

**U.S. Fish & Wildlife Service**

# **Klamath River Fish Die-off September 2002**

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## **Report on Estimate of Mortality**



**Report Number AFWO-01-03**

Klamath River Fish Die-off, September 2002, Mortality Report, FWS, Arcata, CA

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Report on Estimate of Mortality

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## Summary of Findings

This report provides an estimate of the fish mortality that occurred during the September 2002 Klamath River die-off. The intent of this report is to provide natural resource agencies and trustees with information describing the magnitude of this event for their consideration in near-term decisions regarding the affected fisheries resources and related assets under their authority. The Fish and Wildlife Service (Service), in cooperation with other federal and state agencies and Tribes, will continue to collaborate and evaluate information collected during the die-off. This report describes a conservative assessment, which probably underestimates the total number of fish that died during this event.

Findings described in this report include the following:

- The most accurate estimate of the total number of observable fish that died during the incident is 34,056.
- Approximately 98.4 percent of the dead fish observed were adult anadromous salmonids
- Out of 33,527 anadromous salmonids estimated to have succumbed during this event, 97.1 percent (32,533) were fall-run Chinook salmon, *Oncorhynchus tshawytscha*, 1.8 percent (629) were steelhead, *O. mykiss*, and 1.0 percent (344) were coho salmon, *O. kisutch*. Only one coastal cutthroat, *O. clarki clarki* was found dead during the investigation.
- Approximately 91.5 percent of the coho salmon, and 38.7 percent of the steelhead observed had marks indicating that they were of hatchery origin. All hatchery coho originated from the Trinity River Hatchery. After accounting for variable tagging and shed rates, the Klamath River Technical Advisory Team (KRTAT) estimated that 7,060 (21.7 percent) Chinook were of hatchery origin. A total of 2,921 (9 percent) Chinook were of Iron Gate (Klamath River) Hatchery origin. A total of 4,139 (12.7 percent) Chinook were of Trinity River Hatchery origin.
- The KRTAT also estimated that dead Chinook salmon represented 19.2 percent of the total (169,297) in-river Klamath-Trinity River run.
- Other dead fish observed during the investigation included sculpins, *Cottus spp.* (87 fish), speckled dace, *Rhinichthys osculus* (9 fish), Klamath smallscale sucker, *Catostomus rimiculus* (311 fish), one American shad, *Alosa sapidissima*, and one green sturgeon, *Acipenser medirostris*.

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- Throughout the investigation, live adult and juvenile fish of affected and unaffected species were observed in the river. In addition, some species (e.g. American shad, speckled dace, and green sturgeon) did not appear to experience extensive mortality. Almost all (greater than 99 percent) of the dead fish observed were adults or larger species of fish.
- The majority of the recently dead fish examined exhibited one or more outward gross signs of disease including gill necrosis, bacterial growth, sores, bloody vents, and ulcerations. Pathological examinations confirmed that white spot disease and columnaris were the principle immediate causes of death.

Additional information collected by the Service and cooperating agencies included a suite of water quality parameters collected during the summer and fall of 2001 and 2002, fish pathology analyses, and related hydrologic information. The Service will provide reports on this additional information after it has received quality assurance review. A more comprehensive report addressing contributing factors associated with causes of the fish die-off will follow.

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## **Introduction**

This report provides an estimate of mortality from a fish die-off that occurred in the lower Klamath River from approximately September 18 through October 1, 2002. In response to verbal reports of dead and dying salmon in the lower Klamath River received on September 19, 2002, the U.S. Fish and Wildlife Service's Arcata Office coordinated an investigation of the die-off. The die-off investigation involved collaboration with and ultimately included representatives of the Yurok Tribal Fisheries Program, Hoopa Valley Tribe, Karuk Tribe of California, and California Department of Fish and Game (CDFG).

Investigations of fish die-offs are often complicated by logistical issues such as limited access and the physical location of dead fish. Limited access prevents samplers from investigating areas that may contain dead fish and hence bias the final estimate, especially if the numbers of fish in these unsurveyed areas (e.g. deep water, heavy vegetation) vary considerably from other survey areas (open shoreline, visible areas). These areas may contain large numbers of fish and if so, any final estimate will underestimate the true magnitude of the die-off (American Fisheries Society 1992).

The intent of this report is to provide natural resource agencies and trustees with an estimate of dead fish. In the future, we intend to complete another report that will evaluate environmental factors associated with the incident.

## **Methods**

The investigation conducted generally followed sampling methods described in the publication *Investigation and Valuation of Fish Kills* (American Fisheries Society 1992). Surveys were conducted using 1-day, sequential independent counts. These methods were altered as necessary to accommodate conditions on the river and are described in greater detail throughout this section.

### Survey Locations

On September 19, 2002, immediately after receiving verbal accounts about the observation of "hundreds of dead salmon" on the Lower Klamath River, the Service sent field staff to the lower River to assess the magnitude of the kill and coordinate actions with other agencies and Tribes. Based upon this initial reconnaissance survey, these staff provided a qualitative assessment of the magnitude and location of dead fish they observed. Most of the dead fish were observed below the confluence of Coon Creek at River Mile (RM) 36 (Figure 1). Using this preliminary assessment of the die-off, we decided to stratify our sampling effort into areas exhibiting similar

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fish concentrations to maximize our search and effort efficiency and to minimize within-area variance. As a result, we subdivided the river into four sampling strata (Figure 2) or reaches as follows:

Reach 1 - Mouth of the Klamath River (RM 0) upriver to McCovey riffle (RM 10.1).

Reach 2 - McCovey riffle upriver to confluence of Blue Creek (RM 16.4).

Reach 3 - Blue Creek confluence upriver to confluence of Pecwan Creek (RM 25.0).

Reach 4 - Pecwan Creek confluence upriver to confluence of Coon Creek (RM 36.0).

### Personnel and Equipment

Surveys of the four survey reaches were conducted on three separate days, September 20, 24, and 27, 2002 by four field crews each assigned to a separate reach. The four crews consisted of two or three fishery biologists each, representing the Yurok Tribe, CDFG, and the Service.

Reach surveys were conducted using jet-drive power boats. Jet-boats were usually launched in the vicinity of the Highway 101 bridge over the Klamath River, near the town of Klamath Glen, California, located approximately 5.7 river miles from the ocean.

### Dead Fish Counts in Primary Survey Reaches

On each of the three sample dates, crews generally launched in the morning between 8:00 and 9:00 a.m. and proceeded to their designated sample reach. All surveys were conducted during daylight hours in order to maximize ability to observe and identify dead fish in and along the River. Jet-boats were navigated through each sample reach at a speed slow enough for crews to count fish washed-up on the shoreline, floating in open water, or submerged and laying on the bottom of the river. Where the river was too wide to see and count dead fish on each river bank and the entire visible portions of the bottom in a single pass, crews made a pass along each shoreline to get complete shoreline counts. In many instances, one or more additional passes along longitudinal transects in the middle portions of the river were also made for complete coverage of the bottom in visible mid-channel areas. Due to the poor water visibility encountered in Reach 1 on September 24 and the exceptional width of the lower river from Turwar Riffle (approx RM 5.6) to the mouth, crews surveyed each river bank and subsampled the river bottom within the survey areas of this reach.

