	40	36.5	2.45
1/22/2002	32	39	35.9	2.41
1/23/2002	33	39	36.0	2.16
1/24/2002	33	39	36.1	2.03
1/25/2002	33	40	36.5	2.45
1/26/2002	34	38	36.0	1.58
1/27/2002	34	40	37.0	2.16
1/28/2002	34	39	36.5	1.87
1/29/2002	32	40	36.4	2.67
1/30/2002	33	40	36.5	2.45
1/31/2002	32	39	35.9	2.41
2/1/2002	35	39	37.0	1.58
2/2/2002	34	41	37.1	2.41
2/3/2002	32	40	36.4	2.67
2/4/2002	31	40	35.5	3.03
2/5/2002	33	41	36.6	2.67
2/6/2002	34	210	55.9	57.83
2/7/2002	33	39	36.0	2.16
2/8/2002	34	40	36.8	2.12
2/9/2002	32	40	36.0	2.74
2/10/2002	34	40	37.0	2.16
2/11/2002	33	40	36.5	2.45
2/13/2002	33	44	37.5	3.33
2/14/2002	34	40	37.0	2.16
2/15/2002	34	40	37.0	2.16
2/16/2002	33	41	36.6	2.67
2/17/2002	34	41	37.5	2.45
2/19/2002	34	40	37.0	2.16
2/20/2002	33	40	36.5	2.45
2/21/2002	34	40	37.0	2.16
2/22/2002	31	40	35.8	3.07
2/23/2002	34	40	37.0	2.16
2/26/2002	33	40	36.5	2.45
2/27/2002	28	57	41.4	9.83
2/28/2002	35	41	37.8	2.12
3/1/2002	32	40	36.1	2.60
3/2/2002	33	40	36.1	2.57
3/3/2002	30	40	35.5	3.08
3/4/2002	32	41	36.2	2.82
3/5/2002	34	47	39.0	4.90
3/6/2002	34	56	39.8	6.67
3/7/2002	32	54	41.5	6.66
3/8/2002	34	62	44.3	10.28
3/9/2002	33	40	36.5	2.45
3/10/2002	34	55	40.9	7.34
3/11/2002	33	44	37.0	3.46
3/12/2002	33	38	35.5	1.87
3/13/2002	33	46	37.6	3.75
3/14/2002	33	45	37.5	4.11
3/15/2002	33	62	42.9	11.20
3/16/2002	31	40	35.9	2.93
3/17/2002	30	39	35.3	2.92
3/18/2002	31	64	41.6	10.99
3/19/2002	33	56	41.4	8.75
3/20/2002	33	54	40.3	7.48
3/21/2002	31	61	41.0	10.07
3/22/2002	33	62	43.5	9.16
3/23/2002	32	50	39.4	6.52
3/24/2002	33	52	41.6	6.73
3/25/2002	32	54	41.5	7.38
3/26/2002	33	65	43.6	11.22
3/27/2002	32	70	42.1	10.39
3/28/02	31	62	39.3	8.86
3/29/02	34	50	38.8	6.53
3/30/02	33	40	36.1	2.41
4/2/02	33	39	36.0	2.16
4/3/02	33	66	48.2	10.60
4/4/02	34	74	50.2	10.99
4/5/02	33	71	49.6	11.07
4/7/02	33	74	47.2	10.84
4/9/02	42	76	57.5	9.99
4/10/02	47	80	62.4	9.59
4/11/02	36	83	58.5	11.93
4/12/02	46	78	63.5	9.22
4/13/02	49	76	64.0	8.82
4/15/02	49	77	64.0	7.51
4/17/02	45	80	65.3	9.06
4/18/02	52	81	68.4	8.84
4/19/02	48	81	66.0	9.46

Appendix 1G. Live Oak 2002 daily fall-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/20/02	51	82	66.4	8.74
4/22/02	53	80	68.8	8.02
4/23/02	47	82	66.9	8.87
4/24/02	54	83	67.7	7.97
4/26/02	58	75	68.3	7.94
4/29/02	54	86	72.8	8.52
4/30/02	52	85	70.9	9.73
5/1/02	60	87	72.8	8.24
5/2/02	67	86	76.7	5.08
5/3/02	60	90	74.5	8.33
5/8/02	53	85	72.1	8.13
5/13/02	64	89	78.4	6.72
5/15/02	70	86	77.9	5.11
5/17/02	69	87	79.2	6.85
5/22/02	74	74	74.0	
5/31/02	70	79	74.5	6.36
6/12/02	82	92	87.0	7.07
6/14/02	84	84	84.0	

Appendix 1H. Thermalito trap 2004 daily spring-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/11/03	35	37	35.8	0.96
12/13/03	36	38	37.0	1.00
12/15/03	36	36	36.0	0.00
12/16/03	37	38	37.5	0.71
12/17/03	37	37	37.0	0.00
12/18/03	38	38	38.0	
12/20/03	38	38	38.0	
12/22/03	38	39	38.5	0.71
12/24/03	39	40	39.5	0.71
12/26/03	39	40	39.5	0.71
12/27/03	39	40	39.5	0.71
1/2/04	44	53	48.5	6.36
1/7/04	42	42	42.0	
1/12/04	50	50	50.0	
1/20/04	53	53	53.0	
1/24/04	50	50	50.0	
2/3/04	53	53	53.0	
2/5/04	55	55	55.0	
2/18/04	56	56	56.0	
2/19/04	62	62	62.0	
2/20/04	57	59	58.0	1.41
2/28/04	68	68	68.0	
3/1/04	64	64	64.0	
3/11/04	69	69	69.0	
3/14/04	70	70	70.0	
4/20/04	83	83	83.0	
4/29/04	90	90	90.0	
5/20/04	102	102	102.0	

Appendix 1I. Live Oak West trap 2004 daily spring-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/13/03	36	39	37.3	1.53
12/15/03	36	39	37.5	1.29
12/16/03	34	38	36.2	1.48
12/17/03	37	38	37.5	0.71
12/18/03	37	37	37.0	
12/20/03	38	40	39.0	1.00
12/22/03	38	38	38.0	
12/29/03	40	40	40.0	
12/30/03	40	40	40.0	
12/31/03	45	45	45.0	
1/13/04	56	56	56.0	
1/15/04	45	46	45.5	0.71
1/22/04	48	48	48.0	
1/24/04	48	48	48.0	
1/26/04	48	57	51.7	4.73
1/27/04	50	58	53.0	3.56
1/29/04	49	60	54.4	5.03
1/31/04	55	55	55.0	
2/1/04	52	56	54.0	2.83
2/2/04	55	55	55.0	
2/3/04	52	52	52.0	
2/4/04	55	62	57.7	3.79
2/5/04	51	60	55.5	6.36
2/8/04	58	58	58.0	
2/10/04	55	58	56.5	2.12
2/11/04	56	57	56.5	0.71
2/12/04	60	60	60.0	
2/17/04	57	57	57.0	
2/18/04	56	72	62.4	6.23
2/19/04	64	68	65.7	2.08
3/8/04	64	65	64.5	0.71
3/14/04	69	70	69.5	0.71
3/17/04	67	70	68.3	1.53
3/26/04	71	71	71.0	
3/27/04	74	74	74.0	
3/28/04	74	74	74.0	
3/31/04	77	83	80.0	4.24
4/3/04	80	80	80.0	
5/28/04	99	105	102.7	3.21
5/30/04	108	108	108.0	

Appendix 1J. Live Oak East trap 2004 daily spring-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/13/03	36	38	37.0	1.00
12/15/03	36	37	36.5	0.71
12/16/03	36	37	36.5	0.71
12/17/03	37	39	38.0	1.41
12/20/03	38	38	38.0	
12/22/03	38	38	38.0	
12/23/03	38	38	38.0	
12/24/03	39	39	39.0	
12/30/03	40	40	40.0	
1/13/04	45	45	45.0	
1/22/04	58	58	58.0	
1/23/04	54	54	54.0	
1/24/04	55	55	55.0	
1/26/04	51	57	54.0	4.24
1/27/04	49	69	57.7	10.26
1/29/04	51	51	51.0	
1/31/04	50	53	51.5	2.12
2/2/04	53	53	53.0	
2/3/04	51	51	51.0	
2/5/04	51	51	51.0	
2/10/04	57	57	57.0	
2/13/04	63	63	63.0	
2/17/04	60	64	62.0	1.83
2/18/04	56	70	62.5	4.57
2/21/04	59	59	59.0	
2/22/04	66	66	66.0	
3/4/04	63	63	63.0	
3/5/04	63	67	65.0	2.83
3/6/04	63	70	66.0	3.61
3/9/04	66	66	66.0	
3/11/04	64	64	64.0	
3/12/04	68	68	68.0	
3/13/04	71	71	71.0	
3/14/04	69	70	69.5	0.71
3/15/04	67	67	67.0	
3/21/04	68	68	68.0	
3/25/04	74	74	74.0	
4/1/04	74	84	77.7	5.51
4/6/04	79	79	79.0	
4/7/04	91	91	91.0	
4/10/04	78	79	78.5	0.71
4/13/04	79	79	79.0	
4/15/04	84	86	85.0	1.41
4/19/04	84	86	85.0	1.41
4/22/04	86	101	93.0	4.85
4/23/04	88	88	88.0	
4/26/04	90	96	93.3	3.06
4/27/04	87	87	87.0	
4/28/04	89	89	89.0	
4/29/04	95	97	96.0	1.41
5/1/04	93	93	93.0	
5/2/04	94	94	94.0	
5/3/04	95	95	95.0	
5/5/04	94	94	94.0	
5/8/04	96	96	96.0	
5/13/04	104	104	104.0	
5/30/04	109	110	109.5	0.71

Appendix 1K. Thermalito trap 2002-2003 daily spring-run-size fork length and standard deviation.

