BEFORE THE UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Pacific Gas and Electric Company,	)	
Drum – Spaulding Hydroelectric	)	FS Docket No. 2310
Project	)	
FERC No. P-2310	)	
	)	

FOOTHILLS WATER NETWORK, AMERICAN RIVERS, AMERICAN WHITEWATER, CALIFORNIA SPORTFISHING PROTECTION ALLIANCE, FRIENDS OF THE RIVER, GOLD COUNTRY FLY FISHERS, NORTHERN CALIFORNIA COUNCIL FEDERATION OF FLY FISHERS, SIERRA CLUB, SOUTH YUBA RIVER CITIZENS LEAGUE, AND TROUT UNLIMITED SUBMIT ALTERNATIVE CONDITIONS TO THE PRELIMINARY SECTION 4(E) CONDITIONS FOR DRUM – SPAULDING HYDROELECTRIC PROJECT

I. INTRODUCTION

On July 30, 2012, the Forest Service filed before the Federal Energy Regulatory Commission (FERC) "Preliminary Terms and Conditions Provided Under 18 CFR § 4.34(b)(1) In Connection with the Application for Relicensing for the Drum-Spaulding Hydroelectric Project (FERC No. 2310)" (e-Library no. 20120731-5114) (July 30, 2012). The Forest Service filed "Revised Preliminary Terms and Conditions Provided Under 18 CFR § 4.34(b)(1) In Connection with the Application for Relicensing for the Drum-Spaulding Hydroelectric Project (FERC No. 2310)" (e-Library no. 20120824-5005) on August 24, 2012. Pursuant to 7 C.F.R. § 1.671(a)(2), Foothills Water Network, American Rivers, American Whitewater, California Sportfishing Protection Alliance, Friends of the River, Gold Country Fly Fishers, Northern California Council Federation of Fly Fishers, Sierra Club, South Yuba River Citizens League, and Trout Unlimited (collectively, "the Network") submit this alternative to the Forest Service's Revised Preliminary Section 4(e) Condition No. 29 ("Flow Measures") in part. The Forest Service modified its original

Condition No. 30 (also entitled "Flow Measures") primarily to address concerns expressed by licensee (PG&E). The Network understands that PG&E supports the revised Condition 29, which is the modified version of original condition 30.[1]

The Network does not believe that the revised Condition 29 is adequate to protect the biological resources in the South Yuba River. In terms of biological benefit, it is a step backwards from the original Forest Service Condition 30. The Network supported many aspects of the original Condition 30, including the overall concept of a "block flow" that would require licensee to augment summer minimum flows in the South Yuba River when measured water temperatures warrant such an increase.

The Network offers an alternative Condition 29 that requires licensee to release up to a total of 2,500 acre-feet of water into South Yuba River annually between June 15 and September 15 in Critically Dry (CD), Dry, Below Normal (BN), Above Normal (AN), and Wet water year types for the purpose of maintaining a mean daily water temperature of 19ºC or less in the South Yuba River below Spaulding Dam as measured immediately upstream of Canyon Creek. The Network's proposal would result in an increase in suitable habitat for coldwater fish species. The Network's alternative would also increase fishing opportunities by adding suitable trout habitat in the South Yuba River downstream of Canyon Creek, in an area that is more accessible to anglers than the South Yuba River upstream of Canyon Creek.

As set forth more fully below, the Network's alternative will provide a greater level of protection for the Forest Service reservation as compared to the revised Condition 29. This alternative will also enhance recreational values by increasing angler access to the South Yuba River. In order to ensure that the Network's alternative measure generates more power than the

1 Numeration of Preliminary Conditions was changed for reasons not substantively related to either version of flow measures.

Forest Service's revised Condition 29, the Network proposes to reduce the minimum instream flow in the South Yuba River in February and March to 25 cfs in all water year types except EC. (*See* 4(e) Condition 30, Table 2, bottom of p. 18 for comparison.) The Network explains below how its proposed alternative condition is more protective of the resource and provides for greater hydropower production and water supply reliability than the revised Condition 29 proposed by the Forest Service.

II.
PARTY STATUS

On July 31, 2012, the Foothills Water Network, as a coalition and distinct entity, and each of the individual member organizations of the coalition signatory to this document, filed a timely motion to intervene in the relicensing proceeding. (*See* e-Library no. 20120731-5147.) Because the motion was unopposed, the Network and these member organizations became parties in this proceeding by operation of law 15 days after its motion was filed. (*See* 18 C.F.R. § 385.214.) As licensing parties, the Network and the undersigned member organizations of the Network may file alternative conditions to Preliminary 4(e) conditions under 7 C.F.R. §1.671(a)(1)(i).

III.
PRELIMINARY CONDITION FOR WHICH THE NETWORK IS SUBMITTING AN ALTERATIVE CONDITION

The relevant portion of the Forest Service's revised Preliminary Condition 29 for the Drum-Spaulding Project reads as follows:

> **South Yuba River Supplemental Flows**
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> Licensee shall, within one year of license issuance, in coordination with FS, CDFG, State Water Board, Licensee for the Yuba-Bear Hydroelectric Project, and other interested stakeholders as identified by the FS, establish a meeting schedule with the Ecological Group (Condition No. 30, Ecological Group) for the purpose of evaluating the monitoring data as collected pursuant to Licensee's Monitoring Plan as approved by the Commission for the South Yuba River, including the data related to foothill yellow-legged frogs (FYLF) and

resident rainbow trout, and assessing the effect of any Supplemental Flows, if applicable, on habitat, including water temperatures, for FYLF and native fish species (e.g., resident trout, hardhead, pikeminnow). Consistent with the approved Monitoring Plan, Licensee will collect data regarding FYLF and fish populations, including rainbow trout, in the South Yuba River below Lake Spaulding and will provide those data to the Ecological Group on an annual basis (no later than January 31 of each year, for the previous year's data), if applicable, during the term of the license. Water temperature monitoring data will be provided to the Ecological Group every two weeks from June 1 through August 15 unless otherwise agreed to. For the first 5 years after license issuance, or until the low-level outlet at Lake Spaulding Dam is retrofitted, whichever is sooner, Licensee will make a good faith effort to meet Supplemental Flows in the South Yuba River below Lake Spaulding as measured at YB-29.

For the purposes of this measure, Supplemental Flows mean water Licensee may be required to release in addition to the Minimum Streamflows into South Yuba River below Lake Spaulding annually between July 1 and September 15 in CD, Dry, and BN water year types so that the total minimum flow (i.e., the Minimum Streamflows plus Supplemental Flows) as measured at YB-29 shall be no greater than 30 cfs. The purpose of the Supplemental Flows is to provide habitat for resident rainbow trout without decreasing habitat or otherwise negatively impacting FYLF or other native species, such as hardhead.

The Ecological Group will be responsible for providing annual recommendations to FS, and FS shall then determine, whether in CD, Dry, and BN water year types any Supplemental Flows shall be implemented each year. If FS determines that any Supplemental Flows will be implemented during any year of the license term, FS shall inform Licensee of that determination in writing (electronic communications acceptable) no later than June 1 of the same calendar year for which the Supplemental Flows shall be implemented and shall inform Licensee of the requested total minimum flow (e.g., the monthly number between the Minimum Streamflows and a maximum of 30 cfs) for each month between July 1 and September 15. With reasonable notice (10 days), the FS may request one adjustment to these flows during this time period. Table 7 provides the monthly Supplemental Flow range and the total minimum flow range for the South Yuba River as measured at YB-29 in CD, Dry, and BN water year types. Although Supplemental Flows do not apply to the month of June, Minimum Streamflows for June are included in Table 7 to provide a reference for the time period immediately preceding the period when Supplemental Flows may be implemented.

Table 7. Minimum Streamflows in South Yuba River below Lake Spaulding Dam as Measured at YB-29 with Supplemental Flow Range and Total Minimum Flow Range

Period	Minimum Streamflow (cfs)	Supplemental Flow Range (cfs)	Total Minimum Flow Range (cfs)
CRITICALLY DRY WATER YEARS			
June 15 – 30	35	--	35
July	25	0-5	25-30
August	20	0-10	20-30
September 1 – 15	20	0-10	20-30
DRY WATER YEARS			
June 15 – 30	40	--	40
July	30	--	30
August	23	0-7	23-30

September 1 – 15	23	0-7	23-30
BELOW NORMAL WATER YEARS			
June 15 – 30	50	--	50
July	35	--	35
August	25	0-5	25-30
September 1 – 15	25	0-5	25-30

If the FS does not inform Licensee by June 1 that it wants to implement Supplemental Flows in the South Yuba River for that calendar year, Licensee shall implement the Minimum Streamflows for the South Yuba River as set forth in the Streamflows Measure. Nothing in this measure shall require Licensee to release flows above 30 cfs in CD, Dry, and BN water year types, or allow the Licensee to release flows in the South Yuba River that are lower than the Minimum Streamflows, as measured at YB-29 as set forth in the Streamflows Measure.

The Ecological Group will also be responsible for providing annual recommendations to FS, and FS shall then determine, whether in AN and Wet water year types the Minimum Streamflows for the South Yuba River as measured at YB-29 should be decreased between July 1 and September 15 to no less than 30 cfs, as approved by FERC. If FS determines that any Minimum Streamflow should be decreased in Above Normal and Wet water years as described in this paragraph, FS shall inform Licensee of that determination in writing no later than June 1 of the same calendar year for which the decreased Minimum Streamflow is to be implemented and Licensee shall implement the decreased Minimum Streamflow as approved by FERC. FS shall not require Licensee to implement more than one Minimum Streamflow in a calendar month (i.e., the FS will only provide one Minimum Streamflow for each month from July 1 through September 15). If FS does not inform Licensee by June 1 that it wants to decrease the Minimum Streamflows in the South Yuba River in an AN or Wet water year as described in this paragraph, Licensee shall implement the Minimum Streamflows for the South Yuba River as set forth in the Streamflows Measure. Nothing in this measure shall require Licensee to release flows above the Minimum Streamflows in the South Yuba River as measured at YB-29 in Above Normal or Wet water years as set forth in the Streamflows Measure.

If, after at least three years of monitoring (including at least one Dry or CD water year), data indicate that daily average water temperatures immediately above Canyon Creek are exceeding 20ºC mean daily, an important transition temperature for rainbow trout and other native species, for two consecutive days, FS may require that the Licensee develop a plan to amend this South Yuba River Flow Adjustment Measure for the South Yuba River above Canyon Creek. This plan, if required, will describe methods for providing flows below Lake Spaulding from June 15 through September 15 to quickly reduce water temperatures if they exceed 20ºC for two consecutive days (daily average, measured as close to Canyon Creek as reasonably possible). The plan shall be filed with FERC within two years of the request by the FS and shall include empirical data from at least one dry or critically dry water year type. The plan will develop recommendations to meet the rainbow trout water temperature objective without negatively impacting, as determined by FS, FYLF and other native species. The plan shall be based on stream temperature monitoring and existing modeling of the affected reach from immediately below Lake Spaulding Dam downstream to Canyon Creek. The plan shall also propose empirically determined ramping rates and Total

Minimum Flows not to exceed 40 cfs that will avoid negative effects to FYLF and other native species within this reach. The plan will also consider potential impacts to generation and water supply. Licensee shall submit the plan for FS approval prior to submission to the Commission. Licensee shall implement the plan upon Commission approval.

Licensee shall provide to FS, CDFG, State Water Board, interested stakeholders, and the Commission by no later than the Annual Consultation meeting of the next calendar year a report of the activities of the Ecological Group for the previous calendar year.

Ecological Group

Licensee shall, within 3 months of license issuance, in coordination with FS, BLM, CDFG, State Water Board, and other interested stakeholders, establish an Ecological Group for the purpose of assisting Licensee in the implementation of project-wide monitoring plans and review and evaluation of monitoring data. The Ecological Group will also provide guidance on implementation of the South Yuba River Flow Adjustment Condition (Condition No. 29).

Licensee shall provide to FS, BLM, CDFG, State Water Board, interested stakeholders, and the Commission by June 30 of each year an annual report of the activities of the Ecological Group.

IV. ALTERNATIVE CONDITION PROPOSED BY THE NETWORK

The Network proposes the following alternative condition to the above-quoted portion of revised Condition 29 entitled "South Yuba River Supplemental Flows."

Proposed Alternative Section of Condition 29:

South Yuba River - Supplemental Flow Release for Water Temperature Management

The licensee shall be required to release additional water into South Yuba River below Spaulding Reservoir Dam annually between June 15 and September 15 in CD, Dry, BN, AN, and Wet water year types for the purpose of temperature control as follows. The Block of Water available for this purpose shall not exceed 2,500 acre-feet annually. The Block of Water specified shall be the total amount of additional water available for release in the specified time periods. The Block of Water shall be made available concurrent with implementation of the new minimum streamflows and through the remainder of the license term.

The objective of the Block of Water is to maintain mean daily water temperatures at less than 19ºC in the South Yuba River below Spaulding Reservoir Dam as measured immediately upstream of Canyon Creek, and also to proactively release additional water from the Block of Water should a heat storm be predicted.

Real time telemetered temperature monitor in South Yuba River immediately upstream of Canyon Creek, and additional temp monitoring immediately upstream of Poorman Creek

During the first month of June after license issuance, licensee shall install a real time, telemetered temperature monitor in the South Yuba River immediately upstream of Canyon Creek. Additionally, the licensee shall install a temperature logger during June – September immediately upstream of Poorman Creek. This data does not need to be real time or telemetered, but should be downloaded monthly during the months of July and September.

