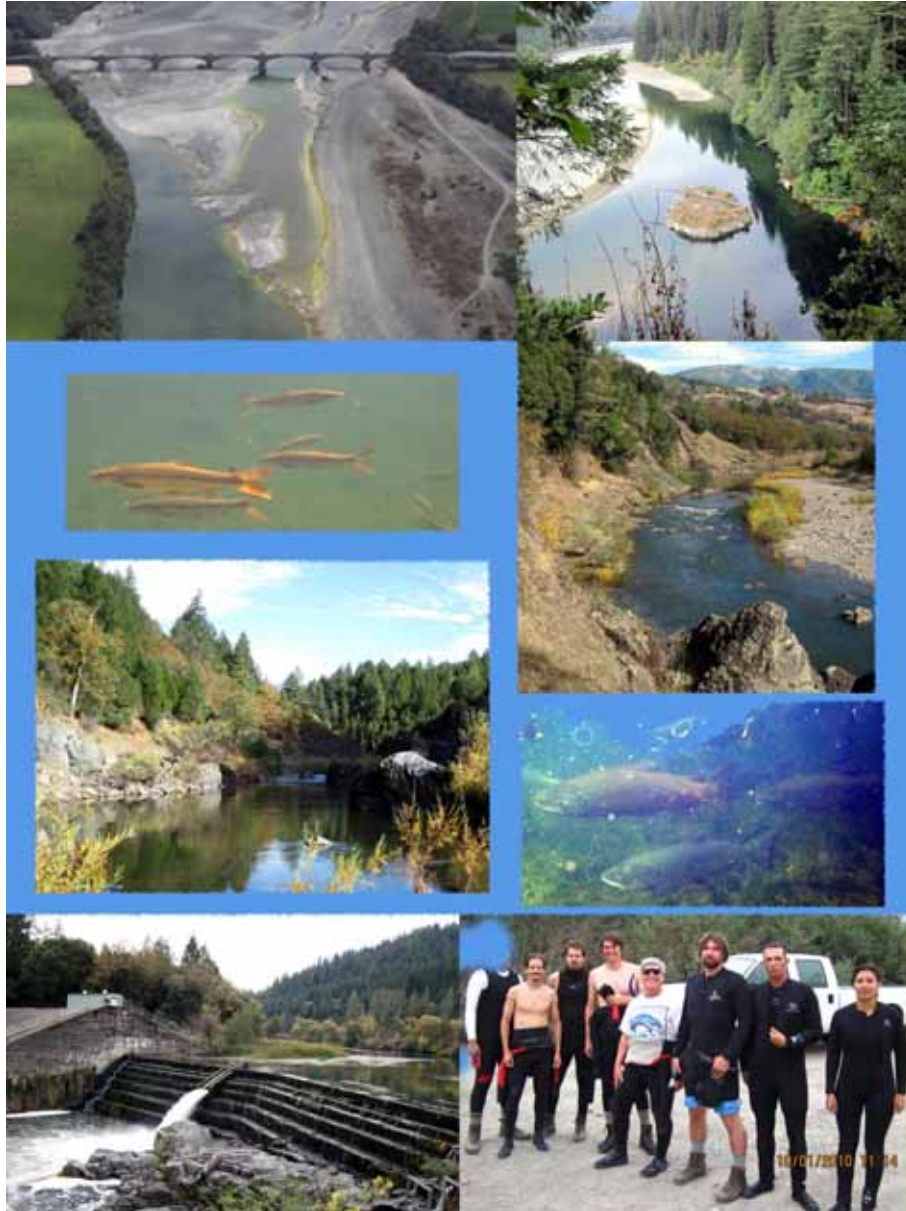


# Eel River Fall Chinook Monitoring Project Final 2010 Report



Report Prepared for: **Friends of Eel River**

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The October 1 survey crew pictured here are Ernest Chen, Steve Gough, Tony Heacock, Phil Colombano, Pat Higgins, Andrew Goodman, Eli Sanderson and Madison Ayala. Eli and Madison are staff to the Bear River Rancheria. All others besides Higgins are with the USFWS Arcata Fisheries Assistance Office. Thanks to the divers!

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I also had the pleasure of making the acquaintance of a number of dedicated Eel River anglers and they readily shared their knowledge. Thanks to Kelly Futheys, Sam Humphrey, Travis Sheets and Jake Luna.

## **Executive Summary**

The 2010 fall Chinook monitoring project sponsored by Friends of Eel River was set up to document impediments to migration during low fall flows from the Potter Valley Project (PVP) that had been common in recent years. Only a small run was anticipated. Instead there were very high fall flows and one of the largest fall Chinook salmon runs since 1985-87 or possibly 1955-58. Prior to the salmon disbursing, a dive count on the lower Eel River was organized and over 400 fall Chinook were counted. Before the onset of rains on October 23, more than 2,000 fall Chinook salmon were estimated to be holding from just above the Van Duzen River to Fernbridge.

It is impossible to accurately estimate the escapement for the Eel River for 2010, but field observations, Van Arsdale Fish Station (VAFS) counts and professional judgment are used to bracket the size of the run, which was likely between 10,000 and 30,000 adults basin-wide. The California Department of Fish and Game (CDFG) survey of tributary spawning that is conducted annually can help further define the magnitude of this years run, but results were not available at the time of publication of this report.

The Chinook salmon rebound may have been going on for the last two or three years, with record counts at VAFS this year resulting from higher natural flows. The major reasons for the population rebound include 1) mainstem Eel River spawning habitat recovery, 2) high spring flows for recent brood years, 3) good ocean conditions, 4) reduced fishing pressure, and 5) a cycle of reduced pikeminnow abundance.

Favorable spring flows and mostly good ocean productivity are part of the Pacific decadal oscillation cycle (PDO), which has been favorable since 1995 and is likely to switch to dry on-land conditions and poor ocean conditions sometime between 2015-2020 (Collison et al. 2003). Some restoration efforts like those in the upper South Fork Eel in Hollow Tree Creek may be assisting with salmon recovery, but mostly the rebound is resulting from natural forces.

The Chinook salmon is not necessarily the best indicator of Eel River ecological conditions because they only require a brief period of freshwater residence. In fact the Eel River is showing signs of extremely perturbed watershed hydrology and its water quality has so deteriorated that the South Fork, Van Duzen and lower Eel River are plagued with toxic algae. Habitat conditions in the lower Eel River are extremely poor and suitable deep water pools for Chinook salmon are limited. Algae blooms within these pools are a sign of acute nutrient pollution and pose a threat to fish health. Speedy action is needed to increase the pool holding capacity of the lower Eel River and some steps like deflection of flow into holding pools should be considered on an emergency basis. If the number of fish holding in the lower Eel were to double and the fall rains failed to materialize, a major fish kill is possible similar to the Klamath (CDFG 2003). Chinook salmon gene resources for the Van Duzen River are still present, despite the river losing surface flow for most of late summer and fall in most years since 1997. Aggressive restoration action is needed there, using bioengineering, to bring the river back onto the surface and to create a refugia from Yager Creek to the mouth of the Eel River befitting these magnificent fish.

While mainstem Eel River spawning habitat appears to be recovering from past sediment impacts, and is driving the current population increase, tributaries are drying up and their productivity decreasing (Higgins 2010). A basin-wide effort is needed to implement water conservation and to reduce nutrient pollution, if the Eel River is to be recovered.

Potter Valley Project (PVP) spring flows have increased since the implementation of the National Marine Fisheries (NMFS 2000) Biological Opinion (B.O.). Summer flows have improved in some years like 2006 when 40 cfs was released, but baseflows in 2009 were only 10 cfs. PVP fall releases have remained very low, however, and there are strong indications that adult migration and spawning has been delayed. For example, the high flows in 2010 allowed free migration to VAFS and the peak of the run was in the second week of November, while the 2009 run struggled in low flow conditions and peaked a month later in mid-December at VAFS. The worst case fall flow scenario caused a fish kill in the lower Eel River below Fernbridge on November 2, 2002 that is documented herein, when the mainstem Eel at Scotia was flowing just 87 cfs and releases at Cape Horn Dam and the PVP were just 28 cfs. It is recommended that “block water” reserved for salmon protection should be increased to 7,500 acre feet (AF) from its current 2,500 AF under the NMFS B.O. so that 100 cfs could be released from the PVP for up to 30 days when needed to prevent future fish kills. This increase would still only represent less than 5% of the water currently exported.

The Sacramento pikeminnow population exploded during drought cycles after its introduction in 1980, but the population of adults that predate on salmonids is currently in a down cycle in response to several factors. Pillsbury Reservoir is a pikeminnow factory of sorts and the upper river will remain dominated by them for as long as that PVP impoundment remains. There are ample opportunities for pikeminnow control downstream of Cape Horn Reservoir and several actions are recommended below.

Ultimately, Scott Dam needs to be removed and Chinook salmon and steelhead allowed to re-inhabit the hundreds of miles of headwater streams above the PVP. Gravelly Valley underneath Pillsbury reservoir was one of the most productive salmonid habitats in the basin (Williams et al. 2008) and could be a refugia, if restored. Although the fall Chinook salmon return to VAFS was a record dating back to 1946, the likelihood of spawning success of these fish is low because spawning habitat between Scott Dam and Cape Horn Dam is extremely degraded. Similar steps to the Trinity River Restoration Program (McBain and Trush 1997) are needed to augment spawning gravels and to alter confining riparian vegetation. The 9 MW of power generated by the PVP is miniscule compared to the benefits of restoring the Eel River salmon and steelhead. A phased decommissioning should be planned with the removal of Scott Dam no later than 2020. Users of Eel River water in Mendocino, Sonoma and Marin counties need to start paying for it, which could fund needed restoration measures. Prompt action to restore the Eel River has the potential to rebuild the fall Chinook salmon population to 100,000 fish annually, and State and federal government agencies need to do more to actively manage Eel River fisheries resources and to restore the river’s ecosystem function. The Native American tribes of the basin have a strong interest in becoming co-managers of the Eel River basin and they may have access to additional resources necessary to monitor fisheries and water quality and to restore the river and its fish before it is too late.

## Project Activities Summary

This project started in mid-September 2010 and was intended to track Eel River fall Chinook and document problems for migration caused by low flows due to the operation of the Potter Valley Project. Yoshiyama and Moyle (2010) had estimated that the fall Chinook population might be down to as low as 1,000 fish and characterized them as being at high risk of extinction within the next 50 years. Consequently, a second objective of this study was to attempt to get an understanding of the distribution and abundance of Chinook salmon to confirm or refute that hypothesis.

Expecting a dry fall season, FOER volunteers were recruited who could help count salmon at various locations on the mainstem Eel River. The volunteers had been watching salmon pass at riffles for years and low flow conditions would have made counting them possible in years passed. Fall Chinook started pushing up out of the estuary following an early rain event from September 14-16 and a solo reconnaissance dive indicated that there were hundreds of Chinook and lesser numbers of adult steelhead and half pounders. Although not originally planned, a dive census was organized and conducted on October 1 (Higgins 2010b). Surveillance of fish in the lower Eel River continued until the rain storm of October 23. Once the Eel River rose, it stayed high and volunteer counting at most Eel River riffles became infeasible. The emphasis changed from the lower river to upstream areas to document spawning activity and habitat quality. Reports compiled for each major field activity are summarized in Table 1. Although not required, water pollution, toxic algae, tributary habitat quality, pikeminnow distribution and abundance and habitat restoration needs are also addressed in this report.

**Table 1. Fall Chinook Monitoring Project Field Reports with date of field visit and subject and title. Click for [Internet link](#) to report page. All reports are also linked individually below.**

Field Date	Subject/Title
9/14/10	<a href="#">Shively-Holmes Reconnaissance: Otters, Pikeminnow and Juvenile Steelhead</a>
9/17/10	<a href="#">Solo Dive Creamery Pool and Base of Fernbridge: Early Chinook Salmon Run Confirmed</a>
9/20/10	<a href="#">River Walk (12<sup>th</sup> Street Pool) to Fernbridge Solo Dive: Hundreds of Chinook in Lower River!</a>
9/21/10	<a href="#">Reconnaissance of Mainstem Eel at Alderpoint and Lower Steelhead Creek</a>
10/7/10	<a href="#">Hansen Pool and the Eel/Van Duzen Convergence Pool: Salmon Upstream as far as Van Duzen River</a>
10/8/10	<a href="#">Upper Eel at Hearst and Emandal: Pikeminnow but also Steelhead Juveniles</a>
10/10/10	<a href="#">Holmes Bluff Pool and High Rock: How Far Upstream Are the Salmon?</a>
10/20/10	<a href="#">Eel River Estuary: Lots of Salmon!</a>
10/22/10	<a href="#">Thousands of Fish Poised to Run</a>
11/4 and 11/17/10	<a href="#">Hearst and Mainstem Eel River Outlet Creek to Dos Rios: Chinook Spawning Everywhere!</a>
11/16/10	<a href="#">Fernbridge to Alderpoint Reconnaissance: Plenty of Water for Chinook and the Run Continues</a>
11/5 and 11/17/10	<a href="#">Scott Dam to Van Arsdale Dam and Below: Chinook Spawning Reconnaissance and Habitat Assessment</a>

## **Methods**

### ***October 1 Dive Census***

Fall Chinook salmon and steelhead adults and half pounders were counted in the lower Eel River from the pool below Fernbridge to the 12<sup>th</sup> Street Pool (Higgins 2010b). No dive counts had taken place in the lower river since 1996 and 1997 (Halligan 1997, 1998). The dive leader, fisheries biologist Patrick Higgins, and all five USFWS divers had salmon and steelhead census experience on large rivers in the region (i.e. Salmon, NF Trinity, Klamath) and used standard dive observations techniques (Hankin and Reeves 1988, Heggenes et al. 1990). Dive surveys are generally conducted while moving downstream, but excessive algae in the lower Eel River made it more desirable to conduct the dive moving upstream. The approach to each pool varied because channel width sometimes did not require eight divers. All divers maintained independent counts that were compared at the end of each dive to arrive at the final estimate. Chinook jacks are less than 24" in length, having spent only one year in the ocean. Half pounder steelhead were those between 14-20 inches in length. Fish larger than that were classified as adults, but smaller fish are juveniles and were not counted. Dennis Halligan, a fisheries biologist for Stillwater Sciences provided estimates for the Hansen Pool and the pool at the convergence of the Van Duzen that were added to dive team totals. See the full report, [\*Lower Eel River Fall Chinook Dive Census: October 1, 2010\*](#) (Higgins 2010b), for more details.

### ***October 22 Lower Eel River Chinook Salmon Estimate***

Fisheries biologist Dennis Halligan noted a major influx of Chinook salmon in the lower Eel River on October 20 and indicated that the number might be double or triple that of October 1. Since there wasn't time to organize another group dive, a solo dive estimate of several pools was conducted and video was used to document concentrations of Chinook salmon. Under water estimates of lower Eel River pools were combined with visual observations of Weymouth Pool from the Grizzly Bluff Road. A walking and dive reconnaissance was also conducted upstream on the mainstem Eel River at various pools to see if there were more concentrations of salmon further upstream.

### ***Extent of Chinook Spawning Distribution and Indications of Abundance***

Once the rains began and water flows increased, the emphasis of the project shifted to document spawning in various mainstem reaches. The scope of this project only allowed for reconnaissance, not any quantitative measure of the number of fish spawning at various locations. Polarized sunglasses helped improve visibility and surveys were conducted by walking or using points of observation from Highway 162 between Dos Rios and Outlet Creek. FOER volunteers also notified me when they saw Chinook spawning activity and I was able to go into the field and confirm their observations. Angler accounts provide an understanding of run strength and timing and are utilized in discussions below.

## ***Habitat Assessment***

Areas visited during this project spanned from the estuary to Pillsbury Reservoir above Scott Dam in Lake County. Hundreds of photos and dozens of videos were taken in the field to document flow, aquatic habitat conditions and water quality problems. Photos are used as illustrations in reports listed in Table 1 with annotations explaining observations. Videos are also posted on-line.

## ***Water Pollution and Toxic Algae***

Water temperatures were measured using a hand held thermometer during all early fall habitat surveys. Problems with algae blooms, indicative of nutrient pollution, were extensively photo documented and described in field reports (Table 1). Toxic algae poses a risk to both fish and human health and the latter is documented in a memo from Humboldt County Public Health (Hill 2010) that is discussed below.

## ***Pikeminnow***

Low flow conditions that prevailed until October 23 allowed direct observation of pikeminnow and field reports detail distribution and abundance (Table 1).

## **Results**

### ***October 1 Dive Results***

A total of 344 adult Chinook salmon, 85 Chinook jacks, 14 adult steelhead and 39 steelhead half pounders were counted, but the number of fish in the 12<sup>th</sup> Street Pool may have been under-estimated. The Hansen Pool and the pool at the convergence of the Van Duzen were counted by fisheries biologist Dennis Halligan and he found an additional 15 Chinook, 34 adult steelhead and 227 half pounders. See [Lower Eel River Fall Chinook Dive Census: October 1, 2010](#) (Higgins 2010b) for full results and discussion.

### ***October 22 Lower Eel River Chinook Salmon Estimate***

Dennis Halligan reported the following in an October 21 email:

“I dove the pool/run downstream of the Mercer Fraser temporary bridge and observed at least 200 Chinook and a couple of dozen steelhead. A shallow riffle upstream of this location might limit upstream movement of larger fish. The head of the Boxcar Pool had even more fish. I dove an 800 ft reach and fish were swimming past me 15-20 at a time. As I was swimming I would see them stacked like cordwood ahead of me (5 fish deep by 15 wide and who knows how long) and peel off as I approached; several hundred fish at least. The Drake pool (upstream of Worswick) had jumpers. Worswick just above Fernbridge had jumpers. Fish were passing thru the riffle upstream of Fernbridge three and four at

a time on about 5 minute intervals. Jumpers were seen downstream of the Creamery and people were watching the fish pass a riffle down there.”