The dead fish counts assume no significant bias from carcasses entering or leaving a reach during a survey and no adjustment was made to account for this. Jet-boat transit times through each survey area in a reach were relatively short (less than 30 minutes), and were always completed on the date of the survey. Also, water velocities, on average, were relatively slow through all reaches. Not only is early Fall generally the period of lowest flow in streams and river segments



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throughout the Klamath Basin, but 2002 was also a year of exceptionally low runoff and discharge as well. Finally, crews did not observe large numbers of dead fish floating through each river reach during any of the surveys.

The objective of field crews at the initiation of surveys was to count, examine and measure all dead fish observed within each reach. However, large concentrations of fish and difficult access to fish at the bottom of deep pools required adjustments in sample design to address these circumstances.

With the exception of Reach 4, there were usually too many dead fish observable within a reach to complete a total count within 1 day. Consequently, these reaches were subsampled by selecting a priori survey sites near the lower, middle, and upper portions. Within each known-length subsample, total counts of visually observable dead fish were conducted. Subsample lengths were measured using a combination of maps, tape measure, and a global positioning system (GPS). Other data were obtained including species, sex, hatchery marks, and length measurements within each of the four major reaches and were used to estimate population, sex, and hatchery composition ratios. Once subsample areas were selected they were generally resampled on subsequent sample dates.

#### Supplemental Dead Fish Counts

In addition to the counts used to estimate total number of visually observable dead fish within the four primary reaches, we also included data collected by Yurok Fisheries Program and Hoopa Valley Tribal staff during supplemental monitoring events. This included areas upriver of the four primary reaches and in the lower portions of Blue Creek, a major tributary of the Klamath River located at RM 16.4 .

#### Weitchpec to Youngs Bar Surveys

During September 27, 2002, a survey of the area between Weitchpec (RM 43.5) and Youngs Bar (RM 35.5) was conducted by the Yurok Tribal Fisheries biologists. The survey crew drifted downstream and counted all fish found floating, submerged and beached. They also utilized underwater video to census pools that were too deep for direct observation from the surface. In order to adjust for overlap with upstream end of Reach 4 surveyed by the primary survey teams, the raw count for this survey were converted to a density (number of fish per river mile) and multiplied by the distance above Coon Creek (RM 36.0) to calculate the estimated number of dead fish for this reach.

#### Blue Creek Vicinity Surveys

Additional counts were also conducted in the vicinity of Blue Creek (RM 16.4) by the Yurok Tribal Fisheries biologists for the purposes of collecting additional data on the composition of the

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fish die-off during September 25-26, 2002. On September 25, 2002 their biologists conducted two surveys. The first survey was conducted for a standard cruise time of 2 minutes above the confluence of Blue Creek and the Klamath River in the mainstem river. The second survey was conducted for 2 minutes below the confluence of Blue Creek the mainstem. On September 26, 2002 their biologists surveyed for a standard cruise time of 4 minutes below the confluence of Blue Creek and the Klamath River in the mainstem. On both survey dates the field crew counted all fish on the bottom and surface, including the shoreline.

### Supplemental Mainstem CDFG Biological Surveys (Reach 1 and Blakes Riffle)

The CDFG conducted additional surveys to collect more biological data, for determination of adipose clip rates, collection of coded wire tags and scales, and determination of hatchery and age composition. On September 27, 2002 CDFG surveyed a total of approximately 3,500 feet of shoreline at four sites located between the mouth of the estuary and Terwar (RM 5.3) in Reach 1. They also conducted a second shoreline survey in Reach 2 between Blakes riffle and Blue Creek at five sites. They surveyed a total of approximately 2,100 feet of shoreline on this date. On October 1, 2002 they conducted a third survey at seven sites within Reach 1 between Ida Jane riffle (RM 8.5) and the estuary. They surveyed a total of 9,490 feet shoreline on October 1, 2002. CDFG conducted an additional survey on September 29, 2002 to document fish being removed from the beach near Blake's Riffle by private landowners. The information included both species composition, hatchery marks, and fish condition. No information was provided on shoreline length. These data were used to supplement information needed by the Klamath River Technical Assessment Team (KRTAT) for age composition and stock projection assessment work.

### Supplemental Mainstem CDFG Reach 4 October 1, 2002 Surveys

On October 1, 2002 the CDFG conducted a total count of Reach 4. No attempt was made to quantitatively determine species composition or condition of fish. The objective was to determine the status of the fish die off and whether dead fish were still present.

### Supplemental Mainstem USFWS Reach 3 October 1, 2002 Surveys

Service biologists conducted a survey of Reach 3 during October 1, 2002 at two sites. Site one was located between river mile 19.9 and 20.4. The second site was located between river mile 18.2 and 18.6. They surveyed a total of 0.9 mile or 4,752 feet of open water and adjacent shoreline for total numbers and condition. A systematic survey of every tenth fish was conducted to obtain species composition. Adipose clip rates were noted and scales and heads taken.

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### Blue Creek Surveys

Overlapping the dates of the primary mainstem river surveys, three site visits were also made on September 24, 27 and October 1, 2002 to the mouth and the lower portion of Blue Creek, a tributary to the lower Klamath River located at RM 16.4. September 24 and October 1, 2002 surveys were conducted by the Yurok Tribal Fisheries biologists. September 27, 2002 surveys were conducted by the Service. These September 24 and 27, 2002 surveys were conducted primarily for the purposes of collecting additional data on the species composition of the fish die-off. On October 1, 2002, total counts and species composition data were collected. In addition, scales and coded wire tags were collected from dead specimens. Yurok Tribal Fisheries Program staff surveyed these areas by walking along the shoreline and using boats to count and identify all dead fish.

Unlike the main stem investigation, a large proportion of dead fish in Blue Creek were coho salmon. A total of 231 coho were counted during three sites visits (Table 8). Fish counted on September 24, 2002 by the Yurok Fisheries biologists were marked (by removing the heads which were later checked for coded wire tags). The highest number of coho was recorded on October 1, 2002, when 193 individuals were observed. Many of these were older carcasses and may represent fish that were previously counted on September 27. Therefore, we only used counts from September 24, 2002 and October 1, 2002.

### Supplemental Yurok Mainstem Surveys September 29, 2002

Yurok Tribal Fisheries biologists systematically sampled two mainstem river sites, McCovey Riffle and 0.5 mile below the mouth of Blue Creek on September 29, 2002 for adipose clipped chinook and coded wire tags only. These data were used to supplement information needed by the KRTAT for age composition and stock projection assessment work.

### Trinity River Surveys

Hoopa Valley Tribe Fisheries biologists surveyed the lower portion of the Trinity River from Weitchpec to Red Rock (Trinity RM 7.4), between September 20 and September 26, 2002. Due to low carcass densities, these surveys represent total counts for this portion of the Trinity River. During this survey Hoopa Valley Tribe fisheries staff floated the river and recorded all fish observed on the water surface, shoreline, and submerged in pool areas.

