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STEWARDS OF THE FISHERIES

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28 January 2016
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State Water Resources Control Board
Division of Water Rights
Water Quality Certification Program
P.O. Box 2000
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RE: PCFFA and IFR Scoping Comments on Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082).

Dear Board Members and Staff:

These CEQA scoping comments are submitted on behalf of the **Pacific Coast Federation of Fishermen's Associations (PCFFA)** and the **Institute for Fisheries Resources (IFR)**. Both organizations have been involved in Klamath Basin salmon restoration efforts for decades, and both represent the working men and women and their communities that make up the West Coast commercial fishing industry, much of which is economically dependent on the salmon productivity of the Klamath River. The Klamath Basin was once the third-largest salmon producing river in the continental U.S., before it was bisected by the Klamath Dams which have no fish passage – an environmental mitigation lack that is illegal under current law, and which will have to be fixed in any Klamath Hydropower Project relicensing.

We will discuss the scoping issues that should be considered in two categories: (1) basic scoping issues (including baselines, geographic and temporal scope of your EIR analysis) that would generally be required or advisable under CEQA, and; (2) specific issues related to adverse water quality impacts and the relationship of those impacts to losses of biological and economic productivity in the Klamath River's once-abundant salmon fisheries and the related impacts of these declines on the economies and lives of coastal and in-river fishing-dependent communities.

A number of important documents are included as Attachments for the Administrative Record, as well as evidence that these adverse impacts are substantial and pervasive. We wish to enter into the record, by reference, all reports and studies: (1) related to the Klamath Basin Agreements CEQA/NEPA Analysis and Secretarial Determination (all available from www.klamathrestoration.gov); the formally approved Total Maximum Daily Loads (TMDLs) for the Klamath and Lost Rivers in Oregon and California and associated studies in Oregon and California; all studies on water quality and dam removal impacts within the FERC Docket P-2082, and; all monitoring reports and studies related to Interim Reservoir Management and Interim Measures under the Klamath Hydropower Settlement Agreement (KHSA).

Our previous scoping comments dated 23 February 2009, with Attachments, are incorporated by reference and will also be filed separately as a supplement filing for this current Record, including the attachments thereto. Many of our previous comments have yet to be addressed in the most recent Application and will thus be revisited herein.

These fisheries-specific comments are submitted to supplement, and are in addition to, other written comments being submitted separately by other entities, and which we also endorse and incorporate herein by reference, including all written comments and their attached documents and studies to be submitted separately by: the California Water Impact Network (CWIN); the Karuk Tribe; the Yurok Tribe; the Hoopa Valley Tribe; the Quartz Valley Rancheria; the Klamath Riverkeeper; and the Klamath Inter-Tribal Water Quality Working Group. And while we are not specifically dealing with the many issues raised by the Tribes in our own comments (leaving a full explication of those issues to the Tribes with the most expertise in those issues), we too are concerned about severe impacts on both water quality and Tribal cultures and economies raised by the Tribes in their separate comments, and reiterate those issues by reference.

In summary, for the Klamath 401 permit EIR, we request a full analysis of dam removal alternatives, including the alternatives of four dams out and five dams (i.e., including Keno) out. The EIR should discuss cumulative impacts of reservoirs and dam management, and all past, present and reasonably anticipated future actions, including (if relicensed) the certainty of Federal Power Act Sec. 18-required fish passage, and both the environmental and economic the impacts those fish passage facilities would have in and of themselves.

We also request a full and complete analysis of the impacts of fish passage, TMDL compliance and providing protective and bypass flows, including reductions to the Project of its production of electrical power in order to meet those other legal requirements.

We also request that the EIR include full and complete analyses of all economic and socioeconomic impacts on ocean fisheries management in the geographic area from Oregon to Mexico and out 200 miles, as well as in the Klamath Management Zone (KMZ) that extends into Oregon waters. As we will make clearer in our comments below, lack of fish passage at the Klamath dams in the past has had huge adverse economic impacts on salmon productivity from the Klamath River, which in turn can and has triggered massive shutdowns of commercial fisheries over more than 700 miles of coastline, from Monterey, CA to the Oregon-Washington border, and sometimes well beyond. Some of these adverse impacts could be partially mitigated, but many cannot, and some current adverse impacts on beneficial uses such as salmon production (such as sediment starvation and lack of spawning gravel recruitment below the dams) cannot be adequately mitigated with the current dams in place.

Moreover, J.C. Boyle and Keno Dams in Oregon are part of the same Project under their FERC unified single license, and their ramping and bypass flow and TMDL water quality impacts should be considered with both dams in/dams out comparisons. Toxic algae impacts on beneficial uses must also be thoroughly discussed; discharge of *mycrocystin* at the Iron Gate Dam's outflow is also a point source which must be separately regulated.

The Reservoir Management Plan contained in the Application, which is nothing more than a vague "plan to plan" and to conduct yet more vaguely described studies, should be replaced with concrete mitigations that have greater assurance of success. No FERC license, and no 401 Certification, should be issued on the basis of such uncertainties, particularly when it is by no means certain that any of the mitigation measures "to be studied" or "to be proposed" will actually result in real and practical mitigations.

Additionally, PacifCorp's flow recommendations are in violation of the Section 18 fish passage requirements that will now be mandatory conditions in any FERC license, and which have already been tested in litigation and found to be technically and legally sound.

(1) Geographic Scope of Cumulative Impacts Analysis: The "Project Area" for purposes of cumulative impacts analysis should be the entire area from Upper Klamath Lake's Link River Dam (containing the first structures within the Klamath Hydropower Project (KHP)), downstream to the estuary, *and also including* all impacts on salmon population and fisheries losses and declines that can be causally linked to the KHP and which occur within the coastal areas of the Klamath Management Zone ("KMZ") – an area extending from the shores of California and Oregon offshore out to 200 miles, and which extends north to at least Humbug Mountain, (OR) and south to at least Horse Mountain (near Shelter Cove), California. Constraints on ocean fishing related to Klamath origin stocks have in some years reached from Central Oregon to the Mexican border. It should also be noted that PacifiCorp itself acknowledged that this entire region is all within the "Project Area" in its original Application for Relicensing to FERC in 2004 (see footnote 1 below).

This is because Klamath-origin salmon, once they finally leave the Klamath River and enter the Pacific Ocean, are highly migratory. Thus adverse impacts at or below the KHP dams that affect out-migrating juvenile salmon (as for instance increasing their mortalities) also necessarily impact ocean salmon fisheries and coastal fishing-dependent communities and economies far to the south and far to the north of the Klamath River estuary.