The October 22 estimate of Chinook jack salmon and adults combined is displayed in Figure 1. An estimated 150 adult Chinook and jacks were holding in the front of the 12<sup>th</sup> Street Pool and captured on video. The Mercer Fraser run had at least 200 Chinook salmon and the Boxcar Pool had at least 1,000, but a slight amount of sediment introduced by a temporary bridge removal while the dive was taking place made video poor. There was an estimated 350 Chinook salmon in the run immediately upstream of Fernbridge that were captured on video (Figure 2). The Weymouth Pool is above the Van Duzen River between Howe and Price creeks and 200 Chinook salmon were seen circling from an overlook on along Grizzly Bluff Road.

No salmon or steelhead were seen in a dive and walk of the mainstem Eel above and below the Stafford Highway 101 Bridge, including the pool at the mouth of Twin Creek upstream to the pool below Stitz Creek. A dive at the convergence of the mainstem Eel and South Fork at Dyerville revealed no adult salmonids except for a few half pounders. Visual observations from above water looking for rolling adults at the Holmes Bluff Pool and High Rock also gave no indication of adult salmon or steelhead on October 22. To summarize results, 1900 Chinook adults and jack salmon were observed holding from the Weymouth Pool downstream to the run above Fernbridge and no Chinook concentrations further upstream were detected. The total in the lower river was likely well over 2,000, if the Worswick Pool and Creamery Pool had been counted, since Halligan had noted fish holding there two days prior.

### ***CDFG Van Arsdale Fish Station Returns***

Harris (2010) provides a historical count of fall Chinook salmon returns to the Van Arsdale Fish Station (VAFS) (Figure 3). Although steelhead were counted at VAFS as far back as 1933, Chinook salmon were first counted in 1946 and 1947 and only consistently reported since 1955. The lack of fish in many years may not be an indicator of run strength but rather a result of lack of sufficient flows from the PVP for passage.



**Scott Harris of CDFG at VAFS.**

Scott Harris (personal communication) of CDFG provided 2010 data for VAFS Chinook salmon returns through December 31. The count was a high for the entire VAFS period of record and a total of 2,315 fish were counted (814 males, 755 females and 746 jack salmon). Chinook salmon weekly counts for 2010 are captured in Figure 4 and those for 2009 are displayed in Figure 5. The total return to VAFS in 2009 was 519 (Harris 2010). The 2010 run began arriving on October 29, peaked by mid-November and few fish returned in December. This contrasted with run timing in 2009 when flows were lower and the run peak occurred in December. Male Chinook arrive earlier than females and jack salmon are not present later in the run (Harris 2010).

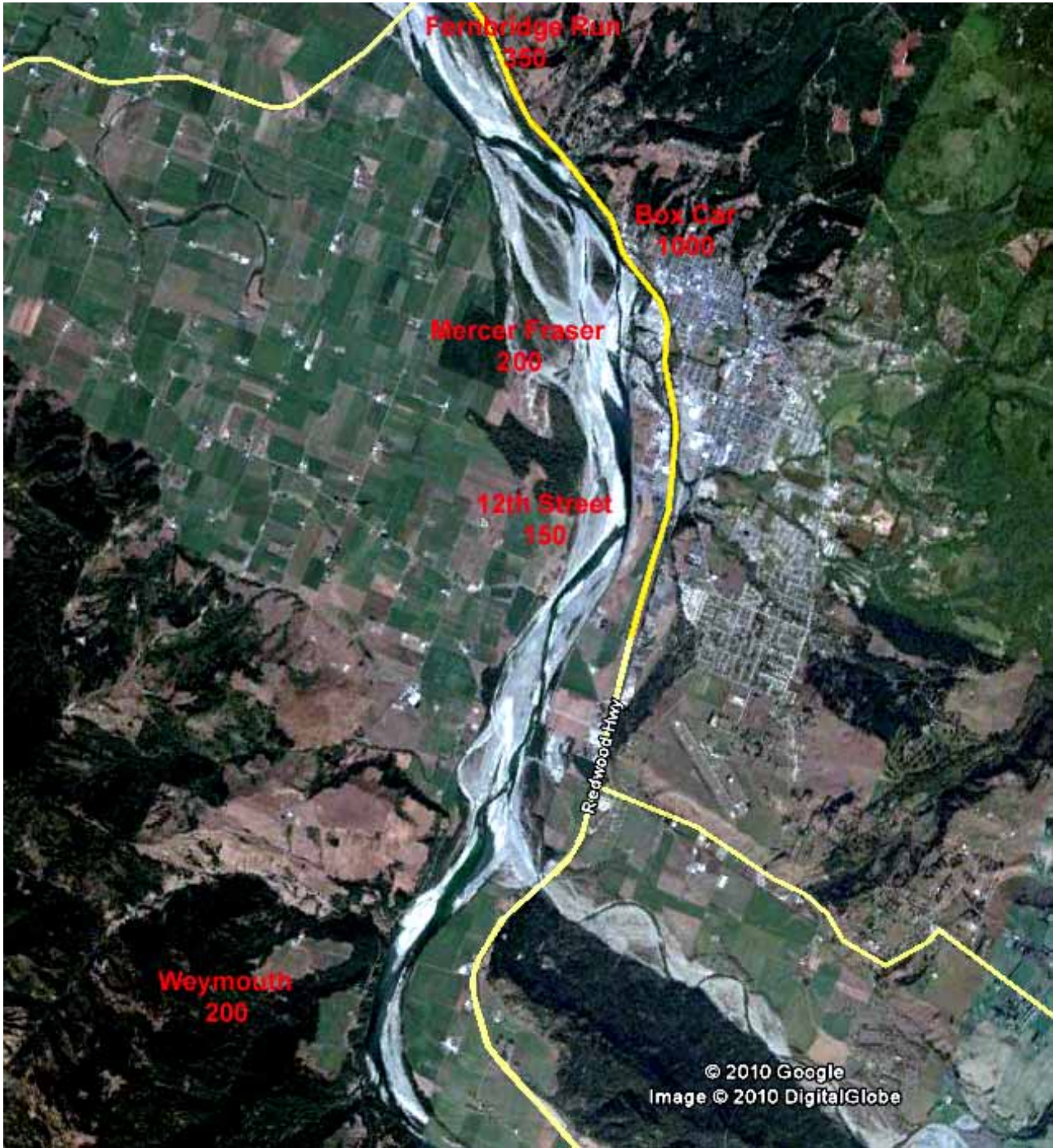


Figure 1. Estimates from diving and direct observation by fisheries biologist Patrick Higgins on October 22, 2010. Video of fish concentrations is available [on line](#). Map base is from Google Earth.



Figure 2. Photo of adult Chinook salmon school in a run immediately above Fernbridge. Photo taken by Patrick Higgins.

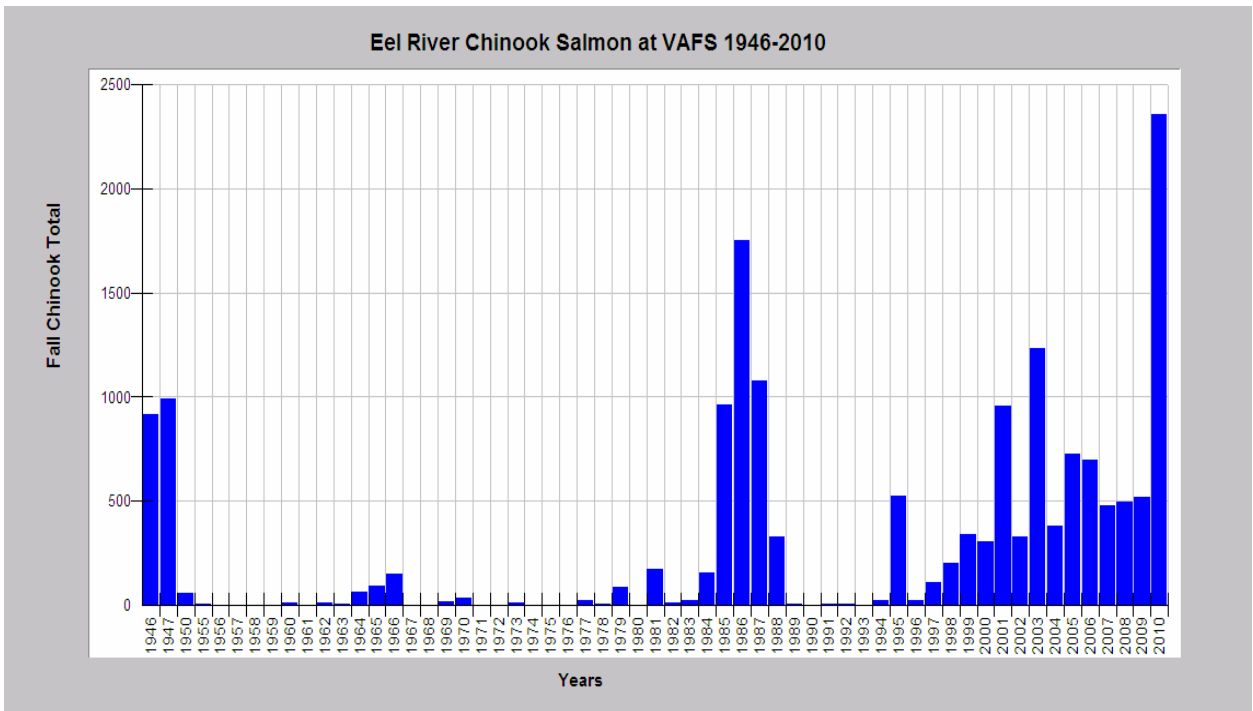
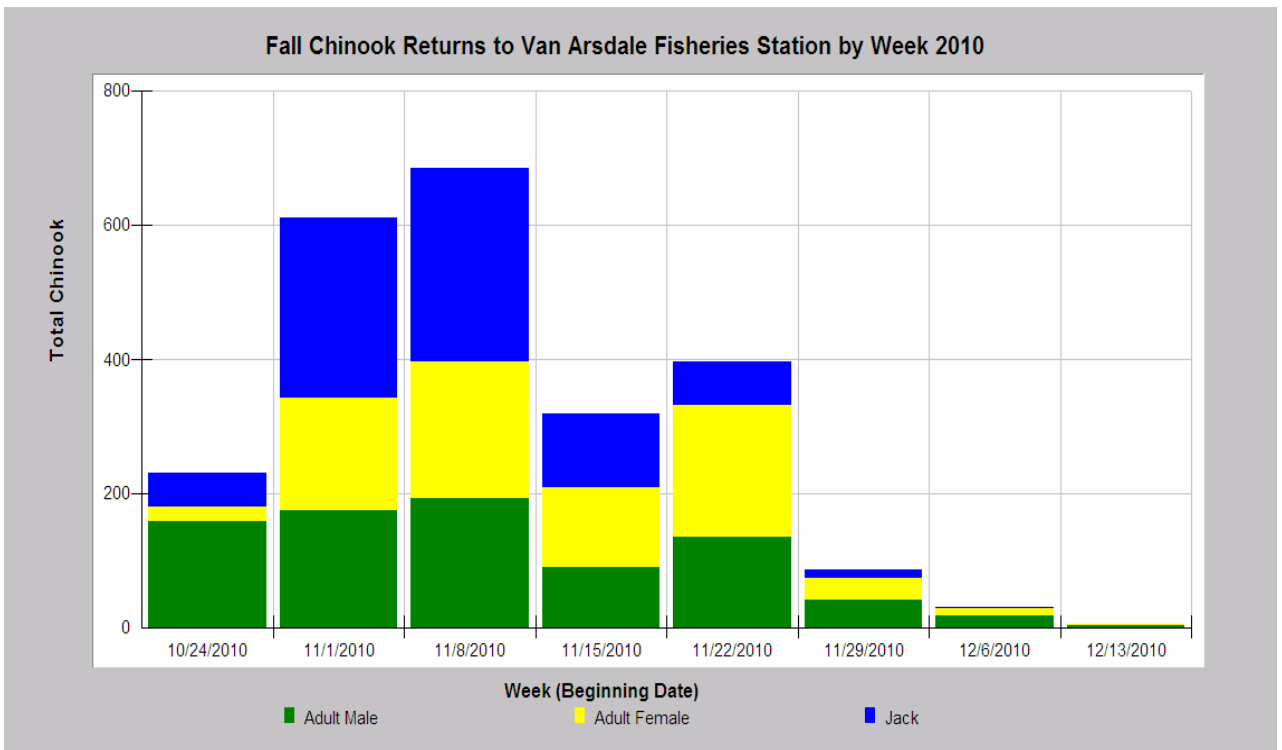
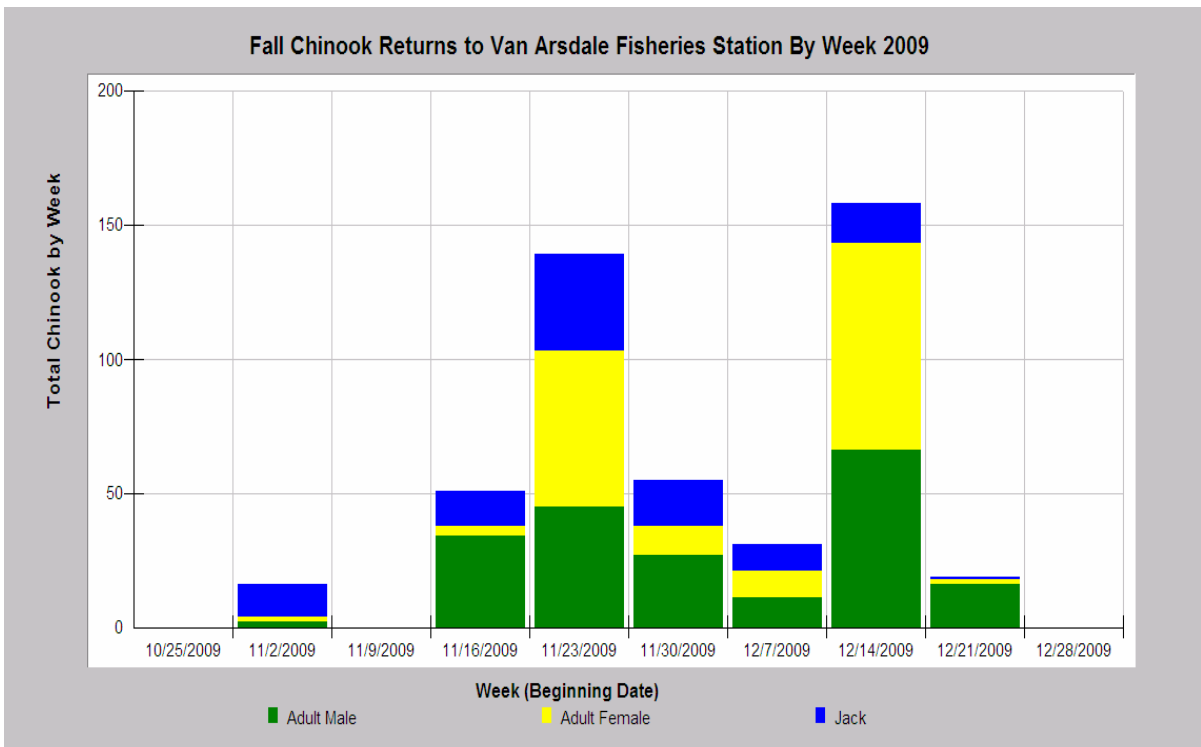


Figure 3. VAFS Chinook salmon returns from 1946 to 2010. There are no data before 1946 and only 1946, 1947 and 1950 returns were reported before 1955. Lack of returns in many years could be as a result of insufficient flow releases at Cape Horn Dam for Chinook to migrate that far. Data from Harris (2010).



**Figure 4.** VAFS Chinook salmon returns by week in fall 2010 show the peak of the run in early November due to excellent flows for passage . Preliminary data Scott Harris, CDFG via email.



**Figure 5.** VAFS Chinook salmon returns by week in fall 2009. Flows were poor for migration and as a result the peak of the run is in December. Data from Harris (2009).

### ***Upper Mainstem Eel River Chinook Salmon Escapement 2009 Estimate***

Although mainstem spawning counts are not available for 2010, CDFG did make an estimate in 2009 of the reach from Dos Rios to VAFS and lower Outlet Creek. Harris (2010) was able to survey 40% of the reaches physically then extrapolated redd density to the entire length. He estimated redd density of 8.4 redds/km on the mainstem Eel River from Dos Rios to VAFS and 9.3 redds/km within Outlet Creek. Population estimates were based on a female to male ratio of 0.32, including jack salmon. The escapement of Chinook salmon in the upper mainstem Eel River and Outlet Creek was 3,092. Harris (2010) acknowledged that Eel River Chinook mainstem spawning continues into December but the estimate does not include this later portion of the run.

### ***Extent of 2010 Chinook Spawning Distribution and Relative Abundance***

A spawning reconnaissance of various mainstem reaches of the Eel River from Dos Rios to Scott Dam was conducted on November 4-5<sup>th</sup> and 17<sup>th</sup>. Figure 6 highlights all survey reaches, including spawning areas and tributary reaches assessed for habitat quality. On November 5, spawning was observed on every suitable area of gravel from below Outlet Creek to Dos Rios. There was also a school of large Chinook holding at the mouth of Outlet Creek, which was too low for optimal migration and spawning. Extensive spawning was documented at Hearst on November 17 with abundant clean gravel available at most riffle crests within a mile upstream and downstream of the Hearst Bridge (Figure 7). Extremely high flows in December prevented any late 2010 mainstem spawning reconnaissance and so there is no index of this portion of the run.

A reconnaissance survey of the riffles immediately downstream of Cape Horn Dam and the VAFS found less frequent spawning (Figure 8-9). Active Chinook salmon spawning was also noted below Soda Creek on the Upper Eel River, but riffles immediately below Scott Dam appeared to lack suitable spawning substrate and no spawning was observed (Figure 10). Spot checks of other locations between Scott Dam and Cape Horn Dam found other unoccupied riffles that seemed to lack appropriate spawning gravels (see Habitat Quality).

Angler accounts (Kelly Futheys, personal communication) and direct observation by FOER volunteer Michael Guerriero indicated that there were thousands of Chinook salmon in the Van Duzen River and that a substantial number were headed upstream of Bridgeville. A December 1 upper South Fork reconnaissance indicated only a few Chinook spawners and a lack of spawning gravels. Other FOER volunteers spotted concentrations of spawning fish in Outlet Creek tributaries Baechtel and Willits creeks and in Ten Mile Creek, a tributary of the South Fork Eel River.