### Estimation of Dead Fish Numbers in Mainstem Survey Reaches

Except for Reach 4 where observations and counts of the entire reach were possible in a single day, estimates of the numbers of observable dead fish in each reach were based on reach length and the carcass densities observed within sub-sampled areas of the reach. Calculations of

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estimated dead fish numbers for subsampled reaches on each survey date were conducted as follows:

Subsample Densities (SSD) was calculated as Subsample Count (SSC) divided by Subsample Length (SSL) in river miles.

$$SSD_1 = SSC_1 \div SSL_1$$

Reach Density (RD) is calculated by pooling SSC and SSL from subsamples within the reach

$$RD = (\sum SSC_{1 \dots n}) \div (\sum SSL_{1 \dots n})$$

Reach Total (RT), an estimate of the total number of observable fish within each reach, is the product of Total Reach Length (TRL) in river miles and RD.

$$RT_1 = (TRL_1)(RD_1)$$

Total Count (TC) is the estimated total number of observable fish within the entire four-reach survey area for a given survey date and is the sum of all Reach Totals.

$$TC = \sum RT_{1 \dots n}$$

During the September 24, 2002 survey, the Reach 1 count was further adjusted to account for uninspected portions of the mid-channel bottom areas. Foggy and windy conditions in this portion of the river this day hindered bottom visibility and prevented the survey crew from being able to inspect portions of the mid-channel areas with confidence that double counting would not occur. According to CDFG personnel that conducted this portion of the September 24 survey, surveys in two subsample areas within Reach 1 covered 100 percent of the shoreline but only about 25 and 70 percent of the total river bottom (Bairrington 2002). Therefore, bottom fish counts were multiplied by the respective correction factors of 100/25 (4), and 100/70 (1.43) to account for areas that were not surveyed. Following this adjustment, counts for the sample areas surveyed were further expanded for the entire reach following methods already outlined above.

During the September 27, 2002 survey, CDFG did not survey Reach 1 due to boat operation problems. Therefore, estimates for that portion of the river were based on density estimates obtained from adjacent river Reach 2 and expanded to the lower reach using the Reach 1 and 2 density relationship developed from the previous September 24 survey.

Ultimately, we selected the best single day estimate based on the following criteria: (1) increasing numbers, when compared to earlier estimates; (2) higher numbers of recently dead fish, when compared to other estimates; (3) complete survey coverage of the affected area; and (4) whether all reaches were surveyed.

#### Additional Information Collection

To partition the dead fish counts among the species present, we collected sub-samples of dead fish from each sampled area to determine percent species composition of the fish die-off within that reach. Carcasses were identified to the lowest possible taxon. These same carcasses were also examined for hatchery marks, identified by sex, if possible, and their fork length (FL) was measured. Carcasses were inspected for external indicators of disease such as fungus or lesions. We used clear eyes and red gills as criteria to identify fish that had recently died. These criteria are generally only observable within 1 to 2 days of a fish's death. However, it was very difficult to evaluate the "freshness" of the dead fish due to obvious scavenging and associated damage. We applied the subsample distribution of species composition and mark ratios for each survey date to the total fish counts for that date to partition mortality estimates across the species and marks observed by reach. Most heads of Chinook salmon marked with an adipose fin clip, indicating a fish marked with a coded wire tag (CWT), were collected for later tag recovery to be performed by CDFG. Scale samples were collected and provided to the Yurok Tribal Fisheries biologists for age composition analysis.

The CDFG and Yurok Tribal Fisheries staffs tabulated scale age and coded wired tag data and provided this information to the KRTAT for inclusion in the 2002 Klamath River fall Chinook stock assessment (Pierce 1998). Summaries of those data and results of those analyses are included in this report. Comparisons with in-river run sizes are also provided. Results of these analyses are subject to change if new data on the in-river run are provided. The KRTAT performs data analyses at the request of the Klamath Fisheries Management Council (KFMC), and develops stock estimates and data analyses for review by the Salmon Technical Team (STT), the technical advisor to the Pacific Fishery Management Council (PFMC).

### **Results**

Eight taxa including green sturgeon (*Acipenser medirostris*), speckled dace (*Rhinichthys osculatus*), Klamath smallscale sucker (*Catostomus rimiculus*), cutthroat trout (*Oncorhynchus clarki*), coho salmon (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), American shad, (*Alosa sapidissima*) and sculpin species (*Cottus* spp.), were observed during the fish die-off (Table 1). Because Chinook salmon were such a significant percentage of the total number of fish that died in this event, most of the results and discussion that follows are focused on that species.

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The estimated number of dead fish varied considerably between sampling dates, especially when later surveys are compared to the initial survey (Table 2). The dead fish were composed primarily of Chinook and coho salmon, steelhead, and Klamath smallscale sucker. These species were collected during each of the three major surveys. The most complete record of hatchery-marked fish was obtained on September 24, 2002. The most complete records for percent diseased (live-stressed and recent dead), size distribution, and sex ratios were obtained on the September 20, 2002 sample date.

### September 20, 2002 Survey

We estimated that 2,769 dead fish were present in the surveyed area on September 20, 2002 (Table 2). In addition, numerous live, lethargic and active fish were also observed in deeper pool areas. Based on these observations and initial counts, the fish die-off was apparently in the early stages of development. The dead fish were composed of an assemblage of species including 2,687 Chinook, 12 coho, 35 steelhead, and 35 Klamath smallscale sucker.

Mean fork length (FL) for the dead Chinook salmon in each reach varied between 31.9 and 34.4 inches (average 83.4 centimeters (cm) or 32.8 inches FL - Table 3), with actual measurements ranging between 19.7 and 40.9 inches (50 and 104 cm). The percent female composition for Chinook salmon varied between 53.3 and 87.5 percent among the four reaches surveyed (average 63.5 percent - Table 3). Approximately 81.1 percent of the recently dead fish examined exhibited one or more outward signs of disease including gill necrosis, bacterial growth, sores, bloody vents, and ulcerations.

### September 24, 2002 Survey

We estimated that a total of 33,360 dead fish were present in the four reaches on this date (Table 2). Of this total, we determined that 19,145 fish were present on shoreline areas, 11,124 in visible portions of pools, and 3,091 floating on the surface. An attempt was made to segregate recently dead fish from older (and perhaps already counted) individuals from the September 20, 2002 surveys. Based on our criteria of clear eyes and red gills, the percentage of recently dead fish varied depending on their location in the water column (Table 3). The percentage of recently dead specimens observed in floating and bottom fish counts were 14 and 97 percent respectively. Shoreline counts were composed of approximately 20 percent recently dead fish. The overall ratio of recently dead to total dead fish was 47.1 percent. This indicated that the fish die-off was still in progress. A higher percentage of recently dead fish were more likely to be found in deeper pools. As fish began to decompose they would float and drift downstream and eventually strand in shallow snags, rocks, and other river structures and habitat features.

On September 24, 2002, 94 percent of the dead fish were composed of Chinook salmon. However, other species of salmonids were also affected. We estimated an additional 135 dead

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coho salmon and 590 dead steelhead were present in the lower Klamath River. Estimated coho numbers were based on an actual count of only 4 coho out of 406 fish examined for species and mark composition ratios over all four reaches. These four coho were observed in Reach 4. This number was then expanded based upon the total number of dead fish counted in Reach 4. We also observed other species including Klamath smallscale sucker and sculpin (*Cottus* spp.).