Mean Daily Water Temperature Greater than 19°C

In the second half of June, in July and August, and in the first half of September in all water year types (except EC water years), the licensee shall promptly, but not later than within 1 business day, notify SWRCB, CDFG, BLM, and FS if the average daily water temperature in the South Yuba River immediately upstream of Canyon Creek exceeds 19°C. In such event, the licensee shall release from Spaulding Dam up to a total of 60 cfs, as necessary to reduce the average daily water temperature above Canyon Creek at RM 32.5 to 19°C or less. Licensee shall initially increase the flow by 10 cfs with additional increases made in 5 to 10 cfs increments spaced no less than 8 hours apart. Licensee shall maintain this flow until the mean daily water temperature in South Yuba River immediately upstream of Canyon Creek drops to 19°C. If after three days, the mean daily temperature is still greater than 19°C, licensee shall consult with SWRCB, CDFG, BLM, and FS to determine (1) whether the flow should be continued, (2) whether the flow should be increased to achieve the water temperature objective described above, and (3) the rate at which flows should be adjusted, either to increase or to return to the minimum streamflow if the water temperature objective has been achieved. Once a daily average water temperature of 19°C or less is achieved above Canyon Creek at RM 32.5, licensee may begin to decrease the supplemental flow release to the required minimum streamflow consistent with attempting to maintain an average daily water temperature of 19°C or less.

Extreme Heat Events

To address extreme heat events, between June 15 and September 15th in all water year types, the licensee will review the weather forecast for Blue Canyon by noon each Monday and Thursday. The licensee will provide an electronic copy of the weather forecast to SWRCB, CDFG, BLM, and FS. If maximum air temperatures of greater than 32°C 2 (90°F) are forecast to occur for 2 or more days during the next 7-day period, licensee shall release from Spaulding Dam up to a total of 60 cfs, as necessary to reduce the average daily water temperature above Canyon Creek at RM 32.5 to 19°C or less. Licensee shall initially increase the flow by 10 cfs with additional increases made in 5 to 10 cfs increments spaced no less than 8 hours apart. During this 3-day period (business days), the licensee shall consult with SWRCB, CDFG, BLM, and FS to determine (1) whether the flow should be continued, (2) whether the flow should be adjusted to achieve the water temperature objective described above, and (3) the rate at which flows should be adjusted, whether to increase, or to decrease, or to return to the minimum streamflow if the water temperature objective has been

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2 The 32ºC temperature indicator may be adjusted based on monitoring during the first 5 years after license issuance to more accurately reflect the air temperature at which the mean daily water temperature in the South Yuba River immediately upstream of Canyon Creek is expected to rise above 19ºC.

achieved. Once a daily average water temperature of 19°C or less is achieved above Canyon Creek at RM 32.5, licensee may begin to decrease the supplemental flow release to the required minimum streamflow consistent with attempting to maintain an average daily water temperature of 19°C or less.

South Yuba River Water Temperature Operations Group

Within three months of license issuance, the licensee shall form an Operations Group that consists, at minimum, of FS, licensee, NID, CDFG, SWRCB, BLM and 2 NGOs. The Operations Group will be responsible for providing recommendations, based on monitoring, for modifications to the block flow release schedule if warranted by current information. The Operations Group will schedule regular phone conferences during the year as necessary for real-time operations, and meet at least once annually in May to discuss and review information related to anticipated project operations and biological issues for the coming year.

Five Year Status Report and Recommendations

Five years after license issuance, Licensee shall consult with the Operations Group and prepare a report that describes the five-year history of the data collected during water temperature management of the South Yuba River and recommend any modifications to procedures and requirements described in this measure. After approval by FS, CDFG, SWRCB, and BLM, licensee shall file this report with FERC.

In addition, as part of the alternative condition, the Network proposes to reduce the minimum instream flow in the South Yuba River in February to 25 cfs in BN, AN and Wet water years, and to 25 cfs in March of Dry, BN, AN and Wet water years. (*See* table below for proposed changes to minimum instream flow; also preliminary 4(e) revised Condition 29, Table 2, bottom of p. 18, for comparison.)

South Yuba River Below Spaulding Dam

Month	Dry	Below Normal	Above Normal	Wet
February	25	25	25	25
March	25	25	25	25

V.
THE ALTERNATIVE PROVIDES FOR ADEQUATE PROTECTION AND UTILIZATION OF THE RESOURCES OF THE RESERVATION

The Network's alternative Condition 29 will provide a greater level of protection to the Forest Service reservation than the revised Condition 29 proposed by the Forest Service. Revised

Condition 29 is plagued with many problems, most notably that it will leave summer water temperatures in the South Yuba River too warm to provide sufficient suitable habitat for cold-water fish species. It also lacks defined thresholds and clear outcomes. In addition, the best available science does not support the conclusion that it is adequate to protect the biological resources in the South Yuba River. The inadequacies of the Forest Service's revised Condition 29 are discussed in more detail below. In contrast, the Network's alternative Condition 29 has clear terms, thresholds and outcomes. Its "block flow" construct ensures that flow increases over the otherwise required minimum flow will only be required when water temperatures warrant that increase. The benefit of a "block flow" concept is clear not only for water supply but for other aquatic biota. It benefits the biological resources that need it most when appropriate and at minimal cost to other public interest values. Such a construct ensures more effective results and less unintended consequences.

(A) The Network's alternative condition will protect the biological resources in the South Yuba River

The Network's alternative condition ensures that adequate habitat is available to cold-water aquatic species in the South Yuba River by reserving an annual quantity of water for real-time water temperature management. In terms of instream resources, the Network's alternative condition ensures two things: 1) that the Project's impacts on existing cold-water species are properly mitigated by providing thermally suitable habitat in the South Yuba River at minimal cost or benefit to other biota; and 2) that rainbow trout are able to exist and thrive in a key section of the South Yuba River that is readily accessible to anglers and members of the public.

(1) The Network's alternative will provide thermally suitable habitat for cold-water fish species.

The Network's alternative condition will improve the habitat for aquatic species in the South Yuba River by maintaining adequately cool water temperatures in the summer.

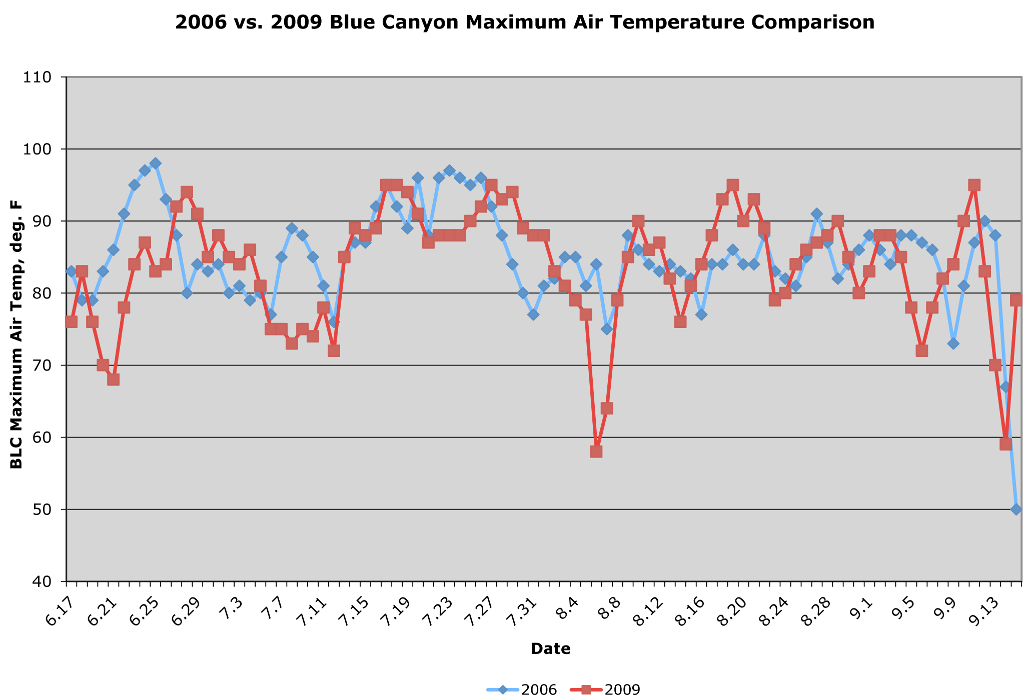
Physical habitat as modeled with PHABSIM has little value for cold water fish such as trout if thermal conditions are too warm to support them. Trout population metrics in the South Yuba River Reach #5 where surveyed near Poorman Creek are low. The Fish Populations Technical Memo 3-1 demonstrates that the 4 year-old age class in the South Yuba River downstream of Poorman Creek is made up of fish that are seven to eight inches long, indicating very poor growth rates. (*See* Stream Fish Populations Technical Memorandum, Figure 3.6-25, p. 169.) The Forest Service notes in its Rationale Report for its original preliminary 4(e) conditions: "although multiple age classes of rainbow trout were present in both years, the population did not exhibit a typical age class distribution in either year." (*See* e-Library No. 20120731-5121, Forest Service Rationale Report for the Drum-Spaulding Project, p. 116.)

As also noted in the Forest Service's Rationale Report, a mean daily water temperature of 20° C. is a threshold that FERC has accepted in California proceedings as a benchmark above which thermal conditions for rainbow trout become unacceptably stressful. (*See* Forest Service's Rationale Report, ibid, p. 280.) Water temperature modeling shows that maintaining temperatures at 19° C. at Canyon Creek will place the mean daily 20° C. threshold downstream in the vicinity of the town of Washington (RM 30) in most cases. (*See* water temperature model runs SYR_HFAMresults_LongPlots_L062612F-I_2008 and SYR_HFAMresults_LongPlots_L062612F-I_2009, especially plots 3-6 for each year; output from these runs is to be filed in the record by licensee per FERC order no later than August 31, 2012.) This results in the addition of 2½ miles of additional habitat for coldwater fish species as compared to revised Condition 29.

This most recent temperature modeling (made available to the Network and other relicensing participants on August 21, 2012) does not show that 19° C. at Canyon Creek maintains water temperatures below 20° C. at Poorman Creek 4½ miles downstream, as was suggested in the

Rationale Report for the Section 10(j) Conditions submitted by the California Department of Fish and Game (*See* DFG Rationale, e-Library No. 20120730-5181, Enclosure C, p. 296, especially regression figure at top of page.) As noted above, implementation of the Network's block flow proposal will result in a mean daily 20° C. threshold downstream in the vicinity of the town of Washington (RM 30) in most cases. In addition, with a temperature differential of between 2° and 3° C. in the South Yuba River between Canyon Creek and Poorman Creek, block flow releases will also serve to moderate the worst high temperature events downstream to Poorman Creek, and reduce the likelihood of heat events that are lethal to trout. Network members living in the area of Washington have reported repeated cases of trout mortality in the summer of 2012. Summer flows that will result from implementation of the Forest Service's revised Condition 29 will not provide thermally suitable habitat for trout on the South Yuba River at Poorman Creek on many summer days (even assuming that the Forest Service requires the Licensee to release the maximum amount of supplemental flows allowed under the measure). Under modeled conditions, water temperatures in the South Yuba River at Canyon Creek would have exceeded 20° C. in 2009 in two separate two-day events, around July 18-19 and July 29-30, with a flow of 30 cfs. (*See* 2009 LongPlots, slide 12.) Water temperatures would have been near or above 19° C. at Canyon Creek for most of the July 18-30 period. Maximum daily water temperatures at Canyon Creek would have exceeded 22° C. from about July 15 through August 3, and average daily water temperatures at Poorman Creek would have exceeded 22° C. for most of this prolonged time period. Such prolonged thermal stress increases the risk of mortality of trout in the South Yuba River at Canyon Creek and Poorman Creek. The Network's alternative measure ensures that such prolonged thermal stress events are avoided or substantially minimized.

In addition, the Network's alternative measure anticipates extreme heat events and ensures that the effect of such events to cold-water aquatic resources is minimized. The summer of 2009 overall was a hot summer. In order to consider the effects of more severe meteorological conditions, the Network analyzed the meteorological data from the hotter year 2006. Meteorological data from 2006 was used in the DeSabla – Centerville relicensing to represent particularly hot conditions, since this year was among the hottest on record. The Network compared summer air temperatures at Blue Canyon (BLC) in 2006 and 2009. The meteorological station at BLC was chosen by the Department of Fish and Game to formulate part of the block flow measures, since air temperatures of 90° F at BLC correlated well to water temperature exceedences of 19° C. in the South Yuba River at Canyon Creek.



Source: http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=BLC

From July 14 through August 1, 2006, maximum air temperatures at Blue Canyon were at least 87° F.; for five consecutive days, July 22-26, 2006, maximum BLC air temperatures exceeded

95° F. By comparison, the hottest days of 2009 saw maximum temperatures at BLC on July 17-19, of 95°, 95°, and 94° F. and on July 28-29 maximum temperatures of 94° and 93°, respectively.

From this data, the Network draws several important conclusions:

1) There is a time lag of about a day between high air temperatures (over 90° F.) and elevated water temperatures. A measure that exclusively reacts to temperatures monitored at Canyon Creek will likely allow elevated water temperatures to persist for two days: one day to identify an exceedence, and another day for water released from Spaulding Dam to reach Canyon Creek.

2) A summer flow of 30 cfs in the South Yuba River will not cool the river to 20° C. at Canyon Creek during a prolonged heat storm such as that which occurred in the second half of July, 2006. A summer flow of 30 cfs will likely leave an average daily water temperature at Poorman Creek during such a heat storm at greater than 23° C., and a maximum daily temperature at close to 25° C. Prolonged exposure to such temperatures will cause widespread mortality of trout at or downstream of that location, and likely upstream as well.

The alternative condition proposed by the Network addresses the deficiencies of revised preliminary 4(e) Condition 29 in several ways. First, it requires that supplemental water be released to the South Yuba River when temperatures are forecast to exceed 90° F. at Blue Canyon. This eliminates warm water conditions during the time lag caused by travel time of water moving downstream. Second, the alternative condition allows release of water in quantities greater than the maximum amounts specified in revised preliminary Condition 29: 30 cfs in CD, Dry and BN years, and 40 cfs in AN and Wet years. The alternative condition will effectively cool the South Yuba River both upstream and downstream of Canyon Creek in circumstances where 30 cfs cannot.

Third, the alternative condition protects coldwater habitat for more river miles, and better protects the habitat in river miles that are addressed by revised preliminary Condition 29. The use of block flows is a low cost, high value approach that provides the flexibility to use the required amount of water when needed and save water when minimum flows are sufficient. The Network's alternative condition will directly and surgically solve water temperature problems as they arise.