### ***Habitat Conditions***

A major deliverable for this project was to assess the quality of river habitat available to fall Chinook salmon, particularly under low flow conditions. Although it was beyond the scope of contract requirements, Eel River tributary conditions were also assessed and are documented in field reports (Table 1) and summarized below.

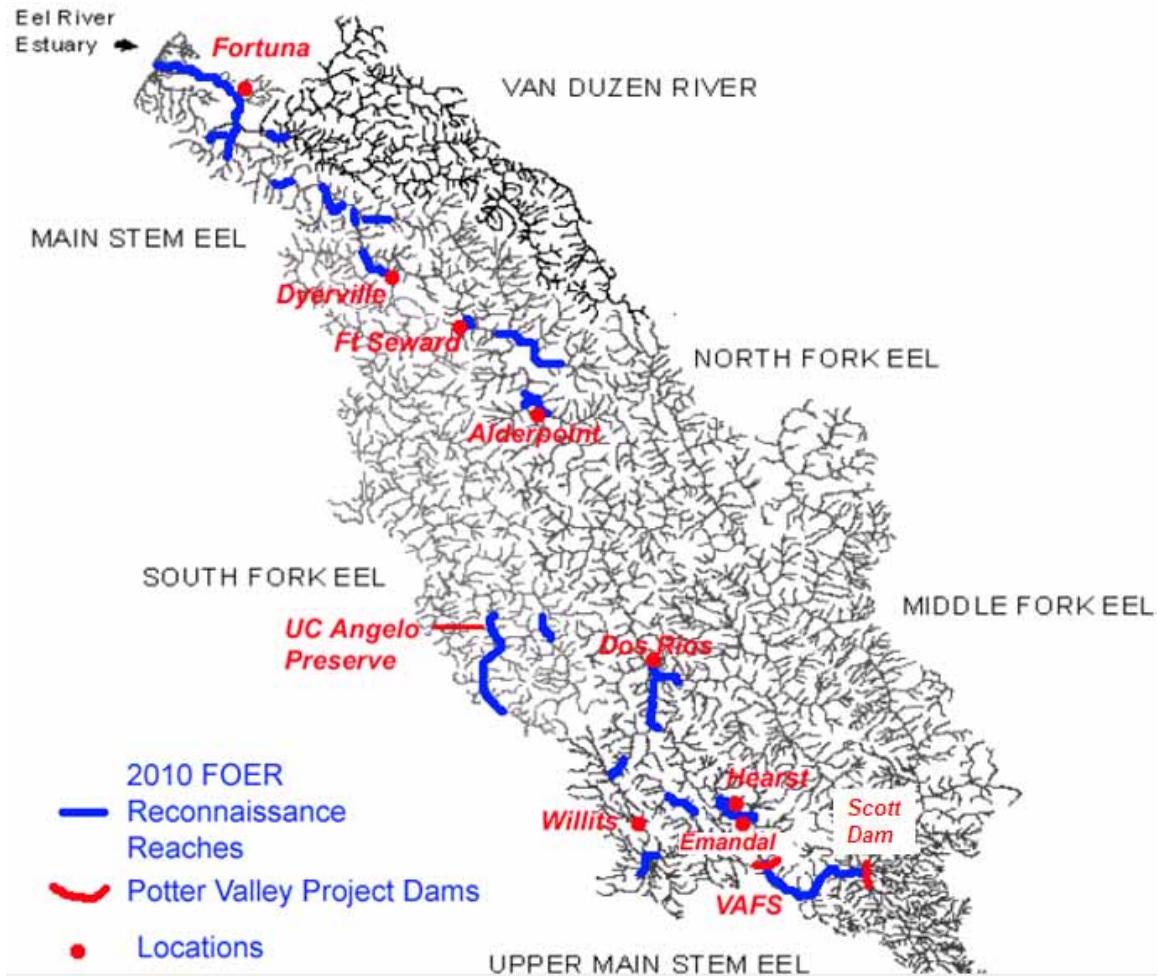


Figure 6. Eel River mainstem reaches and tributaries covered by FOER fall Chinook salmon tracking project from September-November 2010. Some reaches covered more than once. Base map adapted from Friedrichsen (1998).

Lower Mainstem Eel River: Habitat in the lower mainstem Eel River is very poor for holding adult Chinook salmon downstream of the Van Duzen River during low flow conditions. This reach historically had deep pools and required a ferry to cross (Higgins 1991), but today pools are generally less than 15 feet deep maximum. There are also major problems with algae that could create very adverse water quality (see Water Pollution/Toxic Algae). Chinook holding capacity may vary depending on how shifting gravel bars in spring deflect flows into pools or around them. The Creamery Pool below Fernbridge has good riparian cover and depth but flows in 2010 were deflected into its lower end where it lacked depth (<5 ft.) except at the point of convergence. The Hansen Pool, immediately downstream of the Van Duzen River, had no flow through its deeper complex sections in 2010. Instead a very shallow riffle formed, which was a partial barrier to Chinook migration, and that deflected flow into the back of the pool.



**Figure 7. Riffles above and below the Hearst Bridge that had active Chinook salmon spawning on November 17.**

Sub-surface flow from the Van Duzen River, indicating hyporheic connection, can help keep the Hansen Pool cool in summer. When it is connected, it serves as a summer steelhead refugia for adult fish that cannot enter the Van Duzen because it loses surface flow in late summer. The Worswick Pool (Figure 10) just upstream of Fernbridge has a vertical, raw dirt cut-bank that is sloughing soil into the pool and diminishing its volume and suitability for adult Chinook salmon holding. The configuration of the Worswick Pool also lends itself to accumulation of floating algae that can potentially depress dissolved oxygen (see Water Pollution/Toxic Algae).

Lower Van Duzen River: Historic accounts prior to the 1955 and 1964 flood document excellent sport fishing in the lower Van Duzen River in August (Ferndale Enterprise, Aug. 6, 1907), but the river today loses surface flow for much of the alluvial flats below Yager Creek in late summer (Figure 11). A reconnaissance of the lower Van Duzen River below Yager Creek on October 7 found insufficient flow for any adult fish passage and extremely degraded habitat conditions (Figure 12).

Middle and Upper Mainstem Eel River Habitat: Late rains and higher flows allowed the upper mainstem above Hearst to sustain juvenile steelhead, as indicated by staff at Emandal catching and releasing over two dozen juvenile steelhead while targeting pikeminnow from June to October. Juvenile steelhead were observed at Emandal (10/8) but also the mainstem at Shively (9/14), indicating suitable mainstem temperatures.

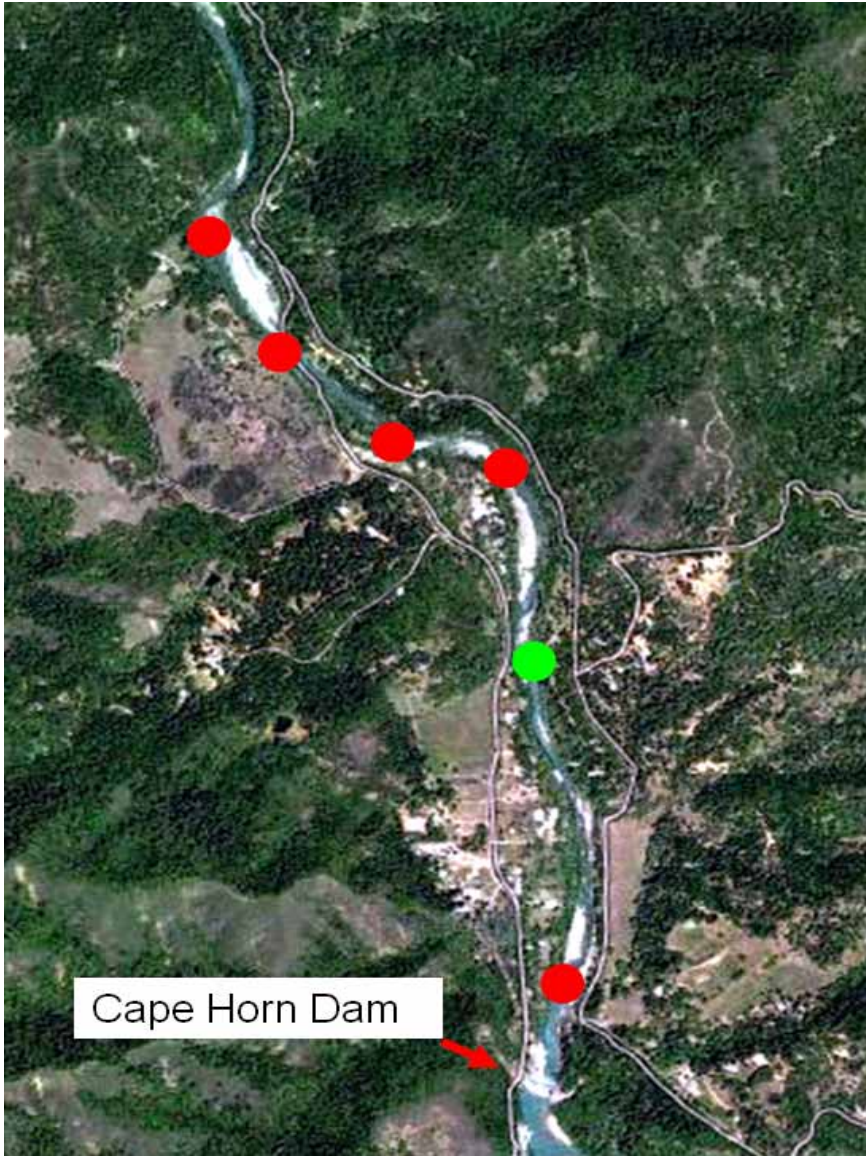
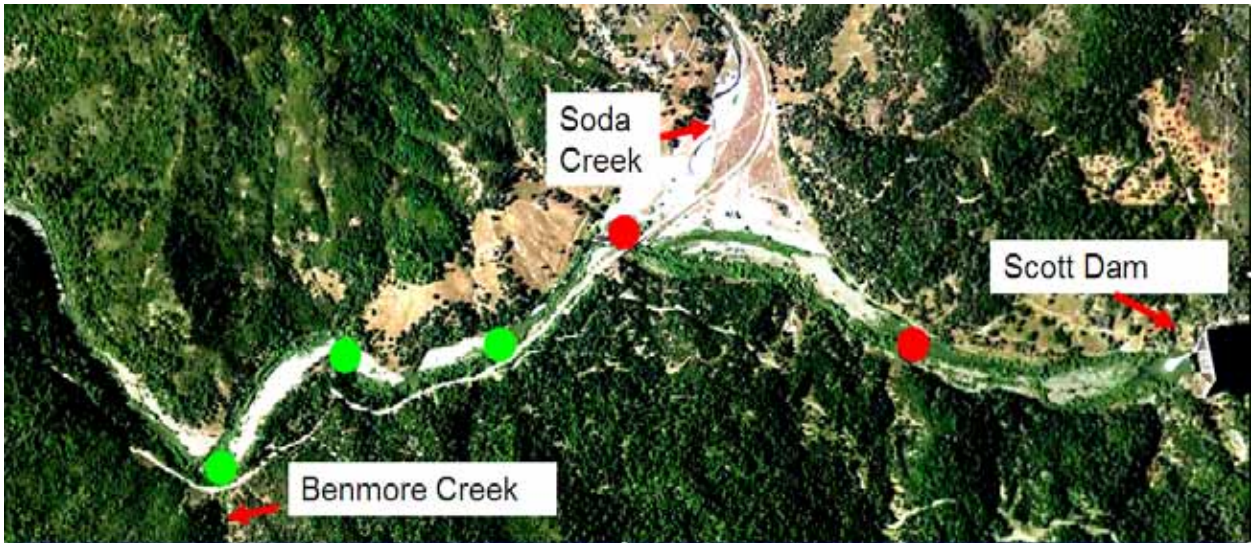


Figure 8 (left). Most riffles surveyed below Cape Horn Dam on November 5 were not occupied by spawning Chinook salmon, although hundreds had migrated upstream of Van Arsdale Fish Station. Green dots indicate active spawning and red dots no spawning.

Figure 9 (below). Spawning Chinook salmon were seen below Soda Creek and at the mouth of Benmore Creek on November 17 (green dots). No salmon were seen on two riffles above Soda Creek (red dots), which is a source of spawning gravel.





**Figure 10.** This photo shows a raft of floating algae along the south bank of the lower Eel River in the middle portion of the Worswick Hole just upstream of Fernbridge. This pool currently has very poor habitat. Photo by Patrick Higgins from 9/20/2010.



**Figure 11.** The pool at the convergence of the mainstem Eel River and the Van Duzen River with the latter barely flowing and just inches deep. Photo October 7, 2010 by Pat Higgins.



**Figure 12.** This photo was taken looking upstream on the mainstem Van Duzen River not far below Yager Creek. The channel is shallow and lacks pools. Low flow conditions promote stagnation. Use of old flatcars has failed to stabilize the bank. Photo by Pat Higgins.



**Figure 13.** Chinook salmon spawning area with ideal gravel above the Hearst Bridge. Pat Higgins. 11/17/10.

The most interesting and somewhat unexpected finding was the apparent total recovery of Chinook salmon spawning habitat in the mainstem Eel River from Dos Rios to above Hearst and Emandal. Fine sediment levels were low and gravel of the appropriate size available in abundance (Figure 13). Gravel supply likely increases sufficiently to support Chinook salmon below Tomki and Thomas creeks downstream of Cape Horn Dam. It is possible that unusual, sustained high flows in the spring of 2003, 2005 and 2006 helped rejuvenate the spawning beds of the mainstem (see Flow Discussion). Riparian encroachment is not evident at Emandal or downstream, likely because there are sufficient flows from wildland hydrology to rejuvenate gravel bars. Middle Fork Eel River spawning substrate may also have similarly recovered (Harris 2007).

Spawning habitat within and below the PVP on the other hand is limited. Lack of appropriate size gravel immediately below Cape Horn Dam and Scott Dam reduced available spawning habitat and limit spawning activity, although spawning habitat improves immediately downstream of Soda Creek. The upper mainstem within the PVP has another problem with regard to spawning gravel accretion; the confined riparian zone due to the altered flow regime since 1922 (Figure 14 & 15). The riparian zone of the mainstem Eel River between Scott Dam and Cape Horn Dam and just downstream has encroached on the low flow channel because of restricted spring flushing flows. This is very similar to problems that developed on the Trinity River below Lewiston Dam (McBain and Trush 1997). The confinement can increase shear stress in the active channel that tends to flush spawning gravels, especially when flows are increased in winter to prevent Pillsbury Reservoir from over-filling. Channel confinement can also make water too swift for juvenile Chinook salmon rearing (McBain and Trush 1997). Gravel suitable for spawning may also accrete on river terraces, but rarely recruits to the stream because it is isolated from the channel by the senescent willow thicket. The only openings in the riparian are where anglers cut them for fishing access (see Fishing/Poaching).

Tributary Conditions: Field reports (Table 1) include more illustrations and detail on tributary conditions. Price, Howe, Chadd and Shively creeks remain massively aggraded by sediment that came off steep headwater areas logged by the Pacific Lumber Company during the 1990s. They are largely disconnected from the mainstem Eel except at very high water. Bear Creek and Larabee are still over-supplied with sediment, but are in somewhat more advanced recovery, having re-established at least partial connectivity to the mainstem. The mouth of Soda Creek and upper Tomki Creek also show significant problems with excess sediment and the latter has very serious problems with flow depletion. While Tomki has an excess of fines from active upland erosional sources, it has also been depleted of spawning gravel by past mining during major highway construction projects.

FOER volunteer Geoff Davis had observed Steelhead Creek since the 1970s and the lower reaches just above the convergence with the Eel were buried 10-15 feet deep as a result of the 1964 flood. On a September 21 walk upstream from the mouth, it became evident that lower Steelhead Creek had cut back down to its pre-1964 grade. Old riparian stumps buried by the flood were re-emerging (Figure 17) and pools had scoured where a shallow riffle existed for more than 40 years (Figure 18). It is likely that sustained high spring flows mentioned as a factor in mainstem bed rejuvenation are also responsible for Steelhead Creek's recovery (see Discussion). Outlet Creek tributaries Baechtel Creek and Willits Creek, above the town of Willits, both maintain functioning habitat patches for spawning Chinook salmon. The South Fork Eel on the U.C. Angelo Preserve had few spawning Chinook salmon on December 1 and appears to be spawning gravel limited, as does the mainstem upstream near Branscomb.

Tomki Creek has experienced a Chinook salmon population collapse since 1985 and other tributaries monitored by CDFG (2009) have very low productivity. Favorable conditions that fostered very high mainstem returns should produce a similar Chinook returns in tributaries in 2010, unless their habitat is too impaired.



**Figure14.** The mainstem Eel River riparian zone below Scott Dam has become overgrown due to altered flow patterns and the flood terraces (red arrows) are disconnected as a result. Google Earth map image.



**Figure 15.** The Eel River floodplain is completely disconnected from the active mainstem channel that is behind the riparian willow thicket at left (red arrow). Photo taken looking downstream from the Trout Creek Campground. By Pat Higgins.



Figure 16. Geoff Davis examines the top of re-emerging alder stump in lower Steelhead Creek buried by the 1964 Flood. Red circle highlights metal pipe that was part of the plumbing at the old Steelhead Creek Hatchery, which was washed out by the 1964 flood. Photo by Pat Higgins.

