Biological Context of the Spring 2008 De-Watering Event in the Upper Mainstem of the Russian River

National Marine Fisheries Service, Southwest Region
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Introduction

The cultivation of wine grapes is a major industry in the Mendocino County portion of the Russian River. There are currently an estimated 15,539 acres of wine grapes under cultivation in this region; which represents a 30 percent increase in vineyard acreage over the last 20 years.

A significant challenge to the successful harvest of wine grapes in the upper Russian River is the threat that frost damage poses to crops. In spring, grape vines emerge from their winter dormancy with the initiation of new vegetative growth, which sprouts from buds established in the previous growing season. This "bud break" often coincides with spring frost events. Frost can damage this new tissue and significantly affect the subsequent yield of grapes.

As the frost risk map (Figure 1) indicates, Mendocino County faces a substantially greater frequency (and intensity) of frost events than other areas in the basin. To combat this climatic threat to their crops, growers have increasingly used water, dispersed via overhead sprinklers at a typical rate of 55gal./minute/acre. Water applied in this manner forms a protective layer of ice over the new growth and protects it from frost damage. This practice in conjunction with the expansion of vineyards, has resulted in an intensive demand for water along the mainstem Russian River (Figure 2). The 2008 frost protection events from April 19th to April 23rd resulted in the removal of an estimated 412 acre-feet of water (134 million gallons), as documented at the Hopland gauge.

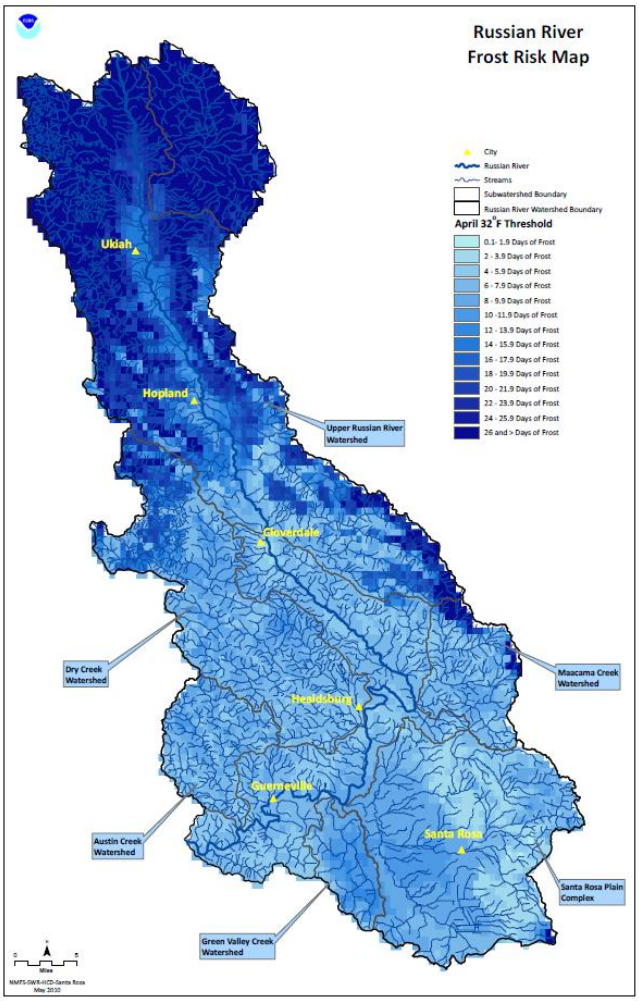

Figure 1. Frost risk map indicating a pronounced increase in the probability of frost events in the Mendocino County portion of the Russian River basin. Product developed by Fox Weather using PRISM climate model and 20 years of data from 16 local weather stations.

2008 Fish Kills

The hydrologic effects of frost protection diversions can coincide with the emergence of salmonid fry from their redds. Fry typically rear in shallow low velocity areas of the stream such as stream margins and side channels. Fry are particularly susceptible to stranding because they occupy shallow habitats, have poor swimming ability and respond to flow changes by seeking refuge in the interstitial species of cobble or gravel substrates which can then dry out. Parr, smolt and even adult salmonids may also get stranded depending on the circumstances. We have observed mortalities of all these life stages in Russian River tributaries associated with frost events.

On the morning of April 20, 2008, during a frost event, a NMFS biologist documented the stranding mortality of 10 steelhead fry along the gravel margins of the mainstem river just north of Hopland (Figure 3). This effort is best described as an opportunistic spot check. The biologist spent approximately 1 hour searching dewatered margins of the river and covered 50 to 75 meters of river length. The biologist's search was limited to a quick scan of the surface to search for stranded fish. Due to the tendency for fry to get stranded in interstitial spaces and other issues with detectability, it is likely a significant portion of stranded fish went undetected even within the small area that was searched.