2002

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/2/01	33	33	33.0	
12/4/01	34	37	35.5	2.12
12/5/01	34	35	34.5	0.71
12/7/01	34	35	34.3	0.58
12/8/01	36	37	36.5	0.71
12/10/01	35	37	35.8	0.96
12/12/01	36	36	36.0	
12/14/01	37	37	37.0	
12/19/01	38	38	38.0	
1/23/02	54	54	54.0	
1/27/02	48	48	48.0	
1/30/02	49	49	49.0	
2/20/02	56	61	58.5	2.38
2/21/02	58	58	58.0	
2/25/02	61	65	63.0	2.83
2/27/02	59	59	59.0	
3/5/02	70	70	70.0	
3/6/02	64	64	64.0	
3/9/02	65	65	65.0	
3/11/02	76	76	76.0	
3/14/02	65	65	65.0	
3/15/02	69	69	69.0	
4/12/02	89	89	89.0	

2003

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/7/02	34	38	35.6	1.51
12/8/02	35	38	36.2	1.17
12/9/02	35	38	36.2	1.17
12/10/02	35	37	36.0	0.82
12/12/02	36	37	36.3	0.58
12/14/02	36	37	36.3	0.58
12/15/02	36	38	36.8	0.84
12/16/02	37	38	37.3	0.58
12/17/02	37	40	38.4	1.14
12/19/02	37	37	37.0	
12/22/02	38	40	39.0	1.41
12/23/02	38	41	39.5	1.29
12/31/02	40	40	40.0	
1/6/03	44	44	44.0	
1/11/03	51	51	51.0	
1/16/03	49	49	49.0	
1/17/03	52	52	52.0	
1/24/03	48	48	48.0	
1/26/03	51	51	51.0	
1/30/03	54	54	54.0	
2/9/03	56	56	56.0	
2/16/03	57	57	57.0	
2/17/03	58	61	59.3	1.53
2/20/03	56	56	56.0	
2/25/03	68	68	68.0	
3/11/03	66	67	66.5	0.71
3/17/03	64	64	64.0	
3/21/03	67	67	67.0	
3/22/03	70	74	72.0	2.83
3/24/03	72	72	72.0	
3/25/03	74	74	74.0	
3/31/03	87	87	87.0	
4/1/03	74	74	74.0	
4/3/03	75	75	75.0	
4/7/03	80	80	80.0	
4/8/03	82	82	82.0	
4/15/03	82	82	82.0	
4/19/03	89	89	89.0	
4/24/03	88	88	88.0	
4/26/03	92	92	92.0	
5/22/03	105	105	105.0	

Appendix 1L. Live Oak trap 2003 daily spring-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/05/02	34	39	36.0	1.79
12/07/02	34	38	35.6	1.43
12/08/02	34	39	36.4	1.67
12/09/02	35	38	36.3	1.11
12/10/02	35	38	36.4	1.27
12/12/02	34	40	37.3	1.91
12/14/02	36	38	37.2	0.84
12/16/02	37	39	37.8	0.96
12/17/02	37	39	37.8	0.96
12/19/02	37	37	37.0	
12/21/02	38	42	40.0	2.83
12/22/02	38	38	38.0	
12/23/02	38	38	38.0	
12/29/02	42	42	42.0	
12/30/02	40	40	40.0	
01/01/03	59	59	59.0	
01/16/03	53	55	54.0	1.41
01/17/03	51	56	53.5	3.54
01/19/03	52	52	52.0	
01/28/03	53	53	53.0	
02/07/03	66	66	66.0	
02/10/03	58	58	58.0	
02/14/03	62	62	62.0	
02/20/03	57	60	58.5	2.12
02/21/03	68	68	68.0	
03/01/03	72	72	72.0	
03/03/03	62	62	62.0	
03/04/03	68	68	68.0	
03/06/03	64	65	64.5	0.71
03/08/03	64	64	64.0	
03/10/03	64	64	64.0	
03/11/03	64	78	69.7	7.37
03/12/03	64	64	64.0	
03/13/03	65	65	65.0	
03/16/03	67	72	69.0	2.65
03/17/03	70	74	72.0	2.83
03/18/03	74	74	74.0	
03/19/03	68	69	68.5	0.71
03/21/03	88	88	88.0	
03/26/03	71	72	71.5	0.71
03/29/03	75	75	75.0	
04/01/03	73	82	77.5	6.36
04/02/03	74	84	79.3	5.03
04/03/03	75	83	79.0	3.16
04/05/03	76	87	79.5	5.07
04/07/03	80	85	82.5	3.54
04/08/03	79	82	80.5	2.12
04/09/03	77	88	80.6	4.39
04/10/03	79	87	83.7	4.16
04/12/03	80	84	82.0	2.00
04/14/03	80	89	83.7	4.73
04/15/03	82	95	89.0	6.48
04/16/03	82	86	84.0	2.00
04/19/03	90	90	90.0	
04/21/03	84	101	89.0	5.89
04/23/03	85	94	89.0	3.16
04/24/03	85	93	88.2	3.13
04/26/03	88	104	94.6	7.06
04/28/03	88	93	90.3	2.22
04/29/03	88	95	90.5	3.11
04/30/03	89	93	90.8	1.71
05/01/03	89	95	92.0	4.24
05/03/03	91	97	93.3	3.21
05/05/03	93	95	94.0	1.41
05/06/03	94	108	101.3	7.02
05/08/03	94	98	96.0	1.58
05/22/03	90	105	97.5	10.61

Appendix 1M. Live Oak trap 2002 daily spring-run-size fork length and standard deviation.

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/14/01	37	37	37.0	
1/17/02	52	52	52.0	
1/19/02	59	59	59.0	
2/5/02	53	53	53.0	
2/10/02	54	54	54.0	
2/13/02	53	56	54.5	2.12
2/21/02	56	56	56.0	
2/23/02	65	65	65.0	
2/26/02	61	61	61.0	
2/28/02	61	61	61.0	
3/1/02	60	61	60.5	0.71
3/2/02	61	64	62.5	2.12
3/5/02	62	62	62.0	
3/6/02	62	73	65.8	4.99
3/9/02	63	63	63.0	
3/10/02	71	71	71.0	
3/14/02	65	67	66.0	1.00
3/16/02	66	79	70.5	5.80
3/19/02	68	68	68.0	
3/20/02	69	69	69.0	
3/29/02	72	72	72.0	
4/5/02	75	87	80.3	4.99
4/9/02	81	82	81.5	0.71
4/12/02	79	89	82.7	5.51
4/17/02	82	88	84.8	2.50
4/18/02	84	93	88.3	4.51
4/19/02	82	82	82.0	
4/20/02	85	92	88.8	3.30
4/22/02	90	90	90.0	
4/29/02	88	88	88.0	
5/2/02	91	91	91.0	
5/3/02	91	91	91.0	

Appendix 1N. Thermalito trap 2002-2004 daily late fall-run-size fork length and standard deviation.