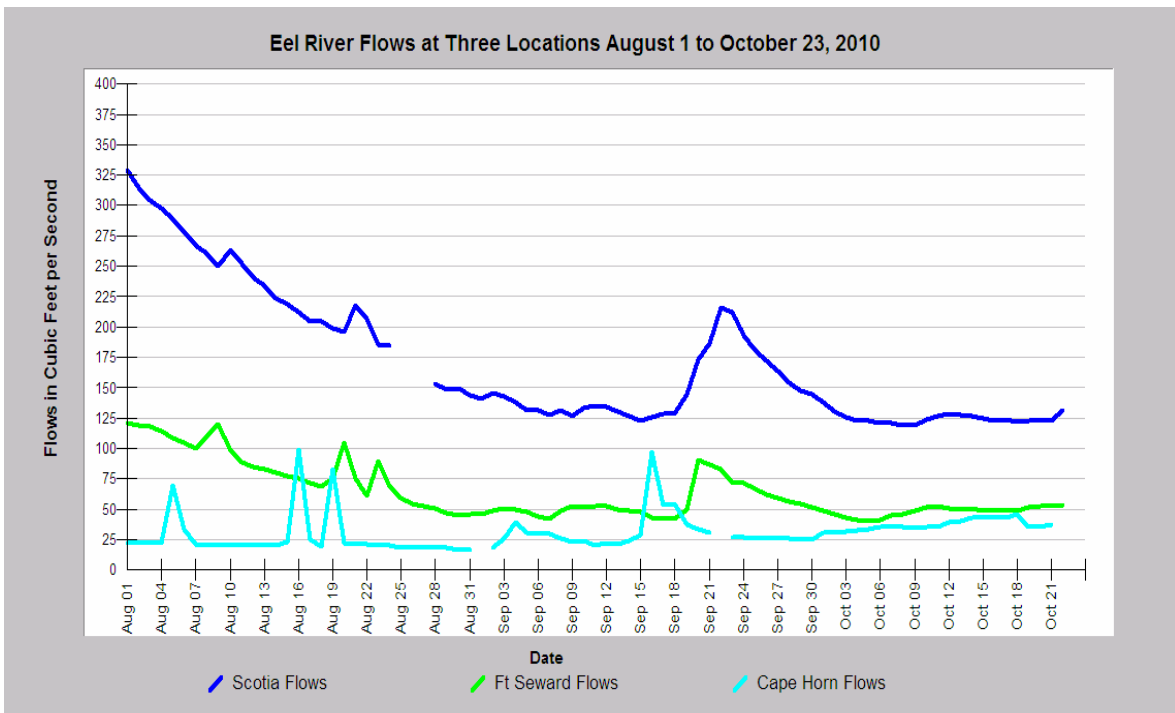


Figure 17. Steelhead Creek pool not far up from the mouth that re-formed after cobble over-burden was flushed sometime in the last several years. Steelhead yearlings photographed under water in this reach are inset at lower left. Photos by Pat Higgins. 09/22/10.

### *Flow Patterns*

U.S. Geologic Survey (USGS) and California Data Exchange Center (CDEC) flow gauge records for various Eel River locations are reported here, including data collected by the Pacific Gas and Electric (PG&E) for releases from the Potter Valley Project (PVP) at Cape Horn Dam. Flow records released by PG&E to the CDEC for Cape Horn Dam only go back as far as March 27, 2007 and historic data from USGS before that period were included to allow comparison of before and after the NMFS (2002) Biological Opinion and implementation of Reasonable Prudent Alternatives associated with PVP operation.

Spawning Migration Flows in 2010: This project was launched over concerns of low flow releases from the PVP and their potential impacts on the 2010 fall Chinook migration, and indeed low flows were impeding fish passage in the lower Eel River before the onset of rain. Eel River flows are displayed in Figure 18 for Cape Horn Dam, Ft Seward and Scotia from August 1 to October 22. Travel time of flows causes a delay in peaks downstream. The lowest flows recorded were 17 cfs on August 31 at Cape Horn, 40 cfs at Ft Seward on October 5 and 119 cfs on October 9 at Scotia, respectively. At these flows,



**Figure 18. USGS flow data for the Eel River and Ft Seward and Scotia and PG&E flow data for the below Cape Horn Dam from August 1 to October 22. Data from the USGS, CDEC and PG&E.**

there were numerous riffles that were very problematic for Chinook salmon passage, including below Fernbridge (Figure 19), at the top of the 12<sup>th</sup> Street Pool (Figure 20), above the Mercer-Fraser run (Figure 21) and at the Hansen Hole below the Van Duzen (Figure 22). Other shallow riffles are documented in field reports (Table 1).



**Figure 19 (above). Riffle below Fernbridge pouring into Creamery Pool. Photo by Nadananda, 09/19/10.**



**Figure 20 (right). Extremely shallow riffle at the top of the 12<sup>th</sup> Street Pool that impeded Chinook migration. Photo by Nadananda, 09/19/10.**



**Figure 21. Shallow riffle spilling into the Hansen Pool below the Van Duzen River, which would be difficult for a large adult Chinook to pass. Photo by Pat Higgins on 10/07/10.**



**Figure 22. Hundreds of Chinook salmon were holding downstream in a relatively shallow run (Mercer-Fraser) likely because this riffle was so shallow. Seagulls may opportunistically benefit when salmon don't make it (see Discussion). Photo by Pat Higgins.**

The forces of nature far overwhelmed the effects of the PVP after the rain event of October 23-25. The mainstem Eel River at Scotia rose from 133 cubic feet per second (cfs) on October 22 to a peak of 29,000 cfs on October 25 and the thousands of Chinook salmon documented holding in the lower Eel River disbursed throughout the watershed. USGS average daily flow charts for both Ft Seward (Figure 23) and Scotia (Figure 24) show that levels remained well above average to the end of the year. Eel River flows after October 23 never dropped below 684 cfs at Ft Seward or below 1360 cfs at Scotia. Rain storms spaced no more than a week to ten days apart made flows for fish passage and spawning abundant. Peak flows in late December exceeded 50,000 cfs at Ft Seward and 70,000 cfs at Scotia.

Flow releases from the PVP were not critical to salmon migration this year because of high rainfall, but numerous releases benefited fish passage (Figure 25). The first peak on October 24 resulted in flows of 534 cfs at Cape Horn Dam and releases never dropped below 145 cfs thereafter. Additional flow peaks of 334 cfs (11/7), 514 cfs (11/23) and 699 cfs (12/6) all allowed for optimal fish passage. However, peak flows associated with spilling of Pillsbury Reservoir on December 29 of 7,960 cfs likely created very adverse conditions for redd stability in the Eel River reach within the PVP.

Flows Before and After NMFS (2002) Biological Opinion: NMFS (2002) issued a Biological Opinion (B.O.) for the PVP, but Reasonable and Prudent Alternatives (RPA) increasing flows were implemented in 2004. Figure 26 shows flows between April 1 and November 15 for 1997, 2000, 2001 and 2002, which are before the RPAs. Flows in mid-to late May in 1997 and 2001 were down to below 40 cfs, which would be particularly

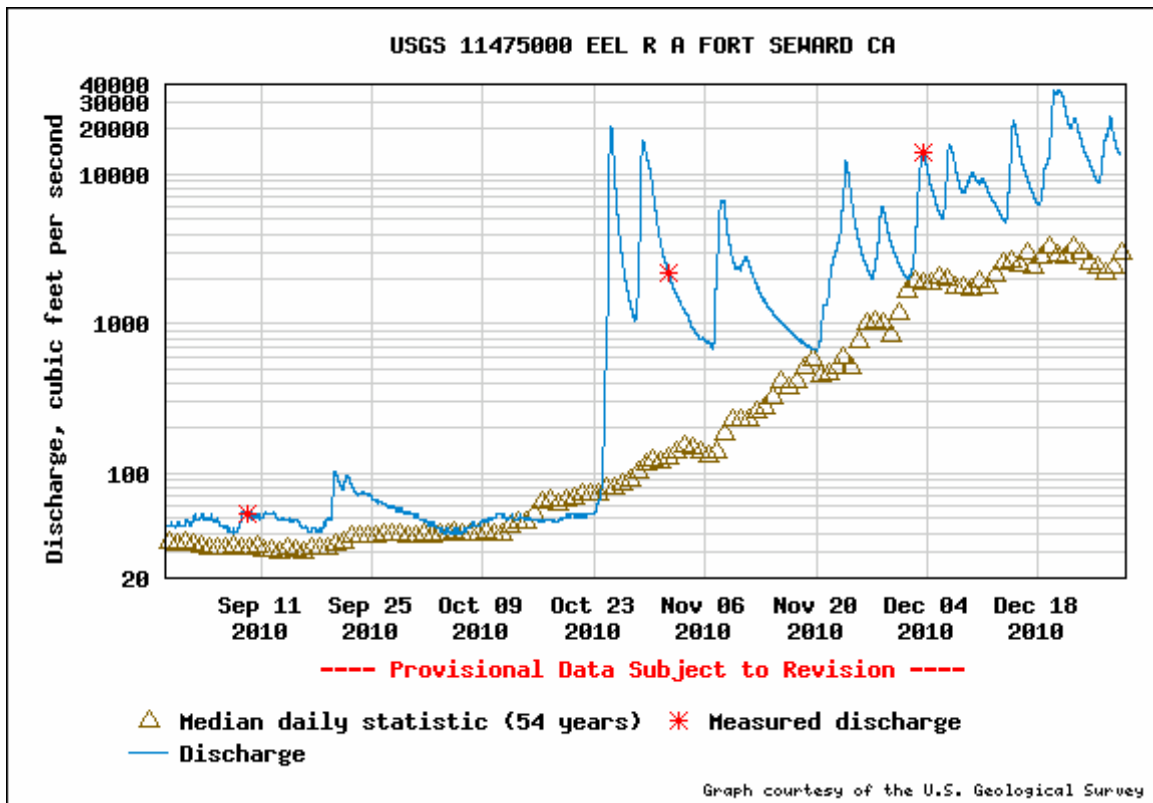


Figure 23. USGS gauge data for Ft Seward with average daily flows during the period of this project.

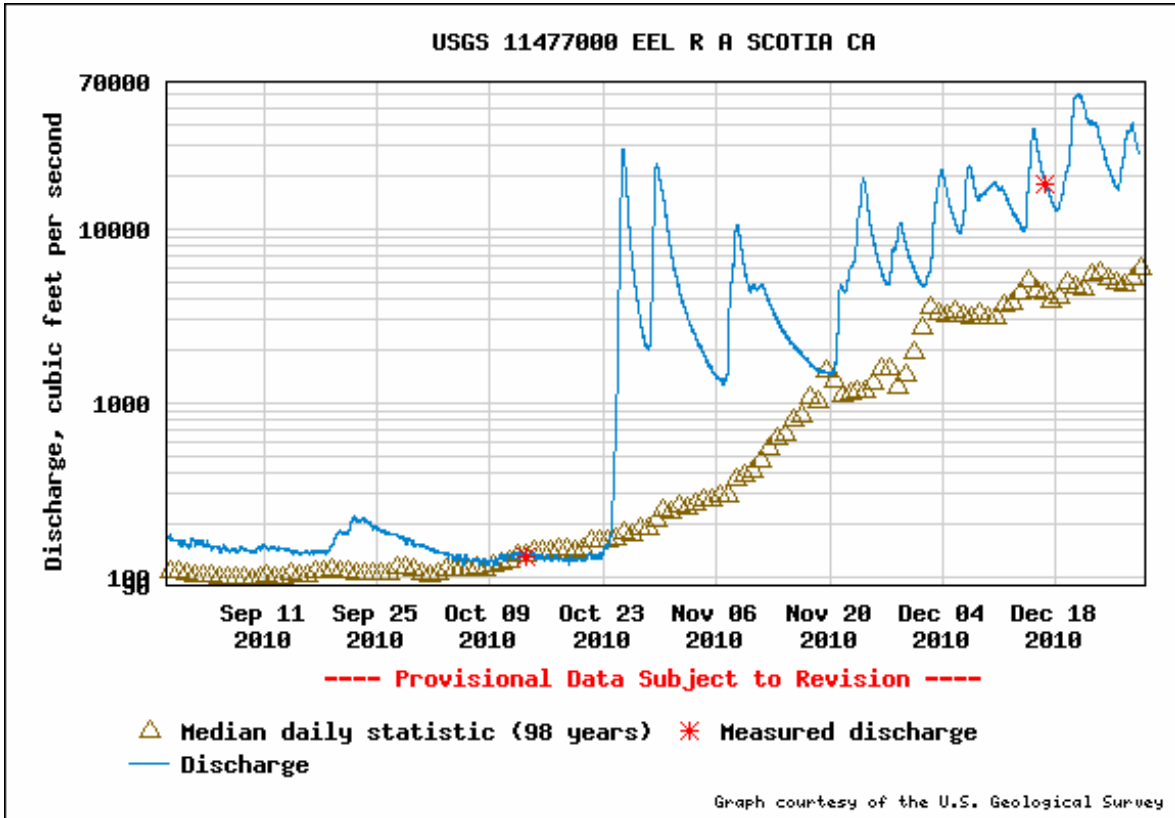


Figure 24. USGS gauge data for the mainstem Eel River at Scotia with average daily flows during the period of this project. Flows after 10/23 exceeded the daily median for the last 98 years except for a few days around November 17-20.

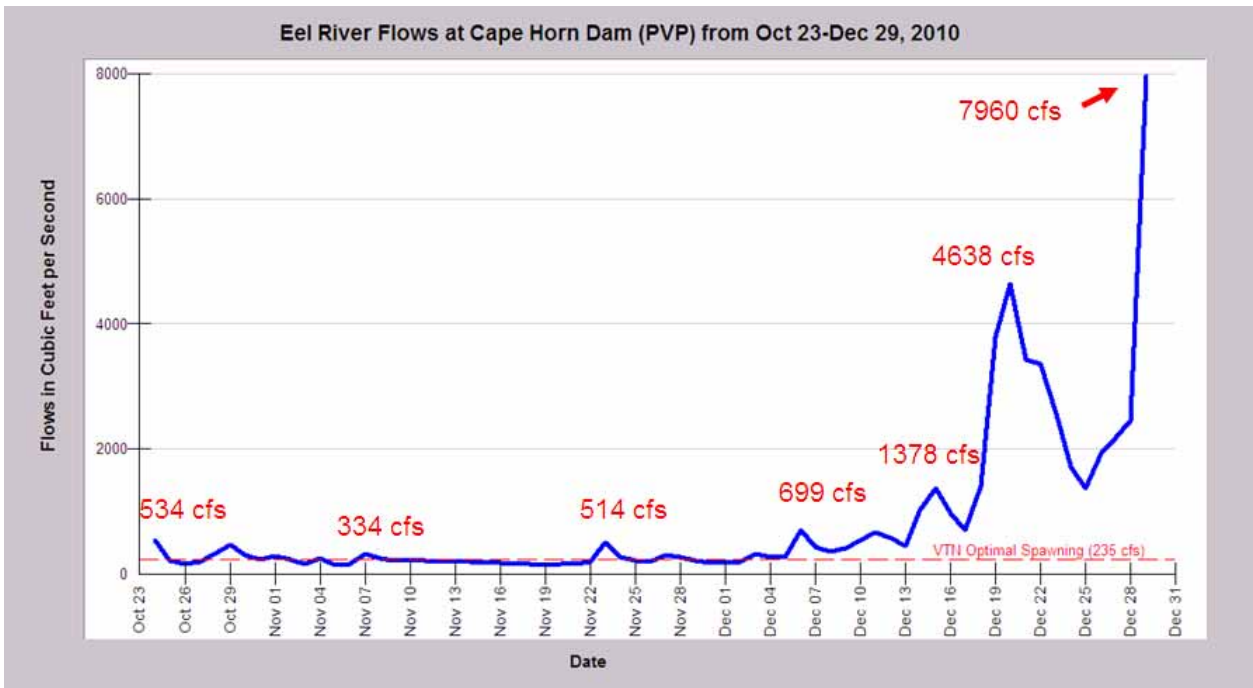
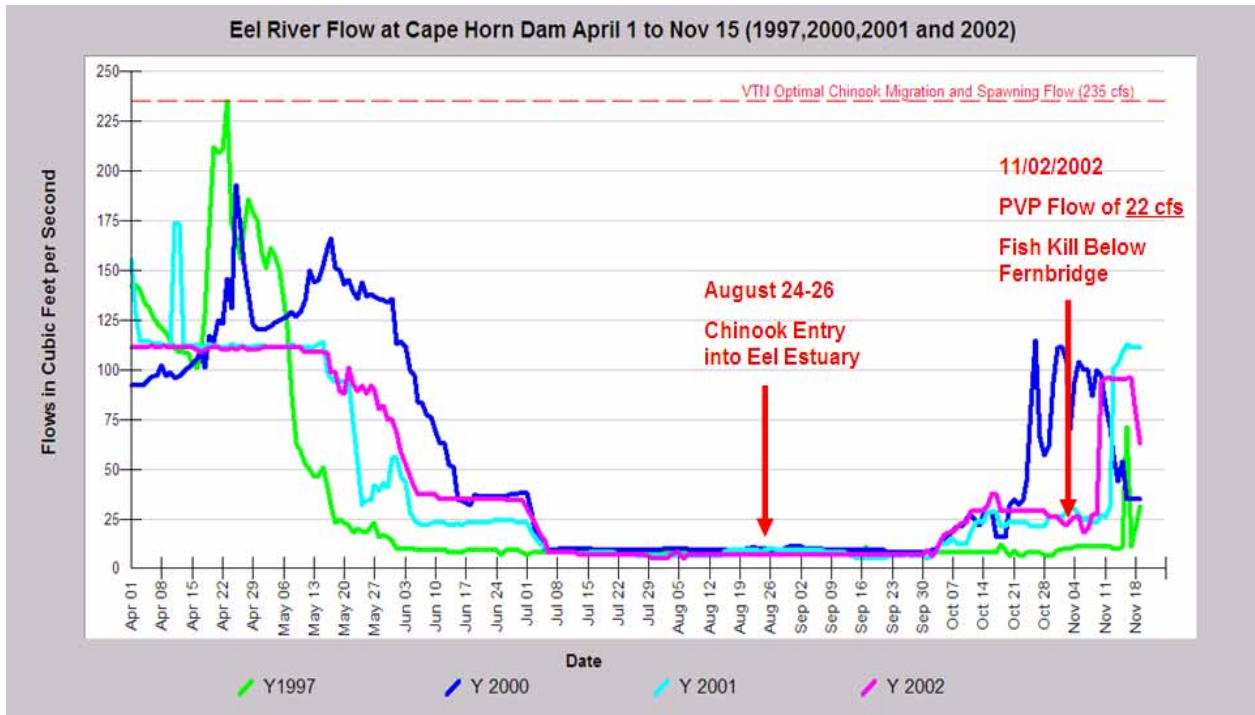


Figure 25. Eel River releases from the PVP at Cape Horn Dam after October 23 rain event. Data from PG&E and the CDEC.