(2) The Network's alternative will enhance recreational opportunities along the South Yuba River

The Network's alternative condition also has the added benefit of improving recreational opportunities along the South Yuba River. The upstream portions of the South Yuba River emphasized in revised Condition 29 have limited access opportunities for anglers and other members of the public seeking recreational opportunities. The areas emphasized by the Network's alternative condition have much better public access. The South Yuba River in the vicinity of the town of Washington offers one of the best opportunities for angling improvements on the hundreds of miles of project-affected stream reaches.

(3) The Network's alternative will minimally impact, or benefit, other native species in the South Yuba River.

(a) Native Warm Water Fish Species

The Network's alternative will minimally impact native warm-water fish species in the South Yuba River.

Revised Condition 29 identifies hardhead and pikeminnow as warm water fish species that must be considered by the Ecological Group in evaluating the resource impacts of actions to cool the South Yuba River. Hardhead were not detected in the South Yuba River during Fish Population surveys despite some special effort made in the lower reaches to locate them. Only one document in the record points to their existence in the South Yuba River. Gast et al (2005) observed hardhead only up to RM 3.9 during extensive snorkel surveys of the South Yuba River. According to Moyle, *Inland Fishes of California*, the optimal temperature range of hardhead is between 24° and 28° C., which is compatible only with the lowest few miles of the South Yuba River near Englebright Reservoir. (*See* Moyle, p. 152.) While some may suggest that their suitable range in the South Yuba River could be moved downstream by maintaining cooler water temperatures, modeling data shows that upstream flow augmentations have such a declining effect on water temperature in the downstream direction that the expected results near Englebright are negligible. Even at Humbug Creek, RM 19.6, thermal equilibrium is close to being reached, and flows to 60 cfs reduce the water temperature only 2° C when compared to a flow of 10 cfs. (*See* e.g. SYR_HFAMresults_LongPlots_L062612F-I_2009, Slide 10.) Moreover, increased flows in the lower South Yuba River may improve hardhead habitat given the strong preference of hardhead for well oxygenated waters. (*See* Moyle, *ibid.*)

California Department of Fish and Game (DFG) included as a 10(j) recommendation a block flow measure identical to that proposed in the Network's alternative; DFG's Rationale notes that it does not expect negative effects on hardhead from its measure as proposed. (*See* DFG Rationale, *ibid*, p. 298.)

The other warm-water fish species explicitly called out in revised Condition 29 and possibly affected by the Network's alternative is pikeminnow. However, pikeminnow is not a management species in any FERC project in California. The optimal temperature range for pikeminnow is considerably lower than for hardhead. (*See* Moyle, ibid, p. 155.) From a recreational perspective, these fish are undesirable predators of trout, and they are hard to eradicate in rivers that have high water temperatures. According to Moyle, pikeminnow are also predators of frogs. (*See* Moyle, *ibid.*) The only apparent desirable characteristic of pikeminnow, which are abundant throughout the tributaries of the Central Valley, is that they are native.

The preferred temperature range for these species may be moved slightly downstream by revised Condition 29, though pikeminnow are found where summer water temperatures are often as low as 18° C. (*See* Moyle, *ibid.*) In any case, pikeminnow will still have plenty of adequate habitat and will remain the dominant fish species in the 28 miles of river downstream of Poorman Creek.

(b) Foothill-Yellow Legged Frogs

At various times during this proceeding, the Forest Service has expressed concern that lowering the water temperatures in the South Yuba River may negatively impact FYLF. This concern is now memorialized in revised Condition 29, which goes so far as to contemplate future reduction of summer flows in the South Yuba River during Above Normal and Wet water years out of concern for FYLF. However, revised Condition 29 is too vague and undefined to provide any quantifiable or tangible benefit to the FYLF population in the South Yuba River. In contrast, the best available scientific information in the record supports the Network's position that its alternative condition will benefit most lifestages and subpopulations of FYLF. These points are discussed more fully below.

Revised Condition 29 does not define how the Forest Service and the proposed Ecological Group will analyze, quantify and determine whether the requirements of revised Condition 29 are "negatively impacting FYLF." The measure also fails to analyze why measures that would inarguably improve coldwater habitat for trout through implementation of a block flow, such as those in original preliminary Condition 30 or those in the competing measure now proposed as the alternative condition, were weakened in a revised condition based on a vague, undefined, and unquantified perceived benefit to FYLF.

The revised Condition 29 also does not explain how the Forest Service has balanced benefits to FYLF across the population's extensive range in the South Yuba River, or how over the next three to five years the Forest Service plans to balance such benefits. In fact, the measure does not even appear to acknowledge the benefits of reducing water temperatures on the FYLF population. The measure appears arbitrarily crafted to address perceived "impacts" to the upstream-most subpopulations of FYLF on the South Yuba River, while ignoring the effects on other subpopulations, including those as far upstream as the frog sampling sites near Canyon Creek.

The Network disputes the Forest Service's lack of analysis, the lack of rigor and breadth in the analysis that it has performed, and the conclusions regarding FYLF that are embodied in the "South Yuba River Supplemental Flow" section of revised Condition 29. The following sections explain how the best available scientific information supports the conclusions that (1) FYLF will substantially benefit from measures already included in the preliminary 4(e) measures and (2) the Network's alternative will benefit most subpopulations of FYLF in the South Yuba River.

(i) Improvements for FYLF are secured through other provisions included in the preliminary 4(e) conditions

The section of revised preliminary Condition 29 entitled "Spill cessation in the South Yuba River" has already addressed the primary known adverse effect of project operations on FYLF in the South Yuba River. This measure requires a downramp of up to 21 days following late spring and summer spills at Spaulding Dam. This will reduce scouring and desiccation of egg masses and tadpoles based on precipitous flow fluctuations due to dam operations. The benefits of the measure will combine with the benefits of a similar measure for spills from the Yuba-Bear Project's Bowman-Spaulding Diversion Dam into Canyon Creek.

These spill cessation measures were championed by the Network, and much of the hydrologic analysis that led to their development was performed by Network members. Overall conditions for FYLF in the South Yuba River will already greatly improve because of the spill cessation measures. FYLF subpopulations closest to Spaulding Dam (i.e. above Canyon Creek) should benefit most from the South Yuba River spill cessation requirement.

(ii) General distribution of FYLF on the South Yuba River

In order to compare the effects on FYLF from revised Condition 29 with the effects from the proposed alternative condition, the Network assembled two tables from VES surveys on the South Yuba River. The Network set aside the table based on egg masses, because anomalies in survey dates and problems with accessibility caused VES surveys to show no egg masses in the South Yuba River at many sites where tadpoles were later detected. The table presented below that shows VES detections of other lifestages of FYLF is designed to provide a snapshot of the spatial distribution of FYLF on the South Yuba River today, clearly organized by river mile.

South Yuba River FYLF VES Detections, all life stages except egg masses (from YBDS Tech Memo 3-6, Table 3.4-7)

Sites where FYLF Found, all life stages	Estimated Site River Miles	Total non-egg mass FYLF Detections at Site Survey 1*	Total non-egg mass FYLF Detections at Site Survey 2*	Total non-egg mass FYLF Detections at Site Survey 3*
SY-2 Main	11.2	23	20	97
Tributary	11.2	15	8	N/A
SY-9A Main	15	327	38	69
Tributary	15	32	36	43
SY-3 Main	19.6	6, 12	27, 167	208, 1300
Tributary	19.6	16	48	107
SY-4 Main	28	2, 19	1, N/A	14, N/A
Tributary	28	8	15	4
SY-5 Main	30.4	63	N/A	31
Tributary	30.4	6	N/A	N/A
SY-6 Main	32	346	N/A	27
SY-7 Main	33.7	6, 12	N/A, 13	N/A, N/A
SY-11A Main	35	24	N/A	N/A
SY-8 Main	35.6	2	N/A	N/A
Tributary	35.6	12	N/A	N/A
SY-10 Main	40	0, 0	0, 0	0, N/A
Tributary	40	0	0	0

N/A indicates survey not conducted according to study proposal or because tributary was dry.
*Where two values are shown, first value is from 2008, second value from 2009.

The table shows that the vast majority of FYLF in the South Yuba River occur downstream of Canyon Creek (RM 32.5), and that substantial numbers of FYLF occur between Canyon Creek and Poorman Creek (RM 28). By far the largest number of FYLF detections occurred in the area of Humbug Creek (RM 19.6), with significant numbers further downstream at Spring Creek (RM 15). These data suggest a FYLF population in the South Yuba River that extends at least 24 miles (and possibly 11 more in the downstream direction), with a marginal subpopulation above Canyon Creek.

(iii) South Yuba Water Temperature Management does not affect the egg mass lifestage of FYLF

The Network's alternative will not affect the egg mass lifestage of FYLF. Almost all breeding and ovipositing by FYLF on the South Yuba River occurs earlier in the season than the summer period when temperature measures might be required to maintain water temperatures at less than 19° C. at the confluence with Canyon Creek. In addition, accretion in the reach is a large factor during the breeding season in most years at FYLF sites. By far the greatest threat to egg masses on the South Yuba River is rapid flow fluctuations. To the extent that the project can control these fluctuations, revised Condition 29 has addressed this threat in the spill cessation measure for the South Yuba River, as noted above. Also as noted above, frogs in the South Yuba River downstream of RM 32.5 are further protected by the spill cessation measure for Canyon Creek, which Yuba-Bear preliminary 4(e) Condition 29 protects from spills from the Yuba-Bear Project's Bowman Reservoir.

(iv) Thermal effects of South Yuba Water Temperature Management on FYLF tadpoles downstream of Canyon Creek

The Network's alternative will provide a thermal benefit to all subpopulations of FYLF downstream of Canyon Creek. In a document circulated in both the Middle Fork American Project relicensing and in this proceeding, Forest Service amphibian biologist Amy Lind describes known temperature preferences and conditions for FYLF. (*See* Summary of FYFL Tadpole Water Temperature Effects from Recent Studies, compiled by Lind, 2010; internal cites are given below.) Notable in this summary document are the following notes (bulleted in the original):

- 15-16 C (59-60.5 F) water temperatures that occur throughout the rearing season (June-August) appear to result in very low survival rates.
- 16.5 - ~20 C (62-68 F) had the highest survival rates.
- Summer rearing temperatures above 21 C (~70 F) also appear to result in reduced survival. However, direct effects of temperature may be confounded with increases in parasite numbers and loads at these higher temperatures.
- Tadpole growth rates are lower in low (<16C, 60.5F) and high (>20C, 68F) water temperatures than in moderate water temperatures (~18-20C, 64-68F)

  (internal cite: S. Kupferberg to Amy Lind, personal communication, April 2010.)

Given this frame of reference, and temperature data (existing and modeled) for the South Yuba River, the Network concludes that the alternative condition will increase the amount of time that optimal temperatures for FYLF will be present in the South Yuba River between Canyon Creek and Poorman Creek (sites SY-4, SY-5, and SY-6) compared to revised Condition 29. The 19° C. threshold proposed in the alternative condition will put temperatures in this reach in the optimal FYLF rearing range at times when the water temperatures would otherwise be above optimal. For these FYLF subpopulations, the Network's alternative provides more of a benefit than the revised Condition 29.

For all FYLF downstream of RM 28, subpopulations which appear an order of magnitude larger still than the subpopulations between RM 28 and RM 32.5, there is a thermal benefit from both measures, in that the temperatures greater than optimal will be brought closer to optimal. As noted by Lind as quoted above, tadpole growth rates are lower in high and low water temperatures than in moderate water temperatures; also, "Temps below 17 C and > 20 C result in lower survival rates." (Lind, ibid, p. 2.) The benefit would be much greater under the Network's alternative measure due both to the extent of cooling and the responsiveness of cooling to when it is most needed. Revised Condition 29 would be only slightly beneficial, at least initially, and this benefit could be more than offset if flows in AN and Wet years are later reduced as allowed under revised Condition 29.

(v) Viability of FYLF subpopulations upstream of Canyon Creek and criteria for evaluation.

The question remains whether or not either the Network's alternative or the revised Condition 29, or any reasonable and complete flow measure for the South Yuba River will support a viable FYLF subpopulation on the South Yuba River near Fall Creek (sites at RM 35 and RM 35.6) and near Diamond Creek (site at RM 33.7). In order to evaluate this question, the Network first references the marginal nature of this subpopulation based on the survey data summarized in the table above. There were four egg masses found near Fall Creek and four egg masses found near Diamond Creek in 2008, but very few tadpoles in subsequent surveys. (*See* Tech Memo 3-6, Table 3.4-7.) These subpopulations are likely an artifact of a historic regulated flow regime that for decades has been below unimpaired in July and at or below unimpaired in August. (For impaired flow in South Yuba River, *see* Table SY-1, Forest Service Rationale Report, ibid, p. 123.) The Forest Service does not protect the reservation by basing fundamental flow decisions for 40 miles of river based on very small subpopulations of amphibians that are potential outliers artificially maintained by conditions that cause severe impacts to other aquatic biota. This is all the more pertinent in that the other aquatic biota include diverse and more abundant subpopulations of FLYF in the affected watershed.

If this subpopulation and the one downstream at Diamond Creek (RM 33.7) are in fact viable going forward, then the Forest Service, in order to support management decisions for the benefit of these subpopulations, needs to quantify the impacts of various actions, events, and factors, and their relative importance. The Rationale Report for the original 4(e) conditions discussed potential effects on FYLF, but provided no clarity on how it had made evaluations to date or how it would make evaluations going forward. The Forest Service must at minimum consider the following:

- How will statistically defensible conclusions about viability, variability, and effects to very small subpopulations of FYLF upstream of Canyon Creek be generated with very small data sets?
- How will stochastic events be evaluated and taken into account in analyzing upstream subpopulations?
- How will the population-level effect to FYLF in the entire South Yuba River be weighed in managing for thermally favorable conditions for the upstream-most subpopulation of FYLF?
- Previous sightings of FYLF at Rush Creek (RM 6) are noted on the map that was used for FLYF VES site selection. How will downstream subpopulations or the opportunity for downstream expansion of FYLF range be evaluated in managing for thermally favorable conditions for upstream FYLF?