2002

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/2/02	30	30	30.0	
4/4/02	31	31	31.0	
4/5/02	32	33	32.5	0.71
4/7/02	33	34	33.5	0.71
4/10/02	31	41	34.8	3.77
4/12/02	35	35	35.0	
4/13/02	30	35	33.0	2.16
4/15/02	36	69	48.8	14.31
4/17/02	34	36	35.0	1.00
4/18/02	33	36	34.7	1.53
4/19/02	32	36	34.3	1.71
4/20/02	34	37	35.5	1.29
4/22/02	33	35	34.0	1.00
4/23/02	34	35	34.5	0.71
4/24/02	33	36	34.5	1.29
4/26/02	33	34	33.5	0.71
5/3/02	34	34	34.0	
5/10/02	35	35	35.0	
5/13/02	34	35	34.5	0.71
5/17/02	35	35	35.0	
5/20/02	34	37	36.0	1.73
5/22/02	35	36	35.5	0.58
5/24/02	34	37	35.7	1.00

2003

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/2/03	30	32	31.0	1.41
4/3/03	32	33	32.5	0.71
4/10/03	32	35	33.7	1.53
4/12/03	34	34	34.0	
4/14/03	33	36	35.0	1.41
4/15/03	33	35	34.0	1.00
4/19/03	34	36	35.0	1.00
4/21/03	30	30	30.0	
4/26/03	35	35	35.0	
4/28/03	36	36	36.0	
4/30/03	36	36	36.0	
5/1/03	34	36	35.0	1.00
5/3/03	34	35	34.5	0.71
5/5/03	34	37	35.3	1.53
5/6/03	33	36	34.5	1.29
5/10/03	34	35	34.5	0.71
5/12/03	36	38	37.0	1.41
5/15/03	34	34	34.0	

2004

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/1/04	29	30	29.5	0.71
4/5/04	32	32	32.0	
4/12/04	35	35	35.0	
4/13/04	34	35	34.5	0.71
4/14/04	34	35	34.5	0.71
4/15/04	34	36	35.0	1.00
4/19/04	33	36	34.5	1.29
4/20/04	36	36	36.0	
4/22/04	34	37	35.3	1.53
4/24/04	34	34	34.0	
4/26/04	35	37	35.7	1.15
4/27/04	36	37	36.5	0.71
4/28/04	35	38	36.5	1.29
4/29/04	34	39	36.5	1.87
5/2/04	29	33	31.0	2.83
5/13/04	44	44	44.0	
5/17/04	35	35	35.0	
5/19/04	33	33	33.0	

Appendix 1O. Live Oak trap 2002-2004 daily late fall-run-size fork length and standard deviation.

2002

Date	Min Fork	Max Fork	Avg Fork	S.D.
12/17/01	146	158	152.0	8.49
4/7/02	33	33	33.0	
4/9/02	31	34	32.5	1.29
4/10/02	29	36	32.4	2.30
4/11/02	30	34	32.0	1.31
4/12/02	32	32	32.0	
4/13/02	32	34	32.8	0.84
4/15/02	31	34	32.3	1.11
4/17/02	30	36	33.0	2.24
4/18/02	32	34	33.0	1.00
4/22/02	33	33	33.0	
4/24/02	35	35	35.0	

2003

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/2/03	32	32	32.0	
4/10/03	33	34	33.5	0.71
4/12/03	34	35	34.3	0.58
4/14/03	33	36	34.5	1.29
4/15/03	35	35	35.0	
4/21/03	34	34	34.0	
5/8/03	36	36	36.0	
5/15/03	41	41	41.0	

2004-West

Date	Min Fork	Max Fork	Avg Fork	S.D.
4/28/04	34	37	35.3	1.53
5/6/04	34	34	34.0	
6/4/04	47	47	47.0	

2004-East

Date	Min Fork	Max Fork	Avg Fork	S.D.
1/13/04	176	176	176.0	
4/6/04	32	32	32.0	
4/8/04	32	34	33.0	1.00
4/11/04	33	35	34.0	1.00
4/12/04	32	35	33.3	1.53
4/13/04	35	36	35.5	0.71
4/14/04	35	35	35.0	
4/15/04	36	36	36.0	
4/19/04	35	35	35.0	0.00
4/20/04	34	36	35.0	1.41
4/22/04	36	36	36.0	
4/23/04	35	35	35.0	
4/26/04	34	37	35.5	1.29
4/27/04	32	36	34.2	1.79
4/28/04	37	37	37.0	
5/13/04	41	41	41.0	
5/30/04	56	56	56.0	

Appendix 2A. Confidence intervals (95%) for daily passage estimates at Thermalitio (2001-02).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
12/1/01	*	*	*	*	1/21/02	*	*	*	*
12/2/01	34	951	806	1095	1/22/02	8192	227218	180567	273869
12/3/01	*	*	*	*	1/23/02	6857	190194	151145	229244
12/4/01	15	434	368	500	1/24/02	6071	168396	133822	202970
12/5/01	49	1358	1152	1565	1/25/02	1939	53802	42755	64848
12/6/01	*	*	*	*	1/26/02	816	22657	18005	27309
12/7/01	100	2745	2327	3163	1/27/02	2528	70137	55737	84537
12/8/01	191	5219	4425	6014	1/28/02	13523	235081	192335	277828
12/9/01	*	*	*	*	1/29/02	7993	138956	113688	164223
12/10/01	312	8509	7214	9804	1/30/02	8224	142971	116974	168968
12/11/01	*	*	*	*	1/31/02	6455	112221	91815	132627
12/12/01	206	5627	4771	6484	2/1/02	1936	33669	27547	39791
12/13/01	*	*	*	*	2/2/02	6436	111891	91545	132237
12/14/01	217	5926	5024	6828	2/3/02	6190	107615	88046	127183
12/15/01	456	12424	10533	14316	2/4/02	4974	86477	70753	102202
12/16/01	*	*	*	*	2/5/02	3618	62907	51468	74345
12/17/01	787	21424	18163	24685	2/6/02	3413	59343	48552	70134
12/18/01	505	13757	11663	15851	2/7/02	1710	29741	24333	35149
12/19/01	249	6796	5762	7831	2/8/02	5079	88303	72246	104359
12/20/01	521	14192	12032	16352	2/9/02	4682	81402	66600	96204
12/21/01	665	18107	15351	20863	2/10/02	4248	73858	60428	87288
12/22/01	534	14545	12331	16759	2/11/02	2058	58681	45041	72320
12/23/01	599	16313	13830	18795	2/12/02	*	*	*	*
12/24/01	**	**	**	**	2/13/02	6222	177355	136131	218578
12/25/01	**	**	**	**	2/14/02	4210	120013	92118	147907
12/26/01	*	*	*	*	2/15/02	4784	136372	104674	168069
12/27/01	731	19901	16872	22931	2/16/02	3640	103768	79648	127887
12/28/01	452	12316	10441	14190	2/17/02	1687	48107	36925	59289
12/29/01	402	10956	9289	12624	2/18/02	*	*	*	*
12/30/01	208	5682	4817	6546	2/19/02	5026	143269	109968	176569
12/31/01	1520	41354	35059	47648	2/20/02	3609	102884	78970	126798
1/1/02	*	*	*	*	2/21/02	7023	200183	153654	246712
1/2/02	1413	38445	32593	44296	2/22/02	6129	174704	134097	215311
1/3/02	8689	236273	200310	272236	2/23/02	2064	58852	45172	72531
1/4/02	10051	175031	132169	217894	2/24/02	*	*	*	*
1/5/02	2432	42364	31990	52738	2/25/02	8212	190522	150598	230445
1/6/02	1429	24899	18802	30997	2/26/02	3900	90493	71530	109456
1/7/02	1179	20546	15515	25577	2/27/02	2442	56671	44796	68546
1/8/02	4010	69841	52738	86944	2/28/02	2989	69360	54826	83894
1/9/02	4963	86436	65269	107602	3/1/02	3484	80843	63902	97783
1/10/02	6020	104841	79167	130515	3/2/02	1983	46023	36379	55667
1/11/02	4240	73846	55762	91930	3/3/02	960	22292	17621	26963
1/12/02	3280	90992	72310	109674	3/4/02	1135	26352	20830	31874
1/13/02	3213	89134	70833	107434	3/5/02	920	21364	16887	25841
1/14/02	2505	69499	55230	83768	3/6/02	596	13848	10946	16750
1/15/02	*	*	*	*	3/7/02	1011	67738	44310	91165
1/16/02	7315	202896	161238	244554	3/8/02	1375	92102	60248	123957
1/17/02	3110	86277	68563	103991	3/9/02	351	23560	15412	31709
1/18/02	4929	136724	108653	164796	3/10/02	215	14457	9457	19457
1/19/02	4609	127850	101600	154099	3/11/02	1102	73829	48294	99363
1/20/02	5013	139054	110504	167604	3/12/02	437	29317	19177	39456