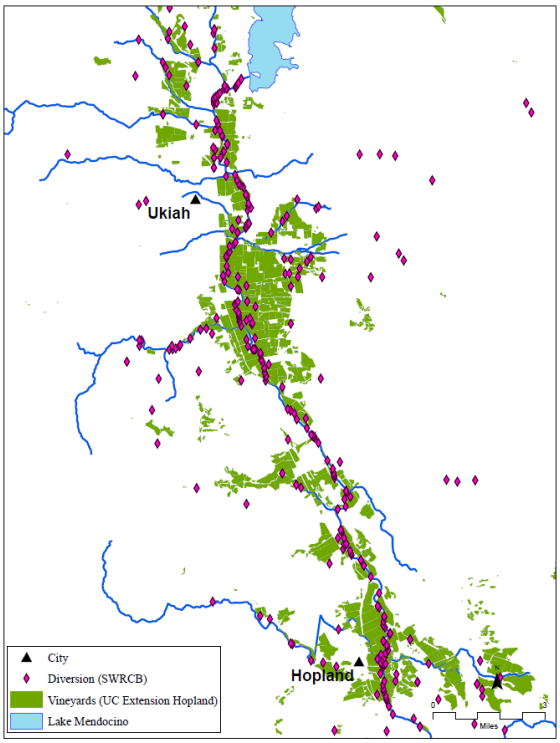

Figure 2. Distribution of vineyards and documented diversions along the Russian River mainstem between Ukiah and Hopland.

Significance of the Threat to Salmonids

Despite the seemingly insignificant nature of the observations of April 20, a consideration of the totality of evidence clearly indicates the fish kill was "substantial" and that it is reasonable to conclude the threat to salmonids is significant. To support this, we first summarize the hydrologic effects, and use that to provide an estimate of the fish kill to indicate the scope of the impact in the mainstem. We then summarize the overall threat, with particular reference to tributary streams.

Figure 3. Salmonid fry mortality observed near Hopland, April 20, 2008.

Though frost protection impacts occur throughout the basin and to a lesser extent in the mainstem below Hopland, we limit our estimate of the 2008 fish kill to the 28 miles of mainstem river from the East Branch/West Branch confluence below Coyote Valley Dam in the northern Ukiah Valley to the USGS gauge north of Cloverdale where hydrologic signals from the frost events were still detected.

Hydrologic Effects: The USGS stream flow gauge on the mainstem Russian River just north of Hopland is located 14.4 miles south of the East Branch/West Branch confluence. This gauge indicates at least 20 discernable stage reductions at low flows associated with air temperatures approaching 32°F between March 15 and May 30, 2008[1] (Figure 4). The most severe event occurred on April 21 when stage dropped 8.5 cm at a rate of 1cm per hour. Although this is not in itself impressive, due to the low gradient configuration of the channel, a drop of that magnitude would expose an 8 foot wide strip of gravel substrate, assuming a cross-sectional slope of 2°. Gravel bars do not occupy the entire channel, but typically form alternating bars interspersed with vegetated banks. For the sake of this estimate, we assume 25 percent of the river channel by length has gravel substrate, side channel, backwater pool, or some other feature where fish could potentially be stranded.

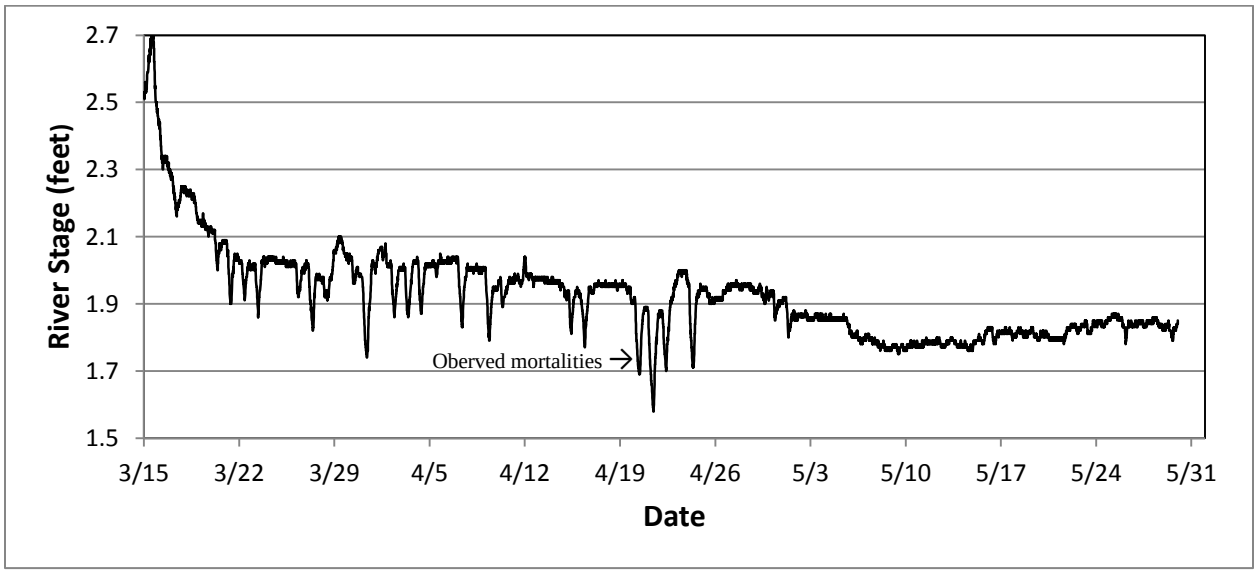

Figure 4. River stage as measured by the USGS gauge near Hopland, California from March 15 to May 30, 2008.