As noted above, the best available scientific information in the record does not support the Forest Service's decision to base fundamental flow decisions for 40 miles of river on very small subpopulations of amphibians especially when such critical questions regarding those small subpopulations remain unanswered and when such decisions will cause severe impacts to other aquatic biota.

(vi) South Yuba Water Temperature Management effects on physical habitat for FYLF

The Network's alternative will not limit the amount of physical habitat available to FYLF.

Technical Memo 3-7, FYLF Habitat Modeling, describes habitat modeling that licensee's consultants performed at RM 33.4. This was the only site on the South Yuba River where the licensee performed FYLF habitat modeling. Although the Technical Memo characterizes the modeling as applicable to multiple South Yuba River sites, modeling at this site captures very close to the greatest impacts of flow increases in the 15 to 50 cfs range, because the river channel downstream is substantially broader than the river channel at this site.

Technical Memo 3-7 shows on p. 49, Table 3.1.3-1 the Tadpole Weighted Usable Area (WUA) at RM 33.4 for various flow values. The WUA includes both depth and velocity components. While a flow of 6 cfs as modeled showed maximum WUA, the table shows 98% exceedence of this flow in both unimpaired and regulated conditions; since flow is greater all but 2% of the time, this flow is not material to further analysis. Overall, as flow increases, WUA decreases. However, WUA at a flow of 50 cfs is about 87% of WUA at a flow of 15 cfs. Since flows at issue in the Water Temperature Management proposals do not exceed 50 cfs, the largest physical habitat loss from block flow management therefore appears to involve a loss of 13% of physical habitat. Simply put, a case cannot be made that flows in this range cause physical habitat to be limited.

(vii) On a watershed-wide basis, the alternative condition will benefit FYLF

Any action, including inaction, that affects thermal regimes in the South Yuba River will have some negative effects on some groups of frogs. The question is how the Forest Service evaluates and balances those effects against other values. The Forest Service, through its revised Condition 29, has chosen a condition that emphasizes potentially reducing impacts to the upstream-most subpopulation of FYLF at the known expense of subpopulations further downstream, and at the known expense of other cold-water species. It has not quantified the potential effects at this time, and has not shown how it will quantify the potential effects at some time in the future. This decision is unsupported, and should be reversed.

The Network's alternative, on the other hand, does balance the value to cold-water aquatic species with the effects to other species. Its block flow construct ensures that the most thermally stressed species receive benefit when required at minimal cost to other biota. Most FYLF subpopulations will benefit from the Network's alternative, and on a watershed-wide basis, the Network's alternative will benefit FYLF as a whole.

(4) The alternative condition protects the reservation

Avoiding unknown risk to a marginal upstream subpopulation of FYLF by inadequately cooling the South Yuba River is not worth the resulting more certain and quantifiable negative effects on viable FYLF subpopulations further downstream, or on other coldwater species such as trout. The Network's alternative condition ensures that thermally suitable habitat is available to coldwater species in the South Yuba River. The Network's alternative condition will provide a greater level of protection to the Forest Service reservation than revised Condition 29.

(B) The Forest Service's Revised Preliminary Condition Number 29 does not ensure adequate protection for the biological resources in the South Yuba River.

In its Rationale Report for its preliminary 4(e) Condition 30 as filed on July 31, 2012, the Forest Service indicated why the measure was necessary: "Taking the above benthic macroinvertebrate, FYLF, and rainbow trout information into account, the Resource Agencies do not consider the biota in this reach [South Yuba River Below Spaulding Dam] to be in good condition." (*See* Forest Service Rationale Report, p. 122.) The Forest Service further stated that water temperature modeling on the South Yuba River conducted in 2008 and 2009 showed that "more than thirty-two miles of potential good quality fish habitat exceeded the 20°C threshold for two months or longer during both water years. This is not consistent with the SWRCB's designation for this reach as cold freshwater habitat." (*See* ibid, p. 279.)

In response, the Forest Service developed Preliminary 4(e) Condition 30. However, Preliminary 4(e) Condition 30 as filed on July 31, 2012 started out weak by providing only eight miles of coldwater fish habitat in the South Yuba River, suggesting that improving 8 miles out of 40 would be sufficient to leave coldwater fish in a designated coldwater reach in "good condition." Revised Condition 29, like original Condition 30 before it, is intended to provide "eight miles of thermally suitable habitat" for rainbow trout in the South Yuba River. (*See* supplemental Rationale Report for Revised Preliminary Conditions, e-Library No. 20120828-5019, p. 8.)

However, Revised Condition 29 as proposed by the Forest Service weakens an already weak measure. The Forest Service developed its original Condition 30 as a "block flow" proposal that allowed for real-time management of water temperature to at least achieve, on an enforceable basis with clear metrics, 8 miles of thermally suitable habitat for cold water species. The revised measure substitutes a process for a defined outcome. The measure as revised not only limits coldwater habitat to a maximum of eight miles, but allows the Forest Service to further retreat from that already inadequate requirement. The extended process states no clear thresholds of choice, and defines no points of decision. The measure allows, but does not require, the Forest Service to require licensee to develop a plan for further temperature improvements. In defining FYLF as "warmer water associated species" (p. 2) and calling out as negative impacts to FYLF only "low water temperatures and abrupt changes in flow," the revised rationale arbitrarily and prejudicially biases the potential outcomes of the post-licensing process. The lack of defined triggers and criteria for decision-making create an improper deferral of decision, and requires those who advocate in the public interest to wait another five years to protect cold water species.

(1) Revised Condition 29 will provide less thermally suitable habitat for cold-water fish species than the Network's alternative condition.

After acknowledging that water temperature is inextricably linked to the health and persistence of cold-water fish species, the Forest Service replaced its original Condition 30 with a new condition that doesn't guarantee any definitive water temperature results. Instead the measure gives the Forest Service discretion to minimally (maximum 10 cfs) enhance minimum flows to the South Yuba River in advance of the summer in CD, Dry and BN years. Such a determination will be made regardless of actual ambient temperatures and before the start of the summer. In other words, the measure will not respond to heat events, but will require the Forest Service to predict the conditions and implement its response in advance of the summer's meteorology with only one opportunity to change. In the event of a change, the new decision will govern for the rest of the season, regardless of actual conditions.

The minimal supplemental flows that the Forest Service "may" require to be released in the summer in CD, Dry and BN years are not sufficient to produce a discernible decrease in water temperature. Analysis contained in CDFG's rationale report for its 10(j) recommendations used the temperature model to show that the 5 to 10 cfs increments that define the decision space of the revised Condition 29 would be inadequate to meet the temperature threshold of 19° C. at Canyon Creek. (*See* CDFG Rationale document, e-Library No. 20120730-5181, Enclosure C, pp. 296-297.) Therefore, it is clear that the revised measure will not cool the South Yuba River downstream of Canyon Creek.

(2) Revised Condition 29 does not contain any defined criteria or triggers to justify future decision-making, leaving the biological outcome of the measure uncertain.

It is impossible to ascertain what biological outcomes might result from implementation of revised Condition 29 given the alarming lack of decision-making criteria and triggers. As noted above, the measure gives the Forest Service discretion to minimally (maximum 10 cfs) enhance minimum flows to the South Yuba River in advance of the summer in CD, Dry and BN years. The measure does not contain criteria or triggers to indicate how the Forest Service will determine whether or in what quantity supplemental flows are required. The Forest Service is not even obligated to determine that the supplemental flows are ever necessary. In addition, the measure would allow the Forest Service to unilaterally reduce 4(e) minimum flows in the South Yuba in AN and Wet years at its discretion, again with no definition of the criteria or rationale. Flows could not be increased above 40 cfs in any case, regardless of water temperatures, even in wetter water years when water is abundant; again, the measure provides no rationale.

The measure also purports to have an adaptive management function through the Ecological Group. However the measure will not produce anything substantive for the group to assess. The flow differentials are too small and the time period set out is too short to support a conclusive assessment. The measure also does not mandate a particular course of action following assessment beyond the possibility of a new plan: “the Forest Service may require that the Licensee develop a plan” after at least three years of water temperature monitoring data is collected. There is no assurance that there will be a plan, let alone what will be contained in the plan. Even if a plan is required, three years is an insufficient time period to provide adequate information to form a basis for final judgment particularly given the length of the license and expected changes that may result from climate change.

(3) Revised Condition 29 leaves key terms undefined ensuring implementation will be contested and ineffective.

In an effort to appease every stakeholder in this process, the Forest Service has conditioned the success of this measure on the achievement of several unachievable outcomes. Most notably, the Forest Service will not require supplemental flows if it can be determined that such flows will decrease habitat or otherwise negatively impact Foothill Yellow-Legged Frog (FYLF) or other native species, such as hardhead. The measure does not specify what constitutes a "negative impact" to FYLF or other native species. The measure does not consider that a "negative impact" to one subpopulation of FYLF may have a positive effect on another subpopulation of FYLF, and as a corollary does not contemplate how such a trade-off among frogs should be quantified and evaluated. In addition, the measure does not rationalize why reduction of the habitat of one species, even if small, must preclude the expansion of habitat of another. The Forest Service avoids undertaking thoughtful analysis regarding the relative worth of the new habitat to cold-water species versus the potential quantitative or qualitative cost of lost habitat to the upstream-most subpopulation of FYLF. In addition, the Forest Service provides no rationale why it has suddenly chosen Sacramento pikeminnow as a management species. The Forest Service's lethargic analysis effectively ensures that coldwater fish species will always lose out to other native species.

(4) Revised Condition 29 is an improper deferral of decision.

Revised Condition 29 provides no guaranteed results, avoids making a decision based on the available substantial evidence in the record, and postpones a decision (assuming one is ever made) for at least five years. In spite of the overwhelming evidence in the record regarding the negative effects of sub-optimal water temperatures on cold-water species, the Forest Service declines to require any measure that ensures thermally suitable water temperatures will be achieved. The Licensee is not even required to prepare a plan in the future to address water temperatures if monitoring proves the current measures to be inadequate. This result is untenable and not supported by the record.

VI.

THE NETWORK'S ALTERNATIVE WILL PROVIDE FOR MORE HYDROPOWER GENERATION THAN THE FOREST SERVICE'S REVISED CONDITION 29

Alternative Condition 29 proposed by the Network will allow licensee to generate more hydropower than would the Forest Service's Revised Preliminary 4(e) Condition 29.

A. Water cost of revised Condition 29 supplemental flows

For the purposes of this analysis, the Network compared the annual water cost to implement the Forest Service's revised Condition 29 and the annual water cost to implement the Network's alternative condition.

The nature of the Forest Service's measure required the Network to make certain assumptions in order to facilitate a water cost analysis. Since revised Condition 29 contains no clear decision points or criteria for possible changes or modifications of flow requirements, it is possible that there could be different outcomes in any given year or over the course of many years. Therefore, the Network assumed for the purposes of this analysis that the maximum supplemental flow identified in Table 7 of revised Condition 29 will be implemented throughout the term of the license. This assumes flows of 30 cfs in July, August and Sept 1-15 of CD years, and 30 cfs in August and Sept 1-15 of Dry and BN years.

The annual water cost of the revised Condition 29 as compared to required revised 4(e) Condition 29 minimum flows alone is thus:

CD years: 1218 AF
Dry years: 637 AF
BN years: 455 AF
AN: 0 AF
W: 0 AF

B. Water cost of Network alternative condition block flows

Implementation of the Forest Service's revised Condition 29 could result in greater or smaller water costs than what the Network assumes in this analysis. The Network's simplifying assumption is the most reasonable assumption available, and the most definite since it will likely occur for at least three years. Such an assumption is necessary in order to allow the Network to evaluate the power and water supply cost relative to minimum flows without "supplemental flows." The Network also assumes, consistent with the approach taken in revised Condition 29, that the 2008 and 2009 years used in the temperature model are representative, and can be used to calculate a representative water cost for flows that are determined by a threshold water temperature. This assumption provides an equal risk to power, water supply, and resource values, consistent with the equal consideration clause of Section 4(e) of the Federal Power Act.

In order to calculate the water cost of the Network's alternative, the Network relied on information contained in DFG's Rationale Report for Section 10(j) recommendations as well as its own analysis. The DFG report calculated that the annual water cost of its proposed measure "Flows for Temperature in South Yuba River" (which is identical to the Network's alternative) would have been 1970 AF in 2008 (a Dry year) and 1370 AF in 2009 (a BN year). (*See* DFG Rationale Report, e-Library No. 201207310-5181, Enclosure C, p. 298.) The Network assumes these calculations are representative water costs for the Network's alternative measure in Dry and BN years. As a further simplifying assumption, the Network assumes that the maximum volume of water proposed in the Network's alternative (2500 AFA) will be entirely used in CD years. Finally, the Network assumes as a conservative estimate that the water cost for AN and Wet years will be the same as in BN years. This is a very conservative assumption, since additional water can be taken from storage in Fordyce Reservoir and/or Spaulding Reservoir in W and AN years in order to make up for any generation that might otherwise be lost by flow increases into the South Yuba River to meet the Network's alternative measure requirements.

The annual water cost of the Network's alternative measure as compared to required 4(e) minimum flows alone is thus:

CD years: 2500 AF
Dry years: 1970 AF
BN years: 1370 AF
AN: 1370 AF
W: 1370 AF

C. Calculation of water cost differential between revised Condition 29 supplemental flows and alternative condition block flows

Finally, in order to calculate the difference in water cost between the complete revised preliminary 4(e) Condition 29 and the alternative condition, the Network subtracted the water cost of the 4(e) supplemental flows from the water cost of the alternative condition block flows, by water year type:

CD years: 1282 AF
Dry years: 1333 AF
BN years: 915 AF
AN: 1370 AF
W: 1370 AF

D. Reduction of minimum flows in the South Yuba River in February and March

In order to ensure that the Network's alternative measure generates more power than the Forest Service's revised Condition 29, the Network proposes to reduce the minimum instream flow in the South Yuba River in February and March to 25 cfs in all water year types except EC. (*See* table below, and see also revised 4(e) Condition 29, bottom of p. 18 for comparison.)