Cumulative impacts analysis (especially socioeconomic impacts) within this broader KMZ area is consistent with the "Project Area" designated by PacifiCorp in its 2004 License Application.[1] The FERC FEIS geographic scope for its cumulative impacts analysis includes the area from central Oregon

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[1] See PacifiCorp *Final License Application, Socioeconomic Resources Final Technical Report* (Feb. 2004), section 2.4.3 "Geographic Scope," particularly the following (page 2-7): "The preliminary study area for the socioeconomic analysis [of KHP impacts] includes Klamath, Jackson, and Curry counties in Oregon and Siskiyou, Humboldt, and Del Norte counties in California. These are the counties that contain the Project boundaries or whose economies, local services, and human resources are potentially affected by the incremental changes to the Project and PM&E measures." For PacifiCorp's own estimates of specific socioeconomic impacts of the Project on coastal salmon fishing dependent ports and communities within the KMZ, see PacifiCorp *Final License Application, Socioeconomic Resources Final Technical Report* (Feb. 2004), pp. 2-108 through 2-115 inclusive.

to central California (FERC FEIS, Sec. 3.2.1 (pp. 3-3—3-4). The FERC FEIS itself notes:

> "For anadromous fish, we include the mainstem Klamath River and all habitat that was historically accessible upstream of the mouth of the river... We also consider appropriate management plans for salmon fisheries including those related to the Klamath Management Zone, which extends 200 miles offshore from Humbug Mountain, Oregon, to Horse Mountain (near Shelter Cove), California. We consider these plans because harvest (including commercial, tribal, and recreational) and escapement for Klamath stocks can affect the numbers of adult salmonids returning to the Klamath River Basin to spawn. We acknowledge that management measures for Klamath River fall Chinook salmon currently constrain fishing on other salmon stocks, from central Oregon to central California. As mentioned above, Klamath Hydroelectric Project structures and operation can affect adult spawning and subsequent downstream migration of juvenile salmonids which, in turn, serve as the basis for future harvests." (FERC FEIS pg. 3-4)

Using the same geographic area for the 401 Certification CEQA analysis that was used both by FERC in its Final EIS and by PacifiCorp itself in its 2004 FERC Relicensing Application allows a consistent and logical "apples to apples" comparison of impacts generally. However, analyzing different areas in different ways would not conform to the evaluation criteria regarding cumulative impacts of a proposal under CEQA, nor under Chapter 40 *Code of Federal Regulations (CFR),* Sections 1500-1508.

The Project Area should also include the Trinity River tributary to the Klamath mainstem (and other smaller tributaries), at least insofar as Trinity River and other tributaries do contribute flows, sediment and affect other water quality conditions in the mainstem that affect multiple beneficial uses, and that will affect the required KHP mitigation measures necessary to meet Basin Plan standards for all water quality parameters. Water quality standards may not be achievable in the Klamath mainstem unless the impacts of Trinity River and other tributary influences are also considered as part of the baseline conditions.

(2) Temporal Scope of Analysis: The 401 Certification CEQA EIR should likewise analyze the cumulative and other impacts within the same time scale as the FERC FEIS, which is based on the proposed PacifiCorp license application itself, i.e., 30 to 50 years. (FERC FEIS Sec. 3.2.2 (pg. 3-4)).

(3) Comparison Standards Should Also Include The "Natural Baseline Conditions" That Existed Prior To The KHP Dams: PacifiCorp must show that it can meet *all applicable water quality standards* and be consistent with the Basin Plan with any new FERC license. Mere incremental improvements from an already highly degraded condition are not enough to fully protect other beneficial uses – either legally or biologically – for Clean Water Act certification and approval.

The Water Board is being asked to compare various options and alternatives/mitigation measures for bringing into compliance an *already highly degraded river system*. Some of the dams in the Klamath River (such as the CopCo 1 Dam) have been in place since 1917, with others built later but none later than 1962 with the completion of Iron Gate Dam. Adverse impacts on water quality in the Klamath River from Klamath dams have occurred for at least 90 years. The choice of baselines to compare to under CEQA is therefore critically important in obtaining meaningful information on whether water quality standards can be met under *any* future KHP configuration.

Unfortunately, the CEQA process is not well suited to analyzing additional impacts on an *already highly degraded system*. As presently configured and operated, the Klamath River cannot even *currently* meet state water quality standards with the KHP in place. It would therefore be legally inappropriate, as well as quite illogical, to use the current highly degraded system existing on the date of issuance of the NOP as the sole "baseline" against which to compare the various options for environmental mitigations.

The proper (and far more logical) "baseline" for EIR comparisons and for ascertaining the environmental impacts of the dams themselves, as well as changes (positive or negative) that may result from the various dam mitigation and removal options, is instead the comparison of these options to the "natural baseline conditions" that existed before the KHP dams were constructed -- and which would presumably exist without the dams in place today. Use of this more biologically meaningful baseline then gives us a straightforward comparison between the various alternative options and "dams out" or "Project out" environmental conditions meeting all water quality standards, which standards are themselves based on those natural conditions.

Such a comparison would give us a much clearer idea of just what environmental impacts the KHP dams actually created, positive or negative, when compared to a "no Project" or natural dams-out condition. This "no Project" baseline is also consistent with the comparisons used in the FERC Final EIS, which throughout uses a "dams in" vs. "dams out" comparison framework.

It should also be noted that if PacifiCorp's KHP ultimately cannot be certified under Sec. 401, then "dams out" is also the default condition since without that certification FERC cannot issue a license to operate and the dams will then have to be removed. Thus the "dams out" or "natural conditions" scenario is a logical baseline against which to compare all potential mitigation measures.

Water quality standards in the Klamath Basin were in fact originally derived from these pre- Project "natural baseline conditions." Under pre-KHP natural conditions, all existing beneficial uses were preserved, and the full range of water quality parameters the natural aquatic species evolved within were protected. Various specific and numeric water quality standards derived for what this baseline looked like also create specific regulatory standard "baselines" of their own, for each parameter, which by law *must be met by the KHP if the Project as mitigated is to be certified*.

The Clean Water Act Sec. 401 states clearly that "if the imposition of conditions cannot insure such compliance such agency [in this case FERC] shall not issue such license or permit."[2]

It should be noted that ascertaining the river's "natural baseline conditions" pre-KHP development, and then assessing adverse water quality impacts of the KHP against that pre-development baseline, is also precisely the methodology in use by the North Coast Regional Water Quality Control Board ("Regional Board") in its development of the Klamath Mainstem TMDLs. In the Klamath Mainstem TMDL Action Plan, Section IV-C, the "compliance lens" for combined Dissolved Oxygen and temperature for the reservoirs is based on the standard of a "free-flowing river."