We estimated that approximately 622 or 2.0 percent of the Chinook salmon present on September 24, 2002 had their adipose fin clipped, indicating that they originated from a hatchery. However, not all fish released from CDFG's Klamath (Iron Gate) and Trinity hatcheries have an adipose fin clip. Normally these clipped specimens also contain coded wire tags (CWTs), which provide information on release date, age and hatchery origin of the fish. Using this information, one can adjust these counts for unmarked hatchery releases and arrive at an estimate of the proportion of tagged fish. For fall Chinook, this information is usually generated by the KRTAT which is charged by the KFMC with developing stock projections each year during January and February. Part of this process involves reconstructing the age structure of hatchery and wild fish from the most recent year. We provided all CWT and scale age data for Chinook salmon for this purpose to the CDFG and Yurok Tribal Fisheries biologists, who serve on the KRTAT, for age and hatchery composition analyses.

We also estimated that approximately 236 or 40 percent of the steelhead possessed an adipose fin clip. In recent years all steelhead released by CDFG's Klamath and Trinity hatcheries have been clipped. We estimated that 135 or 100 percent of the dead coho were right maxillary marked. Right maxillary marked coho originate from Trinity River Hatchery (Borok 2002).

### September 27, 2002 Survey

We estimated that 37,032 dead fish were present in the lower Klamath River on September 27, 2002. Depending on reach, from 0 to 21 percent of the specimens examined during field surveys were recently dead fish (Table 3). Over 97 percent of dead fish were Chinook salmon. However, this estimate is based only on surveys of Reaches 2 through 4. Due to mechanical difficulties with a boat, a survey of Reach 1 did not occur. Therefore it was necessary to use densities and species values for Reach 2 to estimate numbers of dead fish for Reach 1. Consequently, we are not as confident in estimates derived from this survey as those obtained from the September 24, 2002 survey. On September 27, 2002 the Bureau of Reclamation increased discharge levels from 760 to 1300 cfs below Iron Gate dam. Yurok Tribal Fisheries biologists working on the lower river on that date observed slightly increased flows near the end of the day. Increased flows were definitely detected at the U.S. Geological Survey (USGS) Klamath gage on September 28, 2002. These increased flows would tend to redistribute fish from upstream to downstream reaches. According to Yurok Tribal biologists they observed more fish drifting downstream on this date. This would alter the density relationships between the reaches.

### Supplemental Survey Results

#### Weitchpec to Youngs Bar Surveys, September 27, 2002

We estimated that a total of 170 fish were found above Coon Creek (Table 4). Approximately 48 percent of the fish sampled were Chinook salmon. Approximately 50 percent of the count was composed of unidentified specimens. The majority of these were too decayed to identify. Only 6 percent of the fish were classified as recently dead.

#### Blue Creek Vicinity Surveys

A total of 726 fish were collected and examined in the vicinity of Blue Creek during the September 25 and 26, 2002 surveys (Table 5). When these data were pooled with the survey data for areas above Coons Creek surveyed by the Yurok Tribal Fisheries biologists on September 27, 2002 we found that a total of 743 or 82 percent of the fish were Chinook salmon. Seventy-nine percent were fish that possessed no marks. A total of 47 were 2-year old precocious males (jacks). A total of three coho salmon were observed, all with a right maxillary clip hatchery mark. Biologists observed other species including steelhead, Klamath smallscale sucker, and some unidentified carcasses. They also observed one adult dead American shad, *Alosa sapidissima*, on September 27, 2002.

#### Supplemental CDFG Mainstem Surveys (Reach 1 and Blakes Riffle)

A total of 2,946 fish were observed during the supplemental mainstem surveys on September 27 to October 1, 2002 in Reach 1 and Blakes Riffle. The overwhelming majority (93.5 - 99.5 percent) of fish collected during September 27 to October 1, 2002 by the CDFG were older carcasses (Table 6). Many carcasses were in advanced stages of decay and had been dragged onto higher ground. In addition, increased flows from augmented Iron Gate dam releases had begun to disperse carcasses downstream into the estuary and out to the ocean. The majority of specimens were Chinook salmon. About 3.2 percent of these were adipose clipped specimens. A total of 46 coho were examined during these dates. Approximately 37 percent of these were right maxillary clipped specimens. A total of 106 adipose clipped steelhead were observed during these dates. Two Klamath smallmouth suckers and one coastal cutthroat trout were also observed during these collections.

#### Supplemental CDFG October 1, 2002 Mainstem Reach 4 Surveys

The CDFG counted a total of 1,040 dead fish in Reach 4 during October 1, 2002 (Table 6). They did collect some recently dead fish including 10 Chinook, 3 hatchery-marked coho, and 1



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steelhead. Again these were not collected randomly and cannot be used to estimate recently dead versus older fish ratios. However, this suggests that some fish were still dying during October 1, 2002.

### Mainstem USFWS Reach 3 October 1, 2002 Surveys

On October 1, 2002 the Service counted a total of 528 carcasses in a survey of Reach 3 at two sites (Table 6). A total of 25 fish were examined for species composition. Approximately 92 percent of the fish examined were Chinook salmon. About 17 percent of the Chinook were adipose clipped individuals. Only one coho with a right maxillary mark was found. Approximately 98.9 percent of the fish were older carcasses.

### Trinity River Surveys

During their surveys, the Hoopa Valley Tribe Fisheries staff observed a total of 19 dead fish (Table 7). Most were Chinook salmon. However, one coho and one steelhead were also counted.

### Blue Creek Surveys

Unlike the main stem investigation, a large proportion of dead fish in Blue Creek were coho salmon. A total of 231 coho were counted during three sites visits (Table 8). The highest number of coho was recorded on October 1, 2002, when 193 individuals were observed. However, many of these were older carcasses and may represent fish that were previously counted on September 24 and 27. Therefore, we did not use counts from the earlier dates and instead relied only on the counts from October 1, 2002.

### Uncommon Species

Throughout the investigation, other accounts of uncommon species were reported. The most numerous non-salmonid species, Klamath smallscale sucker, was observed in Reaches 2, 3 and 4 and above Coon Creek during September 20, 24, and 27, 2002 (Tables 2 and 4). During these sample dates we estimated that a total of 311 Klamath smallscale sucker were present. An estimated nine speckled dace were present in mainstem surveys during September 24 and 27, 2002 (Table 2). An estimated 86 dead sculpin were present during September 24, 2002 in Reach 3 (Table 2). One large (more than 4 feet long) green sturgeon carcass was observed in the vicinity of Blake's riffle (RM 7.7) on September 29, 2002, and a single coastal cutthroat trout was observed immediately downstream of the Hwy 101 bridge (RM 2.8) along the shoreline on October 1, 2002 (Table 6).

During this investigation various investigators and fisherman reported that juvenile fish and many surviving adult fish of many of the affected species appeared healthy and unaffected. In

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addition, while conducting underwater digital photographic surveillance on October 1, 2002 we observed large schools of apparently healthy swimming juvenile American shad. In addition, the Yurok Tribal Fisheries Program and Service had been conducting a radiotelemetry study of green sturgeon. Tagged individuals appeared to be unaffected during the die-off.

Dead fish were not observed above Weitchpec on the Klamath River. The Karuk Tribe did indicate that some live Chinook observed at Ishi Pishi falls did exhibit lethargic behavior and some possessed gill erosion and sores after September 27, 2002 (Reed 2002).