South Yuba River Below Spaulding Dam

Month	Dry	Below Normal	Above Normal	Wet
February	25	25	25	25
March	25	25	25	25

E. Water operations modeling

In order to verify that the proposed alternative condition allows the Drum-Spaulding Project to generate more power than the revised 4(e) conditions will allow, the Network sought assistance from the Department of Fish and Game to comparatively model the two measures using the HEC-ResSim operations model. Copies of the sheets that display the model output are included as an appendix to this document. A DVD with the model runs is available on request.

VII.
THE NETWORK'S ALTERNATIVE WILL PROVIDE GREATER WATER SUPPLY RELIABILITY AND WILL NOT NEGATIVELY AFFECT OTHER PUBLIC INTEREST VALUES

(A) Water supply

The Network's alternative provides greater water supply reliability than the revised Condition 29 proposed by the Forest Service. By requiring reduced minimum instream flows in the South Yuba River in Dry, BN, AN and Wet water years, the alternative condition reduces the risk associated with early precipitation in a given water year that is followed by dry conditions. These circumstances require winter release of water into the South Yuba River that is lost to the Drum-Spaulding system. If spring precipitation fails to produce sufficient water to fill the Project's storage reservoirs, water supply shortages are possible. By allowing earlier storage of water in project reservoirs, reduced February and March flow requirements in the South Yuba River reduce the risk associated with dry spring conditions.

(B) Reduced February and March flow releases into the South Yuba River have minimal effects on physical habitat for trout

The revised 4(e) Condition 29 February and March minimum flow requirements for the South Yuba River were based on the principle that in progressively wetter water years, higher flows would increase physical habitat for trout. South Yuba River 4(e) flows were therefore developed from Weighted Usable Area (WUA) for trout as determined in the Instream Flow Study.

WUA for adult trout at 25 cfs in the South Yuba River in the Jordan Creek reach is 48% of maximum. Adult WUA at 40 cfs in the reach is 67% of maximum; adult WUA at 50 cfs is 76% of maximum; adult WUA at 70 cfs is 87% of maximum.

Equivalent WUA in the South Yuba River's Canyon Creek reach downstream requires higher flows than the Jordan reach. Adult WUA at 25 cfs in the Canyon Creek reach is 40% of maximum; adult WUA at 40 cfs is 54% of maximum; adult WUA at 50 cfs is 62% of maximum; adult WUA at 70 cfs is 73% of maximum.

In order to analyze the actual flows in the South Yuba River during the months of February and March, the Network used the feature of the HEC-ResSim model that allows the viewer to determine the accumulated flow including accretion at each accretion node. The Network selected the node above Fall Creek, the first node that shows accretion downstream of Jordan Creek, and the node above Canyon Creek in order to examine the actual river flows in these winter months.

Flows in the South Yuba River above Fall Creek (not including Fall Creek inflow) were almost without exception greater than 50 cfs in February and March of all years under both the revised Condition 29 requirement and the alternative condition required flow; in wetter years flows averaged 75 cfs. Above Canyon Creek, flows under both flow release requirements were greater than 100 cfs in 1978, 1980, 1983, 1984, 1986, 1993, 1995, 1996, 1997, 1998, 1999, 2000, 2003, 2005 and 2006. In drier years, February and March flows above Canyon Creek still averaged greater than 75 cfs under the alternative condition scenario; the differential between alternative condition flow releases and revised 4(e) flow releases in these months is also very small.

The take-home message of this exercise is that the actual flow in the South Yuba River in February and March is invariably much greater than the required flow release at Spaulding Dam. Reduction of the required flow release in February and March has far less effect than it would in summer months, and has only a small increment of effect on physical habitat for trout. The issues identified in the Forest Service Rationale Report, such as desiccation of trout redds and stranding of fry and juvenile fish, will not be a factor under the alternative condition. Spawning in these reaches is unlikely to occur in this reach until April; high April flows for spawning are maintained in the alternative condition.

(C) Other public interest values.

The Network's alternative will have no effect on energy supply, distribution, cost, and use; flood control; navigation; air quality; or any other aspects of environmental quality.

VIII. REFERENCES

In conformity with 7 CFR §1.671(b)(5), the Network identifies that it has relied on the following studies and documents to support its proposal for its alternative condition.

1. California Department of Fish and Game, *Notice of Intervention in the Relicensing of Drum-Spaulding Hydroelectric Project (FERC Project No. 2310) and Submission of Recommended Conditions Fish & Wildlife Protection, Mitigation and Enhancement Provided Under Federal Power Act Section 10(j), 10(a)(2) 18 C.F.R. 4.34(b)(2)* (e-Library No. 20120730-5181).
2. United States Department of Agriculture, Forest Service, *Preliminary Terms and Conditions Provided Under 18 CFR § 4.34(b)(1) In Connection with the Application for Relicensing for the Drum-Spaulding Hydroelectric Project (FERC No. 2310*) (e-Library No. 20120731-5114) (July 30, 2012).
3. United States Department of Agriculture, Forest Service, *Transmittal of Rationale for Revised Section 4(e) Conditions Drum-Spaulding Hydroelectric Project (FERC No. 2310)* (e-Library No. 20120828-5019) (August 28, 2012).

4. The Foothills Water Network et al., *Comments and Recommendations, Ready for Environmental Analysis, Final License Application, Drum-Spaulding Hydroelectric Project (FERC No. 2310),* (e-Library No. 20120731-5130).
5. Nevada Irrigation District and Pacific Gas and Electric Company. 2011. Technical Memorandum 3-7, Special Status Amphibians, Foothill Yellow-legged Frog Habitat Modeling. Yuba-Bear Hydroelectric Project (FERC Project No. 2266-096) and Drum-Spaulding Project (FERC Project No. 2310-173). January.
6. Nevada Irrigation District and Pacific Gas and Electric Company. 2010a. Technical Memorandum 3-6, Special Status Amphibians, Foothill Yellow-legged Frog Surveys. 72 pp. October.
7. Nevada Irrigation District and Pacific Gas and Electric Company. 2010. Technical Memorandum 3-1, Stream Fish Populations.
8. Nevada Irrigation District and Pacific Gas and Electric Company. 2010. Technical Memorandum 3-2, Instream Flow. 272 pp. September.
9. Nevada Irrigation District, *Transmittal of Supplements No. 1, 2, 3, 4, and Attachment 1 for the Yuba-Bear Hydroelectric Project under P-2266* (e-Library No. 20120817-5135).
   a. Specifically, updated runs of the HEC-ReSim Water Balance/Operations Model
10. Lind, Amy. 2010. Summary of FYFL Tadpole Water Temperature Effects from Recent Studies.
11. Gast, Tom, Mark Allen, and Scott Riley. 2005. Middle and South Yuba Rainbow Trout Distribution and Abundance Dive Counts. August 2004. Appendix G of the Upper Yuba River Watershed Habitat Feasibility Report, May 2006. California Dept of Water Resources.

All of the references cited above are in the record of this proceeding. The following references were also relied upon by the Network but are not currently in the record of this proceeding. Copies of the references cited below are attached to this filing as appendices.

(1) Foothills Water Network, "*Yuba-Bear/Drum Spaulding ResSim Alternative Operations Model Run Summary"*and *"Assumptions for Drum-Spaulding Alternative Condition Flow Model Runs"* (August 2012).
(2) Moyle, Peter. *Inland Fishes of California*, p. 151-158. (2002).

VIII.
CONCLUSION

The Foothills Water Network, American Rivers, American Whitewater, California Sportfishing Protection Alliance, Friends of the River, Gold Country Fly Fishers, Northern California Council Federation of Fly Fishers, Sierra Club, South Yuba River Citizens League, and Trout Unlimited respectfully submit this alternative condition for consideration in place of the relevant portion of the Forest Service's revised Preliminary 4(e) Condition 29. The Network requests that the Forest Service and PG&E undertake, with us and other parties, to resolve these and other remaining disputes by settlement. In the absence of settlement, the Network respectfully requests that the Secretary accept the Network's alternative condition because it better protects the reservation at less cost to hydropower, and order its inclusion in the final 4(e) conditions for the Drum-Spaulding Project.

Dated: August 29, 2012

Respectfully submitted,

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VERIFICATION

I hereby certify that I have read this document; to the best of my knowledge, information, and belief, the statements contained herein are true; and this document is not being filed for the purpose of causing delay.

Dated: August 29, 2012

Respectfully submitted,

Megan Hooker

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CERTIFICATE OF SERVICE

I hereby certify that I filed and served this "**FOOTHILLS WATER NETWORK, AMERICAN RIVERS, AMERICAN WHITEWATER, CALIFORNIA SPORTFISHING PROTECTION ALLIANCE, FRIENDS OF THE RIVER, GOLD COUNTRY FLY FISHERS, NORTHERN CALIFORNIA COUNCIL FEDERATION OF FLY FISHERS, SIERRA CLUB, SOUTH YUBA RIVER CITIZENS LEAGUE, AND TROUT UNLIMITED SUBMIT ALTERNATIVE CONDITIONS TO THE PRELIMINARY SECTION 4(E) CONDITIONS FOR DRUM-SPAULDING HYDROELECTRIC PROJECT,"** as stated below**.**

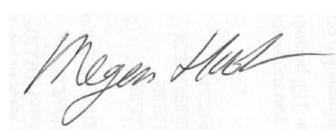
FILING

I filed these Alternative Conditions via overnight delivery, sent August 29, 2012 for delivery the next day, to:

Deputy Chief
National Forest Systems, Forest Service
Washington Office Lands Staff
Mail Stop 1124
1400 Independence Avenue, S.W.
Washington, D.C. 20250- 0003.

SERVICE

I served the Alternative Condition as indicated to each representative on the attached primary service list on August 29, 2012, according to 7 CFR 1.63(c)(2) via express mail where no electronic address was available, and 7 CFR 1.63(c)(4), via e-mail with return verification requested and a hardcopy via regular U.S. mail. I further served the Alternative Condition to each representative on the attached secondary service list on August 29, 2012, via electronic mail or via regular U.S. mail.



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Assumptions for Drum-Spaulding Alternative Condition Flow Model Runs

General:

1. Used L061812 Run as the basis for modeling. This run includes existing water supply needs (not projected), buffer flows, and NO recession limb flows.

2. Although we support the inclusion of recession flows, those flows were post-processed by the Licensee and cannot be included in iterative model trials. Running these models without recession flows should be a conservative assumption though, when considering block flows, because sometimes recession flows will continue later into summer and may supersede the need for block flows on those days.

South Yuba:

1. Assume FS 4(e) conditions as baseline. This includes back-to-back (B2B) Water Year (WY) type turning to EC year (6 months in 1988). B2B applies for Spaulding and Lake Valley Reservoir and Lake Valley Diversion Dam reaches. Additionally, the FS 4(e) conditions include the SEC year, where a B2B CD as well as EC year means that Spaulding can go to 10 cfs year round, except 20 cfs in summer.

2. In the FS 4(e) run, I included their most recent proposal, which is:

Table 7. Minimum Streamflows in South Yuba River below Lake Spaulding Dam as Measured at YB-29 with Supplemental Flow Range and Total Minimum Flow Range

Period	Minimum Streamflow (cfs)	Supplemental Flow Range (cfs)	Total Minimum Flow Range (cfs)
CRITICALLY DRY WATER YEARS			
June 15 – 30	35	--	35
July	25	0-5	25-30
August	20	0-10	20-30
September 1 – 15	20	0-10	20-30
DRY WATER YEARS			
June 15 – 30	40	--	40
July	30	--	30
August	23	0-7	23-30
September 1 – 15	23	0-7	23-30
BELOW NORMAL WATER YEARS			
June 15 – 30	50	--	50
July	35	--	35
August	*25*	*0-5*	*25-30*
September 1 – 15	*25*	*0-5*	*25-30*

Since the model cannot assume a range of flows, 30 cfs was used to calculate the amount of water whenever the FS condition specified “20-30” or “25-30.” Also because half-months are more challenging to preprocess, all model runs were conducted with September flows averaged between the specified Sept 1-15 and the Sept 16-30 values. (green line on hydrology plots)

3. Using the DFG calculations from the SY block rationale in the July 30, 2012 DFG Rationale Report for its 10(j) recommendations, I input a water volume for each water year type, assuming that in CD years 2500 would get used, 1970 in a Dry year, 1370 in a BN year, and 1370 in AN and Wet years.