> "The reservoir's compliance lens is equal to the average hydraulic depth of the river in a free-flowing state for the length and width of the reservoir."(Sec IV-C, Klamath Mainstem TMDL

[2] Federal Water Pollution Control Act ("Clean Water Act"), Sec. 401(a)(2) [33 U.S.C. §1341(a)(2)].

Action Plan)

This 401 Certification analysis process should at least be consistent with the Regional Board's TMDL analytical methodologies so that this process can take advantage of the extensive prior Regional Board work already done, including its water quality models, and so that the standards used in this certification process will also be consistent with that later TMDL.

It should be noted that the FERC FEIS for the Klamath Dams relicensing itself confirms that the Klamath Hydroelectric Project does contribute significantly to water quality impairment in the Klamath River and suggests that the only way to fully mitigate the Project's impacts on water quality is through dam removal. *See* FERC FEIS, at 3-166. According to the FERC FEIS, dam removal will significantly improve water quality in the Klamath. Dam removal would result in reduced ammonia and pH fluctuations, and reduce the risk of algae and microscystin blooms. *Id*. Temperature, DO, and nutrient impacts would be reduced. *Id.* Disease impacts will also be mitigated.

Significantly, FERC itself also suggests that water quality objectives will not be met absent dam removal. The FERC FEIS states: (1) "the project [without dam removal] would continue to adversely affect water quality conditions downstream of Iron Gate Dam, which has the potential to adversely affect [ESA-listed] juvenile coho salmon" (FEIS, at 3-426); (2) "the project, as proposed, would continue to affect temperatures in the Klamath River;" (3) "even with implementation of best management practices that may be developed as part of a project-wide water quality management plan, it is likely that algal blooms would continue to occur in project reservoirs;" and (4) "some degree of project related nutrient enrichment would occur in the Klamath River downstream of Iron Gate Dam."

> "Dam removal will have an immediate effect on water quality (e.g., temperature, DO and cyanobacteria) both within and downstream of the Klamath Hydroelectric Project reach. (Assessment of Long Term Water Quality Changes for the Klamath River Basin Resulting from KHSA, KBRA, and TMDL and NPS Reduction Programs, August 2011)

(4) J.C. Boyle And Keno Dam Impacts Directly And Indirectly Affect California Beneficial Uses As Well As Water Quality and Quantity, And Therefore Must Also Be Considered And Their Impacts Analyzed: The Klamath Hydroelectric Project (KHP) is operated under a single unified FERC license and as one operationally integrated whole, with each structure upriver influencing the total -- and cumulative -- water quality impacts of the Project as a whole, well downstream into California and even out to the estuary. Thus water quality problems generated in the Oregon portion of the KHP inevitably wash downstream into California. The portions of the Project that are upstream in Oregon (J.C. Boyle and Keno Dams) are therefore not exempt from CEQA analysis because they generate "emissions or discharges that would have a significant effect on the environment in this state."[3]

The Notice of Preparation (NOP) issued November 2015 (as amended to Dec. 23, 2015) acknowledged that several dams of the KHP are sited in Oregon but only says this about impacts on the Klamath River coming into California downstream from Oregon KHP structures:

> "Modification to the Oregon facilities will be addressed through the Oregon Department of

[3] CA Public Resources Code §21080(b)(14).

> Environmental Quality's water quality certification. The EIR will address operation and potential modification of Oregon's facilities to the extent modifications impact California environmental resources." (NOP, pg. 11)

The Board Staff are correct that at least these two major Oregon-KHP-origin impacts affect the lower river well into California, and must therefore also be considered as part of the KHP's cumulative impacts analysis under CEQA. In fact, prior to the construction of Iron Gate Dam rapid daily ramping rates at J.C. Boyle were extremely destructive to stream-edge fish spawning and rearing habitat in the reaches of the river below J.C. Boyle Dam.[4]

Remember, however, that both water and water quality problems flow downhill, in this case from Oregon to California *within* the KHP. There are also many other significant impacts from these Oregon KHP structures and operations that additionally impact California waters, and therefore should also be considered and analyzed under CEQA. Those additional J.C. Boyle and Keno Dam water quality impacts on California waters include *at least* the following:

> (1) Both Oregon dams create slack, warm-water reservoirs that expose the Klamath River to sunlight for longer periods of time and with less shade over a much broader surface area, thus raising its overall ambient daily water temperature. This plume of warmed water washes far downstream before it is fully attenuated, if at all, by other colder spring-fed inflows.
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> (2) J.C. Boyle and Keno both trap and hold natural sediments that would otherwise contribute to spawning and rearing gravel below them, thus impoverishing instream spawning and rearing habitat in what would otherwise have been prime spawning and rearing areas for resident rainbow and redband trout (and would have similar impacts on salmon and steelhead after fish passage is provided).
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> (3) Because J.C. Boyle and Keno (as all dams do) trap sediments, they serve to concentrate nutrients that are the primary food sources for the growth of various algae species that thrive in these warm-water reservoirs, including the highly toxic blue-green algae species.
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> (4) Both the J.C. Boyle and Keno Reservoirs increase total exposed water surface areas and thus increase total evaporation in the system, costing the Klamath River perhaps an additional 10,000 to 15,000 acre-feet/year in additional evaporation of increasingly limited inflows. During droughts, this additional evaporative water loss can have significant impacts.

All these impacts, although originating in Oregon, need to be analyzed insofar as they impact the ability of the KHP to achieve California water quality standards, or affect the ability to achieve those standards at the Oregon-California border.

Microcystis aeruginosa. The toxic blue-green algae species *M. aeruginosa*, which is endemic to the upper Klamath Basin, produces the highly toxic but colorless and odorless liver toxin microcystin, which is highly soluble in water. Several recent algae monitoring studies in the reservoirs (see the comments of the Karuk Tribe of California) indicate that *Microcystis aeruginosa*, which is rare to non-existent in Upper Klamath Lake and Link River, first appears in dangerous concentrations within Keno

[4] See Expert Report of Mike Rode, PCFFA/IFR Scoping Comments 23 February 2009, Attachment 1, at 9-10.

Reservoir where ideal conditions (warm, still water with high nutrient concentrations) exist there almost certainly primarily due to the existence of Keno dam. This problem affects California water quality in, among other ways, through the following impacts:

(4) Microcystin generated by *Microcystis aeruginosa* in Keno Reservoir, then in J.C. Boyle Reservoir, naturally washes downriver and into California waters where it has been shown to concentrate in human food chains all the way to the estuary. Likewise the algae mats that first develop and grow in Keno Reservoir (toxic and otherwise), also wash downriver where they can "seed" new areas downstream (such as Iron Gate Reservoir) with these algae species wherever similar ideal conditions exist for their growth.