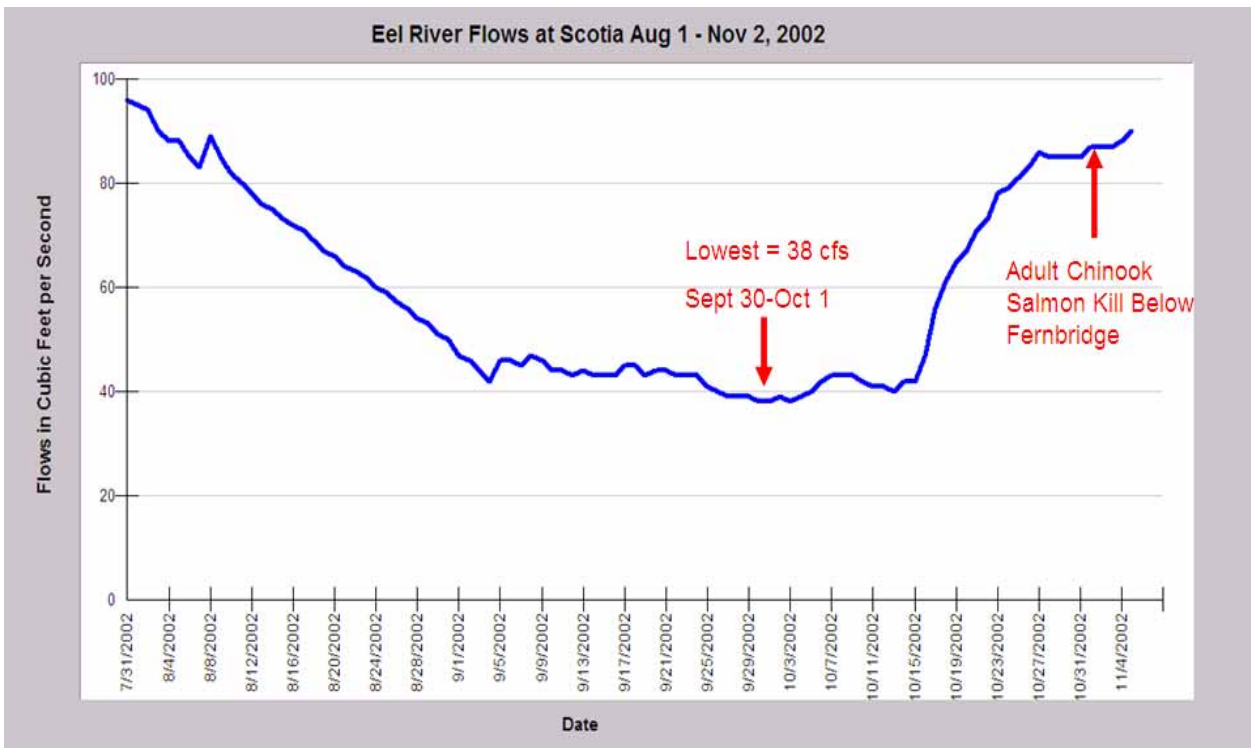


**Figure 26. Eel River mainstem flow releases from the PVP at Cape Horn Dam from April 1 to November 15 for the years 1997, 2000, 2001 and 2002, which are before the NMFS RPA implementation. Data from USGS. See Discussion for explanation of entry timing and fish kill annotation.**

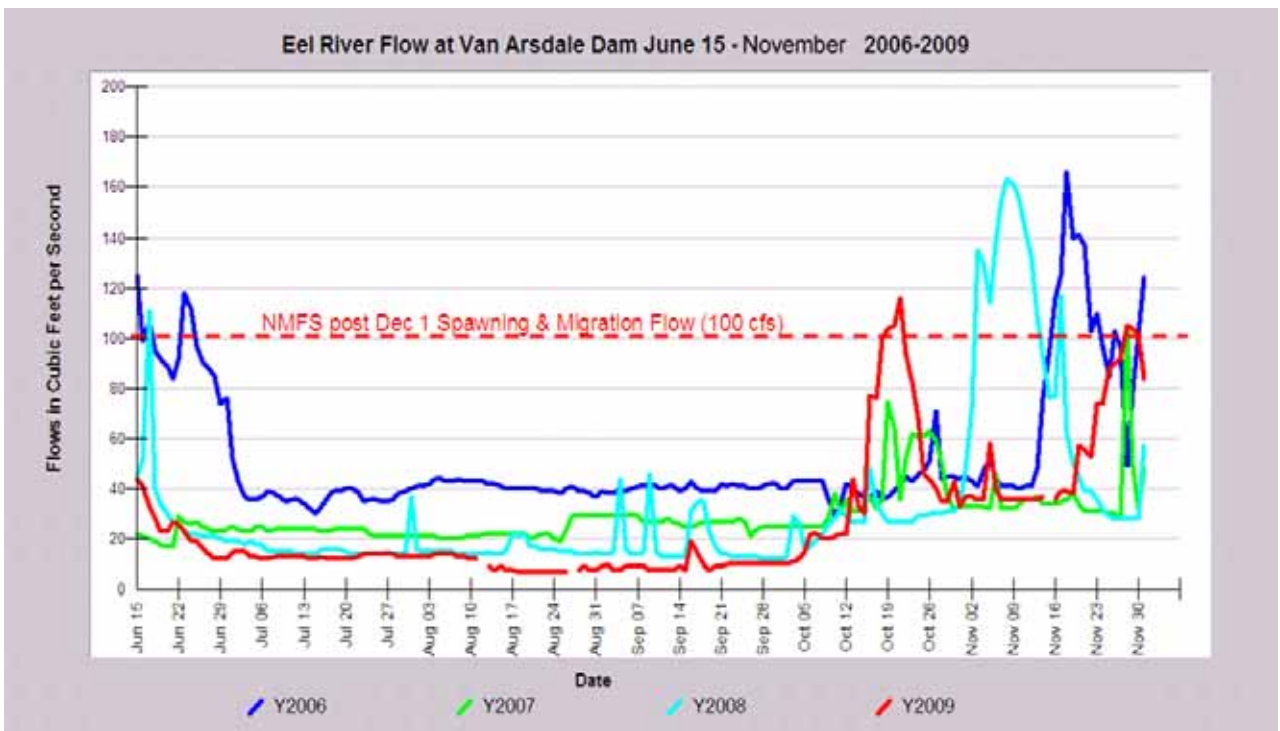
poor for juvenile salmonid survival. Base flows below Cape Horn and the PVP were 10 cfs from July 1 to September 30 in all years. Annotation includes timing of Chinook salmon entry and a November 2, 2002 fish kill (see Discussion). Flows of the lower mainstem Eel River at Scotia in fall 2002 (Figure 27) are also displayed to show mainstem conditions at the time of the fish kill, when the 3,600 square mile basin was only producing 87 cfs of flow.

Post B.O. flow releases from the PVP for 2006-2009 at Cape Horn Dam (Figure 28) for June 15 to November 30 indicate that flows for Chinook salmon adult migration were very low, with 100 cfs only achieved intermittently in November in all years. Adult migration and spawning flows in 2007 and 2009 were particularly poor, with flows often ranging near 40 cfs well into November (see Discussion). Base flow conditions since the B.O. vary with the “wet year” 2006 allocated 40 cfs from July through October, but “dry year” 2009 flows releases during those months were only around 10 cfs (Figure 28).

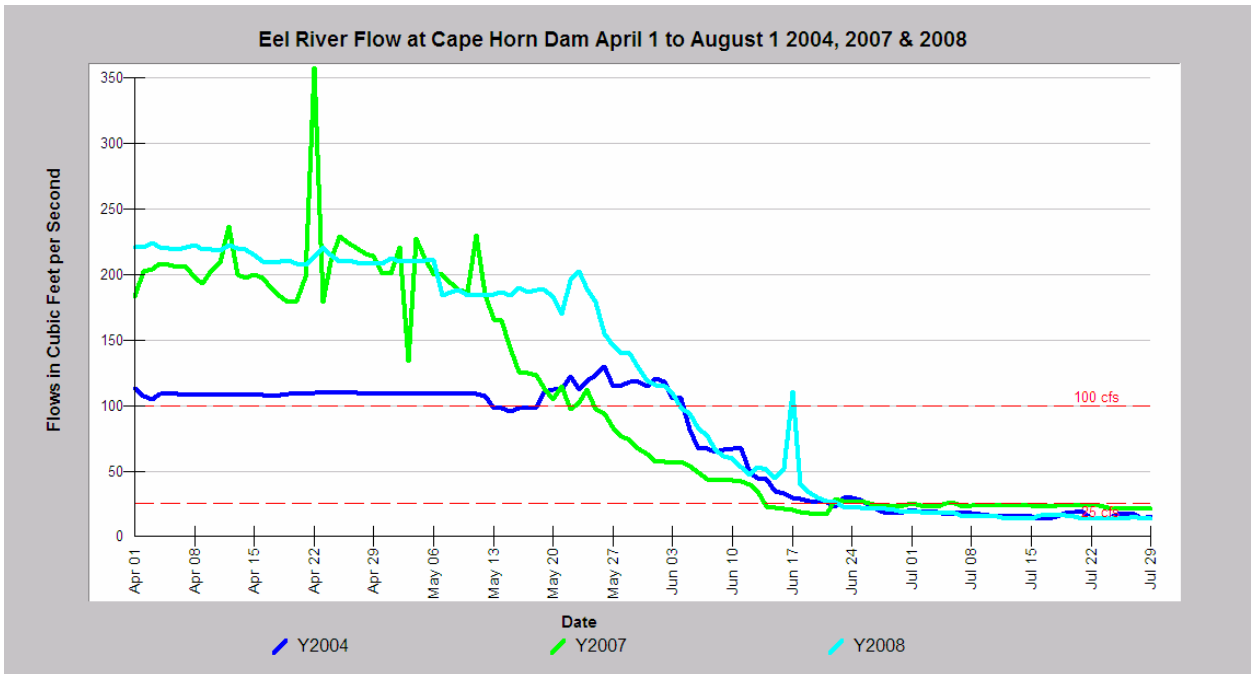
Figure 29 shows spring releases at Cape Horn in recent relatively dry years (2004, 2007, and 2008). An improvement versus levels prior to the RPAs is evident, with 100 cfs maintained through May 30 in all years. USGS flow data from Ft Seward and Scotia indicate that there were very high spring flows in 2003, 2005 and 2006 (Figure 30). They are presented here to provide support for the hypothesis that high flows in those years rejuvenated mainstem Eel River spawning gravels for Chinook salmon.



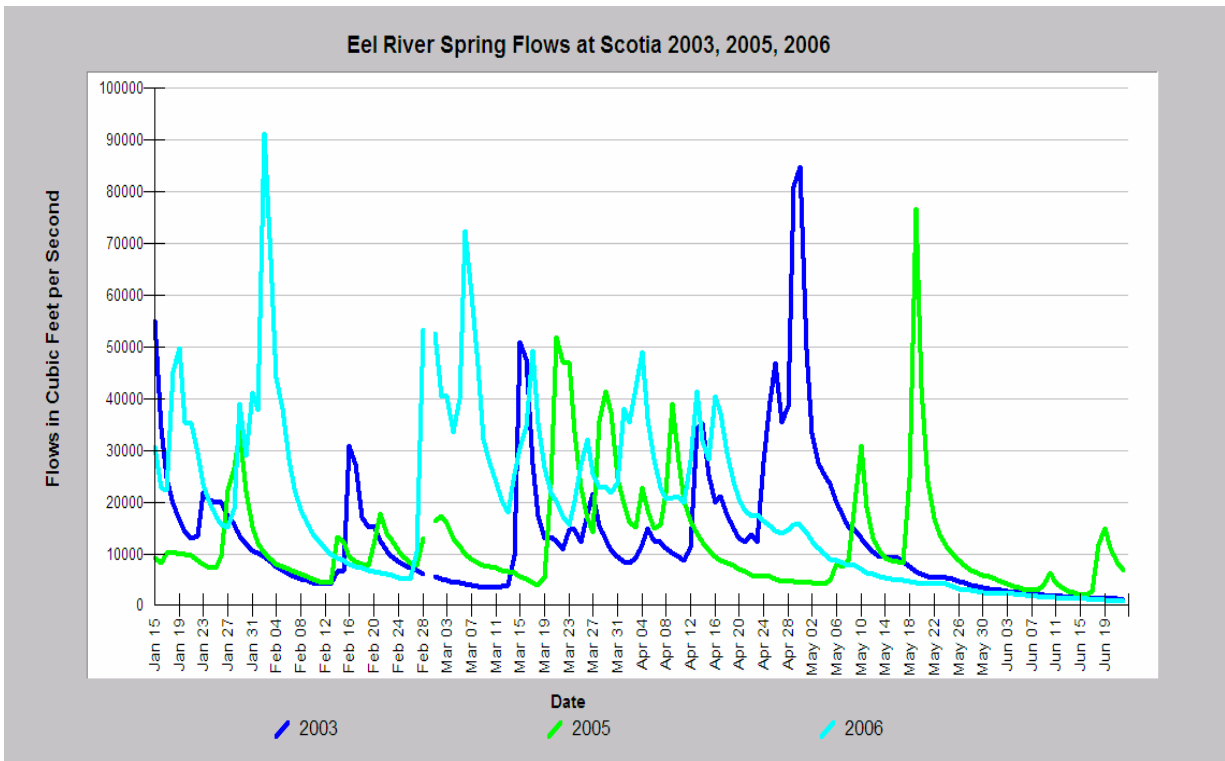
**Figure 27. Eel River mainstem flows from August through early November 2002 at Scotia show a worse case scenario for holding and passage of Chinook salmon. See Discussion for explanation of fish kill annotation. Data from USGS.**



**Figure 28. Eel River mainstem flow releases from the PVP at Cape Horn Dam from June 15 to November 30 for the years 2006-2009, which are after the NMFS RPA implementation. Data from USGS (pre 3/27/07) and CDEC and PG&E (post 3/27/07).**



**Figure 29. Spring flow releases at Cape Horn Dam to the Eel River below the PVP for 2004, 2007 and 2008. These years had drier springs than other years since 2002. Data from USGS (pre 3/27/07) and CDEC and PG&E (post 3/27/07).**



**Figure 30. High spring flows in the mainstem Eel River at Scotia in 2003, 2005 and 2006 are displayed above to support the hypothesis that they helped rejuvenate mainstem spawning gravels. Data from the USGS.**

Spring Flow Patterns 1970 to 2009: A spring flow index for the mainstem Eel River at Ft Seward was developed based on the assumption that a flow of 1000 cfs is sufficient to help juvenile Chinook salmon successfully migrate downstream and avoid predation by pikeminnow. Table 2 ranks years based on the date flows drop below 1000 cfs, with the later dates equating to better survival for Chinook salmon (see Discussion).

Water Pollution and Toxic Algae: Water temperature is a chronic problem in the Eel River (Friedrichsen 1998), but not during the time of this study because of the high flow year and early onset of cool fall air temperatures in 2010. There were, however, signs of major problems with algae blooms in the lower Eel River and such dense growths of benthic algae are recognized as symptomatic of nutrient pollution (U.S. EPA 2000). The bed of the lower Eel River was covered with dense algae growth (Figure 31A), but there was also algae in suspension (B), in the margins of the stream (C) and even in floating rafts (D).

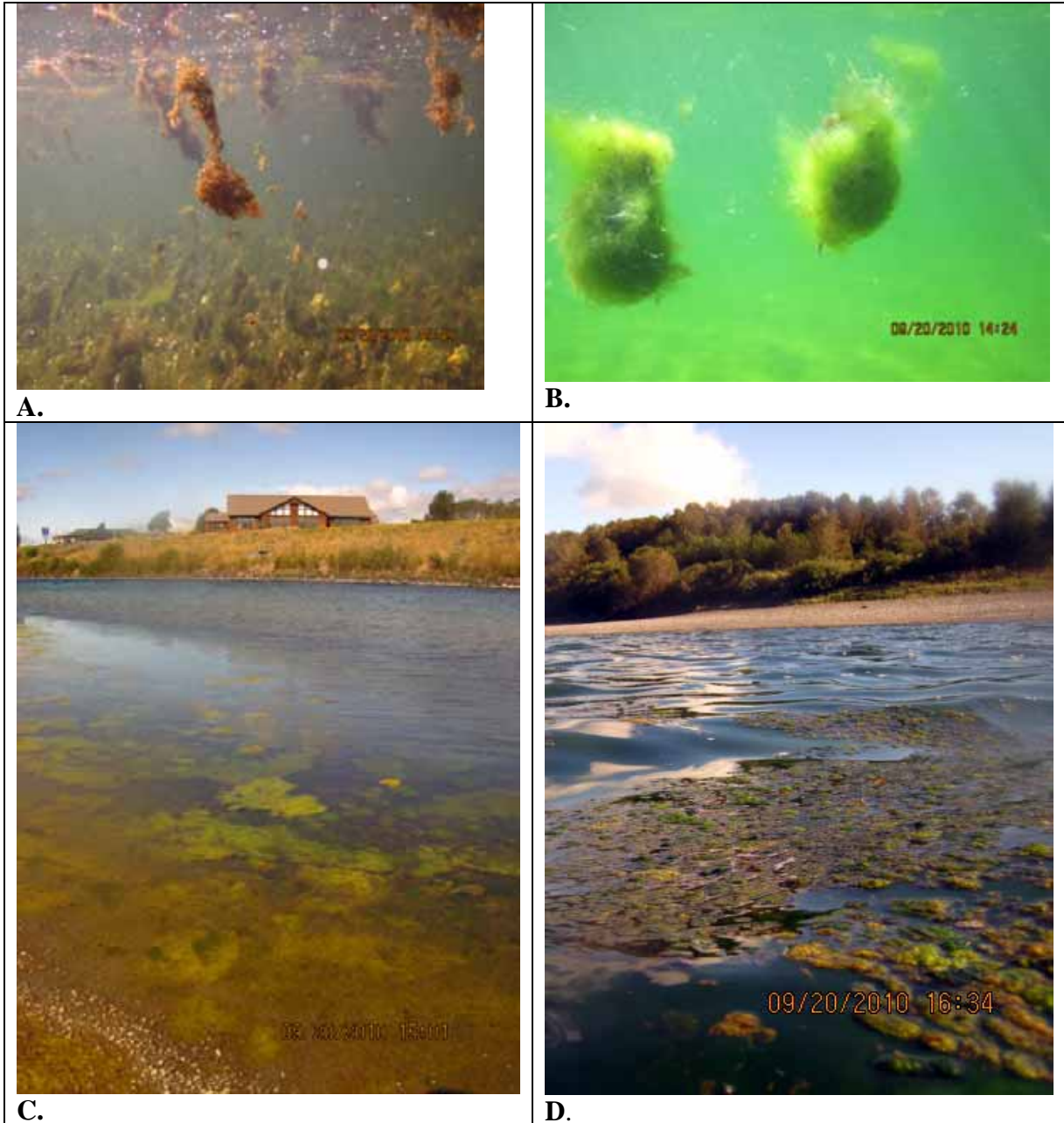
The Eel River has also experienced increasing problems with toxic algae species in recent years and eleven dogs have died of its effects between 2001 and 2010 on the South Fork Eel and Van Duzen River (Hill 2010). Although the onset of problems was late in 2010, the Van Duzen River, South Fork and lower mainstem Eel River were all posted for toxic algae (Harriet Hill, personal communication). Klamath River toxic algae problems are caused by *Microcystis aeruginosa* (Kann and Korum 2006), but the worst pollution events in the Eel River basin resulted from other toxic blue-green algae genera *Anabaena* and *Planktothrix* (Puschner et al. 2008).