Appendix 2A. Confidence intervals (95%) for daily passage estimates at Thermalitio (2001-02).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
3/13/02	528	35408	23162	47654	4/29/02	9	9	N/A	N/A
3/14/02	443	29718	19440	39997	4/30/02	18	19	N/A	N/A
3/15/02	307	20615	13485	27745	5/1/02	3	3	N/A	N/A
3/16/02	239	16064	10508	21619	5/2/02	2	2	N/A	N/A
3/17/02	149	10039	6567	13512	5/3/02	4	4	N/A	N/A
3/18/02	403	27041	17689	36393	5/4/02	*	*	N/A	N/A
3/19/02	240	16130	10552	21709	5/5/02	*	*	N/A	N/A
3/20/02	211	14189	9282	19097	5/6/02	*	*	N/A	N/A
3/21/02	171	11512	7530	15493	5/7/02	2	2	N/A	N/A
3/22/02	210	14122	9238	19007	5/8/02	*	*	N/A	N/A
3/23/02	145	3969	3365	4573	5/9/02	18	18	N/A	N/A
3/24/02	88	2419	2051	2787	5/10/02	14	14	N/A	N/A
3/25/02	105	2881	2443	3320	5/11/02	*	*	N/A	N/A
3/26/02	*	*	*	*	5/12/02	*	*	N/A	N/A
3/27/02	205	5600	4748	6452	5/13/02	13	13	N/A	N/A
3/28/02	73	2011	1705	2317	5/14/02	*	*	N/A	N/A
3/29/02	61	1685	1428	1941	5/15/02	*	*	N/A	N/A
3/30/02	14	407	345	469	5/16/02	*	*	N/A	N/A
3/31/02	*	*	*	*	5/17/02	16	23	N/A	N/A
4/1/02	*	*	*	*	5/18/02	*	*	N/A	N/A
4/2/02	7	217	184	249	5/19/02	*	*	N/A	N/A
4/3/02	11	325	276	375	5/20/02	10	10	N/A	N/A
4/4/02	7	217	184	249	5/21/02	*	*	N/A	N/A
4/5/02	8	244	207	281	5/22/02	6	6	N/A	N/A
4/6/02	*	*	*	*	5/23/02	*	*	N/A	N/A
4/7/02	3	108	91	124	5/24/02	25	25	N/A	N/A
4/8/02	*	*	*	*	5/25/02	*	*	N/A	N/A
4/9/02	4	135	114	155	5/26/02	*	*	N/A	N/A
4/10/02	4	135	114	155	5/27/02	*	*	N/A	N/A
4/11/02	3	108	91	124	5/28/02	*	*	N/A	N/A
4/12/02	4	135	114	155	5/29/02	*	*	N/A	N/A
4/13/02	8	244	207	281	5/30/02	*	*	N/A	N/A
4/14/02	*	*	*	*	5/31/02	2	2	N/A	N/A
4/15/02	9	271	230	312	6/1/02	*	*	N/A	N/A
4/16/02	*	*	*	*	6/2/02	*	*	N/A	N/A
4/17/02	9	9	N/A	N/A	6/3/02	*	*	N/A	N/A
4/18/02	16	16	N/A	N/A	6/4/02	*	*	N/A	N/A
4/19/02	8	8	N/A	N/A	6/5/02	4	4	N/A	N/A
4/20/02	14	17	N/A	N/A	6/6/02	*	*	N/A	N/A
4/21/02	*	*	N/A	N/A	6/7/02	1	1	N/A	N/A
4/22/02	5	5	N/A	N/A	6/8/02	1	1	N/A	N/A
4/23/02	10	10	N/A	N/A	6/9/02	2	2	N/A	N/A
4/24/02	3	3	N/A	N/A	6/10/02	*	*	N/A	N/A
4/25/02	*	*	N/A	N/A	6/11/02	*	*	N/A	N/A
4/26/02	16	16	N/A	N/A	6/12/02	*	*	N/A	N/A
4/27/02	3	3	N/A	N/A	6/13/02	2	0	N/A	N/A
4/28/02	*	*	N/A	N/A					

Appendix 2B. Confidence intervals (95%) for daily passage estimates at Thermalitio (2002-03).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
12/7/02	191	4680	3745	5615	1/26/03	7656	167177	141058	193296
12/8/02	205	5021	4018	6024	1/27/03	2303	50303	42444	58162
12/9/02	221	5411	4330	6492	1/28/03	7810	170539	143895	197183
12/10/02	102	2510	2009	3012	1/29/03	4752	103773	87560	119986
12/11/02	*	*	*	*	1/30/03	5348	116786	98539	135032
12/12/02	954	23281	18629	27933	1/31/03	3889	84931	71661	98200
12/13/02	*	*	*	*	2/1/03	4778	104341	88039	120642
12/14/02	330	8068	6456	9681	2/2/03	3218	70281	59300	81261
12/15/02	696	16991	13596	20386	2/3/03	3465	75673	63850	87496
12/16/02	696	16991	13596	20386	2/4/03	3997	113828	87367	140289
12/17/02	1533	37396	29924	44868	2/5/03	4676	133160	102205	164115
12/18/02	*	*	*	*	2/6/03	466	13295	10205	16386
12/19/02	5062	123430	98768	148091	2/7/03	3825	108931	83608	134253
12/20/02	4029	98246	78616	117876	2/8/03	2269	64629	49605	79653
12/21/02	2220	54145	43326	64963	2/9/03	3895	110924	85138	136709
12/22/02	10857	264706	211816	317595	2/10/03	5034	143353	110028	176677
12/23/02	6984	170286	136262	204310	2/11/03	3776	107536	82538	132534
12/24/02	**	**	**	**	2/12/03	4692	133615	102555	164676
12/25/02	**	**	**	**	2/13/03	*	*	*	*
12/26/02	**	**	**	**	2/14/03	*	*	*	*
12/27/02	**	**	**	**	2/15/03	*	*	*	*
12/28/02	*	*	*	*	2/16/03	3281	93442	71720	115164
12/29/02	5941	144859	115915	173802	2/17/03	10830	308373	236688	380058
12/30/02	6622	100113	81672	118554	2/18/03	5761	164051	125915	202187
12/31/02	4741	71679	58476	84883	2/19/03	1835	52273	40121	64424
1/1/03	10624	160607	131023	190192	2/20/03	1415	40315	30943	49686
1/2/03	5753	86977	70955	102998	2/21/03	670	32341	23902	40780
1/3/03	5203	78663	64173	93153	2/22/03	1073	51766	38258	65273
1/4/03	*	*	*	*	2/23/03	703	33932	25078	42786
1/5/03	4991	75458	61559	89358	2/24/03	*	*	*	*
1/6/03	5928	89622	73113	106131	2/25/03	532	25690	18986	32393
1/7/03	5531	83621	68218	99024	2/26/03	956	46126	34090	58162
1/8/03	6485	98042	79982	116102	2/27/03	465	22460	16600	28321
1/9/03	2429	36731	29965	43497	2/28/03	*	*	*	*
1/10/03	2340	50041	40335	59747	3/1/03	461	22267	16457	28078
1/11/03	10325	220730	177918	263542	3/2/03	391	18893	13963	23823
1/12/03	6440	137683	110979	164388	3/3/03	373	18026	13322	22729
1/13/03	4856	103823	83686	123961	3/4/03	279	13495	9974	17016
1/14/03	12131	259336	209035	309636	3/5/03	169	8193	6055	10331
1/15/03	19785	422949	340915	504984	3/6/03	229	11085	8193	13977
1/16/03	15576	332977	268393	397560	3/7/03	*	*	*	*
1/17/03	12819	274042	220890	327195	3/8/03	187	9061	6696	11425
1/18/03	1350	35954	27890	44017	3/9/03	*	*	*	*
1/19/03	2345	62434	48432	76436	3/10/03	275	13302	9831	16773
1/20/03	4080	108608	84250	132966	3/11/03	348	16821	12432	21210
1/21/03	3402	90564	70253	110875	3/12/03	246	11904	8798	15011
1/22/03	4029	107251	83197	131304	3/13/03	144	3534	2858	4210
1/23/03	4536	99057	83581	114533	3/14/03	*	*	*	*
1/24/03	12852	280623	236779	324466	3/15/03	46	1145	926	1364
1/25/03	3927	85760	72361	99159	3/16/03	153	3753	3035	4471