(5) The very existence of Keno Reservoir further increases already warm Klamath River water temperatures by flooding out and/or inundating a number of small cold-water tributaries and springs that would in the past have served as important cold-water refugia for salmon and steelhead during critical water summer months. Many salmonids depend on these types of cold-water refugia flowing into the Klamath River for their summer survival. Today, several of these cold-water streams and springs are inundated by the reservoirs and their refugial benefits are completely lost.

(6) Problems with high water temperatures at Keno and J.C. Boyle Reservoirs result, as a consequence, in lowered dissolved oxygen (DO) levels.[5] Additional sudden DO concentration dips can be caused by algae bloom die-offs. As these algae mats die off, their natural decay process also leads to elevated ammonia levels and various changes in pH from normal baseline conditions. These pervasive water quality problems all begin at Keno Dam and in its warm-water reservoir, continue downstream into the J.C. Boyle Dam and reservoir, where they get more widespread and more impactive; then they all wash well downstream into California, where they then exacerbate all the water quality problems of the river below, making it that much harder to meet TMDL and other California water quality standards.

All these adverse water quality impacts at J.C. Boyle and Keno Dams are widely known and just as widely documented. Additionally, in his *Ultimate Findings of Fact and Conclusions of Law* in the Federal Adjudicatory Decision[6] of the Hon. Judge Parlen L. McKenna in the Administrative Appeal by PacifiCorp of the federal agency "prescriptions" under the Federal Power Act, on Sept. 27, 2006, Judge McKenna also concluded:

"**Ultimate Finding of Fact 6: USFWS/NMFS ISSUE 3:** Project operations have and continue to adversely affect the resident trout fishery by, among other things:

a) confining the resident trout between the Project dams and associated reservoir thereby impairing their utilization of the full range of life history strategies and spawning productivity;
b) unscreened flow through Project turbines result in mortality of juvenile and adult

[5] The physical ability of water to absorb dissolved oxygen is more or less *inversely* proportional to its temperature at normal temperature ranges.
[6] *In the Matter of Klamath Hydroelectric Project (FERC Project No. P-2082)*, U.S. Dept. of Commerce Adjudication Docket No. 2006-NMFS-0001, Final Order and Decision Sept. 27, 2006. This Final Order is in the FERC Record under Docket No. P-2082, and is included in these comments by reference.

> trout migrating down stream; and the inability to effectively migrate adversely affects the genetic health and long term survival of the resident species.

> "**Ultimate Finding of Fact 7: USFWS/NMFS ISSUE 4:** Entrainment at Project facilities have and continue to adversely affect the resident fishery resources.

The Judge was not limiting this findings to only those dams in California, but also included impacts on fisheries at J.C. Boyle and Keno Dams. Judge McKenna also formally found that:

> "**Ultimate Finding of Fact 14: BLM ISSUE 16:** Current Project operations, particularly sediment blockage at the J.C. Boyle Dam, the flow regime, and peaking operations, negatively affect the redband trout fishery. The proposed River Corridor Management Conditions would improve fishery resources.

> "**Ultimate Finding of Fact 15: BLM ISSUE 17:** The BLM's proposed upramp rate will improve conditions for fish resources and other aquatic organisms by reducing adverse effects caused by the existing nine inch/hour upramp rate."

Judge McKenna also made numerous other secondary "Findings of Fact and Conclusions of Law" in this Adjudicatory Hearing, all based upon and specifically referencing the evidence submitted on the hearing record, to the effect that both J.C. Boyle and Keno Dams have considerable adverse impacts on both water quality and fish populations (all of which are "beneficial uses" under California's Porter-Cologne Water Quality Act) that would normally have impacts far downriver and well into the State of California.

These various Oregon-origin adverse impacts on California beneficial uses cannot be ignored, simply because they originate in Oregon. None of these impacts are exempt from CEQA analysis as noted above, especially as they are *significant* contributors to cumulative adverse Klamath River environmental impacts well into California. Many of these impacts are inherent in the structure and existence of the KHP and cannot be feasibly mitigated.

Additionally, if and when the two CopCo dams and Iron Gate Dam either have fish passage installed as called for in the federal agency Sec. 18 "prescriptions," or are ultimately removed, rapid and adverse peaking flow fluctuations (and other associated adverse water quality impacts) from J.C. Boyle will no longer be moderated by the CopCo and Iron Gate reservoirs, and will once again play an important negative role in the health of the Klamath River much farther downriver than they do today. Before the construction of Iron Gate Dam primarily as a flow regulation dam, these J.C. Boyle daily fluctuating ramping rates killed large numbers of juvenile salmon, stranded many spawning adults and dewatered many salmon egg nests ("redds").[7]

Therefore as a matter of law, the California State Water Board's CEQA analysis <u>must also include</u> a review of impacts on California Basin Plan and other water quality standards of <u>the entire Klamath Hydro Project</u>, including the Oregon dams and reservoir components of the KHP at J.C. Boyle and Keno Dams.[8]

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7 See Expert Testimony of Mike Rode, PCFFA/IFR Scoping Comments 23 February 2009, Attachment 1, Sec. 5.2.
8 CA Public Resources Code §21080(b)(14).

The Board Staff cannot escape the necessity of analyzing the water quality impacts of the Oregon portions of the KHP, nor should they seek to. CEQA requires that *all portions* of the same Project be analyzed for their environmental impacts. In spite of the artificial divisions of a state line, the Klamath Hydroelectric Project is one single project, under one single FERC license, all parts of the Project are designed to interact in various ways.

Analyzing California-side KHP-caused pollution and operations without a thorough analysis and discussion of J.C. Boyle and Keno would lead to an incomplete analysis and could possibly also impact Oregon's application or help to create a situation where only the California dams come down because no single analysis of dams' interactions on the receiving reservoirs' exist. See *Calif. Farm Bureau Federation v. California Wildlife Conservation Board* (App. 3rd Dist. 2006, 49 Cal.Rptr.3d 169, 143 Cal.App.4th 173 ("Improper for an agency to divide a project into separate parts to avoid CEQA analysis"), and *San Joaquin Raptor Rescue Center vs. County of Merced* (App. 5th Dist. 2007), 57 Cal.Rptr.3d 663, 149 Cal.App.4th 654, as modified ("The entirety of a project must be described in an EIR, and not some smaller portion of it.").