Pikeminnow: Field observations from September 14 through October 23 (Table 1) at many locations found the distribution and abundance of the introduced Sacramento pikeminnow to be variable. Major concentrations were seen at Windswept Ranch (Figure 32) not far downstream of Hearst, at Alderpoint, at the convergence of the South Fork and the Holmes Bluff Pool. Large adult pikeminnow were absent at the community swimming hole in Alderpoint likely due to local suppression efforts (see Discussion). No pikeminnow were seen in the pool at the mouth of Chadd Creek or in adjacent reaches, except 12 large adult pikeminnow observed a mile downstream below Bear Creek closely associated with large woody debris. Sighting of an adult otter and abundant nearby otter scat suggested that intense predation might have caused the patchy distribution of pikeminnow here (see Discussion). Adult pikeminnow are rare in the lower Eel River and the only adult sighted was at the mouth of the Van Duzen River. A few juvenile pikeminnow were noted in the lower river, as far downstream as the Creamery Pool, but they too are uncommon. One exception is a breeding ground in the middle of the Boxcar Pool associated with large woody debris that also supports numerous California roach.

Fishing and Poaching: Fall Chinook entered the lower Eel River with mid-September rains and fishing pressure was high in pools upstream of Fernbridge (Table 1). The reach above the Fulmore Pool in the estuary closes to fishing at flows than less than 300 cfs after October 1. Not all anglers may be aware of no kill regulations and reports indicate that keeping salmon is not uncommon. In the Boxcar Pool, a beach seine net was photographed hanging from submerged limbs of riparian vegetation on September 20. A fish gig (Figure 34) and another spear were documented on October 22.

**Table 2. Calendar year and the date average daily flows at the Scotia and Ft. Seward gauges. Red = Very Poor, Orange = Poor, Light Green = Fair, Light Blue = Good, Dark Blue = Very Good.**

<b>Year</b>	<b>Date Scotia &lt;1000cfs</b>	<b>Date Ft. Seward &lt;1000 cfs</b>
1970	May 23	<b>April 17</b>
1971	June 18	<b>June 4</b>
1972	June 4	<b>May 23</b>
1973	June 4	<b>May 27</b>
1974	June 12	<b>June 2</b>
1975	June 19	<b>June 12</b>
1976	May 23* (<1000 2/7 to 2/13)	<b>May 13 (&lt;1000 cfs, Jan-Feb)</b>
1977	April 12* (<1000 1/7 to 2/21)	<b>March 31 (&lt;1000 cfs, Jan-Feb)</b>
1978	June 17	<b>June 1</b>
1979	June 11	<b>May 30</b>
1980	June 13	<b>May 23</b>
1981	May 31	<b>May 22</b>
1982	June 16	<b>June 4</b>
1983	July 9	<b>June 25</b>
1984	June 14	<b>May 23</b>
1985	May 17	<b>May 4</b>
1986	June 3	<b>May 18</b>
1987	May 16	<b>May 7</b>
1988	May 24	<b>May 15</b>
1989	June 8	<b>May 13</b>
1990	July 3* (<1000 4/30 to 5/20)	<b>June 18* (&lt;1000 cfs 4/14 to 5/21)</b>
1991	June 4	<b>May 28</b>
1992	May 22	<b>May 5</b>
1993	July 12	<b>June 27</b>
1994	June 1	<b>May 24</b>
1995	July 2	<b>June 24</b>
1996	June 23	<b>June 10</b>
1997	May 31	<b>May 14</b>
1998	July 10	<b>July 5</b>
1999	June 17	<b>June 8</b>
2000	June 5	<b>May 29</b>
2001	May 21	<b>May 12</b>
2002	May 29	<b>May 3</b>
2003	June 25	<b>June 11</b>
2004	June 1	<b>May 13</b>
2005	July 17	<b>July 2</b>
2006	June 18	<b>June 9</b>
2007	May 25	<b>May 16</b>
2008	June 4	<b>May 31</b>
2009	June 9	<b>May 24</b>
2010	July 5	<b>June 23</b>



**Figure 32. A) Mats of algae cover the bottom in a riffle above the Boxcar Pool and globs go into the drift as oxygen bubbles created during photosynthesis cause the masses to float. B) Floating globs of algae in the lower Eel River above the 12<sup>th</sup> Street Pool. C) Algae grows in abundance in warm, shallow side waters with River Lodge in the background. D) Floating mat of algae in the lower Eel River below the Boxcar Pool. Photos by Pat Higgins.**

These observations were reported to CDFG and photographs supplied. A dead female Chinook salmon was found in the Boxcar Pool on October 1 by USFWS divers (Figure 35). The fish was very fresh and had no sign of disease and could have died from crowding and acute stress (see Discussion). There were also signs of illegal “trout” fishing in the Eel River reach within the PVP that targets steelhead juveniles despite well placed signs advising fishermen that fishing for them is prohibited.



**Figure 32. Sacramento pikeminnow and California roach abound in pool on the Windswept Ranch at Hearst. The vegetation is a bed of *Elodea*, which like the two fish species, is not native to the Eel River. Photo by Pat Higgins.**



**Figure 33. Fish gig on the bottom of the Boxcar Pool where other signs of active poaching were also evident. Photo by Pat Higgins.**



**Figure 34. Dead Chinook salmon female of approximately 11 pounds with no seal bites or hook scarring. There was no apparent cause of mortality that could be discerned from on-site evaluation and the fish carcass was not collected. Photo by Pat Higgins.**

## **Discussion**

### *Dive Observations and Other Options for Generating Indices of Abundance*

The abundance of Eel River salmon in 2010 should prompt more effort to estimate the fall Chinook salmon population. Instead of heading for extinction, the population appears to be showing signs of rebuilding and might support a fishery again, if properly managed. Halligan (1997, 1998) used direct dive observation methods to estimate Chinook salmon in the lower Eel River. However, team dives such as on October 1 provide a more accurate count that could be used to provide an index of abundance and trends. Dives should occur at least every two weeks from September 15 to November 15, unless flows rise and fish move upstream. The possibility of getting estuary estimates using a “fish finder” should also be explored.

Sport anglers handle hundreds of fall Chinook and they could apply floy tags to released fish, if supervised. This might provide a basis for Peterson mark/re-capture population estimates (Seber 1982), if enough tags are collected during spawner surveys. Tag recovery could be improved, if volunteer monitoring were used to expand CDFG spawning survey effort. There was substantial interest from FOER volunteers to assist with this project and their help could be enlisted in years when observation conditions are

suitable. However, all such field efforts in the Eel River are subject to being washed out by high flows, as fall and early winter flows of 2010 clearly demonstrate.

Dual frequency sonar systems (DIDSON) are now available that can count individual fish regardless of flow conditions (NMFS 2010). One or more DIDSON units should be installed in the lower Eel River and/or at other strategic locations to get an accurate count of Pacific salmon species, including fall Chinook. A pilot project on the Smith River in 2010 is working extremely well and over 15,000 fall Chinook salmon were counted as of November 28 (Zack Larson personal communication).

***Basin-wide 2010 Chinook Escapement Approximation and Historic Ranking***

Appendix A contains the basis of assumptions for the approximation of Eel River Chinook salmon escapement in 2010 (Table 3). The Eel River run of fall Chinook salmon in 2010 was likely at least 10,000 fish and it is plausible that it may have been three to four times that number. This would place it in the range of U.S. Fish and Wildlife Service (USFWS 1960) survey estimates for 1955-1958 of 14,500 to 38,045 Chinook, with an average of 24,361 fish. CDFG tributary spawning survey results from 2010 were not available at the time of publication of this report, but they may give an indication of whether the escapement is towards the high or low end of Table 3 estimates.

**Table 3. Approximations of Chinook escapement to the Eel River in 2010 by sub-basin.**

<b>Basin</b>	<b>High</b>	<b>Low</b>
VAFS	2315	2315
Upper Eel/Outlet Mainstem	10,000	3000
Middle Fork	5000	1000
Van Duzen	5000	2600
South Fork	7500	2000
<b>Approximations</b>	<b>29,812</b>	<b>10,912</b>

Yoshiyama and Moyle (2010) state that Chinook salmon escapements to the Eel River since 1964 have not totaled more than 10,000, but the years from 1985-1987 may be an exception. Tomki Creek and VAFS combined counts totaled more than 4,000 Chinook in that period and angler catch was substantial. The latter period was before the destructive impacts of Maxxam/Pacific Lumber Company logging; therefore, lower Van Duzen and Eel River tributaries would still have been producing thousands of Chinook salmon cumulatively. The South Fork Eel was also in late recovery from the 1964 flood and impacts of extensive private-land logging there in the mid-1980s had not yet yielded sediment. Although the pikeminnow had been introduced circa 1980, they were not yet a significant predator of year classes making up the 1985-87 escapement.

It is safe to say that the 2010 Eel River Chinook escapement was the largest since 1985-87 and may have been the largest since 1955-58, however, it did not likely equal runs in

the 1940s. The highest returns from Benbow Dam counts on the South Fork Eel (Table 4) indicate that 21,011 Chinook salmon were counted there in 1941. The period before post WW II logging likely still had the capability to produce basin-wide runs of over 100,000. Note also that more coho salmon than Chinook passed Benbow Dam in some years, such as in 1942, 1947 and 1955. Coho are not recovering in much of the Eel River basin and their population is likely down an order of magnitude from recorded highs. An exception is the upper South Fork and its tributaries like Hollow Tree Creek that do maintain a viable coho salmon population (Scott Harris, personal communication).

**Table 4. Chinook, coho and steelhead counts at Benbow Dam and Chinook at VAFS. Data from Yoshiyama and Moyle (2010) and Harris (2010).**

Year	Chinook Benbow	Coho Benbow	Steelhead Benbow	Chinook VAFS
1941	21,011	13,694	17,356	ND
1942	10,612	15,037	25,032	ND
1946	16,024	14,109	19,005	917
1947	13,160	25,289	18,225	994
1950	14,357	12,050	15,138	55
1955	3,974	5,977	10,065	5
1964	8,315*	4,468*	2,358*	63
1970	9,367*	2,070*	3,328*	15
1975**	4,101*	509*	1,847*	2

\* Partial counts due to high flows. \*\* Last year of Benbow Dam fish counts.

### ***Conditions Leading to Fall Chinook Abundance in 2010***

The following factors in order of importance fostered the high Chinook salmon escapement in 2010:

- Mainstem Eel River spawning habitat recovery,
- High spring flows for most recent years,
- Good ocean conditions,
- Reduced fishing pressure, and a
- Cycle of reduced pikeminnow abundance.

**Mainstem Eel River Spawning Habitat Recovery:** Field observations (Table 1) and Harris (2009) document widespread use of the mainstem Eel River for Chinook salmon spawning from Dos Rios to the VAFS in 2009 and 2010. Although the middle and upper Eel River reaches are listed as sediment impaired (U.S. EPA 1999, 2000), it would seem that gravel quality has recovered sufficiently for successful Chinook salmon spawning. Lack of widespread, active land use (passive restoration), coupled with naturally high flushing flows in recent spring periods (Figure 30), seem to have reduced fine sediment.

The Eel River in dry or average water years may only attain flow levels capable of moving bedload for a few days associated with winter storm peaks. In 2003, 2005 and 2006 the Eel had flows capable of moving bedload for weeks, extending into April and May (Figure 30). For example, late spring flows on the mainstem Eel River at Scotia were 84,700 cfs on April 30, 2003 and 76,700 cfs on May 19, 2005. In 2006 peaks included 90,000 cfs in February, 70,000 cfs in March and three flow peaks of over 40,000 in April at Scotia. Similar prolonged wet periods and sustained high flows also occurred in other years, such as 1995, 1998 and 1999, and likely also contributed to bed rejuvenation. These wet years are correlated to the switch in the Pacific decadal oscillation cycle in 1995 (Collison et al. 2003).

High Spring Flows and Chinook Juvenile Survival: Since Chinook can return at 2, 3, 4, 5 or 6 years of age, due to variable periods of ocean residency, contributing year classes to the 2010 escapement extend from 2004-2008. For the basis of comparison, the date when flows dropped 1,000 cfs at Ft Seward is used as an index of conditions for juvenile Chinook survival (Table 2). This is based on the assumption that such high flows into late spring and summer are associated with favorable temperatures for Chinook juvenile migration and that such flows also reduce predation by pikeminnow. Fair to very good spring flows that likely aided juvenile Chinook survival have prevailed during recent brood years. Flows at Ft Seward were optimal in 2005 and 2006 with 1,000 cfs maintained until July 2 and June 9, respectively. Flows of that level held into mid- to late May in all other years, which still likely lead to relatively high juvenile survival. For reference, flows dropped below 1,000 during drought periods as early as January in 1976 and 1977 and on April 14 in 1990. While increased flow releases from the PVP may have somewhat assisted upper Eel River Chinook salmon survival in 2007 and 2008, naturally high spring flows from 2005-2009 played a much larger role in helping the population rebound. High flows may also adversely affect pikeminnow recruitment (see below).

Good Ocean Conditions: Hare et al. (1999) described the climatic and oceanic variations known as the Pacific decadal oscillation (PDO) cycle that affects salmon populations of the Eel River and the northern California region. Productive ocean cycles coincide with wet on-land conditions for a period of about 20-25 years, then alternate with ocean conditions prone to warm El Nino events and periods of lesser rainfall. When conditions are more productive off Alaska, the PDO index is positive and when they create good ocean conditions off California and the Pacific Northwest, the PDO index is negative (Hare et al. 1999). Productive ocean conditions and high rainfall benefited northwest California salmon runs from 1950-1975 and less productive ocean and dry on-land conditions extended from 1975-1995 (Collison et al. 2003). The PDO shift since 1995 has resulted in increased precipitation and mostly favorable ocean conditions off northern California, which is reflected in increased VAFS returns in the time period since (Figure 4).

MacFarlane et al. (2008) found an exception to good recent ocean conditions using the Wells Ocean Productivity Index (WOPI). They concluded that “ocean conditions were poor for salmon growth and survival during the spring–summer of both 2005 and 2006” off the northern California coast, which likely effected survival of both Chinook salmon and coho salmon. Ironically late rain events in 2005 and 2006 that helped increase

juvenile salmonid survival in the Eel River also disrupted spring time northwest wind patterns and upwelling. High survival of juveniles in those years in freshwater may have somewhat offset the effects of poor ocean conditions. More productive ocean cycles have prevailed since 2007 and the large component of jack salmon returning in 2009 and 2010 is an indicator.

Reduced Fishing Pressure: Harvest of Chinook salmon has been illegal in the Eel River since listing of California Central Coast Chinook salmon, which has assisted population recovery. Ocean commercial and sport salmon fishing can still have significant impacts on Eel River fish as they are harvested in “mixed stock fisheries”. Hatchery fish can sustain a very high harvest rate while wild fish may be vulnerable to over-harvest, especially if they return to poor freshwater habitat (Lichatowich and McIntyre 1986). Eel River Chinook salmon are caught in ocean fisheries along with abundant hatchery fish from the Sacramento-San Joaquin, Klamath-Trinity and Columbia River basins. However, since 2007 ocean fisheries have been closed or greatly reduced due to the Central Valley Chinook salmon collapse (Lindley et al. 2009). Although there was an ocean sport season off Eureka and the Eel River in 2010, upwelling near shore that concentrates salmon did not occur and the catch rate was very low.

Pikeminnow Abundance Decline: The dive reconnaissance for this project indicated patchy distribution of large adults and concentrations of pikeminnow (Table 1). McKeon and Reineck (2002) reported that high flows in spring reduced successful survival of juvenile pikeminnow larvae; thus, recent wet springs may also have reduced the population of the predatory pikeminnow. This contrasts sharply with the period of drought from the mid-1980’s through 1994. Distribution in 1993 was more uniform and a September 24 dive survey estimated 266,000 pikeminnow of various age classes in the 140 miles surveyed, which included the lower South Fork, lower mainstem Eel River to Alderpoint and lower Van Duzen rivers (Clancy 1993). Angler efforts, spear fishing and otter predation may also be factors in reducing the pikeminnow population and predation on salmonids (see Pikeminnow Control).

### ***Need for Improved Habitat Conditions***

While the mainstem Chinook salmon spawning habitat from Dos Rios to just below Cape Horn Dam is in recovery from past sediment pollution, the lower mainstem Eel River, lower Van Duzen and habitat within and just below the PVP remain impaired.