Appendix 2B. Confidence intervals (95%) for daily passage estimates at Thermalitio (2002-03).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
3/17/03	116	2851	2306	3397	5/6/03	10	10	N/A	N/A
3/18/03	277	6776	5480	8073	5/7/03	*	*	N/A	N/A
3/19/03	125	3071	2483	3658	5/8/03	0	0	N/A	N/A
3/20/03	*	*	*	*	5/9/03	*	*	N/A	N/A
3/21/03	93	2291	1852	2729	5/10/03	9	9	N/A	N/A
3/22/03	77	1901	1537	2264	5/11/03	*	*	N/A	N/A
3/23/03	*	*	*	*	5/12/03	4	4	N/A	N/A
3/24/03	25	633	512	754	5/13/03	2	2	N/A	N/A
3/25/03	41	1023	827	1219	5/14/03	2	2	N/A	N/A
3/26/03	9	243	196	289	5/15/03	6	6	N/A	N/A
3/27/03	8	218	177	260	5/16/03	2	2	N/A	N/A
3/28/03	*	*	*	*	5/17/03	*	*	N/A	N/A
3/29/03	2	72	70	74	5/18/03	*	*	N/A	N/A
3/30/03	*	*	*	*	5/19/03	2	2	N/A	N/A
3/31/03	13	340	329	351	5/20/03	1	1	N/A	N/A
4/1/03	3	97	93	100	5/21/03	4	4	N/A	N/A
4/2/03	0	23			5/22/03	2	2	N/A	N/A
4/3/03	12	316	306	326	5/23/03	*	*	N/A	N/A
4/4/03	*	*	*	*	5/24/03	*	*	N/A	N/A
4/5/03	12	316	306	326	5/25/03	*	*	N/A	N/A
4/6/03	*	*	*	*	5/26/03	3	3	N/A	N/A
4/7/03	21	535	518	552	5/27/03	*	*	N/A	N/A
4/8/03	0	23			5/28/03	3	3	N/A	N/A
4/9/03	11	292	282	301	5/29/03	1	1	N/A	N/A
4/10/03	21	535	518	552	5/30/03	*	*	N/A	N/A
4/11/03	*	*	*	*	5/31/03	*	*	N/A	N/A
4/12/03	2	72	70	74	6/1/03	*	*	N/A	N/A
4/13/03	*	*	*	*	6/2/03	0	0	N/A	N/A
4/14/03	15	389	377	401	6/3/03	0	0	N/A	N/A
4/15/03	35	877	849	905	6/4/03	*	*	N/A	N/A
4/16/03	2	2	N/A	N/A	6/5/03	*	*	N/A	N/A
4/17/03	6	6	N/A	N/A	6/6/03	*	*	N/A	N/A
4/18/03	3	3	N/A	N/A	6/7/03	0	0	N/A	N/A
4/19/03	6	6	N/A	N/A	6/8/03	*	*	N/A	N/A
4/20/03	*	*	N/A	N/A	6/9/03	5	5	N/A	N/A
4/21/03	10	10	N/A	N/A	6/10/03	*	*	N/A	N/A
4/22/03	*	*	N/A	N/A	6/11/03	10	10	N/A	N/A
4/23/03	6	6	N/A	N/A	6/12/03	0	0	N/A	N/A
4/24/03	13	13	N/A	N/A	6/13/03	*	*	N/A	N/A
4/25/03	*	*	N/A	N/A	6/14/03	0	0	N/A	N/A
4/26/03	112	112	N/A	N/A	6/15/03	*	*	N/A	N/A
4/27/03	*	*	N/A	N/A	6/16/03	*	*	N/A	N/A
4/28/03	17	17	N/A	N/A	6/17/03	*	*	N/A	N/A
4/29/03	7	7	N/A	N/A	6/18/03	4	4	N/A	N/A
4/30/03	22	22	N/A	N/A	6/19/03	*	*	N/A	N/A
5/1/03	8	8	N/A	N/A	6/20/03	*	*	N/A	N/A
5/2/03	*	*	N/A	N/A	6/21/03	2	2	N/A	N/A
5/3/03	5	5	N/A	N/A	6/22/03	*	*	N/A	N/A
5/4/03	*	*	N/A	N/A	6/23/03	0	0	N/A	N/A
5/5/03	2	2	N/A	N/A					

Appendix 2C. Confidence intervals (95%) for daily passage estimates at Thermalitio (2003-04).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
12/8/03	*	*	*	*	1/25/04	*	*	*	*
12/9/03	*	*	*	*	1/26/04	9906	186611	151928	221293
12/10/03	*	*	*	*	1/27/04	1795	33829	27542	40116
12/11/03	143	3838	3002	4673	1/28/04	10250	193091	157204	228977
12/12/03	*	*	*	*	1/29/04	**	**	**	**
12/13/03	204	5464	4274	6653	1/30/04	8390	437877	300528	575226
12/14/03	*	*	*	*	1/31/04	5383	280959	192830	369087
12/15/03	1029	27456	21479	33433	2/1/04	1095	57193	39253	75133
12/16/03	648	17300	13533	21066	2/2/04	732	38250	26252	50248
12/17/03	537	14341	11219	17463	2/3/04	6597	344310	236311	452310
12/18/03	542	14474	11323	17625	2/4/04	10725	559727	384157	735296
12/19/03	*	*	*	*	2/5/04	26053	297015	253173	340856
12/20/03	453	12101	9467	14736	2/6/04	10453	119175	101584	136766
12/21/03	*	*	*	*	2/7/04	8667	98814	84228	113400
12/22/03	2807	74853	58557	91149	2/8/04	17980	204982	174725	235239
12/23/03	881	16618	12913	20323	2/9/04	16868	192306	163920	220691
12/24/03	283	5350	4157	6543	2/10/04	10792	123039	104878	141201
12/25/03	*	*	*	*	2/11/04	6535	74509	63511	85508
12/26/03	7138	134513	104521	164504	2/12/04	3819	95692	76951	114433
12/27/03	5382	101426	78812	124040	2/13/04	2083	52204	41980	62428
12/28/03	*	*	*	*	2/14/04	1351	33867	27234	40500
12/29/03	3898	73464	57084	89844	2/15/04	1425	35721	28725	42717
12/30/03	1997	37646	29252	46039	2/16/04	1395	34970	28121	41818
12/31/03	1747	32935	25592	40278	2/17/04	14476	362655	291630	433681
1/1/04	*	*	*	*	2/18/04	39409	987239	793890	1180589
1/2/04	18266	456674	357263	556085	2/19/04	59415	1583435	1238725	1928145
1/3/04	23901	597549	467471	727627	2/20/04	34602	922169	721415	1122923
1/4/04	*	*	*	*	2/21/04	8432	224738	175813	273663
1/5/04	13702	342574	268001	417147	2/22/04	2911	77604	60710	94498
1/6/04	1379	34499	26989	42009	2/23/04	1724	45970	35963	55978
1/7/04	934	23374	18286	28462	2/24/04	1190	31739	24830	38649
1/8/04	1243	31099	24329	37869	2/25/04	400	10686	8359	13012
1/9/04	*	*	*	*	2/26/04	**	**	**	**
1/10/04	8849	221249	173086	269412	2/27/04	*	*	*	*
1/11/04	*	*	*	*	2/28/04	2719	252021	161954	342088
1/12/04	20495	512399	400857	623941	2/29/04	1525	141391	90861	191921
1/13/04	5503	137599	107646	167552	3/1/04	548	50867	32688	69045
1/14/04	4795	90338	73548	107128	3/2/04	2029	188089	120870	255308
1/15/04	2535	47768	38890	56646	3/3/04	860	79775	51265	108285
1/16/04	1748	32943.8	26821	39067	3/4/04	1837	170299	109438	231161
1/17/04	2510	47297.1091	38507	56087	3/5/04	1629	151027	97053	205001
1/18/04	*	*	*	*	3/6/04	973	54105	37573	70637
1/19/04	1701	32058	26100	38017	3/7/04	1169	64993	45134	84851
1/20/04	2494	46996	38261	55730	3/8/04	1425	79213	55009	103417
1/21/04	7310	137712	112117	163306	3/9/04	1893	105211	73063	137358
1/22/04	5417	102054	83087	121022	3/10/04	2400	133375	92621	174128
1/23/04	4432	83501	67982	99020	3/11/04	1911	106211	73757	138664
1/24/04	1661	31305	25487	37123	3/12/04	109	6110	4243	7976