Section 401 of the Clean Water Act is also quite clear on this issue. It stated that to the extent that a state certifying agency proposes to certify a project under Section 401 that would cause or contribute to violations of a downstream state (or Tribe's) water quality standards, the Clean Water Act provides a mechanism to resolve such disputes. 33 U.S.C. § 1341(a)(2); 33 U.S.C. § 1377(e); 40 C.F.R. §§ 121.11-121.16; 40 C.F.R. § 131.7; *see also Wisconsin v. EPA*, 266 F.3d 741, 748-49 (7th Cir. 2001).

CEQA also stipulates that in a situation where a project includes many facilities working together they have to be analyzed as one. There is no mentioned state line exemption in any of California Clean Water laws and California actually has very specific language that states that California's authority includes "emissions or discharges that would have a significant effect on the environment <u>in this state</u>." (CA Public Resources Code §21080(b)(14) (underline added).

A thorough discussion on KHP Dam pollution in the State of Oregon, and impacts to California from polluted receiving water is included in the TMDL's for the Klamath and Lost Rivers in Oregon and California. We hereby incorporate these documents in our comments by reference.

The thorough analysis of the many J.C. Boyle and Keno Dam water quality impacts can easily be coordinated with Oregon's similar and parallel 401 Certification process, which is also once again proceeding in Oregon, albeit on a slower time frame. The Klamath inter-state TMDLs are already coordinated this way through a bi-state Memorandum of Agreement (MOA), and this has proven quite effective.

(5) Inadequacy of Range of Alternatives – Two Additional Dam Removal Options Must Be Considered: Since there are clearly adverse impacts on California water quality and beneficial uses of water from the J.C. Boyle and Keno Dams which must be analyzed under CEQA, the potential futures of J.C. Boyle and Keno Dam should therefore also be included in the CEQA EIR range of analyzed dam removal alternatives. Failure to consider a total removal of the KHP unlawfully truncates consideration of the full range of possibilities available, and even likely, in this situation.

We cannot stress this point enough: both Oregon and California should be analyzing the same range of alternatives. *If California does not analyze removal of dams in Oregon, and Oregon does not analyze* *removal of dams in California, then who will analyze a complete removal option? If full KHP removal options are not analyzed, this unfairly (and unlawfully) biases the decision toward keeping some parts of the Project intact when indeed that option may not meet legal water quality standards.*

While the removal of J.C. Boyle and Keno Dams (both located in Oregon) are not technically within the power of the State of California to legally *require*, the actual and likely future impacts of these dams are certainly within the power of California to *analyze* – a very different issue. They are part of the same FERC license, and both California and Oregon are supposed to be coordinating their efforts in their parallel 401 certification analyses. *The two states should not be analyzing significantly different alternatives.* If they do so, comparison of the two state analyses in any meaningful way will be impossible.

In summary, not to include analysis of J.C. Boyle and Keno removal options would *wrongfully assume* that Oregon will itself certify these two dams as meeting its standards in its parallel process and that they would remain in place under a new license. This artificially and capriciously biases the final decisions on the fate of these dams toward J.C. Boyle retention – merely by the default of never actually considering their removal. The State of Oregon, which does have jurisdiction over those two dams, could also *very well deny* 401 Certification to J.C. Boyle and to Keno, forcing them ultimately to be removed or significantly modified. Under CEQA, therefore, the State of California should therefore include this as a potential (even likely) option that must also be analyzed as to its environmental impacts.

Thus a *complete* set of removal options, including (a) the removal of J.C. Boyle alone in Oregon with removals of the California dams, and; (b) removal of both J.C. Boyle and Keno Dam in Oregon with the removals of the California dams (i.e. "Project-out conditions") should be fully analyzed *on both sides of the state border* as part of the bigger suite of likely KHP removal alternatives. Removal of both Oregon dams is at least a potential outcome of Oregon's own parallel water quality certification process, and therefore surely foreseeable. It is also necessary to have these options analyzed *by both states* in order to be sure that both states are considering the full range of potential options.

Again, the Klamath Hydroelectric Project is a single Project, under a single FERC license, for a very good reason – all the parts of the Klamath Hydroelectric Project are intended to work together. Neither state alone has jurisdiction over the whole KHP, but both acting together certainly do. Thus both states should analyze the same full-removal option regardless of state lines.

Nor is there any requirement of actual legal authority to remove a dam necessary in order to *analyze* that removal as a foreseeable or comparative alternative for purposes of environmental impacts analysis within a full range of foreseeable options. Indeed it is FERC – and not the states – that have the ultimate power to order dam removal of a FERC-licensed dam.

In summary, to take into account the foreseeable contingency decisions that Oregon might make regarding the KHP dams under its jurisdiction, there should thus be two additional options analyzed in the CEQA Alternatives, which are as follows:

> **Additional Option A:** Removal of Iron Gate, CopCo No. 1, CopCo No. 2 and J.C. Boyle: This would be a four-dam removal option that would leave Keno Dam (and Keno Reservoir) in place with appropriate fish passage prescriptions and water quality mitigation measures, but take out

the four hydropower-producing components of the KHP below Keno.

Additional Option B: Removal of Iron Gate, CopCo No. 1, CopCo No. 2, J.C. Boyle *and* Keno Dam: In other words, this would be the removal of all KHP structures in the mainstem Klamath River, resulting in a free-flowing river from Link River all the way downstream to the estuary.

(6) Special Problems at the Keno Dam/Reservoir: Keno Dam and its associated reservoir create their own special water quality problems, including being the first site within the KHP where the toxic blue-green algae species *Microcystis aeruginosa* first blooms and has been observed in any significant quantity (see PCFFA/IFR Scoping Comments of 23 February 2009, Attachment 2 (Kann)). Thus Keno Dam's and its associated reservoirs' impacts should be assessed in such a way that they can be looked at separately as well as a part of Additional Option B impacts above.

There are a number of rather serious water quality and structural problems at Keno Dam that need to be addressed. Among other problems, Keno: (1) effectively blocks current fish passage, and has no adequate passage for salmonids or Pacific lamprey; (2) traps sediment that would otherwise wash downstream and replenish depleted spawning gravel beds; (3) creates a solar "heat sink" to raise water temperatures in its reservoir; (4) traps and concentrates nutrients washing from upriver; (5) encourages the growth of the toxic blue-green algae *Microcystis aeruginosa*, which in turn produces the highly toxic, bio-accumulative but colorless and odorless liver toxin microcystin, both of which naturally float downriver and into California, where the algae mats from Keno help seed *Microcystis aeruginosa* growth in the lower reservoirs in California, and where the microcystin toxin can be absorbed by fish and mussels and in various other ways adversely affect human public health.