Lower Eel River: The poor condition of lower Eel River pools forces Chinook salmon schools to sit in relatively shallow runs where they are more stressed and vulnerable to predation. Profuse algae blooms that coat the bottom of the river, float in the water column and sometimes accumulate on the surface could create stressful or lethal dissolved oxygen conditions. If cycles of abundance continue, it is possible that many more fish will enter the very limited pool habitats of the lower Eel River and that a fish kill could result, similar to the Klamath River (CDFG 2003). The solution offered below would include increasing the size of some key pools like the Worswick through use of bioengineering, similar to a project recently carried out in the Mad River estuary (Stillwater Sciences 2008). Also, consideration should be given to deflecting flow in important holding locations like the Hansen and Creamery pools annually.

Humboldt Redwood Company (HRC) has acquired Pacific Lumber Company lands and could play a strategic role in accelerating recovery of key lower Eel River tributaries like Bear and Larabee creeks.

Lower Van Duzen River: The disconnection of the Van Duzen River is a major ecological problem that puts its early run of salmon and steelhead at risk. In years when drought lasts into November, fish are forced to hold for weeks or months in adjacent lower Eel River pools. Bioengineering using cottonwood trees to confine the channel and rebuild a gallery forest downstream of Yager Creek should be considered. This could cause increased sediment transport and scour of pools that could serve as a Chinook salmon and steelhead refugia. While the upper mainstem Van Duzen has high water temperatures in summer, the river tends to cool as it heads toward the ocean. Also there is a substantial reservoir of cold water under the gravel bar in the lower river, as indicated by the cold water seeps downstream of its mouth in the mainstem Eel River. Re-establishing lower Van Duzen meanders could foster hyporheic connections between surface and groundwater and create a cold water refugia. Creating a “salmon park” from Yager Creek downstream to the Eel River would not only have major conservation benefits, but would provide recreational opportunities that improve local quality of life and help stimulate the economy by increasing angling and eco-tourism.

The HRC has expressed willingness to work with local citizens in the Van Duzen River and to help accelerate salmon habitat recovery. CDFG spawner surveys indicate that upper Lawrence Creek on HRC lands is already a spawning center for Chinook salmon and protection and restoration of this reach is of highest priority (Higgins 2007). The likely existence of a center of spawning activity in the mainstem above Bridgeville is good news because this refugia will likely provide colonists for HRC tributaries as they recover from sediment impacts.

Eel River Estuary: Extended estuary rearing increases Chinook salmon growth and subsequent ocean survival (Reimers 1971). The Eel River estuary is still ecologically functional and water temperatures there remain cool enough for salmonids throughout the year. Disconnection of tidal marsh within the estuary over the last 150 years has decreased its volume and cut off productive rearing habitat. The reduction of tidal flux in the estuary, caused by reducing its size, also reduces tidal energy and promotes filling. Opportunities to reconnect tidal wetlands should be further explored. A major channel at the top of the estuary to the east has been cut off from flow yet maintains good riparian habitat and depth (Figure 35). This area should be considered for reconnection by deflecting flow into it.

PVP Affected Reaches: The area within and just below the PVP has habitat problems similar to the Trinity River below Lewiston (McBain and Trush 1997) and similar restoration actions are needed on the affected reaches of the Eel River. These would include increasing spawning gravel supply, but also removal of some encroaching riparian vegetation and creation of quiet water edge habitat suitable for rearing Chinook salmon. These are called “feather edge” projects on the Trinity River and they also tend to increase spawning gravel supply as the flood terrace is reconnected to the river.



**Figure 35. Isolated Eel River estuary side channel with intact riparian and relatively deep water. Flow into this channel is blocked by gravel deposits in an area just out of view. Photo by Pat Higgins. 10/20/10.**

The large alluvial flat just upstream from Van Arsdale Reservoir should be considered for reconnection to its flood plain. This area is recognized as having both high Chinook and coho salmon intrinsic potential habitat (Bjorkstedt et al. 2005, Williams et al. 2008) and re-establishing meanders here would help create more spawning and rearing habitat capacity.

Bioengineering needs to be applied at the mouth of Soda Creek just downstream of Scott Dam. Massive aggradation at the mouth of this stream has caused elimination of riparian vegetation and created a channel that is very poor fish habitat and that loses surface flow in summer and fall. This project should be given priority, since re-establishment of connectivity here would increase available spawning and rearing areas for steelhead and Chinook salmon spawning within the PVP affected reach of the upper Eel. At the end of December 2010, the Eel River at Cape Horn Dam was flowing at 7960 cfs and associated scour and fill of the stream bed likely reduced spawning success for the 2,315 Chinook within the PVP. Action is needed now.

South Fork Eel: The South Fork flow is being depleted and nutrient contributions are increasing resulting in conditions that foster toxic algae. The greatest restoration needs in this basin are to implement water conservation and to decrease nutrient pollution (see Need for Water Quality Improvement). The upper South Fork Eel River watershed is in recovery from past logging and the stream remains cool, serving as a thermal refugia for salmon and steelhead, but it appears limited by spawning gravel availability. Spawning habitat capability studies are needed for the U.C. Angelo Reserve and reaches of the South Fork upstream. If this hypothesis is confirmed, the possibility of placing large wood structures that span the stream and trap spawning gravel should be considered.



**Figure 36. Lower Soda Creek just upstream of its convergence with the upper Eel River. The wide gravel bar is caused by aggradation and the chains of boulders and two small conifers are signs of past restoration projects. Bioengineering with willows and cottonwoods could help redefine a stream course here and re-establish surface flow and connectivity. Photo by Pat Higgins. 11/18/10.**

Ten Mile Creek is actively used by Chinook salmon and it has some of the best intrinsic potential coho salmon habitat in the Eel River basin (Williams et al. 2008). The creek joins the upper South Fork at the bottom of the Angelo Preserve, where the river maintains perennial cold water temperatures (Friedrichsen 1998) and serves as a summer refugia for salmonid juveniles. The center of the last functional Eel River coho salmon population is just downstream adjacent to and within Hollow Tree Creek (Scott Harris personal communication). Bradbury et al. (1995) point out that the greatest benefit from restoration is derived from activities immediately adjacent to refugia. Therefore, Ten Mile Creek should be a priority for Pacific salmon restoration efforts.

Hollow Tree Creek is a rare example of where previous restoration efforts have made a significant improvement in Chinook and coho salmon habitat and their populations. The Mendocino Redwood Company worked cooperatively with Trout Unlimited to decommission roads and place large wood in the stream, thus both helping restore watershed hydrology and also improving habitat conditions. If the Redwood Forest Foundation ([www.rffi.org](http://www.rffi.org)) is successful in similar recovery of forest health in tributaries from Piercy to Leggett in the western South Fork watershed, then the coho salmon refugia will expand and become more secure.

Outlet Creek (Baechtel Creek): The upper-most reach of Baechtel Creek accessible to Chinook salmon gets consistent spawning returns and even has spawning coho salmon

during strong year classes. Abundant groundwater is available to also assist with maintaining a cool stream temperature. The area used for spawning is just upstream of Indian Creek, but there is a low gradient channel reach downstream that was likely productive historically, and that could be restored. The reach is fallow grazing land that is not being actively managed and its location at the urban interface has led to its use as an illegal garbage dump. Bioengineering could improve habitat complexity and expand the upper Baechtel Creek refugia.

Tributary Deltas: Many Eel River tributaries are disconnected from the mainstem Eel River by massive deltas formed during past large storm events and periods of elevated sediment transport. Cumulatively the loss of these tributaries for early run Chinook salmon is substantial. Migrating juvenile salmonids survival would improve if there was access to these cold streams when the mainstem is too warm for their health and survival. Studies are needed to see if there is a way to improve connectivity of tributaries like Shively, Price, Chadd and Twin Creeks as well as Cummings Creek on the Van Duzen River.

### ***Flow Needs of Chinook Salmon***

Despite wet spring and early summer high flows in most recent years, fall flows have been low (Figure 28) and there is evidence that Chinook salmon migration has been impeded. The return to VAFS of Chinook salmon in 2010 began on October 29 and peaked by mid-November, with very few fish arriving after the week of Thanksgiving. In 2009, only a hand full of fish arrived in the first week of November, and the largest pulse of fish actually passed the VAFS in mid-December. The delay in migration and spawning likely decreased the survival of adult salmon and female fecundity. Also, juveniles that hatch later because of later spawn timing have less time for growth on their journey to the ocean, more likelihood of encountering lethal water temperatures due to slower migration, greater risk of pikeminnow predation, and, therefore, likely lower survival. Thus, lack of flow releases in November appear to be causing a “take” of Chinook salmon under ESA.

Very dry years present an even greater challenge for Chinook salmon migration and this project obtained evidence of a fall Chinook salmon kill below Fernbridge on November 2, 2002. Travis Sheets, a dairyman and angler, was observing a large school of adult Chinook salmon moving up from the Fulmore Pool towards Fernbridge on the evening of November 1 during a very high tide. He returned the next morning to find the gravel bar littered with dead Chinook carcasses that were being eaten by seagulls (Figure 37). He surmised that the fish had panicked as the tide retreated after dark and they became stranded. As noted above, flows on the mainstem Eel River at Scotia were 87 cfs on November 2, 2002 (Figure 26) and releases at Cape Horn Dam were only 28 cfs. Riffle depths were too shallow for passage upstream out of the estuary (Figure 38).



**Figure 35. Dead Chinook stranded on the gravel bar below Fernbridge on November 2,2002. Photo courtesy of Travis Sheets.**



**Figure 36. Riffle in the Eel River below Fernbridge (visible in distance) on November 2,2002 where an adult salmon kill occurred. Photo courtesy of Travis Sheets.**

Low base flows in the Eel River basin in fall 2002 may have been in part due to an extremely dry year in 2001. Sediment also tends to be deposited in low flow years and the shallow riffle may have formed below Fernbridge as a result of the preceding low flow year. This factor was recognized as having contributed to the larger Klamath River adult salmon kill of September 2002 (CDFG 2003).

The magnitude of the November 2, 2002 fish kill is unknown, but its occurrence should prompt action to increase flows when necessary in the future. Average daily flows for the Eel River at Ft Seward (Figure 23) indicate that rains and sufficient flows almost always arrive by December 1, with increasing odds of rain each day. When low flows

similar to those of 2002 recur in early November, 100 cfs should be released from the PVP for a duration of 30 days or until sufficient rainfall occurs. Natural flows allowed salmon passage by November 8 in 2002 and by the 11th the Eel at Scotia was over 8,000 cfs; therefore, only 8-10 days of flows of 100 cfs from the PVP would have been required. If the need extends for 30 days, it requires 7,500 acre feet (AF), which is three times NMFS (2002) mandated 2,500 AF as part of their RPAs. The 2500 AF equates to only 1.5% of the 166,000 AF average annual diversion for power production and water supply in Mendocino, Sonoma and Marin counties. An increase to 7,500 AF would only be 4.5% of average water exports.

A flow of 100 cfs is sufficient for Chinook salmon to travel all the way to Scott Dam. Consequently, fish could get access to the entire mainstem for spawning even if rain did not occur between November 1 and December 1. Chinook salmon would also have a greater chance of successful spawning in tributaries like Outlet and Tomki Creek, if they were staged for the final leg of their spawning journey at the mouth of these creeks, instead of running upstream from Fortuna. Since current RPA flows are causing “take”, the discussion of this issue needs reconsideration by NMFS and FERC.

### ***Need for Improved Water Quality***

It is well recognized that the Eel River has problems related to elevated water temperature (Friedrichsen 1998), but it has also developed significant toxic algae (Hill 2010) and nutrient pollution problems. Photosynthesis associated with algae blooms may supersaturate levels of diurnal dissolved oxygen (D.O.) in water bodies, but at night when algae respire it can cause a D.O. sag that could be stressful or lethal to salmonids. Studies are needed urgently in the lower Eel River to insure that conditions related to algae blooms do not cause D.O. depression that could have adverse effects on Chinook salmon. If staff and funds are not available from the North Coast Regional Water Quality Control Board (NCRWQCB) or other agencies, such studies could also be conducted by the Bear River Rancheria or Wiyot Tribe environmental staff. The NCRWQCB is currently conducting a study of nutrient enrichment on the South Fork Eel River between Redway and Miranda and data were collected in summer and fall of 2010 (Rich Fadness personal communication).

Health warnings brought on by toxic algae are issued annually for the South Fork Eel, Van Duzen and lower Eel River advising against recreational contact and or use of river water for drinking, cooking or dish washing. There is also a potential for adverse health effects from toxic algae on fish species (Best et al. 2003), so allowing increasing toxic algae blooms instead of abating them may ultimately result in fish health problems too. A Van Duzen River nutrient study is also needed to determine how current conditions foster toxic algae and to explore the sources of excess nutrients.

To abate nutrient pollution and toxic algae, flows need to be improved through implementation of water conservation measures throughout the Eel River basin. Changes in land management that restore the historic hydrologic processes of watersheds are also needed. In addition, every measure possible to reduce nutrient releases from domestic and agricultural sources must be pursued. High water temperature increases algae problems; therefore, restoration should also be geared toward restoring cool water

temperatures by restoring riparian zones. Cooler water temperatures directly benefit salmon recovery and reduce stream reaches that favor pikeminnow reproduction.

### ***Pikeminnow Control***

The eradication or reduction of pikeminnow in the Eel River reach within the PVP (Scott Dam to Cape Horn Dam) may not be feasible (PG&E 2008, Higgins 2010a) but more effective pikeminnow suppression could be carried out further downstream during low flow conditions. Some dedicated anglers may already be making a difference and one interviewed caught and killed over 700 pikeminnow in the summer and fall of 2010 (Chris Hayes personal communication). Spear fishing in Alderpoint appears to have reduced the number of large adults (Geoff Davis personal communication), which not only decreases predation on salmonids but also can diminish the pikeminnow population's reproductive capability.

NMFS should mandate that PG&E spend an amount equivalent to costs associated with eradication of pikeminnow between PVP dams for other suppression methods downstream. Supervised spear fishing events, which use volunteers who are experienced and certified divers, could have a measurable impact on the pikeminnow population. Past pikeminnow "derbies" on the Eel River have sparked widespread participation and provision of rewards to anglers for adult fish caught anywhere in the Eel River basin should be considered. Otters are apparently effective in reducing pikeminnow, at least locally in some reaches, and their predation on pikeminnow deserves further study. Brown and Moyle (1991) found that pikeminnow thrive in man-made impoundments and tend to dominate river systems just upstream and downstream of reservoirs. It is unlikely that salmonids and pikeminnow will come into an ecological equilibrium while PVP reservoirs remain; therefore, their removal is highly desirable if salmon recovery is a priority.

### ***Reducing Chinook Salmon Stress from Fishing and Eliminating Poaching***

The Ferndale Enterprise (Aug 26, 1949) documented the timing of the first wave of fall Chinook salmon entry into the Eel River estuary:

"Salmon heading for their spawning grounds came into the Eel River Tuesday evening like jet propelled torpedoes, according to witnesses at the river, and were the first major run of the great sporting fish to make the entrance this season. Records kept by John Brazil and other sports fishermen of this section show the run to be on schedule, their data showing the first run can be expected in the Eel between August 24 and 27 each year."

It is highly likely that some component of Eel River fall Chinook still returns in late August and the movement upstream in 2010 in mid-September supports this hypothesis. When these fish move up into pools above Fernbridge, they are confined to very restricted areas with appropriate depth. Fishing before October 1 low flow closures has the potential to cause substantial fish stress that can lead to reduced fitness, increased disease risk, reduced fecundity and even mortality. If lower Eel River and lower Van Duzen River habitats were improved, such angling would have little negative effect.

However, until habitat is improved, low flow fishing restrictions below the Van Duzen River convergence should begin September 1.

A very large homeless encampment occupies the riparian forest adjacent to the Boxcar Pool and this community appears to be actively poaching Chinook salmon. This is an inappropriate location for the homeless and consideration should be given to purchase of the property for establishment of public park that has both conservation and recreation benefits.

When runs of fish are substantial, many people come out to fish that have not done so for years. They may be unaware of closures and prohibition of take, and more effort is needed to remind the public of newer regulations in years of robust returns. Heightened interest in the Eel River and participation in volunteer salmon watch programs can also put more eyes on the river, so salmon and steelhead populations are better protected. Organizations like FOER, the Tribes and government agencies can also help spread awareness.

If monitoring indicates continuing robust escapements, opening the mainstem to catch and release fishing above 300 cfs after October 1 might be considered to give people legitimate sport fishing access. At present the river is closed to fishing until January 1, despite thousands of fall Chinook migrating upstream between October and December, and any fishing before then is poaching. Opening sport fishing would put legal anglers on the water, which can help to reduce poaching in rural areas. If angling remains consistently good, sport anglers could become a market base for development of bed and breakfast businesses. Once communities have a financial stake in the health of the fish runs, you have a positive cycle.

## **Conclusion**

Forces of nature have aligned with Eel River salmon recovery and prompt action could potentially help make this year's abundance routine. There is the potential for new collaborations to fill data gaps and to begin to actively manage and restore the Eel River while there is still time. Native American Tribes of the Eel River are showing an active interest and willingness to become co-managers of the river and to increase their participation in recovering its health and fish populations. Tribes of the north coast region have harmony based cultures that believe that their people are indivisible from the environment and, if the environment is treated well, then the culture of the people will thrive in the future. If we really work with nature expeditiously, we have the opportunity to attain a fall Chinook population of 100,000 fish and to restore a fishery that was once the pride of the region.

The actions needed are in the Recommendations below but are summarized here:

- Restoring upper Eel River flow,
- Improving watershed hydrology (i.e. removing roads),
- Implementing water conservation watershed-wide,
- Reducing nutrients (and pesticides) from residential and agricultural activities,

- Reconnecting tidal sloughs and wetlands,
- Improving holding pools (i.e. Worswick), and
- Creating a refugia in the lower Van Duzen River.

The salmon rebound of 2009 and 2010 is more a product of the forces of nature during rather than a result of restoration efforts. The Eel River has become unsafe for recreational contact in summer and, if its current downward trajectory continues, the possibility of a water quality crisis and fish kill loom. The PDO will likely switch back to dry on-land conditions some time between 2015 and 2025 and events like the November 2002 fish kill could become common place, if no corrective actions are taken.