4. To increase power generation (alternate condition run), lower flows in the SY to 25 cfs in February and March in all but EC years. (red line on hydrology plots)

Yuba-Bear/Drum-Spaulding Operations Model - Alternative Run Summary						
Name of Alternative Model Run:	**L061812 - EBF with Alt Conditions for FS 4(e)s**					
Powerhouse	**Base Case -EBF**		**L061812 - EBF with Alt Conditions for FS 4(e)s (Licensees' Ammended FLAs)**		**% Difference**	***Max Capability***
	GWh/yr	**Plant Factor**	**GWh/yr**	**Plant Factor**		***GWh/yr***
Bowman	12.1	0.33	11.1	0.31	-8.4%	*36.3*
Spaulding 3	34.8	0.62	31.0	0.55	-10.8%	*56.5*
Spaulding 1	32.4	0.53	29.6	0.48	-8.7%	*61.3*
Spaulding 2	10.9	0.28	10.9	0.28	-0.3%	*38.5*
Deer Creek	22.6	0.45	22.5	0.45	-0.5%	*49.9*
Drum 1	93.2	0.20	79.7	0.17	-14.5%	*473.0*
Drum 2	266.2	0.61	243.7	0.56	-8.5%	*433.6*
Alta	5.1	0.58	5.1	0.59	0.9%	*8.8*
Dutch Flat 1	128.9	0.64	116.0	0.58	-10.0%	*201.5*
Dutch Flat 2	48.4	0.21	42.2	0.19	-12.8%	*227.8*
Chicago Park	139.5	0.38	124.5	0.34	-10.8%	*363.5*
Rollins	66.2	0.59	61.8	0.55	-6.6%	*112.1*
Halsey	51.3	0.55	48.5	0.52	-5.5%	*92.9*
Wise 1	69.2	0.56	64.3	0.52	-7.0%	*122.6*
Wise 2	7.6	0.27	6.6	0.23	-14.3%	*28.0*
Newcastle	27.4	0.27	23.3	0.23	-14.8%	*100.7*
COMBINED TOTAL	**1016**	**0.42**	**921**	**0.38**	**-9.3%**	***2407***
Sub-Total: NID Yuba-Bear	**266**	**0.36**	**240**	**0.32**	**-10.0%**	***740***
Total - Critically Dry Years - YB	99	0.13	83	0.11	-15.7%	*740*
Total - Dry Years - YB	175	0.24	157	0.21	-10.6%	*740*
Total - Below Normal Years - YB	280	0.38	256	0.35	-8.6%	*740*
Total - Above Normal Years - YB	325	0.44	292	0.39	-10.2%	*740*
Total - Wet Years - YB	375	0.51	339	0.46	-9.6%	*740*
Sub-Total: PG&E Drum-Spaulding	**750**	**0.45**	**681**	**0.41**	**-9.1%**	***1667***
Total - Critically Dry Years - DS	404	0.24	348	0.21	-13.8%	*1667*
Total - Dry Years - DS	622	0.37	554	0.33	-11.0%	*1667*
Total - Below Normal Years - DS	804	0.48	734	0.44	-8.7%	*1667*
Total - Above Normal Years - DS	847	0.51	771	0.46	-9.1%	*1667*
Total - Wet Years - DS	914	0.55	848	0.51	-7.2%	*1667*

Yuba-Bear/Drum-Spaulding Operations Model - Alternative Run Summary						
Name of Alternative Model Run:	**L061812 - EBF with FS 4(e)s**					
Powerhouse	**Base Case -EBF**		**L061812 - EBF with FS 4(e)s (Licensees' Ammended FLAs)**		**% Difference**	***Max Capability***
	GWh/yr	**Plant Factor**	**GWh/yr**	**Plant Factor**		***GWh/yr***
Bowman	12.1	0.33	11.1	0.31	-8.5%	*36.3*
Spaulding 3	34.8	0.62	31.0	0.55	-10.8%	*56.5*
Spaulding 1	32.4	0.53	29.5	0.48	-8.9%	*61.3*
Spaulding 2	10.9	0.28	10.8	0.28	-0.4%	*38.5*
Deer Creek	22.6	0.45	22.5	0.45	-0.5%	*49.9*
Drum 1	93.2	0.20	80.4	0.17	-13.7%	*473.0*
Drum 2	266.2	0.61	242.7	0.56	-8.8%	*433.6*
Alta	5.1	0.58	5.1	0.59	0.9%	*8.8*
Dutch Flat 1	128.9	0.64	115.8	0.57	-10.1%	*201.5*
Dutch Flat 2	48.4	0.21	42.1	0.18	-13.0%	*227.8*
Chicago Park	139.5	0.38	124.4	0.34	-10.8%	*363.5*
Rollins	66.2	0.59	61.9	0.55	-6.5%	*112.1*
Halsey	51.3	0.55	48.5	0.52	-5.4%	*92.9*
Wise 1	69.2	0.56	64.5	0.53	-6.8%	*122.6*
Wise 2	7.6	0.27	6.6	0.23	-14.2%	*28.0*
Newcastle	27.4	0.27	23.3	0.23	-14.9%	*100.7*
COMBINED TOTAL	**1015.84**	**0.42**	**920.40**	**0.38**	**-9.40%**	***2407***
Sub-Total: NID Yuba-Bear	**266.25**	**0.36**	**239.50**	**0.32**	**-10.05%**	***740***
Total - Critically Dry Years - YB	98.98	0.13	83.54	0.11	-15.60%	*740*
Total - Dry Years - YB	175.32	0.24	157.55	0.21	-10.14%	*740*
Total - Below Normal Years - YB	280.02	0.38	255.74	0.35	-8.67%	*740*
Total - Above Normal Years - YB	325.08	0.44	291.46	0.39	-10.34%	*740*
Total - Wet Years - YB	374.82	0.51	337.83	0.46	-9.87%	*740*
Sub-Total: PG&E Drum-Spaulding	**749.60**	**0.45**	**680.86**	**0.41**	**-9.17%**	***1667***
Total - Critically Dry Years - DS	404.22	0.24	348.85	0.21	-13.70%	*1667*
Total - Dry Years - DS	622.23	0.37	555.96	0.33	-10.65%	*1667*
Total - Below Normal Years - DS	803.72	0.48	733.02	0.44	-8.80%	*1667*
Total - Above Normal Years - DS	847.38	0.51	768.96	0.46	-9.25%	*1667*
Total - Wet Years - DS	913.69	0.55	846.71	0.51	-7.33%	*1667*

Inland Fishes of California

Revised and Expanded

PETER B. MOYLE

Illustrations by Chris Mari van Dyck and Joe Tomelleri

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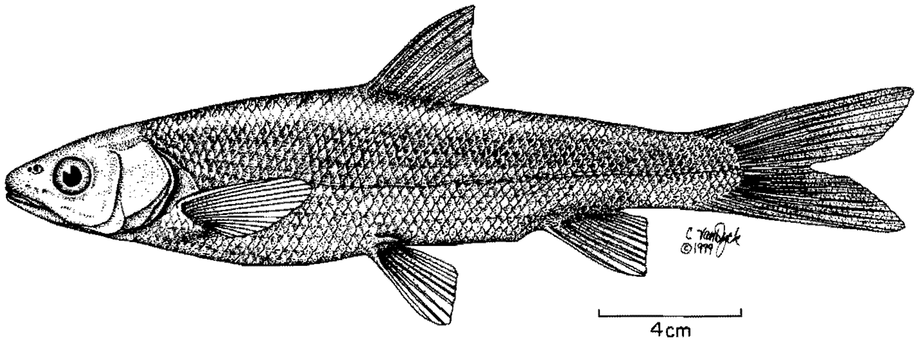


Figure 52. Clear Lake splittail, 21 cm SL, Clear Lake, Lake County, 31 March 1970.

ing. A single specimen is known from Cache Creek, the outlet of Clear Lake (1).

Life History Not much is known about Clear Lake splittail because there was little interest in them until after they became extinct. Their most distinctive features are adaptations for lake living. They once apparently schooled in large numbers over most of the lake, concentrating in littoral areas. Summer die-off of large splittail and other Clear Lake minnows seems to have been an annual event, although its exact cause is not known. Clear Lake splittail were more pelagic in feeding habitats than Sacramento splittail. They were observed eating ovipositing gnats and gnat egg rafts on the surface, as well as bottom-living gnat larvae and emerging pupae (2, 3). Of the diet of 22 splittail examined by Cook (7), 76 percent was zooplankton; the rest was insects or detritus.

Clear Lake splittail spawned in inlet streams in April and May, frequently migrating several kilometers upstream to suitable gravel riffles or areas with flooded vegetation. It is not known how long newly hatched splittail remained in the streams before returning to the lake, but it was probably at least three weeks. Once in the lake they apparently spent the first few months in the littoral zone.

Status IA. The species is globally extinct. Following a major, precipitous decline in the early 1940s (4), Clear Lake splittail managed to hang on until the mid-1970s. The most likely cause of their decline was diversion of streams during spawning and rearing seasons. Splittail apparently spawned later than hitch (which have managed to maintain populations in the lake) and seem to have reared longer in the streams. Likewise, pikeminnows also spawned later in the season (April) than hitch and are now largely absent from the lake (although they persist in tributary streams).

It is possible that channelization of lower reaches of most tributaries was a major contributer to the decline by eliminating flooded areas needed by splittail for spawning and larval rearing. These aspects of their life history may have been particularly critical in dry years, when sudden reduction in water flows either trapped spawning adults or prevented young fish from moving into the lake (5). Other factors contributing to extinction may have been predation, competition, or diseases from introduced fishes. Although splittail managed to coexist with nonnative fishes for about 100 years, negative interactions may have acted synergistically with poor spawning success. It may be significant that splittail were still fairly easy to collect in Clear Lake in the early 1960s (1) and that their disappearance followed the explosive establishment of inland silversides in 1967. Silversides completely dominate the littoral zone of the lake, once the main habitat of juvenile splittail. Ironically, the huge schools of minnows once present in the shallow waters of the lake were referred to by early residents as "silversides" (6).

References 1. Hopkirk 1973. 2. Lindquist et al. 1943. 3. Cook et al. 1964. 4. Cook et al. 1966. 5. Murphy 1951. 6. Coleman 1930. 7. S. F. Cook, unpubl. data.

Hardhead, *Mylopharodon conocephalus* (Baird and Girard)

Identification Hardhead are large cyprinids, occasionally exceeding 60 cm SL, that resemble Sacramento pikeminnow, except that the head is not as pointed, the body is slightly deeper and heavier, the maxillary bone does not reach past the front margin of the eye, and a small bridge of skin (frenum) connects the premaxillary bone (upper "lip") to the head. They have 8 dorsal fin rays, 8–9 anal fin rays, and 69–81 scales along the lateral line. The pharyngeal teeth (2,5-4,2) are large and molariform in adults, slender and hooklike in young fish. Young fish are silvery, gradually turning brown to dusky bronze on the back as they mature. Breeding males develop small white tubercles that cover the snout and extend in a narrow band along the side to the base of the caudal fin.

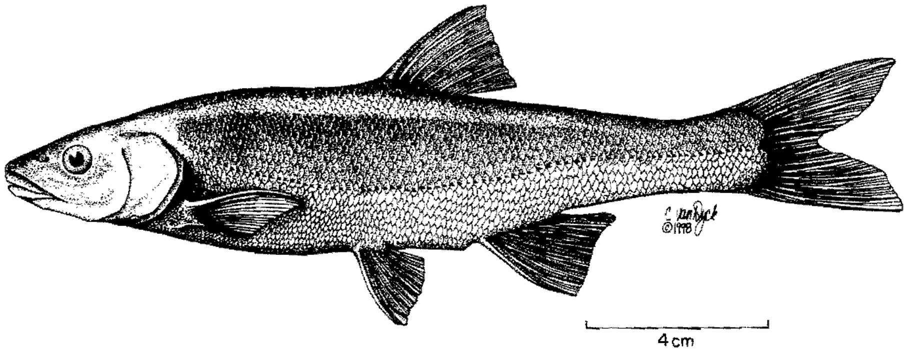
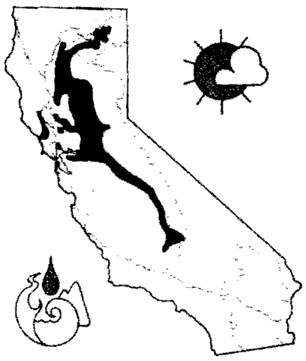


Figure 53. Hardhead, 33 cm SL, Deer Creek, Tehama County.



Taxonomy *Mylopharodon conocephalus* was first described as *Gila conocephala* Baird and Girard (1) from a single specimen from the "Rio San Joaquin." In 1855 Ayres (2) redescribed the species as *Mylopharodon robustus.* Girard (3) then reclassified *G. conocephala* as *Mylopharodon conocephalus* and placed *M. robustus* as a closely allied second species. Jordan (4) united both forms as *Mylopharodon conocephalus* (5). There appears to be little morphological variation among hardhead populations (6). Although it is related to the four species of pikeminnow (*Ptychocheilus*), it is different enough to be retained in a separate genus (7, 8). Fossil evidence indicates that the genus has existed since at least the Miocene period (7, 38).

Names The origin of the name hardhead is obscure, particularly because it was applied to Sacramento blackfish, Sacramento pikeminnow, and other large minnows in the early literature. *Mylo-pharo-don* means mill-throat-teeth, referring to the molariform pharyngeal teeth; *conocephalus* means cone-shaped head, which is mildly descriptive.

Distribution Hardhead are widely distributed in low- to midelevation streams in the main Sacramento–San Joaquin drainage. They are also present in the Russian River (11). Their range extends from the Kern River, Kern County, in the south to the Pit River (south of the Goose Lake drainage), Modoc County, in the north (12, 13). In the San Joaquin drainage, the species is scattered in tributary streams and absent from valley reaches of the San Joaquin River (8, 9, 10). In the Sacramento drainage, the hardhead is present in most larger tributary streams as well as in the Sacramento River. It is absent from San Francisco Bay streams except the Napa River.

Life History Hardhead are typically found in undisturbed areas of larger low- to midelevation streams (8, 13), although they are also found in the mainstem Sacramento River at low elevations and in its tributaries to about 1,500 m (14). Most streams in which they occur have summer temperatures in excess of 20°C, and optimal temperatures for hardhead (as determined by laboratory choice experiments) appear to be 24–28°C (15). In a natural thermal plume in the Pit River, hardhead generally selected temperatures of 17–21°C, which were the warmest available (16). At higher temperatures hardhead are relatively intolerant of low oxygen levels, a factor that may limit their distribution to well-oxygenated streams and to surface water of reservoirs (17). They prefer clear, deep (>80 cm) pools and runs with sand-gravel-boulder substrates and slow velocities (20–40 cm/sec) (8, 12, 15, 18, 40). In streams adults often remain in the lower half of the water column (15, 18), although in reservoirs they can occasionally be seen hovering close to the surface (19, 20). Hardhead are always found in association with Sacramento pikeminnow and usually with Sacramento sucker. They tend to be absent from streams where introduced species, especially centrarchids, predominate (8, 13) and from streams that have been severely altered by human activity (21), although they can persist below dams under certain conditions. Their relatively poor swimming ability at low temperatures may keep them from moving up streams with natural or human-made velocity barriers that permit the passage of salmonids (39).