We do note that PacifiCorp has proposed as part of its License Application to FERC that the Keno Dam be simply omitted from any future FERC license. Its future fate is thus unknown. It may or may not ultimately be sold by PacifiCorp. However, this does not release PacifiCorp from responsibility for the Keno dam merely by omission, nor does it remove Keno Dam from FERC's on-going jurisdiction as part of the current FERC license. Transfer of Keno Dam to the U.S. Federal Bureau of Reclamation was a provision of the Klamath Basin Restoration Agreement (KBRA), but that transfer cannot go forward without Congressional approval, which has never been achieved, and the KBRA has now expired by its own terms as of 31 December 2015.

Keno Dam is a non-power flow regulatory dam that has *always* been a part of the basic FERC license for this Project. Though Keno Reservoir storage capacity is limited, Keno Dam nevertheless lies in the heart of the Klamath Hydroelectric Project, and controls flows to the dams in the other parts of the Project below it. This allows PacifiCorp to better time its peaking power generation and to benefit from the peaking abilities primarily of J.C. Boyle. Keno Reservoir levels are kept high enough in the summer time to serve some 91 water diversion points in Keno Reservoir, but can be varied much more during non-irrigation season, or in emergencies.

FERC's Policy Statement on Decommissioning ("FERC Decommissioning Policy") issued December 14, 1994 (69 FERC ¶ 61,336) states:

> "In those instances where it has been determined that a project will no longer be licensed, *because the licensee either decides not to seek a new license*, rejects the license issued, or is denied a new license, the project must be decommissioned." (FERC Decommissioning Policy,

pg. 3 (emphasis added))

and also:

> "The Commission is of the opinion that implicit in the section 6 surrender provision is the view that a licensee ought not to be able simply to walk away from a Commission-licensed project without any Commission consideration of the various public interests that might be implicated by that step. Rather, the Commission should be able to take appropriate steps that will satisfactorily protect the public interests involved." (*Ibid.*, pg. 37)

In other words, PacifiCorp cannot just walk away from the many water quality problems at Keno dam, which it benefited from for 90 years as part of the FERC license, thus leaving these problems to the States of Oregon and California or to public taxpayers. FERC retains jurisdiction over any dam which leaves a license by default, to make sure the public's interests are protected, including protecting public health, assuring water quality, requiring appropriate fish passage[9] and mitigation for other adverse impacts that arise in this instance. Another good reason for California to analyze the impacts on lower river water quality in California of Keno Dam is that, with FERC retaining jurisdiction over Keno dam, FERC could very well order mitigation and other remediation measures at Keno that would *directly* affect water quality downriver far into California.

PacifiCorp should therefore be obligated in any California 401 Certification Permit to either remove the Keno Dam completely, or alternatively to correct the many water quality problems that the Keno Dam creates and which affect water quality at the California border. Keno Dam and its associated reservoir cannot simply be left out of the 401 Certification process to become an orphaned (and thus unregulated) former component of the Project that would nevertheless still indefinitely adversely affect California water quality.

Keno Dam would also be the only remaining flow regulation dam in the Klamath River should Iron Gate Dam be ultimately removed. However, Keno dam lies above J.C. Boyle, and therefore cannot mitigate for rapid ramping at J.C. Boyle, only for impacts from unpredictable irrigation withdrawals from the Link River's A-Canal intake for the Klamath Irrigation Project and for irrigation withdrawals from its approximately 91 other much smaller reservoir diversion systems and pumps. These are factors that should be assessed as well.

On March 24, 2006, the National Marine Fisheries Service (NMFS) formally recommended full dam removal to FERC as the biologically best option to revive the Klamath's failing salmon runs. In its own Federal Power Act 10(a) recommendations filing, NMFS stated:

> "**Recommendation:** The Licensee shall develop and implement a plan to remove the lower four Project dams (Iron Gate, Copco 2, Copco 1, and J.C. Boyle dams), restore the riverine corridor, and bring upstream and downstream fish passage facilities at Keno dam into compliance with NMFS guidelines and criteria within ten years of license issuance, expiration or surrender.

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[9] Otherwise we might have the bizarre result that federal agencies could require, and FERC could order, volitional fish passage through the rest of the Project below Keno Dam up to Keno, but be unable to secure fish passage through Keno Dam because it has lost jurisdiction over it through the act of the Applicant to simply exclude it from a new license. Such a result would make federal and FERC authority to protect public resources, including to require fish passage, virtually meaningless whenever an Applicant wants to simply omit a key component of a prior license.

Under its justification, NMFS went on to, among many other things, add:

> "While NMFS is prescribing preliminary fishways under its authority in Federal Power Act Section 18, NMFS believes that within this relicensing process the best alternative to contribute to restoration of all fish species of concern in the Klamath watershed is the decommissioning and subsequent removal of the four lower Project dams (Iron Gate, Copco 1 & 2, and J.C. Boyle), combined with improvements in fish passage at Keno Dam. The dam removal alternative is a superior alternative from a fish passage, water quality, and habitat restoration standpoint.... Implementing this dam decommissioning and dam removal alternative would go a long way toward resolving decades of degradation where Klamath River salmon stocks are concerned."

Similar recommendations were also made by the U.S. Fish and Wildlife Service, which has jurisdiction over non-salmon terrestrial fish species in the upper Klamath River.

In summary, J.C. Boyle and Keno Dam removal alternatives must be included in the Board's CEQA analysis because: (1) they are parts of the same FERC license and PacifiCorp's 30 to 50 year license application; (2) they are an integral part of the entire KHP, affecting water quality all the way downstream well into California; (3) impacts at J.C. Boyle and/or Keno may determine whether or not California water quality standards can even be met at the point where the Klamath River enters the California border flowing south, or even well into California; (4) J.C. Boyle's and Keno's warm-water reservoirs both provide ideal breeding conditions for otherwise very rare *Microcystis aeruginosa* toxic blue-green algae, as well as many other algae species, that wash downstream where the adversely affect water quality as well as fisheries, and where they seed new algae blooms into regions and reservoirs far downriver and to the estuary; (5) FERC retains jurisdiction over Keno regardless of whether it remains in any new PacifiCorp license, and has the power to order mitigation and other remediation measures that would inevitably affect lower river water quality far down river and well into California.