#### Overall Estimate of Number of Dead Fish

At this time, we believe the September 24 count is the best estimate of the total number of fish that died during this incident within the four-reach primary survey area. However, additional dead fish counts collected at Blue Creek on September 24 and October 1, 2002 (Table 8), the area above Coon Creek (Table 4), the Trinity River (Table 7), and counts of uncommon species from September 27 and October 1, including green sturgeon and coastal cutthroat sightings should also be included in the overall estimate of the number of dead fish.

Based on this approach, a total of 34,056 dead fish (Table 9) represents our best estimate for the number of dead fish during this event. Approximately 96 percent (32,553) of the dead fish were Chinook salmon. We estimated that one percent (344) of the dead fish were coho. We estimated that a 1.8 percent (629) of the dead fish were steelhead. The most numerous (311 specimens) non-salmonid species was Klamath smallscale sucker. Several uncommon species including speckled dace, coastal cutthroat trout, sculpin, and green sturgeon were also observed during the die-off.

#### Chinook Age and Hatchery Composition

The following projections of hatchery contribution and age composition of dead Chinook were derived based on hatchery and age composition rates developed by the KRTAT (Table 10). As such, these numbers are subject to change if new data on the in-river run become available. The Chinook die-off represented 19.2 percent of the total in-river run. The majority (93.9 percent) of dead Chinook were composed of adult fish. This represented 19.1 percent of the total in-river adult run size. Age 3 fish represented the largest (52.3 percent) component of the Chinook die-off. The KRTAT estimated that 21.7 percent of the die-off was composed of hatchery fish. Iron Gate hatchery fish represented 9.0 percent of the die-off. Trinity River hatchery fish represented 12.7 percent of the die-off.

#### Coho Hatchery Contribution

Data provided in Table 8 indicate that approximately 91.5 percent of the dead coho collected on September 24 and October 1, 2002 were of Trinity hatchery origin. However, additional data

were collected during various surveys (Table 11). In an attempt to maximize the information used to estimate the hatchery proportion of coho, we examined all the coho data collected. Using all the data, we estimated that 81.1 percent of the coho were of hatchery origin (Table 11). We are however, less confident of this estimate because some of the coho may have been recounted, particularly in Blue Creek.

### Steelhead Hatchery Contribution

Approximately 39 percent (244) of the steelhead examined possessed adipose clips indicating that they were hatchery fish.

## **Discussion**

The total number of dead fish estimated during this event represents a conservative assessment, which is probably an underestimate of the true magnitude of the die-off. In general, based on past empirical data and studies, estimates of losses based on countable dead fish will be conservative (American Fisheries Society 1992). Very seldom will the counts represent more than a modest fraction of the fish die-off. The counts are based only on fish actually seen once or a few times during a dynamic, ongoing process. For example, during the September 24, 2002 counts, CDFG staff estimated that some shoreline counts, when compared to boat surveys, underestimated the actual count by a factor of four (Bairrington 2002). In addition, smaller fish are more likely to be overlooked. Therefore counts of smaller specimens will be less accurate than for larger fish.

Another reason why the estimate is likely conservative is that during a fish kill, fish die at different rates, and once dead, they float or sink at different times. For the same species and cause of death, these rates vary with water quality, temperature and size of fish. A count of dead fish will miss many fish that are too deep in the water to be seen, are hidden by debris, have been taken by predators or scavengers, have decomposed, or are visible but overlooked. These factors contribute toward underestimating the numbers of dead fish. The underestimation of total numbers could possibly be reduced by using more sophisticated and costly survey methods. However, in light of the circumstances we believe the best possible response was made during our investigation using the area-sampling procedures described and recognizing the conservative estimate it will generate.

Multi-day fish die-offs are difficult to assess (American Fisheries Society 1992). Various approaches have been advocated including sequential independent daily counts (which we used), marking of counted fish, removing counted fish, and using some conservative marker, such as eye color or red gills, to account for new dead fish. Each approach has its drawbacks. Removal or marking of counted fish requires additional time and labor and potentially introduces logistical

issues associated with disposal of carcasses. Using conservative markers and/or conducting sequential daily total counts may tend to bias estimates on the low side due to potential removals by scavengers and downstream drift of carcasses. New dead fish appear which may be due to more fish dying or fish floating in from adjacent segments. However, fish can also be removed from an area due to scavenging, predation, and floating downstream. These two processes tend to counteract each other but are difficult to quantify during an actual investigation.

Past studies have documented the conservative nature of fish die-off counts using the same counting techniques that we applied as well as other methods. Krumholz (1944) reported picking up fish for 10 days after application of rotenone. Ball (1948) picked up dead fish for 6 days. Parker (1970) found that although most dead fish surfaced in a few days at temperatures above 60 degrees Fahrenheit, it took 30 to 40 days for some fish to rise at lower temperatures. There seems to be no general rule about the percentage of the total recovery of dead fish that can be expected on a particular day. Several studies have indicated that recovery of dead fish is incomplete. Krumholz (1944) marked fish up to a month before applying a fish toxicant and recovered 86 percent of them during a 10-day period. Over a 6-day period Ball (1948) recovered 59 percent of the bluegills and 45 percent of the brook trout that had been marked 4 days before the poisoning. Henley (1967) used SCUBA in Cumberland Lake to estimate that dead fish of all species left on the lake bottom after 3 days of retrieval of carcasses amounted to 34 percent by number and 5 percent by weight of all dead fish. Axon et al. (1980) recovered 91 percent of the fish marked after 3 days in the Barkley Lake study.

Recently, the Texas Parks and Wildlife Department conducted tests of the American Fisheries Society Fish Kill counting guidelines for small streams (Labay and Buzan 1999). They found that in small streams all estimates grossly underestimated the total number of dead fish placed in the stream. Scavengers probably removed most of the dead fish during the 16 hours before the investigation. Ryon et al. (2000) found that daily surveys for dead fish may underestimate actual mortality, in part because there is substantial removal by scavengers.

Data collected from mark recapture surveys of salmon carcasses during spawner surveys also document the conservative nature of dead fish counts. Data provided by the CDFG for the Salmon and Scott Rivers indicate that recovery rates range between 45.2 and 59.8 percent, and 60.3 and 86.7 percent, respectively (Hampton, 2002; Pisano 1993; Pisano 1994; Pisano 1995; Pisano 1999). Preliminary data from the Service mainstem spawner survey documented recovery rates ranging from 24 to 52 percent during 2002.

It is clear that during any fish die-off the numbers of carcasses available to be counted changes over at least several days. The reasons include removal of dying or dead fish by predators and scavengers, and sometimes humans, as well as decomposition. For example, during this fish die-off, in a well publicized event, a private citizen on the lower Klamath River removed an unknown number of dead fish along a less than 0.25-mile long segment of shoreline on September 29, 2002 after mainstem surveys were completed.

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We believe that the data used to generate the September 27, 2002 estimate are less accurate than the September 24, 2002 data because on September 27: (1) Reach 1 was not surveyed and data were extrapolated, (2) we observed a higher density of dead fish in the areas surveyed in Reach 2 compared to the other surveys indicating downstream transport of older carcasses, (3) counts in the upper two reaches were lower than earlier surveys again supporting the likelihood of downstream transport of carcasses, and (4) during this period, at least 1 week had elapsed since the beginning of the fish die-off and consequently most dead fish had surfaced and started to drift downstream. Due to scavenging and currents many of the fish that had died earlier in upstream reaches were probably removed or deposited in the lower river by September 27. However, quantitative field data were not collected in Reach 1 on September 27, and therefore it is impossible to verify whether this occurred.