Appendix 2C. Confidence intervals (95%) for daily passage estimates at Thermalitio (2003-04).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
3/13/04	1197	66548	46214	86882	5/1/04	*	*	N/A	N/A
3/14/04	175	9776	6789	12763	5/2/04	2	2	N/A	N/A
3/15/04	852	53454	35552	71356	5/3/04	8	8	N/A	N/A
3/16/04	632	39667	26382	52952	5/4/04	7	7	N/A	N/A
3/17/04	486	30518	20297	40738	5/5/04	9	9	N/A	N/A
3/18/04	495	31082	20672	41491	5/6/04	1	1	N/A	N/A
3/19/04	281	17671	11753	23589	5/7/04	*	*	N/A	N/A
3/20/04	413	25943	17255	34631	5/8/04	*	*	N/A	N/A
3/21/04	260	16355	10878	21832	5/9/04	*	*	N/A	N/A
3/22/04	136	8584	5709	11459	5/10/04	1	1	N/A	N/A
3/23/04	188	11843	7877	15809	5/11/04	13	13	N/A	N/A
3/24/04	178	11216	7460	14973	5/12/04	32	32	N/A	N/A
3/25/04	87	5514	3667	7360	5/13/04	18	18	N/A	N/A
3/26/04	340	21368	14212	28525	5/14/04	*	*	N/A	N/A
3/27/04	95	6015	4001	8029	5/15/04	*	*	N/A	N/A
3/28/04	69	4386	2917	5854	5/16/04	20	20	N/A	N/A
3/29/04	82	2212	1763	2660	5/17/04	10	10	N/A	N/A
3/30/04	62	1678	1338	2019	5/18/04	*	*	N/A	N/A
3/31/04	63	1705	1359	2051	5/19/04	17	17	N/A	N/A
4/1/04	75	2025	1614	2436	5/20/04	23	23	N/A	N/A
4/2/04	*	*	*	*	5/21/04	*	*	N/A	N/A
4/3/04	75	2025	1614	2436	5/22/04	*	*	N/A	N/A
4/4/04	62	1678	1338	2019	5/23/04	34	34	N/A	N/A
4/5/04	36	985	785	1185	5/24/04	8	8	N/A	N/A
4/6/04	31	852	679	1025	5/25/04	*	*	N/A	N/A
4/7/04	9	266	212	319	5/26/04	12	12	N/A	N/A
4/8/04	*	*	*	*	5/27/04	*	*	N/A	N/A
4/9/04	*	*	*	*	5/28/04	*	*	N/A	N/A
4/10/04	2	79	63	95	5/29/04	*	*	N/A	N/A
4/11/04	4	132	105	159	5/30/04	6	6	N/A	N/A
4/12/04	9	266	212	319	5/31/04	10	10	N/A	N/A
4/13/04	10	292	233	352	6/1/04	*	*	N/A	N/A
4/14/04	13	372	297	448	6/2/04	7	7	N/A	N/A
4/15/04	22	612	488	736	6/3/04	5	5	N/A	N/A
4/16/04	*	*	N/A	N/A	6/4/04	3	3	N/A	N/A
4/17/04	5	5	N/A	N/A	6/5/04	3	3	N/A	N/A
4/18/04	*	*	N/A	N/A	6/6/04	*	*	N/A	N/A
4/19/04	27	27	N/A	N/A	6/7/04	*	*	N/A	N/A
4/20/04	30	30	N/A	N/A	6/8/04	2	2	N/A	N/A
4/21/04	*	*	N/A	N/A	6/9/04	*	*	N/A	N/A
4/22/04	30	30	N/A	N/A	6/10/04	*	*	N/A	N/A
4/23/04	*	*	N/A	N/A	6/11/04	1	1	N/A	N/A
4/24/04	5	5	N/A	N/A	6/12/04	2	2	N/A	N/A
4/25/04	*	*	N/A	N/A					
4/26/04	3	3	N/A	N/A					
4/27/04	8	8	N/A	N/A					
4/28/04	4	4	N/A	N/A					
4/29/04	1	1	N/A	N/A					
4/30/04	*	*	N/A	N/A					

Appendix 2D. Confidence intervals (95%) for daily passage estimates at Live Oak (2001-02).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
12/10/01	1	46	34	57	1/27/02	2337	41741	36869	46612
12/11/01	0	22	17	28	1/28/02	9341	209722	166411	253032
12/12/01	2	69	52	86	1/29/02	14899	334496	265417	403574
12/13/01	*	*	*	*	1/30/02	18569	416885	330792	502978
12/14/01	1	46	34	57	1/31/02	12864	288811	229167	348455
12/15/01	3	92	69	115	2/1/02	2596	58300	46260	70340
12/16/01	0	22	17	28	2/2/02	8262	185499	147190	223807
12/17/01	8	209	157	260	2/3/02	15601	350255	277922	422588
12/18/01	3	92	69	115	2/4/02	10851	243620	193309	293932
12/19/01	2	69	52	86	2/5/02	6399	143675	114004	173347
12/20/01	2	69	52	86	2/6/02	4503	101111	80230	121992
12/21/01	*	*	*	*	2/7/02	3364	75541	59941	91142
12/22/01	8	209	157	260	2/8/02	7372	165519	131337	199701
12/23/01	9	232	174	289	2/9/02	8817	197958	157077	238839
12/24/01	8	209	157	260	2/10/02	8532	191560	152000	231120
12/25/01	8	209	157	260	2/11/02	7764	242291	183400	301183
12/26/01	8	209	157	260	2/12/02	*	*	*	*
12/27/01	5	139	104	173	2/13/02	8414	262573	198752	326394
12/28/01	9	232	174	289	2/14/02	8929	278643	210916	346370
12/29/01	8	209	157	260	2/15/02	16850	525803	398001	653604
12/30/01	3	92	69	115	2/16/02	12009	374749	283662	465835
12/31/01	15	372	279	464	2/17/02	9068	282980	214199	351761
1/1/02	**	**	**	**	2/18/02	*	*	*	*
1/2/02	**	**	**	**	2/19/02	7090	221260	167481	275040
1/3/02	**	**	**	**	2/20/02	11102	346447	262240	430655
1/4/02	**	**	**	**	2/21/02	24216	755645	571978	939312
1/5/02	**	**	**	**	2/22/02	33658	1050265	794988	1305542
1/6/02	**	**	**	**	2/23/02	22390	698668	528850	868486
1/7/02	**	**	**	**	2/24/02	24068	751027	568482	933572
1/8/02	**	**	**	**	2/25/02	24068	622355	484299	760410
1/9/02	*	*	*	*	2/26/02	23012	595049	463051	727048
1/10/02	784	18276	13731	22822	2/27/02	17213	445104	346368	543840
1/11/02	847	19743	14833	24653	2/28/02	22703	587060	456834	717285
1/12/02	675	15739	11824	19653	3/1/02	17021	440139	342504	537774
1/13/02	681	15878	11929	19827	3/2/02	19355	500490	389468	611512
1/14/02	269	6286	4722	7849	3/3/02	15863	410197	319204	501189
1/15/02	**	**	**	**	3/4/02	11075	286393	222863	349922
1/16/02	*	*	*	*	3/5/02	6321	163468	127206	199729
1/17/02	5312	94855	83784	105926	3/6/02	5879	152039	118313	185765
1/18/02	4468	79787	70474	89099	3/7/02	5873	166485	127805	205165
1/19/02	6033	107727	95154	120301	3/8/02	6080	172352	132309	212395
1/20/02	5719	102121	90202	114041	3/9/02	4816	136527	104807	168246
1/21/02	*	*	*	*	3/10/02	2201	62410	47910	76910
1/22/02	10365	185069	163468	206670	3/11/02	4059	115071	88336	141806
1/23/02	15764	281461	248609	314312	3/12/02	3695	104754	80417	129092
1/24/02	12800	228543	201868	255217	3/13/02	2527	71650	55003	88296
1/25/02	4366	77966	68866	87065	3/14/02	3960	207847	116855	298839
1/26/02	1699	30350	26808	33892	3/15/02	2182	114549	64401	164697

Appendix 2D. Confidence intervals (95%) for daily passage estimates at Live Oak (2001-02).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
3/16/02	1873	98335	55285	141384	5/3/02	50	50	N/A	N/A
3/17/02	990	52000	29235	74765	5/4/02	*	*	N/A	N/A
3/18/02	941	49429	27790	71069	5/5/02	*	*	N/A	N/A
3/19/02	789	41453	23306	59601	5/6/02	*	*	N/A	N/A
3/20/02	539	28335	15930	40739	5/7/02	1	1	N/A	N/A
3/21/02	211	11123	6254	15993	5/8/02	41	41	N/A	N/A
3/22/02	270	14219	7994	20444	5/9/02	*	*	N/A	N/A
3/23/02	420	9801	7361	12242	5/10/02	*	*	N/A	N/A
3/24/02	490	11431	8585	14278	5/11/02	*	*	N/A	N/A
3/25/02	568	13247	9949	16546	5/12/02	*	*	N/A	N/A
3/26/02	383	8940	6714	11166	5/13/02	50	50	N/A	N/A
3/27/02	407	9499	7133	11864	5/14/02	*	*	N/A	N/A
3/28/02	225	5261	3951	6571	5/15/02	24	24	N/A	N/A
3/29/02	254	5936	4458	7414	5/16/02	*	*	N/A	N/A
3/30/02	50	1186	891	1482	5/17/02	10	10	N/A	N/A
3/31/02	*	*	*	*	5/18/02	0	0	N/A	N/A
4/1/02	*	*	*	*	5/19/02	*	*	N/A	N/A
4/2/02	344	8032	6032	10032	5/20/02	*	*	N/A	N/A
4/3/02	189	4423	3322	5524	5/21/02	*	*	N/A	N/A
4/4/02	94	2211	1660	2761	5/22/02	1	1	N/A	N/A
4/5/02	107	2514	1888	3140	5/23/02	*	*	N/A	N/A
4/6/02	*	*	*	*	5/24/02	*	*	N/A	N/A
4/7/02	38	907	681	1133	5/25/02	*	*	N/A	N/A
4/8/02	*	*	*	*	5/26/02	*	*	N/A	N/A
4/9/02	36	860	646	1075	5/27/02	*	*	N/A	N/A
4/10/02	39	930	699	1162	5/28/02	*	*	N/A	N/A
4/11/02	34	814	611	1017	5/29/02	*	*	N/A	N/A
4/12/02	50	1186	891	1482	5/30/02	*	*	N/A	N/A
4/13/02	67	1582	1188	1976	5/31/02	2	2	N/A	N/A
4/14/02	39	930	699	1162	6/1/02	*	*	N/A	N/A
4/15/02	50	1186	891	1482	6/2/02	*	*	N/A	N/A
4/16/02	25	25	N/A	N/A	6/3/02	*	*	N/A	N/A
4/17/02	50	50	N/A	N/A	6/4/02	*	*	N/A	N/A
4/18/02	106	106	N/A	N/A	6/5/02	*	*	N/A	N/A
4/19/02	49	49	N/A	N/A	6/6/02	*	*	N/A	N/A
4/20/02	34	34	N/A	N/A	6/7/02	*	*	N/A	N/A
4/21/02	*	*	N/A	N/A	6/8/02	*	*	N/A	N/A
4/22/02	40	40	N/A	N/A	6/9/02	*	*	N/A	N/A
4/23/02	39	39	N/A	N/A	6/10/02	*	*	N/A	N/A
4/24/02	17	17	N/A	N/A	6/11/02	*	*	N/A	N/A
4/25/02	*	*	N/A	N/A	6/12/02	2	2	N/A	N/A
4/26/02	7	7	N/A	N/A	6/13/02	*	*	N/A	N/A
4/27/02	*	*	N/A	N/A	6/14/02	4	4	N/A	N/A
4/28/02	*	*	N/A	N/A					
4/29/02	21	21	N/A	N/A					
4/30/02	26	26	N/A	N/A					
5/1/02	51	51	N/A	N/A					
5/2/02	24	24	N/A	N/A					