CEQA requires that *all portions* of the same project be analyzed for their environmental impacts. In spite of the artificial divisions of a state line, the Klamath Hydroelectric Project is one single project, under one single FERC license, all parts of the Project are designed to work together and interact in various ways – and all parts affect the waters of the State of California. California case law also requires that a proposed project *must be analyzed as a whole*, not broken into separate parts to avoid CEQA analysis.[10]

(7) CopCo 1 Removal Means Immediate Silting Up of the Much Smaller CopCo 2 Dam Just Below: The CopCo 1 Dam is just upriver from the much smaller CopCo 2 Dam. Since Copco 1 was the first dam built in the system (circa 1916), it naturally has the most sediment trapped behind it in its large reservoir, and by blocking this sediment it has greatly reduced the sediment inflows to the much smaller CopCo 2 dam and reservoir built many years later. Thus removal of the Copco 1 Dam while retaining the CopCo 2 Dam (a proposed Alternative in both the FERC and KHSA EIS process) would almost immediately result in the complete silting up of the remaining lower CopCo 2 dam, which has almost no remaining reservoir capacity to store this sediment, quickly making it dysfunctional as a dam

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[10] See *Calif. Farm Bureau Federation v. California Wildlife Conservation Board* (App. 3 Dist. 2006, 49 Cal.Rptr.3d 169, 143 Cal.App.4th 173 ("Improper for an agency to divide a project into separate parts to avoid CEQA analysis"), and *San Joaquin Raptor Rescue Center vs. County of Merced* (App. 5 Dist. 2007), 57 Cal.Rptr.3d 663, 149 Cal.App.4th 654, as modified ("The entirety of a project must be described in an EIR, and not some smaller portion of it.").

and forcing the CopCo 2 turbines to be shut off. As a completely silted-up dam it may also then become a serious safety hazard. Failure to acknowledge or address these CopCo No. 2 siltation issues was one of the lacks of the FERC FEIS in its analysis of its "Retirement of CopCo 1 and Iron Gate Developments" alternative.

Since without CopCo 1 Dam to catch sediment, the CopCo 2 Dam would silt up almost immediately (within weeks, even days) and then also have to be retired or removed, its theoretical retention in any proposed Alternative would be more or less meaningless. Therefore we strongly recommend that the CopCo Dams Nos. 1 & 2 be considered for removal *together* as part of every analyzed scenario.

(8) Ramping Rates Contemplated at J.C. Boyle in the Federal Mandatory Conditions Were Developed With the Presumption that Iron Gate Dam Would Remain in Place to Moderate Extreme Flow Changes: Another problem with the FERC EIS analysis is that it did not take into account that, should Iron Gate Dam and Copco Dams Nos. 1 & 2 all be removed, the intense peaking flow changes at J.C. Boyle would rapidly raise and lower the flows (and thus the height) of the Klamath River on a daily basis, far downstream into California. This is precisely what happened time and again before Iron Gate Dam was constructed, leading to massive losses of salmon and other fish species by periodically dewatering large areas of river edge habitat in which they typically lay their eggs, and by adult and juvenile strandings.[11]

(9) Implementing Tribal Water Quality Standards: The Water Board must consider and implement all Tribal Clean Water Act standards, including those from the Hoopa Valley, Yurok, and Karuk Tribes. At least the Hoopa Valley Tribe's standards have been approved by the US EPA, and so must be incorporated in the Water Board's standards by law. Under the Clean Water Act, the Hoopa Valley Tribe must be considered as equivalent to a "state" in this certification process. Our understanding is that similar standards adopted by the Yurok Tribe are also currently under EPA consideration, and may be approved in the near future.

10) Consistency With Federal and State Fish Recovery Plans and Other State Laws: Under CEQA, the Water Board must also make sure that any 401 Certifications, and any water quality standards required of PacifiCorp, are consistent with various regional Klamath fishery restoration Plans. These Plans include the *Long-Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program* (January 1991 and various updates) created pursuant to the Klamath Fishery Restoration Act of 1986 (the "Klamath Act").[12] This law is still in effect and mandates various efforts to restore salmon fisheries and their habitat to the Klamath Basin, which the *Long-Range Plan* delineates in greater detail.

Coho salmon in the Klamath are also federally protected as "threatened with extinction" under the federal Endangered Species Act (ESA) (16 U.S.C. § 1531 *et seq*.), as part of what is called the "Southern Oregon/Northern California Coho (SONCC)" population unit. In fulfilling its obligations under the ESA, the National Marine Fisheries Service (NMFS) on 30 September 2014 formally released its *Southern Oregon/Northern California Coast (SONCC) Coho Recovery Plan*. Moreover,

[11] See Expert Report of Mike Rode, PCFFA/IFR Comments 23 February 2009, Attachment 1, Sec. 5.5 (Power Peaking Operations) at pp. 9-10.
[12] The Klamath Act was signed into law as Public Law 99-552 (Oct. 27, 1986), codified at 16 U.S.C. §460ss-3 et seq. The Long Range Plan is available at: http://www.krisweb.com/biblio/gen_usfws_kierassoc_1991_lrp.pdf.

NMFS has prepared and formally released a prior Klamath coho recovery plan that is specific to threatened coho sub-populations within the Klamath mainstem river pursuant to separate requirements of the Magnuson-Stevens Reauthorization Act adopted in 2007, titled *Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan* (July 10, 2007).[13] The State Water Board's certification process should also be consistent with and take these formal federal Klamath coho recovery plans into account.

Coho salmon are not only federally protected under the federal ESA, but also listed by the State of California under the California Endangered Species Act (CESA) as of 2003. On February 4, 2004, the California Fish & Game Commission formally approved the *Recovery Strategy for California Coho Salmon* to guide future coho restoration efforts in the state, including coho recovery efforts on the Klamath River. There are nineteen (19) specific strategies in this document for the Klamath mainstem, including the following most relevant to this 401 Certification process:

> "KR-HU-04. Develop a plan, including a feasibility analysis, for coho salmon passage over and above Iron Gate and Copco dams to restore access to historic habitat.
>
> "KR-HU-10. Support efforts to improve quality of water entering the Klamath River mainstem from the upper Klamath River Basin.
>
> "KR-HU-11. Perform cost/benefit analysis of full or partial hydroelectric project removal for the purposes of improving water quality, coho salmon passage, and sediment transport.
>
> "KR-HU-13. Ensure that uplands in key cold-water tributaries are managed in a way that preserves their cold-water thermal regime.
>
> "KR-HU-19. Conduct studies in and around the Klamath River Hydroelectric Project to see if the project is contributing to habitat for the *ceratomyxosis* intermediate host.
>
> "HR-HU-20. Restore appropriate course sediment supply and transport near Iron Gate Dam. Means to achieve this could include full or partial removal of the Klamath River Project, or gravel introduction such as is done below other major dams (e.g., Trinity Dam)."