Hardhead are abundant in a few midelevation reservoirs used largely for hydroelectric power generation, such as Redinger and Kerkhoff Reservoirs on the San Joaquin River (Fresno County) and Britton Reservoir on the Pit River (Shasta County). They are most abundant in the upstream half of Britton Reservoir, where habitat is more riverine, and are less abundant in the more lacustrine habitat downstream, where introduced centrarchid basses are abundant (22). They are largely absent today from most warmwater reservoirs with high annual fluctuations in volume, although they can survive in such reservoirs in the absence of large populations of introduced predatory fishes.

In streams hardhead smaller than 150 cm SL often cruise about pools or slow runs during the day in small groups, rising to take insects from the surface, holding in areas of swifter current to eat insects and algae in the water column, or dropping to the bottom to browse (40). They are sedentary in streams, rarely moving more than a kilometer from home pools (23). Most movements away from home pools are presumably related to reproduction (23). Including such movements, the average home range of adult hardhead in a small foothill steam was estimated to be about 850 m (23). In Britton Reservoir large hardhead concentrate on warm summer days in surface waters (<1 m) and can often be seen remaining motionless close to the surface (19). This behavior makes them an important prey for bald eagles that nest in the area (20). In contrast, in streams adults will aggregate during the day in the deepest parts of pools or cruise about slowly well below the surface (40). They are most active in the early morning and evening when feeding.

Hardhead are omnivores that forage for benthic invertebrates and aquatic plant material on the bottom but also eat drifting insects and algae (40). In reservoirs they feed on zooplankton (24). Smaller fish (<20 cm SL) consume primarily mayfly larvae, caddisfly larvae, and small snails (14), whereas larger fish feed more on aquatic plants (especially filamentous algae), crayfish, and other large invertebrates. The ontogenetic changes in tooth structure are consistent with this dietary switch; juveniles have hooked teeth, characteristic of insectivores, whereas adults have large molariform teeth, needed for grinding hard prey and plants (14).

Hardhead typically reach 6–8 cm SL by the end of their first growing season, 10–12 cm in their second, and 16–17 cm in their third (14, 22, 25, 28). In the American River they can reach 30 cm SL in 4 years (14); in the Pit and Feather Rivers, it takes 5–6 years to reach that length (22, 25). In small streams resident hardhead rarely exceed 28 cm SL (28). Feather River fish measuring 44–46 cm SL were aged (using scales) at 9–10 years, but older and larger (to at least 60 cm SL) fish no doubt exist. If the older records are accurate, hardhead are capable of reaching up to 1 m TL (29).

Hardhead mature in their third year and spawn mainly in April and May (14, 23). Juvenile recruitment patterns suggest that spawning may extend into August in some foothill streams (26). Fish from larger rivers or reservoirs may migrate 30–75 km or more upstream in April and May, usually into tributary streams (24, 27). In small streams hardhead may move only a short distance from their home pools for spawning, either upstream or downstream (23). In Pine Creek (Tehama County) resident hardhead aggregate during spawning season in nearby pools; spawning hardhead from the Sacramento River move into downstream reaches that dry in summer (23).

Spawning behavior has not been documented, but large aggregations of fish found during the spawning season suggest that it is similar to that of hitch or pikeminnow, with fertilized eggs deposited on beds of gravel in riffles, runs, or the heads of pools. Females, depending on size, can produce 7,000–24,000 eggs per year (23, 28). Grant and Maslin (23) noted that there were small undeveloped eggs in each ovary along with mature eggs, indicating that eggs may take 2 years to mature.

The early life history of hardhead is poorly known (26). After hatching, the larval and postlarval fish presumably remain along stream edges in dense cover of flooded vegetation or fallen tree branches. As they grow they move into deeper habitats, where those spawned in intermittent streams are swept down into main rivers, perhaps concentrating in low-velocity areas near the mouth. In Deer Creek (Tehama County) I have observed large aggregations of small juveniles (2–5 cm SL) in shallow backwaters. In the Kern River small juveniles concentrate along edges among large cobbles and boulders (41). Hardhead measuring 5–2 cm SL select habitats similar to those of adult fish. In Deer Creek this means pools or runs that are 40–140 cm deep, with water column velocities of 0–30 cm/sec (18). Such pools invariably contain Sacramento pikeminnows and Sacramento suckers.

Status ID, but IC in the San Joaquin drainage. Historically hardhead have been regarded as widespread and abundant in central California (2, 14, 29, 30, 31, 32, 33, 34). They are still widely distributed in foothill streams, but their populations are increasingly isolated from one another, making them vulnerable to localized extinctions. As a consequence they are much less abundant than they once were, especially in the southern half of their range. Reeves (14) summarized historical records and noted that they were found in most streams in the San Joaquin drainage; but in the early 1970s I found them in only 9 percent of sites sampled (8). Resampling many of the same sites about 15 years later indicated that a number of the populations had disappeared (10). They have a discontinuous distribution in the Pit River drainage, being present mainly in canyon sections of the main river and in hydroelectric reservoirs (13, 36). They are apparently still fairly common in the mainstem Sacramento River, in the lower reaches of the American and Feather Rivers, in some smaller tributary streams (e.g., Deer, Pine, Clear Creeks), and in some river reaches above foothill reservoirs. They have become extremely rare in the Napa River (11) and are uncommon in the Russian River.

Hardhead were abundant enough in Central Valley reservoirs in the past to be regarded as a problem species, under the assumption they competed with trout and other game fishes for food. However, most reservoir populations proved to be temporary and were most likely the result of colonization by juvenile hardhead before introduced predators became abundant. Populations in Shasta Reservoir, Shasta County, declined dramatically within 2 years (14), although hardhead are still present there in small numbers (35). Similar crashes of large reservoir populations have been reported from Pardee Reservoir on the Mokelumne River, Amador/Calaveras County; Millerton Reservoir on the San Joaquin River, Fresno County; Berryessa Reservoir, Napa County; Don Pedro Reservoir, Tuolumne County; and Folsom Reservoir, El Dorado County (14).

The cause of hardhead declines appears to be habitat loss and predation by nonnative fishes. Hardhead require large to medium-size, cool- to warmwater streams with deep pools for their long-term survival. Such streams are increasingly dammed and diverted, eliminating habitat, isolating upstream areas, and creating temperature and flow regimes unsuitable for hardhead. Consequently populations are gradually declining or disappearing throughout the range of the species. A particular problem seems to be predation by smallmouth bass and other centrarchid basses. Hardhead disappeared from the upper Kings River when the reach was invaded by smallmouth bass (10). In the South Yuba River hardhead are common only above a natural barrier for smallmouth bass; only large adult hardhead are found below the barrier (37). The few reservoirs in which they are abundant today are those in which water level fluctuations (such as those for power-generating flows) prevent bass from reproducing in large numbers. However, either stabilization of water levels or increasing the amount of the drawdown in these reservoirs (which expose small hardhead to predation) can result in increased populations of centrarchid basses and decreased hardhead populations.

Although hardhead are still fairly common, their general long-term decline matches declines shown by other California native fishes. It would be prudent to stabilize hardhead populations while they are still at moderate levels. The best way to protect them would be to establish a number of Aquatic Diversity Management Areas in midelevation canyon areas in which normal flow regimes and high water quality would be maintained. Because hardhead are good indicators of relatively undisturbed conditions, a system of such managed waters would protect not only the species but also the entire biotic community of which it is a part. In the meantime, stream populations should be monitored to make sure that the species is holding its own. Particular attention should be paid to Napa and Russian River populations and to those in the San Joaquin drainage, which have the potential for extirpation in the near future.

References 1. Girard 1854. 2. Ayres 1855. 3. Girard 1856a. 4. Jordan 1879. 5. Jordan and Gilbert 1882. 6. Hopkirk 1973. 7. Avise and Ayala 1976. 8. Mayden et al. 1991. 9. Saiki 1984. 10. Brown and Moyle 1993. 11. Leidy 1984 and pers. comm. 12. Cooper 1983. 13. Moyle and Daniels 1982. 14. Reeves 1964. 15. Knight 1985. 16. Baltz et al. 1987. 17. Cech et al. 1990. 18. Moyle and Baltz 1985. 19. Vondracek et al. 1988a. 20. Hunt et al. 1988. 21. Baltz and Moyle 1993. 22. PG&E 1985. 23. Grant and Maslin 1997. 24. Wales 1946. 25. Moyle et al. 1983. 26. Wang 1986. 27. Moyle et al. 1995. 28. Grant 1992. 29. Jordan and Evermann 1896. 30. Evermann 1905. 31. Rutter 1903. 32. Follett 1937. 33. Murphy 1947. 34. Soule 1951. 35. J. M. Hayes, CDFG, pers. comm 1999. 36. Herbold and Moyle 1986. 37. Gard 1994. 38. Smith 1981. 39. Myrick 1996. 40. Alley 1977a,b. 41. L. Brown, USGS, pers. comm. 1999.

Sacramento Pikeminnow, *Ptychocheilus grandis* (Ayres)

Identification Sacramento pikeminnows are large (potentially over 1 m TL) cyprinids with elongate bodies; flattened, tapered (pikelike) heads; and deeply forked tails. The mouth is large, the maxilla extending behind the front margin of the eye, and is without teeth. The pharyngeal teeth (2,5-4,2) are long and knifelike. There are 8 rays in the anal fin, 8 rays in the dorsal fin, 15–18 pectoral rays, 9 pelvic fin rays, 65–78 scales along the lateral line, 38–44 predorsal scales on the back of the head, and 12–15 scale rows above the lateral line. Large fish are generally a dark, brownish olive on the back and gold-yellow on the belly. Small fish tend to be silvery on the sides and belly and have a dark spot at the base of the tail. Fins of breeding adults are tinged with reddish orange. Spawning males develop tiny breeding tubercles on the head and a row of tubercles on the side that can extend to the base of the tail.

Taxonomy Despite its wide distribution in California, no distinctive regional forms of Sacramento pikeminnow have been noted, presumably because it is a highly mobile species favoring large streams. The Sacramento pikeminnow is one of four species of *Ptychocheilus*. Others are *P. lucius* in the Colorado River, *P. umquae* from rivers in west-central Oregon, and *P. oregonensis* in the Columbia River basin (1, 2). Within this group Sacramento pikeminnow appears to be most closely related to Colorado pikeminnow. The hardhead is closely related to pike-

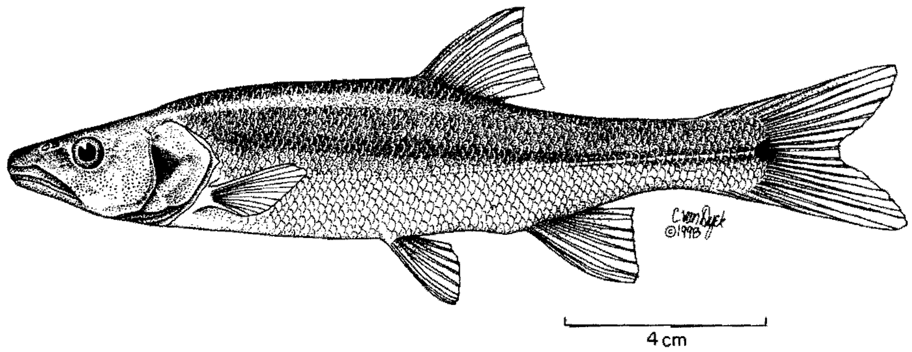
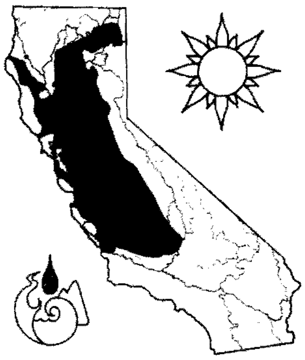


Figure 54. Sacramento pikeminnow, 15 cm SL, Eel River, Mendocino County.



minnows but is distinct enough to be placed in its own genus (*Mylopharodon*) (2).

Names Pikeminnow, adopted in 1998 by the American Fisheries Society, is a replacement for the widely used name "squawfish." Squawfish is a derogatory name conferred by early settlers because pikeminnow was a common food fish of Native Americans and therefore regarded as inferior. Because the name insults Native Americans (and indirectly a fine fish), its replacement by pikeminnow as the official common name is highly appropriate. Many other names have also been applied to the species: Sacramento pike, chub, whitefish, hardhead, chappaul, bigmouth, boxhead, and yellowbelly. *Ptychocheilus* means folded lip, "the skin of the mouth behind the jaws being folded" (3, p. 224); *grandis* means large.

Distribution Sacramento pikeminnows are found in creeks and rivers throughout the main Sacramento–San Joaquin River system, Pajaro and Salinas Rivers, Russian River, Clear Lake basin, and upper Pit River. Sometime before 1975 they became established in Chorro and Los Osos Creeks (San Luis Obispo County), tributaries to Morro Bay (4), presumably via an aqueduct connecting these streams with the upper Salinas River. They have also been transferred via the California Aqueduct into reservoirs in southern California (4). In about 1979 they were introduced into Pillsbury Reservoir in the Eel River and have since spread throughout the drainage (5, 7).

Life History Sacramento pikeminnows are widespread in clear rivers and creeks of central California and present in small numbers in the Sacramento–San Joaquin Delta. They are largely absent from habitats that are highly turbid or polluted and tend to be found in low numbers (mainly as large adults) in lakes and reservoirs that contain centrarchid basses. They are most characteristic of low- to midelevation streams with deep pools, slow runs, undercut banks, and overhanging vegetation. Although they are fairly secretive, in large pools adults can be observed cruising about during the day. They are most abundant in lightly disturbed, tree-lined reaches that also contain other native fishes, especially Sacramento sucker and hardhead (6). The smaller the stream, the more likely pikeminnows are to be found only in pools. Typically during low-flow periods during the day, pikeminnow greater than 12 cm SL are found in water deeper than 1 m with mean water column velocity of less than 40 cm/sec, while smaller fish concentrate in shallower areas with lower velocities, presumably in part to avoid predation by larger individuals (8, 9, 10, 11).