Appendix 2E. Confidence intervals (95%) for daily passage estimates at Live Oak (2002-03).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
12/5/02	7	222	150	294	1/24/03	5180	125841	98950	152732
12/6/02	*	*	*	*	1/25/03	6372	154794	121715	187872
12/7/02	13	389	264	515	1/26/03	8071	196061	154164	237958
12/8/02	87	2453	1662	3244	1/27/03	*	*	*	*
12/9/02	46	1310	887	1732	1/28/03	18731	454983	357757	552210
12/10/02	76	2146	1454	2838	1/29/03	10545	256152	201415	310890
12/11/02	*	*	*	*	1/30/03	10104	238158	190535	285781
12/12/02	318	8894	6026	11761	1/31/03	11188	263706	210975	316437
12/13/02	*	*	*	*	2/1/03	10626	250461	200378	300543
12/14/02	149	4181	2833	5530	2/2/03	11606	273558	218856	328259
12/15/02	0	27	27	27	2/3/03	12719	299789	239843	359736
12/16/02	568	15864	10749	20980	2/4/03	10215	240774	192628	288920
12/17/02	884	24675	16719	32632	2/5/03	9033	212916	170341	255491
12/18/02	*	*	*	*	2/6/03	9339	220128	176111	264145
12/19/02	3348	93379	63271	123488	2/7/03	9630	226986	181598	272375
12/20/02	*	*	*	*	2/8/03	7950	187392	149920	224863
12/21/02	583	16283	11033	21533	2/9/03	8653	203960	163176	244744
12/22/02	2283	63684	43150	84217	2/10/03	10463	246619	197304	295933
12/23/02	4648	129627	87831	171423	2/11/03	*	*	*	*
12/24/02	**	**	**	**	2/12/03	*	*	*	*
12/25/02	**	**	**	**	2/13/03	*	*	*	*
12/26/02	**	**	**	**	2/14/03	2118	58919	39941	77897
12/27/02	**	**	**	**	2/15/03	**	**	**	**
12/28/02	*	*	*	*	2/16/03	**	**	**	**
12/29/02	1551	43273	29321	57226	2/17/03	**	**	**	**
12/30/02	1109	34443	26202	42683	2/18/03	**	**	**	**
12/31/02	2363	73355	55805	90904	2/19/03	*	*	*	*
1/1/03	1934	60043	45678	74407	2/20/03	6345	180507	141476	219539
1/2/03	2698	83750	63713	103786	2/21/03	3156	89798	70381	109215
1/3/03	900	27957	21269	34646	2/22/03	**	**	**	**
1/4/03	1752	54395	41381	67409	2/23/03	**	**	**	**
1/5/03	2329	72300	55002	89597	2/24/03	*	*	*	*
1/6/03	3421	106185	80781	131589	2/25/03	1237	35213	27599	42827
1/7/03	3693	114625	87202	142048	2/26/03	1438	40931	32080	49781
1/8/03	*	*	*	*	2/27/03	2380	67725	53081	82369
1/9/03	6292	195273	148555	241990	2/28/03	*	*	*	*
1/10/03	2180	67676	51485	83867	3/1/03	2615	74410	58320	90499
1/11/03	2621	81360	61896	100825	3/2/03	529	15075	11815	18334
1/12/03	4169	129395	98438	160352	3/3/03	466	13283	10410	16155
1/13/03	2306	71586	54459	88712	3/4/03	2872	81720	64050	99390
1/14/03	6382	275123	231343	439034	3/5/03	*	*	*	*
1/15/03	*	*	*	*	3/6/03	3985	113379	88863	137894
1/16/03	32990	684664	536580	832748	3/7/03	*	*	*	*
1/17/03	19784	852783	588580	1116986	3/8/03	2450	69716	54642	84791
1/18/03	1906	82196	56730	107661	3/9/03	*	*	*	*
1/19/03	1561	67325	46467	88183	3/10/03	1671	47558	37275	57842
1/20/03	2429	104738	72289	137187	3/11/03	1261	35896	28134	43658
1/21/03	1829	78877	54440	103314	3/12/03	784	22328	17500	27156
1/22/03	1846	44861	35275	54448	3/13/03	336	9585	7512	11657
1/23/03	4492	109130	85810	132451	3/14/03	*	*	*	*

Appendix 2E. Confidence intervals (95%) for daily passage estimates at Live Oak (2002-03).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
3/15/03	483	13766	10789	16743	5/4/03	*	*	N/A	N/A
3/16/03	242	6756	4606	8905	5/5/03	34	34	N/A	N/A
3/17/03	194	5421	3696	7146	5/6/03	20	20	N/A	N/A
3/18/03	324	9036	6161	11911	5/7/03	*	*	N/A	N/A
3/19/03	176	4921	3355	6486	5/8/03	23	23	N/A	N/A
3/20/03	*	*	*	*	5/9/03	*	*	N/A	N/A
3/21/03	110	3085	2104	4067	5/10/03	*	*	N/A	N/A
3/22/03	94	2641	1800	3481	5/11/03	*	*	N/A	N/A
3/23/03	59	1667	1137	2198	5/12/03	1	1	N/A	N/A
3/24/03	135	3781	2578	4983	5/13/03	21	21	N/A	N/A
3/25/03	*	*	*	*	5/14/03	17	17	N/A	N/A
3/26/03	50	1417	966	1868	5/15/03	11	11	N/A	N/A
3/27/03	50	1417	966	1868	5/16/03	*	*	N/A	N/A
3/28/03	*	*	*	*	5/17/03	8	8	N/A	N/A
3/29/03	89	2502	1706	3297	5/18/03	*	*	N/A	N/A
3/30/03	*	*	*	*	5/19/03	6	6	N/A	N/A
3/31/03	143	4003	2729	5277	5/20/03	1	1	N/A	N/A
4/1/03	21	611	416	805	5/21/03	4	4	N/A	N/A
4/2/03	27	778	530	1025	5/22/03	1	1	N/A	N/A
4/3/03	34	972	663	1282	5/23/03	*	*	N/A	N/A
4/4/03	*	*	*	*	5/24/03	*	*	N/A	N/A
4/5/03	12	360	246	475	5/25/03	*	*	N/A	N/A
4/6/03	*	*	*	*	5/26/03	2	2	N/A	N/A
4/7/03	43	1222	834	1611	5/27/03	*	*	N/A	N/A
4/8/03	17	500	341	658	5/28/03	*	*	N/A	N/A
4/9/03	60	1695	1156	2234	5/29/03	1	1	N/A	N/A
4/10/03	58	1640	1118	2161	5/30/03	*	*	N/A	N/A
4/11/03	*	*	*	*	5/31/03	*	*	N/A	N/A
4/12/03	40	1139	777	1501	6/1/03	*	*	N/A	N/A
4/13/03	*	*	*	*	6/2/03	4	4	N/A	N/A
4/14/03	99	2780	1895	3664					
4/15/03	41	1167	796	1538					
4/16/03	24	24	N/A	N/A					
4/17/03	5	5	N/A	N/A					
4/18/03	*	*	N/A	N/A					
4/19/03	44	44	N/A	N/A					
4/20/03	*	*	N/A	N/A					
4/21/03	46	46	N/A	N/A					
4/22/03	*	*	N/A	N/A					
4/23/03	65	65	N/A	N/A					
4/24/03	20	20	N/A	N/A					
4/25/03	*	*	N/A	N/A					
4/26/03	85	85	N/A	N/A					
4/27/03	*	*	N/A	N/A					
4/28/03	35	35	N/A	N/A					
4/29/03	32	32	N/A	N/A					
4/30/03	44	44	N/A	N/A					
5/1/03	23	23	N/A	N/A					
5/2/03	*	*	N/A	N/A					
5/3/03	50	50	N/A	N/A					