It is very doubtful that many of the dead fish present in Reach 1 originated in that portion of the river. By the end of September very few adult Chinook are entering the Klamath River, even during years of protracted run-timing (Polos and Craig 1994; USFWS 1992).

Due to increased downstream drift induced by higher Klamath River flows starting on September 27, 2002, we would expect increased densities during and after this date in the lower reaches. Based on qualitative field observations, the estuary appeared to contain more dead fish during September 27, 2002 than during the September 24, 2002 survey. This would alter the density relationship between Reach 1 and 2 generated from the September 24, 2002 data and used to expand the counts from September 27, 2002. Consequently, the use of the Reach1:Reach2 density ratio generated from the September 24, 2002 data will result in a lower estimate of the number of dead fish in Reach 1 on September 27, 2002 than was probably present. Therefore we are less confident regarding the accuracy of September 27 estimates. We believe the estimates of number of dead fish based on the September 24, 2002 data are more defensible, although probably more conservative than estimates based on the September 27 data.

Previous reviews of this manuscript have recommended that estimates of recently dead fish observed on September 27, 2002 be used to supplement the counts on September 24, 2002. This is a potential approach, but it is difficult to apply for several of the same reasons associated with the estimation of raw numbers. Since older fish have a higher likelihood of floating downstream, the ratio of recently dead to old fish will change considerably. Percentage-wise, we would expect even fewer recently dead fish in Reach 1, where the largest number of the dead fish were projected to be found. Supplementary surveys conducted on October 1, 2002 showed that only 0.5 percent of the fish examined in Reach 1 had recently died. Consequently, the use of ratios generated with a higher number of recently dead fish in the upper sections will inflate Reach 1 estimates. This trend was observed in the upper three reaches during the mainstem surveys on September 27, 2002. For example, in Reach 2 samples, recently dead fish comprised 1 to 3 percent of the total counted.

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Therefore, we would expect even fewer recently dead fish in Reach 1, where the largest percentage of the dead fish were projected to be found. Supplementary surveys conducted on October 1, 2002 showed that only 0.5 percent of the fish examined had recently died.

Another problem in estimating numbers of dead fish was the issue of lesser abundant species and associated small sample size. On September 24, 2002 we estimated that 135 dead coho salmon were present, based on counts obtained in Reach 4. However, on September 27, 2002, we obtained a low estimate of coho mainly because few dead coho were observed in Reach 1 or 2 (Table 2). Coho numbers in these reaches were probably low on September 27, 2002 due to downstream transport of carcasses initially counted on September 24, 2002. These less abundant species were subsequently missed in downstream counts. Other less abundant species of fish observed that were probably underestimated include Klamath smallscale sucker, sculpin, and speckled dace.

Throughout the investigation, live adult and juvenile fish of affected and unaffected species were observed in the river. In addition, some species (e.g. American shad, speckled dace, and green sturgeon) did not appear to experience extensive mortality. Almost all (greater than 99 percent) of the dead fish observed were adults or larger species of fish. Even though some smaller specimens may have been under-counted as discussed above, the overall composition of the die-off was numerically dominated by these larger fish.

During all surveys, the majority of the recently dead fish examined exhibited one or more outward gross signs of disease including gill necrosis, bacterial growth, sores, bloody vents, and ulcerations. Pathological examinations confirmed that white spot disease and columnaris were the principle immediate causes of death (Foott 2002; Veek 2002). The species and size selectivity observed during this investigation is consistent with a die-off caused primarily by pathogens (Meyer and Barclay 1990).

At this time, we believe the September 24 count, with the addition of supplementary observations of rarer fish, Trinity River surveys, and surveys of other tributaries and portions of the Klamath River, should be used to generate the conservative estimate of the total number of fish that died during this incident. On this date the highest percentage of recently dead fish were observed, and estimated numbers of dead fish had increased over the initial September 20, 2002 count. After this date the percentage of recently dead fish continued to decline. Various factors including increased downstream drift after September 27, 2002, scavenging, and decomposition of carcasses reduce our confidence in any estimates made from mainstem surveys conducted after September 24, 2002.

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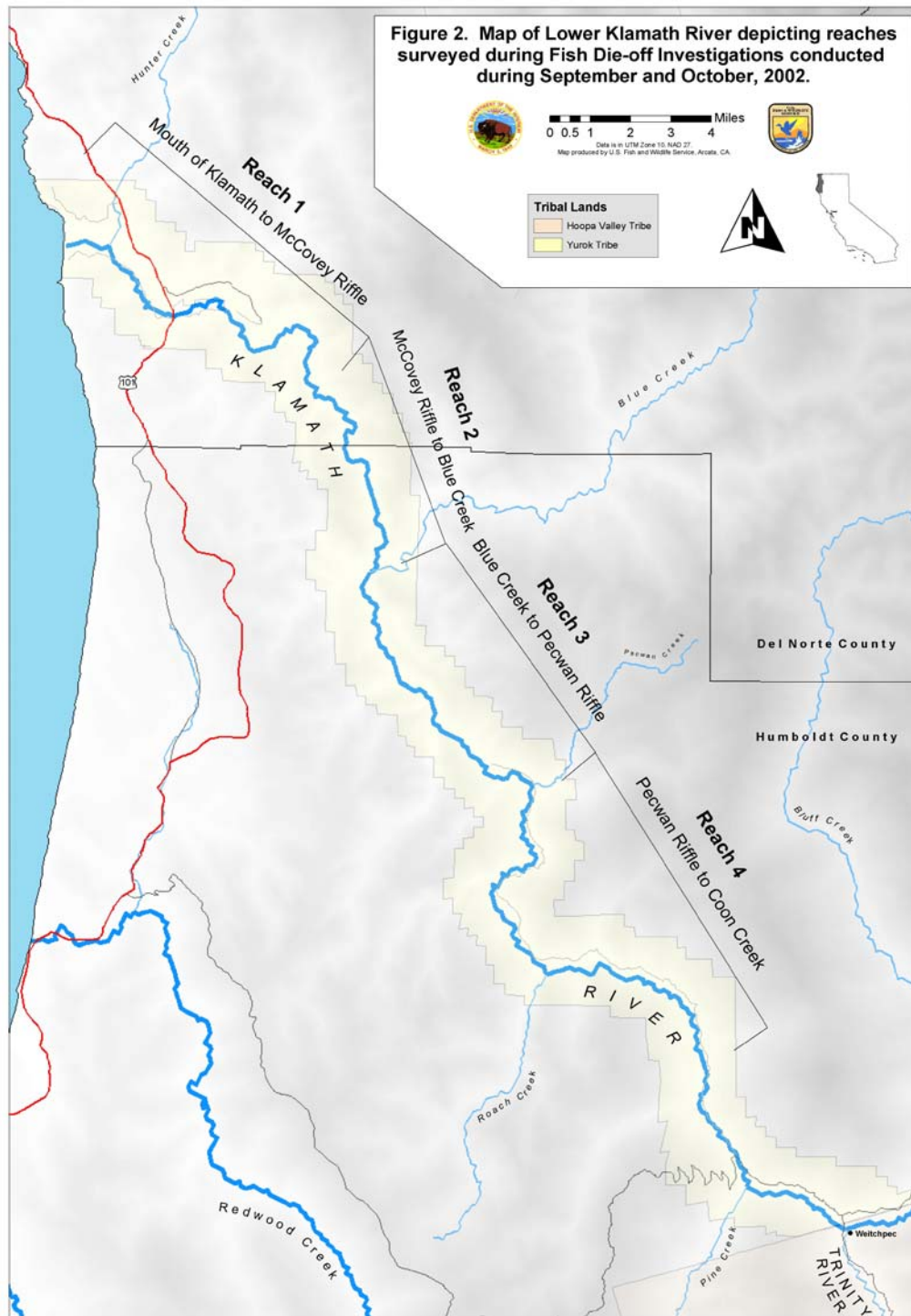
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**Table 1.** Dead fish species observed during the die-off investigation conducted on the Klamath River between September 19 and October 1, 2002 from the estuary to Weitchpec at river mile 43.5.