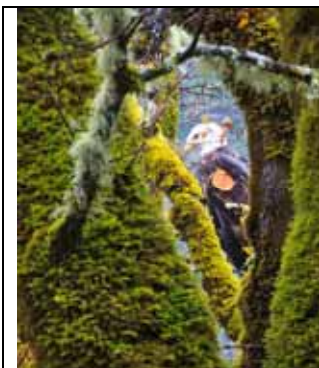
Moyle et al. (2008) made this categorical statement regarding Eel River Chinook populations and their recovery:

“Until water transfers out of the Eel River basin are reduced to provide necessary spring and fall flows for juvenile and adult Chinook, recovery of these multiple populations is unlikely.”

The basis for the FERC PVP license is solely power production and the 9 MW it generates is worth far less than a restored Eel River fall Chinook salmon run (CEED 2002). Society needs to reconsider our long term contract on the PVP given climate change. If the real need for the PVP is as a source of water for Mendocino, Sonoma and Marin counties, then water users there should pay for Eel River water. A phased decommissioning of the PVP could still allow for some diversion to Potter Valley into the future. Revenue from water purchases could be used to fund a much needed Eel River Restoration Program, including Scott Dam removal by 2020.

The urgent need for action from Collison et al. (2003) was in regard to lower Eel River tributaries, but it applies equally well to basin-wide restoration prospects:

“If current patterns prevail, with shifts in the PDO occurring every 20 to 30 years (Hare et al. 1999), the next negative shift in the PDO for California is likely to occur in the 2015 to 2020 timeframe ..... If fresh water habitats have not recovered by that time, the fish will simultaneously face both degraded freshwater habitats and an unproductive ocean. The result could shift the stocks to endangered status or result in extinctions.”



Pictured at left is a tagged bald eagle (#00) that was one of seven dining on salmon carcasses at Hearst on the Eel River on Thanksgiving day. The photo is by Hearst resident June Albright and shows a male bald eagle hatched on Catalina Island in 2007. The bird is part of the Channel Islands bald eagle recovery program and was the first naturally hatched from a nest on Catalina since 1950 (Peter Sharpe personal communication). That this eagle was able to find this year’s abundance of salmon on the Eel is a testament to nature’s resilience and good omen for potential restoration success.

## **Recommendations**

### ***Fish Population Monitoring***

- Acquire DIDSON sonar device(s) to estimate fall Chinook and other Pacific salmon population levels in the Eel River.
- Conduct annual fall Chinook dive surveys in the lower Eel River from Weymouth Bluffs to below Fernbridge at least bi-weekly from September 15-November 15 or until high flows (not needed after DIDSON installation)
- Develop an index of abundance for Chinook salmon in the estuary using standard “fish finder” equipment but sampling in a scientifically valid way
- Consider sport angler participation in marking fall Chinook salmon and expanding spawning count efforts by including volunteers so that a Peterson mark recapture population estimate for the Eel River basin could be generated (not needed after DIDSON installation)

### ***Habitat Restoration***

- Improve Chinook salmon carrying capacity of the Worswick Pool upstream of Fernbridge by stabilizing the bank using bioengineering.
- Acquire easements or riparian property on the lower Van Duzen River from Yager Creek to the mainstem Eel River and restore a functioning river segment using bioengineering.
- Relocate the homeless encampment at the Boxcar Pool, acquire funds for creation of a public park that has both conservation and recreation benefits.
- Restore Chinook salmon productivity in Eel River reaches within the PVP using methods similar to the Trinity River Restoration Program (McBain and Trush 1997).
- Acquire easement on Baechtel Creek below Indian Creek and expand refugia that supports Chinook salmon and coho salmon spawning using bioengineering.
- Study tributary deltas and potential reconnection to mainstem Eel River to increase access for spawning adults and to provide more cold water summer juvenile salmonid rearing habitat.

### ***PVP Operation***

- NMFS needs to reopen RPA requirement process with FERC because low fall flows in recent years have caused “take” of Eel River Chinook salmon.
- Modify RPAs to require increased block water for Chinook salmon fall migration from 2,500 AF to 7,500 AF and release of 100 cfs for 30 days or until it rains, if mainstem Eel River flows at Scotia are below 200 cfs on November 1.
- Phased decommissioning with removal of Scott Dam by 2020.

### ***Water Pollution Abatement***

- Restore riparian zones throughout the Eel River basin to help cool water temperatures and improve nutrient filter capacity.
- Implement water conservation measures in rural areas of the Eel River to reduce domestic and agricultural water use.
- Reduce nutrient and pesticide pollution from agricultural activities and from rural residential development (i.e. improve septic systems)

### ***Pikeminnow Suppression***

- Focus pikeminnow control efforts on areas downstream of the PVP.
- Coordinate volunteer efforts with trained divers to eradicate large adult pikeminnow during summer low flow conditions.
- Fund bounty on adult pikeminnow Eel River basin-wide.

### ***Fishing Regulations***

- Change lower Eel River low flow closure so that it begins on September 1, not October 1 as an emergency measure in 2011.
- Close fishing at Goat Rock falls on the Van Duzen River as soon as possible.
- If monitoring substantiates continuing large runs, open the mainstem above Dyerville to catch and release sport fishing using artificial lures only after October 1 when flows are above 300 cfs.
- Allow pikeminnow angling during low flow closures.
- Permit take of pikeminnow with spears during tournaments or as part of community organized suppression efforts.
- Consider managing for Chinook salmon sport harvest, if populations are robust and showing a stable or increasing trend and habitat restoration and flow improvements are implemented

### ***Water Quality Monitoring***

- Carry out nutrient, algae and water quality studies in the lower Eel River and estuary to discern the risk of adverse fish health effects of current conditions.
- Conduct similar studies on the Van Duzen River as baseline for trend monitoring
- Solicit volunteer participation and expand tributary flow and temperature monitoring to understand current condition and to provide baseline data against which trends can be measured as restoration progresses.

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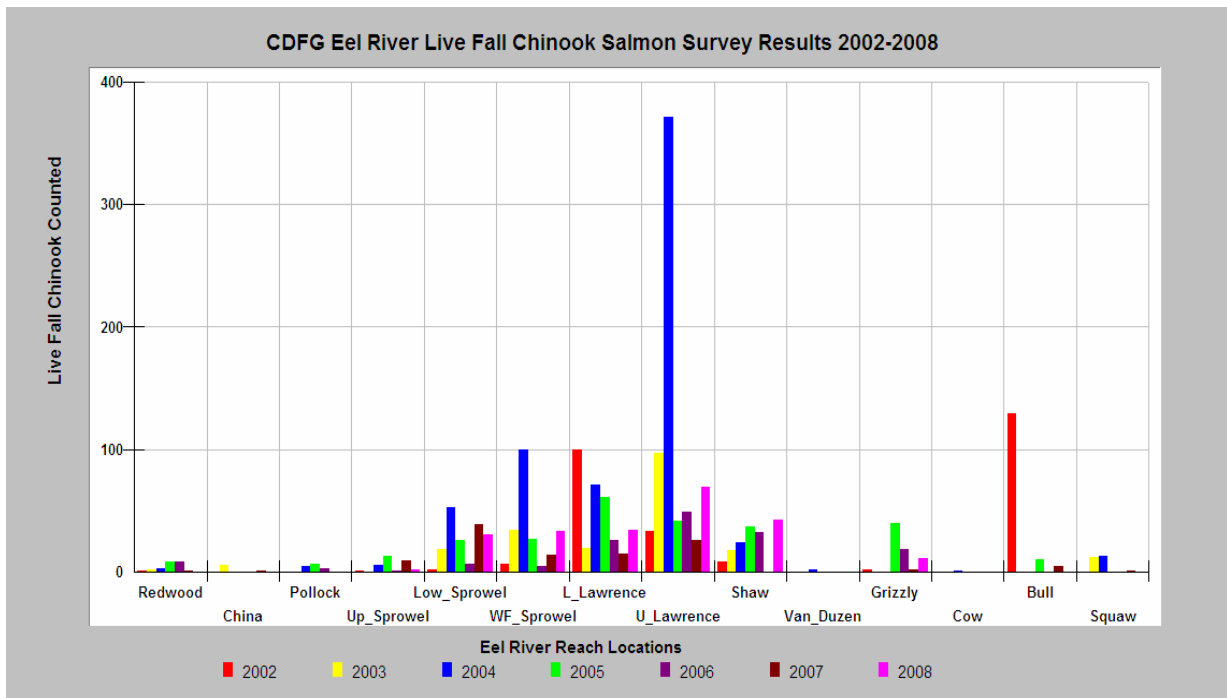
## **Appendix A. Chinook Abundance and Distribution in 2010**

Instead of a run on the brink of extinction, Chinook returned to the Eel River in the thousands or tens of thousands in 2010. The Times Standard (12/24/10) characterized it as the best in the Eel River since the 1940's. The run is undoubtedly the biggest since the mid-1980s, but anglers say this resurgence has been going on for at least the last two to three years. Since there is no way to positively quantify this year's run, its order of magnitude will be discussed and compared with runs of possibly similar strength using historic data. At least 2,000 Chinook were holding from below the Weymouth Pool downstream to Fernbridge on October 22 and there were signs of a large influx of fish in the estuary on that day.

Upper Eel/Outlet Creek Mainstem Spawners: With the rapid rise in flows, Chinook began showing up at the Van Arsdale Fish Station on October 29. The bulk of the run had passed by mid-November but they continued to arrive in diminishing numbers through December totaling 2,315. In 2009 (Figure 5), 519 Chinook arrived at VAFS and an estimated 3092 spawned in the upper Eel mainstem above Dos Rios and in Outlet Creek (Harris 2009). If the ratio of fish spawning in the wild to those passing VADS remained the same in 2010, then 13,778 may have spawned in the upper mainstem Eel River and lower Outlet. Under the assumption that high flows promoted more passage and the same number of fish were spawning downstream, then the total would be 5,404. The number of fish on the spawning beds on November 5 was likely in the range seen by Harris (2009) the year prior. Indications like high angler catch rates in the lower Eel River by sport anglers (Jake Luna personal communication) suggested that a subsequent wave of fish (November 14-17) was substantial. A reasonable high range estimate might be 10,000, including late spawners at various locations, none of which could be estimated due to very high December 2010 flows.

Tributary Chinook Spawning: Higgins (2010a) noted problems with Eel River tributary Chinook salmon production, citing the population collapse in Tomki Creek and very poor returns to most of the 14 tributaries monitored since 2002 by CDFG (Figure A-1). Spawning abundance in Tomki Creek has dropped from over 3,500 Chinook in 1985 and 1987 to the low hundreds or dozens in recent years (PG&E 2008). Although Chinook salmon are absent or present intermittently in many CDFG tributaries, Scott Harris (personal communication) says that Mendocino County Eel tributaries not represented may have consistently higher returns (i.e. Hollow Tree, SF Eel). The high flow allowed passage all the way to headwaters of tributaries throughout the basin in 2010, but the distribution of spawning was not uniform.

While spawning Chinook were observed in Baechtel Creek and Scott Harris (personal communication) counted 45 Chinook and 31 coho redds in two surveys of Willits Creek, few fish were spawning on the Willits Valley floor in reaches of Outlet Creek. This suggests problems with habitat suitability. Data from CDFG 2009 and 2010 and PG&E on Tomki Creek should provide some insight into tributary production, and provide further evidence of a basin-wide upswing. If not, then it suggests locally diminished carrying capacity.



**Figure A-1. Eel River survey fall Chinook live fish counts by stream from 2002-2008 by CDFG (2009). Data from CDFG Fortuna Office.**

Middle Fork Eel River: Harris (2007) reported on helicopter spawning survey results of the mainstem Middle Fork Eel River reaches during low flow conditions in December 2006. He found more Chinook salmon spawning there per kilometer of river surveyed (35 redds, 37 live fish/carcass, 64 km) than in similar reaches of the mainstem Eel River from Dos Rios and Outlet Creek (19 redds, 34 live fish/carcass, 60 km). Harris (2007) also noted spawning in the lower Black Butte River that is tributary to the Middle Fork. The NMFS (Bjorkstedt et al. 2005) rank Middle Fork Chinook salmon intrinsic potential habitat as substantially greater than the middle mainstem and upper Eel River basins (Figure A-2). If gravel conditions in the Middle Fork have undergone a similar rejuvenation to those of the mainstem, then spawning in 2010 there could be on the order of several thousand Chinook salmon. A minimum of 1,000 and a high range estimate of 5,000 Chinook salmon in 2010 are conservative based on the foregoing assumptions

Van Duzen River: Scott Downie (personal communication) has counted 2,600 Chinook salmon in recent years crossing riffles at the convergence of Yager Creek and the lower Van Duzen and that is used as the lower estimate of the 2010 run. The duration of this year's run, with several rainfall events and pulses of fish in November, suggests a return more on the order of 5,000 fish. Chinook salmon were seen leaping over Goat Rock falls and passing upstream of Bridgeville for nearly a month (Mike Guerriero personal communication). This indicates that there is a viable mainstem population center upstream of Bridgeville that has a substantial number of spawners. Yager Creek, the Van Duzen's largest tributary, also had high returns with spawning documented in Lonestar Creek at the headwaters of the North Fork (Times Standard 2010). Higgins (2007) pointed out that upper Lawrence Creek, the largest tributary of Yager, has some of the highest CDFG Chinook spawner counts in the Eel Basin, but results from this year's surveys were not available as this report went to press.

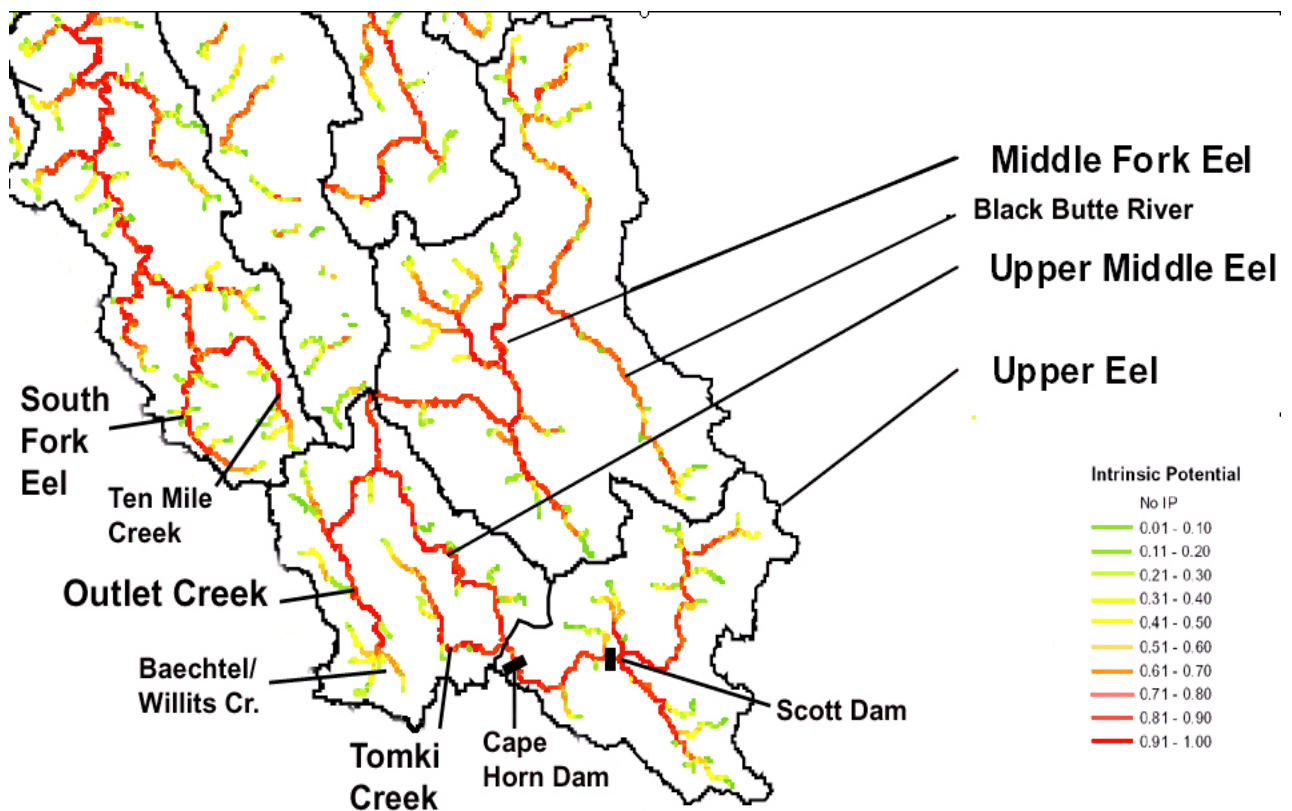


Figure A-2. Chinook salmon intrinsic habitat potential showing extensive optimal gradient for spawning and rearing in the upper Eel, Middle Fork and South Fork. From Bjorkstedt et al. (2005).

South Fork Eel River: FOER volunteer Matt Preciado (personal communication) fished for Chinook salmon on the South Fork Eel River below Miranda from November 1 to November 25 and reported considerable success (caught and released 3 jacks and 7 adults 22-36 inches). The South Fork was not an intended target for this project, but this sub-basin has been an important producer of Chinook salmon, coho salmon and steelhead. A reconnaissance of the upper South Fork above and below Branscomb did not indicate a high number of spawners on December 2, when active spawning was seen in Ten Mile Creek. No Chinook were sighted at or above Branscomb and only a few dozen were seen on the Angelo Preserve likely due to a shortage of suitable substrate (see Habitat Condition above). Past CDFG tributary results indicate poor production in some South Fork tributaries, with Sprowel Creek and Hollow Tree creeks being exceptions. Results of CDFG 2010 tributary spawning counts were not available at the time of publication of this report, but will shed more light on South Fork Chinook escapement.

It is likely that the mainstem South Fork has suitable conditions for Chinook spawning downstream of Ten Mile Creek where gravel availability may improve. Excess sediment transport lower in the lower South Fork, especially below the East Branch, likely makes conditions unsuitable for egg incubation. It is highly unlikely that returns to the South Fork approached historic highs (i.e. 21,011), but a reasonable bounding based on historic ranges, angler reports and an assumption of partial mainstem recovery would be 2,000 to 7,500 Chinook salmon.