Appendix 2F. Confidence intervals (95%) for daily passage estimates at Live Oak (2003-04).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
12/8/03	*	*	*	*	1/25/04	*	*	*	*
12/9/03	*	*	*	*	1/26/04	6774	90757	76245	105269
12/10/03	*	*	*	*	1/27/04	2972	39825	33457	46193
12/11/03	29	735	578	892	1/28/04	*	*	*	*
12/12/03	*	*	*	*	1/29/04	38381	514163	431950	596377
12/13/03	185	4561	3587	5535	1/30/04	*	*	*	*
12/14/03	*	*	*	*	1/31/04	30887	413774	347612	479935
12/15/03	462	11355	8931	13780	2/1/04	4597	61594	51745	71442
12/16/03	386	9491	7465	11518	2/2/04	2392	32231	27041	37422
12/17/03	320	7872	6191	9553	2/3/04	8456	113910	95565	132254
12/18/03	312	7676	6037	9315	2/4/04	20753	279543	234523	324562
12/19/03	*	*	*	*	2/5/04	41433	558090	468211	647968
12/20/03	422	10374	8159	12589	2/6/04	16622	223901	187842	259959
12/21/03	*	*	*	*	2/7/04	30096	405387	340101	470674
12/22/03	1086	26660	20968	32353	2/8/04	29480	397090	333140	461040
12/23/03	511	12557	9876	15238	2/9/04	35473	477812	400862	554762
12/24/03	172	4242	3336	5148	2/10/04	36406	562473	465834	659112
12/25/03	*	*	*	*	2/11/04	29052	448857	371738	525975
12/26/03	1421	34877	27430	42324	2/12/04	21621	334051	276657	391444
12/27/03	1446	35490	27912	43068	2/13/04	14428	222921	184621	261222
12/28/03	*	*	*	*	2/14/04	9548	147527	122181	172874
12/29/03	2048	50256	39525	60986	2/15/04	9208	142274	117830	166719
12/30/03	811	19925	14463	25388	2/16/04	5944	117604	94788	140420
12/31/03	409	10060	7302	12819	2/17/04	19636	388462	313097	463827
1/1/04	*	*	*	*	2/18/04	65667	1299055	1047026	1551084
1/2/04	*	*	*	*	2/19/04	49404	977338	787725	1166950
1/3/04	9939	243927	177051	310803	2/20/04	*	*	*	*
1/4/04	*	*	*	*	2/21/04	10998	217583	175370	259796
1/5/04	*	*	*	*	2/22/04	12443	246168	198409	293927
1/6/04	9913	243289	176587	309990	2/23/04	13075	258671	179509	337833
1/7/04	540	13275	9636	16915	2/24/04	**	**	**	**
1/8/04	362	8907	6465	11349	2/25/04	**	**	**	**
1/9/04	*	*	*	*	2/26/04	**	**	**	**
1/10/04	1688	41447	30084	52810	2/27/04	*	*	*	*
1/11/04	*	*	*	*	2/28/04	2251	112149	77827	146470
1/12/04	4861	198381	155497	241264	2/29/04	**	**	**	**
1/13/04	2012	82134	64379	99889	3/1/04	*	*	*	*
1/14/04	2626	107187	84016	130358	3/2/04	2005	99898	69326	130470
1/15/04	1227	50104	39273	60935	3/3/04	6655	331468	230028	432908
1/16/04	1734	70791	55488	86094	3/4/04	5488	273351	189697	357006
1/17/04	1971	80461	63068	97855	3/5/04	8370	416875	289297	544452
1/18/04	*	*	*	*	3/6/04	8269	411845	285807	537883
1/19/04	4264	174022	136403	211640	3/7/04	5210	259507	180089	338924
1/20/04	2824	115266	90349	140183	3/8/04	4750	236599	164192	309006
1/21/04	2389	97517	76437	118597	3/9/04	20456	1018758	706984	1330531
1/22/04	3949	161169	126329	196009	3/10/04	13870	690775	479375	902175
1/23/04	3918	159904	125337	194470	3/11/04	12765	635746	395959	875532
1/24/04	4405	59022	49584	68459	3/12/04	27406	2104013	1310435	2897592

Appendix 2F. Confidence intervals (95%) for daily passage estimates at Live Oak (2003-04).

Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.	Date	Raw catch	Passage Estimate	Lower C.I.	Upper C.I.
3/13/04	26188	2010508	1252198	2768819	5/1/04	879	780	N/A	N/A
3/14/04	15180	1165433	725862	1605003	5/2/04	568	568	N/A	N/A
3/15/04	22216	1705581	1062281	2348881	5/3/04	413	413	N/A	N/A
3/16/04	8451	648853	404123	893583	5/4/04	368	368	N/A	N/A
3/17/04	11203	860121	535706	1184537	5/5/04	315	315	N/A	N/A
3/18/04	16742	1285346	800548	1770145	5/6/04	359	359	N/A	N/A
3/19/04	10299	790722	492483	1088962	5/7/04	*	*	N/A	N/A
3/20/04	5692	437046	272204	601889	5/8/04	625	625	N/A	N/A
3/21/04	5965	458004	285257	630751	5/9/04	421	421	N/A	N/A
3/22/04	4235	325193	202539	447848	5/10/04	414	414	N/A	N/A
3/23/04	*	*	*	*	5/11/04	412	151	N/A	N/A
3/24/04	2318	178027	110880	245174	5/12/04	303	303	N/A	N/A
3/25/04	1211	93043	57950	128137	5/13/04	324	324	N/A	N/A
3/26/04	339	26101	16256	35945	5/14/04	*	*	N/A	N/A
3/27/04	1218	93581	58285	128877	5/15/04	417	417	N/A	N/A
3/28/04	563	43297	15024	71569	5/16/04	185	185	N/A	N/A
3/29/04	541	116461	40413	192509	5/17/04	227	90	N/A	N/A
3/30/04	2294	493137	171123	815151	5/18/04	*	*	N/A	N/A
3/31/04	836	179849	62409	297289	5/19/04	352	352	N/A	N/A
4/1/04	862	185436	64348	306524	5/20/04	166	50	N/A	N/A
4/2/04	*	*	*	*	5/21/04	*	*	N/A	N/A
4/3/04	614	132147	45856	218438	5/22/04	36	36	N/A	N/A
4/4/04	**	**	**	**	5/23/04	431	124	N/A	N/A
4/5/04	*	*	*	*	5/24/04	138	138	N/A	N/A
4/6/04	288	62098	21549	102647	5/25/04	*	*	N/A	N/A
4/7/04	89	19338	6710	31965	5/26/04	211	211	N/A	N/A
4/8/04	52	11387	3952	18823	5/27/04	*	*	N/A	N/A
4/9/04	*	*	*	*	5/28/04	184	184	N/A	N/A
4/10/04	65	14181	4921	23441	5/29/04	*	*	N/A	N/A
4/11/04	121	26214	9096	43331	5/30/04	278	278	N/A	N/A
4/12/04	94	20412	7083	33741	5/31/04	53	53	N/A	N/A
4/13/04	149	32230	11184	53276	6/1/04	*	*	N/A	N/A
4/14/04	281	60594	21027	100161	6/2/04	175	175	N/A	N/A
4/15/04	333	71767	24904	118631	6/3/04	123	123	N/A	N/A
4/16/04	*	*	N/A	N/A	6/4/04	253	253	N/A	N/A
4/17/04	150	150	N/A	N/A	6/5/04	70	15	N/A	N/A
4/18/04	*	*	N/A	N/A					
4/19/04	205	205	N/A	N/A					
4/20/04	98	98	N/A	N/A					
4/21/04	*	*	N/A	N/A					
4/22/04	1513	1513	N/A	N/A					
4/23/04	419	419	N/A	N/A					
4/24/04	646	646	N/A	N/A					
4/25/04	*	*	N/A	N/A					
4/26/04	864	864	N/A	N/A					
4/27/04	375	375	N/A	N/A					
4/28/04	545	545	N/A	N/A					
4/29/04	489	489	N/A	N/A					
4/30/04	*	*	N/A	N/A					