<b>Common Name</b>	<b>Scientific Name</b>
green sturgeon	<i>Acipenser medirostris</i>
speckled dace	<i>Rhinichthys osculus</i>
Klamath smallscale sucker	<i>Catostomus rimiculus</i>
cutthroat trout	<i>Oncorhynchus clarki</i>
coho salmon	<i>Oncorhynchus kisutch</i>
steelhead	<i>Oncorhynchus mykiss</i>
Chinook salmon	<i>Oncorhynchus tshawytscha</i>
sculpin	<i>Cottus spp.</i>
American shad	<i>Alosa sapidissima</i>

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Table 2. Summary of fish counts and estimated numbers of dead fish determined from surveys to assess the September 2002 Klamath River fish die-off

	Reach Length (miles)	Percent Surveyed	Carcass Density (no./mile)	Total Count	Expanded Count	Chinook*	coho*	steelhead*	sucker*	dace*	sculpin*
Survey Date: 9/20/02											
Reach 1**	10.07	100.0	72.7	732	732	722	0	10	0	0	0
Reach 2	6.33	33.6	189.8	404	1,202	1,190	0	12	0	0	0
Reach 3	8.61	54.4	88.1	413	759	722	0	2	35	0	0
Reach 4	11.02	100.0	6.9	76	76	53	12	12	0	0	0
All Reaches	36.03	77.4	58.2	1,625	2,769	2,687	12	35	35	0	0
Survey Date: 9/24/02											
Reach 1***	10.07	42.3	1,822.4	7,757	18,345	18,138	0	207	0	0	0
Reach 2	6.33	28.2	1,356.6	2,401	8,590	8,519	0	53	14	4	0
Reach 3	8.61	36.1	628.3	1,952	5,411	4,800	0	262	262	0	87
Reach 4	11.02	100.0	92.0	1,014	1,014	777	135	68	34	0	0
All Reaches	36.03	56.0	651.6	13,144	33,360	32,234	135	590	310	4	87
Survey Date: 9/27/02											
Reach 1	10.07	0.0	****	****	22,474	21,873	0	602	0	0	0
Reach 2	6.33	25.8	1,648.3	2,689	10,436	10,157	0	279	0	0	0
Reach 3	8.61	27.4	365.9	864	3,151	3,021	14	73	44	0	0
Reach 4	11.02	100.0	88.0	970	970	943	11	5	5	5	0
All Reaches	36.03	41.7	****	****	37,032	35,994	25	959	49	5	0

\*Chinook = *Oncorhynchus tshawytscha*, coho = *O. kisutch*, steelhead = *O. mykiss*, sucker = *Catostomus rimiculus*, dace = *Rhinichthys osculus*; sculpin = *Cottus sp.*

\*\*Reach 1 = Mouth of Klamath to McCovey Riffle (RM 10.1); Reach 2 = McCovey Riffle to Blue Creek (RM 16.4); Reach 3 = Blue Creek to Pecwan Riffle (RM 25.0); Reach 4 = Pecwan Riffle to Coon Creek (RM 36.0)

\*\*\* Fish found on the bottom raw counts were adjusted to account for portions of the lower river that could not be surveyed.

\*\*\*\*Boat malfunction, survey not completed, Reach 2 densities used to estimate Reach 1 numbers.

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Table 3. Biological data collected during the fish die-off on the Klamath River 2002. FL = fork length, n = number of observations.

<b>Attribute</b>	<b>Data Source</b>	<b>Value</b>
Average Size Chinook	9-20-02	83.4 cm FL (weighted average cm ) n=89, range 50-104
% female Chinook	9-20-02	63.5 (weighted average), n = 104
% diseased visible signs (all species)	9-20-02	81.1 (weighted average), n = 105
% recently dead (all species)	9-24-02	Composite all reaches: 14.3 (floating), 97 (bottom), 20 (shoreline) 47.1 (overall)
expanded number of adipose clip Chinook	9-24-02	622 (2.0% of all Chinook)
expanded number of adipose clip steelhead	9-24-02	236 (40% of all steelhead)
expanded number of right maxillary mark coho	9-24-02	135 (100% of coho)
% recently dead fish (all species)	9-27-02	1-3 composite Reach 2; 0 shoreline Reach 3; 21 composite Reach 4

Composite = surface, bottom and floating fish

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Table 4. Supplementary observations collected during the Klamath River die-off during 2002. Data collected by Yurok Tribal Fisheries Department from Weitchpec (RM 43.5) to Young's Bar (RM 35.5) on September 27, 2002 (8 river miles; 12.9 kilometers).

Species of fish	Count	# per rm	Adjusted Count (above Coon Creek) rm 43.5 - 35.9 (7.6 rm; 12.1 rkm)
Total Fish	180	22	170
Chinook (includes damaged specimens - ad clip unknown)	87	11	83
Chinook without adipose clip (includes jacks)	77	10	73
Chinook with ad clip	9	1	9
Jack Chinook without ad clip	2	0	2
Jack Chinook with ad clip	0	0	0
Steelhead without ad clip	1	0	1
Steelhead with ad clip	0	0	0
Coho with maxillary clip	0	0	0
Coho without maxillary clip	0	0	0
<sup>1</sup> Unidentified fish	90	11	85
American shad	1	0	1
Suckers	1	0	1
Fresh fish (clear eye)	10	1	9
Males	29	4	27
Females	56	7	53
M/F ratio	0.52		
% Fresh	0.06		

<sup>1</sup> 74 out of the 90 unidentified fish were too decayed and unidentifiable

ad clip = adipose fin clipped specimens

Table 5. Biological data collected by the Yurok Tribal Fisheries Program during the Klamath River fish die-off in 2002.

Species of fish	Survey One 9-25-02	Survey Two 9-25-02	Survey Three 9-26-02	Subtotal: Surveys 1-3	Upstream Survey (Coon Creek to Weitchpec)	Total	Percent
Total Fish	66	238	422	726	180	906	100.0
Chinook without adipose (ad) clip	63	219	357	639	77	716	79.0
Chinook with adipose clip	2	9	7	18	9	27	3.0
Jack Chinook with no ad clip	1	1	38	40	2	42	4.6
Jack Chinook with ad clip	0	0	5	5	0	5	0.6
Steelhead with no ad clip	0	1	5	6	1	7	0.8
Steelhead with ad clip	0	4	7	11	0	11	1.2
Coho with maxillary clip	0	2	1	3	0	3	0.3
Coho without max. clip	0	0	0	0	0	0	0.0
Unidentified	0	1	1	2	90	92	10.2
Suckers	0	1	1	2	1	3	0.3

Data source: M. Belchik - Yurok Tribe Surveys in Vicinity of Blue Creek and Upstream to Weitchpec on 9-25 to 9-27-02.