[1] March 15 to May 30 is the period from "bud-break" until the frost events become unlikely with the approach of summer.

Stage changes equal to or greater than those observed here are regular occurrences at higher flows when discharge decreases rapidly after a storm event. What made these events biologically significant was they occurred when stream flows were already very low due to drought conditions[2]. Pre-frost event flows were approximately 250 cubic feet per second (cfs). This volume is low enough, relative to the channel's capacity, that gravel bars and other low-gradient features would be partially exposed. Rapid stage changes at this low flow have no analogue in nature, so fish are likely to have difficulty coping with them (Figure 5).

Estimated Take of Threatened Steelhead: The following estimation may help indicate the scope of the April 2008 events. We make three important assumptions in making this estimate: 1) There was an average stranding density of 10 stranded fish per 100 feet of stream for events equal to that observed on April 20; 2) Stranding density varied by severity of events, and; 3) A constant 25 percent of the river length had features likely to induce stranding during an event. When we applied our calculations to the 28 mile assessment reach, we estimated a total of 25,872 stranding mortalities for 2008 (Table 1). We recognize this is a coarse but conservative approximation which could be modified with quantification of these additional considerations:

- The cumulative effect of diversions would increase the effect in a downstream direction.
- The magnitude and rate of stage change was probably greater at points of diversions than what was documented at the Hopland gauge.
- Channel morphology, especially with respect to the distribution of gravel bars, is unknown and varies.
- Fish density varies in space and time and may be depleted with each event.
- There were additional drawdown events not considered in this estimate.
- Hydrologic effects may have extended beyond the assessment area.

Table 1. Explicit assumptions used to derive estimates of the total number of salmonids killed in the upper Russian River mainstem during the 2008 frost season.

Event Dates	# of Events	Severity	Severity Index	Fish Density	Reach Length	% stranding habitat	Estimated # of Fish
3/23-4/16	10	Less	0.25	2.5/100ft	28 miles	0.25	9,240
4/20	1	Observed	1	10/100ft	28 miles	0.25	3,696
4/21	1	Most	1.5	15/100ft	28 miles	0.25	5,544
4/22	1	Equal to obs.	1	10/100ft	28 miles	0.25	3,696
4/24	1	Equal to obs.	1	10/100ft	28 miles	0.25	3,696
						Total Fish Kill:	**25,872**

[2] Flow in this reach is regulated by releases from Coyote Valley Dam, so low flow conditions were more directly the result of reduced flow releases intended to maximize reservoir storage under drought conditions.

Whether the actual number of stranded fry was 5,000, or 50,000, it should be apparent that: a) The fish mortality constitutes a substantial threat to the reproductive success of steelhead in the assessment area, and; b) These impacts may negatively influence the survival and recovery of local populations, which may in turn be relevant at the species scale.

Figure 5. Mainstem Russian River near Hopland on March 31, 2009 during a stage reduction of less than one inch. Note the recently de-watered stream margin.

Tributary Streams: In addition to the 28 miles of mainstem Russian River considered above, there are over 140 miles of tributary stream occupied by steelhead above that point. Tributaries not only constitute many more stream miles than the mainstem, they typically provide higher quality spawning and rearing habitat as well. For steelhead, the bulk of spawning and rearing therefore takes place in the tributaries when seasonal precipitation provides enough stream flow for adults to ascend them[3]. In dry years however, as was the case in 2008, there is limited access to the tributaries, so a larger proportion of the steelhead run are forced to spawn in the mainstem.

Although the threat of frost protection is clearly significant in the mainstem, we believe the threat to salmonids in tributaries is even greater. First, as it is with Mendocino County, tributaries throughout the Russian River basin provide the great majority of habitat for salmonids; impacts in those areas therefore threaten to harm a far greater portion of salmonid populations. Secondly, flow is typically less in the smaller tributary channels than in the larger mainstem, so cumulative water demands can more easily overtake supply and result in significant stream desiccation. Published research in Maacama Creek, a Sonoma County tributary to the Russian River, documented up to 97% stream flow reductions associated with episodic frost protection activities.

[3] Chinook salmon however, tend to be restricted to the mainstem and lower reaches of the major tributaries.