They generally live in waters with summer temperatures of 18–28°C (7, 12, 13). Within this range pikeminnows often seek warmer temperatures if other aspects of the habitat are appropriate (12, 13). The maximum (acute) preferred temperature is around 26°C; temperatures above 38°C are invariably lethal (9). Temperatures lower than 38°C may also be lethal if the fish were previously living in cooler water. Metabolic rates of pikeminnows increase with temperature (14), although sustained swimming speeds cannot exceed 2–2.5 body lengths per second (15). While basically freshwater fish, Sacramento pikeminnows have been found in Suisun Marsh in salinities as high as 8 ppt, although they are rarely found at salinities higher than 5 ppt.

Juvenile pikeminnows are typically found in small schools, often mixed with other native cyprinids. The depth a school selects is related to the size of the fish, because of the dual threats of heron predation in shallow water and fish predation in deeper water, although large pikeminnows rarely pursue small fish during the day. Thus the smallest fish (<30 mm) are typically found in the shallowest water at stream edges. Larger fish may also school with other fishes;

I have observed mixed schools of pikeminnow and rainbow trout, all about 20–25 cm long, swimming about in tight formation in the Eel River. Schools of 15- to 25-cm pikeminnows in the Eel can contain several hundred individuals. Large pikeminnows typically cruise about in pools during the day in loose groups of 5–10 fish, although very large individuals may be solitary (11, 16). Often by midday, they become relatively inactive and return to cover (11, 17), although there are generally some still cruising about, feeding on surface insects or benthos (17). The largest fish emerge from cover and begin foraging as darkness falls, entering runs and shallow riffles to forage on small fish (40). Individual fish can move over 500 m during the night before returning to their "home" pools (40). Juveniles, in contrast, will forage actively during the day. The behavior of pikeminnows during colder months is not known, but they apparently seek deep cover (e.g., under submerged trees) that can serve as velocity refuges during high flows (16). Harvey and Nakamoto (40) found that individuals would move downstream 2–23 km to find suitable overwintering habitat but then would move back to their original pools, or to pools nearby, for the summer.

Pikeminnows are capable both of living a sedentary life style and of migrating long distances. In small streams adult pikeminnows may rarely leave a single pool or complex of pools (16, 17). Taft and Murphy (18) observed a tagged pikeminnow in the same pool for 3 years. However, in the Sacramento River pikeminnows move upstream past Red Bluff Diversion Dam during all months of the year; peak numbers (up to 10,000 per month) were typically observed in March, April, and May, when the fish were migrating to spawn (19). Some were tagged in the Delta, indicating an ability to migrate at least 400 km (20, 39). In the Eel River, although most adult fish are sedentary, individuals can move long distances; one radio-tagged pikeminnow was followed for 92 km, moving upstream (40). Most movement takes place at night.

As their pikelike appearance and sharp pharyngeal teeth suggest, pikeminnows are predators on large prey. Before the introduction of other predatory fishes such as largemouth bass, large pikeminnows were undoubtedly at the top of the aquatic food chain throughout the Central Valley. They are opportunists, taking prey on the bottom, at the surface, or in between, depending on type, abundance, and time of day. The size and kind of prey depend on the size of the fish. Pikeminnows under 10 cm SL feed predominantly on aquatic insects, switching to fish and crayfish between 10 and 20 cm (5, 17, 18, 19, 20). In the regulated lower American River, juvenile pikeminnows feed on small aquatic insects, especially corixids (water boatmen) and chironomid midge larvae; they also feed on larval suckers when they are abundant (38). Fish larger than 20 cm SL feed almost exclusively on fish and crayfish, but large stoneflies, frogs, and small rodents have been found in their diets. In small streams the switch to fish may occur at a smaller size if potential prey (including smaller pikeminnows) are abundant (17). In the Eel River in the late 1980s, large pikeminnows fed on novel prey (lamprey ammocoetes, frogs), presumably because they were recent invaders to the system and were finding naïve prey (5). In order to avoid predation by large pikeminnows, California roach, Sacramento suckers, and rainbow trout seek out shallower or faster water than they would in the absence of pikeminnows (7, 21). However, large pikeminnows move into these habitats to forage at night. Curiously, threespine sticklebacks seem to have a hard time changing behavior in the presence of pikeminnows and are likely to co-occur with them only if the stream contains large amounts of dense cover (7, 27).

Pikeminnows in the Eel River forage on outmigrating juvenile salmon in spring, predation also characteristic of large pikeminnows holding below Red Bluff Diversion Dam on the Sacramento River (20). Although pikeminnows may consume large numbers of juvenile salmon, they are likely to have significant impact on salmon populations only where humans have created situations in which the natural ability of salmon to avoid predation is reduced, such as below dams (22) or in locations where pikeminnows are introduced, such as the Eel River (5). At Red Bluff heavy predation on salmon occurs mainly when the dam gates are closed, aggregating pikeminnows and disorienting small salmon in turbulent flows (39). In the Columbia River northern pikeminnow predation below dams is regarded as a major factor contributing to salmon declines, and considerable effort is spent on pikeminnow control, although dams and not pikeminnows per se are the ultimate cause of the problems (23, 24). Under natural conditions pikeminnows feed largely on nonsalmonid fishes such as sculpins (25, 39). The fact that large pikeminnows have low metabolic and digestive rates and that they feed infrequently, especially at low temperatures, also reduces their ability to affect salmonid populations during migrations (26).

Peak feeding usually occurs in early morning (small pikeminnows) or at night (large pikeminnows) (11, 17, 19). Nighttime predation rates at Red Bluff Diversion Dam were apparently enhanced when lights on the dam made prey more visible (20).

Pikeminnows are long lived and slow growing, well adapted to persist through periods of extended drought when reproductive success is low. Growth is usually continuous during the warmer months of the year (17), although it may temporarily cease during periods of drought or in streams that become intermittent (18). For the most part, determining the age of pikeminnows by reading scales is unreliable for older fish, although specimens have been aged at up to 12 years old by this method (28). Using opercular bones, pikeminnows measuring 66 cm SL from the Russian River have been aged at 16 years, suggesting that even older fish may not be unusual (29). Most populations of pikeminnows from rivers and reservoirs show fairly consistent growth rates for their first 5 years or so of life, reaching 50–85 mm SL at the end of their first year, 100–150 mm at the end of their second year, 170–250 mm at the end of their third year, 240–270 mm at the end of their fourth year, and 260–350 mm at the end of their fifth year (5, 16, 17, 28, 30, 39). Growth rates tend to be slowest in small streams and fastest in large, warm rivers. The highest growth rates on record are for the lower Sacramento River: 1.2–1.5 times higher than growth rates elsewhere after the first year (17, 39). There appear to be no differences in growth rates between the sexes. The largest Sacramento pikeminnow known, measuring 115 cm SL and weighing 14.5 kg, was caught in Avocado Lake, Fresno County, in an abandoned gravel pit just off the Kings River.

Sacramento pikeminnows typically become sexually mature at the end of their third or fourth year at 22–25 cm SL; males mature a year earlier than females. They may spawn annually thereafter, but they will not spawn in years when conditions are unfavorable (16, 28). Ripe fish move upstream during April and May (16, 18, 28), although larvae have been collected into July (31). Males usually arrive in the spawning area (gravel riffles or shallow flowing areas at the base of pools) first, when water temperatures rise to 15–20°C. Fish from large rivers or reservoirs usually move into small tributaries to spawn, whereas fish resident in small to medium-size streams typically just move into the nearest riffle (16, 18, 28).

The spawning behavior of pikeminnow has not been recorded in detail, presumably because they spawn largely at night (28). However, it is undoubtedly similar to that of other native cyprinids as well as northern pikeminnow (32). Males congregate in favorable spawning areas and wait for females (28). Any female swimming past a swarm of males is immediately pursued by one to six males. Spawning occurs when a female dips close to the bottom and releases a small number of eggs, which are simultaneously fertilized by one or more males swimming close behind her (32). Fertilized eggs sink to the bottom and adhere to rocks and gravel (31).

Fecundity is high (15,000–40,000 eggs per female, for fish measuring 31–65 cm SL) and related to size, although there is considerable variation in the estimates (16, 28, 33). In northern pikeminnow, the eggs hatch in 4–7 days at 18°C, and fry begin shoaling in another 7 days (33). These events are probably similar for Sacramento pikeminnow because, soon after spawning occurs, shoals of larvae or postlarvae can be observed in shallow pool edges or backwaters, often in association with larvae of other native fishes (31). As the small fish become more active swimmers, they enter deeper water, especially in runs and along riffles in cover. Juvenile pikeminnows can disperse widely in their first year of life, colonizing stream reaches that have been dried up by drought (27) or made available to them through introduction (5). Young-of-year typically disperse downstream, whereas yearlings are more likely to move upstream (41).

Status IE. Sacramento pikeminnows are still common in central California and have expanded their range into the Eel River basin and creeks flowing into Morro Bay. Although they have become much less abundant in lowland habitats where they were once dominant predators, they have maintained large populations in the Sacramento River, foothill streams, and many regulated streams. When large reservoirs were created by damming Central Valley tributaries, pikeminnows and hardhead colonized the new reservoirs in high enough numbers to be considered a major management problem (34). However, after 10–15 years, the "rough fish problem" quietly went away on its own, presumably because of predation by centrarchid basses on naïve juveniles. Nevertheless, small populations of pikeminnows are still present in many reservoirs dominated by nonnative fishes, such as Pine Flat Reservoir (Fresno County), Anderson Reservoir (Santa Clara County), or Shasta Reservoir (Shasta County). They seem to persist by spawning in tributary streams, where juveniles remain during the vulnerable first 1–2 years of life. Pikeminnows still maintain large populations in hydropower reservoirs, which behave like giant riverine pools and are not drawn down annually (35).

As indicated previously, the ability of Sacramento pikeminnows to be significant predators on juvenile salmon is limited to unusual locations, such as those below Red Bluff Diversion Dam or in the Eel River (5, 22, 39). The degree of predation at Red Bluff Diversion Dam was greatly overestimated (20), resulting in a number of efforts to control pikeminnows. All—including annual "fish-outs" by anglers—failed. At one point an electrocution device, activated by a person viewing through a television camera, was installed in the fish ladder passing over the dam. The idea was to electrocute pikeminnows passing over the dam in order to reduce their population. The device worked for a short while, killing a number of pikeminnows, but then the pulse of migrants abruptly stopped. Apparently, the shocked fish had released fear substance, characteristic of cyprinids, which served to deter fish below the dam from proceeding. The migration was halted for several days, compounding whatever predation problem may have existed, because large fish then accumulated below the dam. The electrocution device was subsequently abandoned (36). The "problem" at Red Bluff Diversion Dam largely disappeared when gates were left open to allow safe salmon passage through the dam, coincidentally allowing pikeminnows to complete their spawning migration as well.

If the predatory nature of Sacramento pikeminnows gives them an undeservedly bad reputation, it also confers on them sporting qualities (18, 33, 37) recognized by every angler who hooks one (until he or she discovers that the struggling fish is not a trout or a bass). The culinary qualities of large pikeminnows are also underappreciated, although they fetch a good price in oriental markets and, like common carp, are excellent eating when properly prepared. More importantly, pikeminnows are a key component in many stream ecosystems and are fascinating to watch, cruising elegantly about their summer pools.

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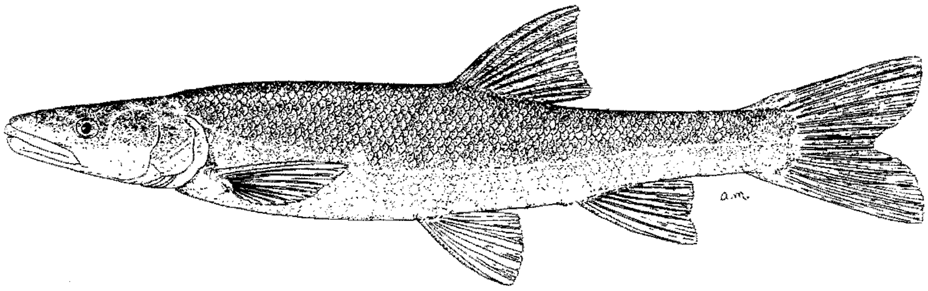
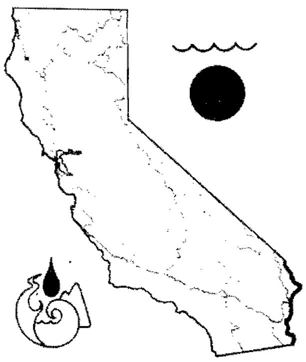


Figure 55. Colorado pikeminnnow, 35 cm SL, Green River, Wyoming. Drawing by A. Marciochi.



Colorado Pikeminnow, *Ptychocheilus lucius* Girard

Identification Colorado pikeminnow are large (up to 2 m), small-scaled cyprinids with elongate bodies, flattened, tapered (pikelike) heads, and deeply forked tails. Their scales are embedded, and there are usually more than 80 in the lateral line (76–97) and 18–23 rows above the lateral line. The toothless mouth is large and horizontal, the maxilla extending behind the front margin of the eye. The pharyngeal teeth (2,5-4,2) are long and knifelike. There are 9 rays in the anal fin and 9 in the dorsal fin, 14–16 pectoral fin rays, and 8–10 pelvic fin rays. The body tends to be silvery, but larger fish become dark on the back and white to yellow on the sides and belly. Juveniles are bright silvery on the sides and belly and have a dark spot at the base of the tail. Breeding adults are silvery on the sides, flecked with gold, and creamy on the belly. Spawning males develop tiny breeding tubercles on the head and a row of tubercles on the side that can extend to the tail.

Taxonomy See the account of Sacramento pikeminnow.

Names The trivial name *lucius* means pike, referring to the superficial resemblance of pikeminnow to true freshwater pikes (Esocidae). Jordan and Evermann (1) listed its common name as "white salmon of the Colorado" or "whitefish." Other names, including the replacement of the common name "squawfish" with "pikeminnow," are discussed in the account of Sacramento pikeminnow.

Distribution Colorado pikeminnows were once common in the Colorado River and its major tributaries from Wyoming (Green River), through Utah, Colorado, Arizona, New Mexico, Nevada, California, and Mexico. Today they are absent