Surveys one and two were conducted 2 minutes upstream or downstream of the mouth Blue Creek in the Klamath River. Survey three was conducted for 4 minutes downstream of the mouth of Blue Creek. No river survey length data collected

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Table 6. Results of supplementary mainstem surveys conducted by CDFG and USFWS during September 27, 29, 30 and October 1, 2002.

Date	Location	Distance (ft)	Chinook	Ch Ad Clip	coho	coho steelhead RM	sh	ad clip	Total	% Old	Note
9/27/2002	Mouth to Terwar - Reach 1	3,500	601	26	3	0	27	12	631	unknown	single shoreline, 4 sites
9/29/2002	Blake Riffle Citizen Pickup	unknown	418	19	6	0	21	10	447	93.5	2 suckers also, 2 shoreline banks
9/30/2002	Mouth to Blue Creek - Reach 1 and 2.	2,100	60	3	10	10	73	41	146	many	Only fresh Chinook examined, single shoreline, 5 sites
10/1/2002	Mouth to Ida Jane Riffle - Reach 1	9,490	1596	38	27	7	96	43	1,722	99.5	single shoreline, 1 cutthroat and 2 sucker
10/1/2002	Pecwan to Coon Creek - Reach 4	58,186	10	10	3	3	1	1	1,040	unknown	Both shorelines, non-random sample
10/1/2002	Two sites: 0.5 miles and 0.4 miles - Reach 3	4,752	23	4	1	1	0	0	528	98.9	2 shorelines and open water, 1 dead sucker, species comp based on 25 fish subsample

Ch = Chinook salmon, sh = steelhead, ad clip = adipose fin clipped specimens  
RM = right-maxillary clipped

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Table 7. Results of fish mortality monitoring in the Trinity River, Weitchpec (RM 43.5) upstream to Red Rock - 7.4 miles, 11.9 km. Data collected by Hoopa Tribe.

Date	Species	Condition
9/20/02	(2) Chinook, ) (2) unidentified salmon, 1 steelhead	all dead + 1 lethargic salmon
9/24/02	(2) Chinook	all dead (one with hook mark)
9/26/02	(8) Chinook, 3 unidentified juvenile salmon, 1 coho	all dead

Table 8. Observations of fish mortality in Blue Creek (RM 16.4) during the Klamath River fish die-off in 2002. FL = fork length, rt. max = right maxillary clip.

Survey Date	Species	Numbers	Observation
9/24/02	Chinook salmon	3	Species comp. sampling only, complete counts not made, 2 females, 1 ad clip, 25% fresh. Average size: 69 cm FL
9/24/02	coho salmon	15	100% rt max clip, 60% female, 93% diseased. Average size: 64 cm FL, 1 coho also had an ad clip and rt max clip.
9-24/02	steelhead	1	ad clip, diseased, male, 64 cm FL
9/27/02	coho salmon	24	subsample: 4 hatchery (rt max) + 2 wild = 6.
10/1/02	coho salmon	193	13 wild (include 2 jacks), 179 rt. max clip (includes 1 jack), 1 ad clip.
10/1/02	steelhead	36	23 wild adult, 6 adult ad clip; 6 half-pounders <sup>1</sup> ; 1 half-pounder ad clip.
10/1/02	Chinook salmon	226	213 no clip, 5 ad clip, 7 jack no clip, 1 jack ad clip.
10/1/02	Unidentified	28	in deep pools, could not collect
10/1/02	Total	483	
10/1/02	% fresh	77	16% fresh.

<sup>1</sup>half-pounders - small immature sea-run individuals returning after less than 1 year in the ocean, usually weighing ½ to 1 ½ lbs.  
ad clip = adipose fin clipped specimens



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Table 9. Total estimate of numbers of observable fish that died during the Klamath River fish die-off during 2002. Numbers include uncommon fish observed during supplementary surveys, and Trinity River, Blue Creek, and above Coon Creek Falls data.

	9-24-02 estimate	10-1-02 & 9-24-02 Blue Creek	9-27-02 above Coon Creek	Trinity River*	9-27-02**	Supplement observations	Total
Total	33,360	499	171	19	5	2	34,056
Chinook	32,234	226	83	10			32,553
Chinook ad-clip	825	6	9	0			840
coho	135	208	0	1			344
coho Rt. max	135	180	0	0			315
steelhead	590	37	1	1			629
steelhead ad-clip	236	8	0	0			244
sculpin	87	0	0	0			87
KR smallscale sucker	310	0	1	0			311
speckled dace	4	0	0	0	5		9
coastal cutthroat	0	0	0	0		1	1
green sturgeon	0	0	0	0		1	1
American shad			1				1
Unidentified	0	28	85	7			120

\* Based on 9-20 to 9-26-02 Trinity River counts

\*\* 9-27-02 mainstem survey counts used to supplement rare species (speckled dace) counts

Rt. max = right maxillary clipped specimens

ad clip = adipose fin clipped specimens

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Table 10. Composition of estimated number of dead Chinook based on hatchery and age proportions developed by the KRTAT.

Component	%	Total	Total In-river run	% Total In-river run
Total	100	32,553	169,297	19.2
<u>Age Composition<sup>1</sup></u>				
Age 2	6.1	2,003	9,246	21.7
Age 3	52.3	17,012	94,229	18.1
Age 4	37.8	12,304	62,137	19.8
Age 5	3.8	1,233	3,684	33.5
Adults	93.9	30,550	160,051	19.1
<u>Hatchery Composition<sup>2</sup></u>				
Total Hatchery	21.7	7,060		
Iron Gate Hatchery	9.0	2,921		
Trinity Hatchery	12.7	4,139		

<sup>1</sup>Age analysis based on 36 specimens that had known age coded wire tags and scales plus 369 additional scales

<sup>2</sup> Hatchery composition based on 1,824 examined fish, 71 adipose clipped fish and 56 coded wire tags processed

Table 11. Proportion of hatchery (right maxillary clip) coho salmon observed during all surveys.

Survey	Date	coho	coho RM	% hatchery	Notes
Reach 4	9/20/2002	12	2	16.7	
Blue Crk	9/24/2002	15	15	100.0	
Reach 4	9/24/2002	4	4	100.0	Used in final count, expanded to 135
Reach 1	9/27/2002	3	0	0.0	
Blue Crk	9/27/2002	6	4	66.7	Subsample of 24 fish
Reach 3	9/27/2002	4	4	100.0	
Reach 4	9/27/2002	2	2	100.0	
Reach 1	9/29/2002	6	0	0.0	Citizen pickup
Reach 1	9/30/2002	10	10	100.0	Only recently dead fish
Blue Crk	10/1/2002	192	179	93.2	Used in final count
Reach 1	10/1/2002	27	7	25.9	
Reach 4	10/1/2002	3	3	100.0	
Reach 3	10/1/2002	1	1	100.0	
Total		285	231	81.1	
From Table 8. Composite final count				91.5	

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