These specific mitigation measures should also be considered as high priority mitigation measures, as well as legal mandates for state action, necessary under CESA. There are also many more *Recovery Strategy for California Coho Salmon* general fish conservation and recovery measures that would apply to coho salmon in the Klamath below Iron Gate Dam that should also be considered in your analysis. This document is readily available from the California Department of Fish and Wildlife (CDFW), which also has a Coho Recovery Team (CRT) in place to assure compliance with these mitigation measures. The CDFW should be consulted by the Water Board Staff as to how best to implement these

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[13] The NMFS 2014 SONCC Coho Recovery Plan is available at: www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/southern_oregon_northern_california_coast/SONCC_recovery_plan.html. The NMFS Magnuson Act Klamath Coho Recovery Plan is cited as: National Marine Fisheries Service. 2007. *Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan*. Prepared by Rogers, F. R., I. V. Lagomarsino and J. A. Simondet for the National Marine Fisheries Service, Long Beach, CA. 48 pp. Available at: www.westcoast.fisheries.noaa.gov/publications/Klamath/msa_klamath_coho_recoveryplan.pdf.

mitigation measures within the 401 Certification Process.

Finally, it should be noted that the Klamath Hydropower Project remains in continuous violation of fish protections in the California Fish and Game Code §5937, which reads:

> "**Sec. 5937.** The owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam. During the minimum flow of water in any river or stream, permission may be granted by the department to the owner of any dam to allow sufficient water to pass through a culvert, waste gate, or over or around the dam, to keep in good condition any fish that may be planted or exist below the dam, when, in the judgment of the department, it is impracticable or detrimental to the owner to pass the water through the fishway."

Given the many negative water quality impacts from the Klamath Dams on downriver salmon fisheries, and the immense fish losses these impacts have caused to these valuable runs, including contributing to the largest adult fish kill ever recorded in the U.S., during the massive 2002 adult spawner fish kill, it could hardly be said that the salmon runs of the Klamath are in "good condition."

And finally, there are several Biological Opinions by both NMFS and the USFWS that apply to all federal actions in the Klamath Basin, as well as several Habitat Conservation Plans to which PacifiCorp is a Party, that also apply, and for which any 401 Certification must be consistent. Those documents are available from their respective authorizing agency.

(11) Irrelevancy of Sources of Nutrient Inflows From Above the KHP: There are clearly problems with elevated nutrient inflows, particularly phosphates, first coming into the Klamath Hydropower Project area from Upper Klamath Lake -- both from anthropogenic as well as natural sources. How these sources divide up between anthropogenic and natural sources, however, *is not relevant* to this KHP 401 Certification process.

While PacifiCorp may not be responsible for, nor can it avoid, most of these nutrient inflows from Upper Klamath Lake which come from areas hydrologically above the Klamath Hydroelectric Project (KHP), nevertheless, PacifiCorp's KHP must still operate within the environmental conditions it finds itself in, *including* any naturally nutrient-enriched water sources.

PacifiCorp is responsible for, *and must mitigate for*, all conditions created by its KHP dams and their operations (and their associated slackened flow, warm-water reservoirs) where, *given already enriched nutrient loads from above the Project*, these nutrients biologically combine with the slack-flow, warm-water conditions artificially created within PacifiCorp's KHP reservoirs to concentrate and "cook" these nutrients under ideal warm-water conditions to contribute to deteriorating water quality and widespread algae blooms. It is these many additional water quality problems, all traceable to configuration and/or operations of the dams, that cause water quality not to meet California state water quality standards, and which greatly and adversely impact lower river salmon as well as in-Project resident fish and other aquatic wildlife. It is these additional impacts that must be analyzed.

And finally, if additional efforts must be made by PacifiCorp to make sure its proposed Project will meet state water quality standards within the KHP because of already degraded conditions in the river, they must nevertheless meet those standards in water discharges from their Project. It is the company asking for the state's permission to use the river, *and not the river itself*, which must bear the burden of any failures to meet these standards.

FISHERIES-RELATED KHP ADVERSE IMPACTS

(1) The KHP's Biologically Adverse Impacts on Biologically and Economically Important Salmon Fisheries: As noted below, before European development of the Klamath River, there were an estimated 660,000 to 1.1 million adult salmon returning to the Klamath River, with an average of about 880,000, predominately spring-run Chinook, returning each year to spawn. This made the Klamath River the third most productive salmon river system in the continental U.S, ranking after only the Columbia and Sacramento-San Joaquin River systems in salmon productivity.

Today, however, the Klamath Hydroelectric Project (KHP) has contributed substantially to an 88% reduction in salmon runs on the Klamath in many different ways. KHP adverse impacts include but are not limited to:

- Physically blocking salmonid access to habitat above Iron Gate Dam from between 300 (for Chinook) and 600 (for steelhead) stream miles of once fully occupied habitat that historically supported runs of between 149,734 to 438,023 adult fish (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 9: Huntington, 2004) and today could potentially support at a conservative estimate 111,230 adult fish (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 10: Huntington, 2006).

- KHP reservoirs inundate and dilute the benefits of some of the most important cold-water tributaries in the basin, historically offering vitally important thermal refugia for salmonids, including Jenny, Spencer, Shovel and Fall Creeks. Occupying these cold water refugia areas during hot summer months was an important strategy for salmonids to survive summer periods of very warm water temperatures. Several former important cold water streams (such as Jenny Creek) now flow *directly* into warm water reservoirs such as Iron Gate where their thermal refugia benefits quickly disappear. Warm-water reservoirs also are high water temperature thermal barriers (even with future fish passage) that will continue to block access to several of these once-important spawning and rearing tributaries. Several formerly important cold-water groundwater springs likewise now disappear into the reservoirs is several places, their cold-water benefits also lost (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 1, Mike Rode Sec. 5.1 (pg. 9)).

- The CopCo 1 and Iron Gate reservoirs particularly slow down and spread out the water that would naturally flow quickly through the river without the dams, and this allows sunlight to heat it up to near-fatal temperatures for downstream cold-water salmon. Warmer waters also favor the growth and predation by warm-water fish predators generally, increasing predation against cold-water salmon whose defenses are already weakened by these warmer waters. Also, adult salmon typically die when exposed to prolonged water temperatures of 20^{o} Centigrade (68^{o} Fahrenheit) or higher, but today reservoir water temperatures typically exceed such temperatures for several weeks of each year. Elevated water temperatures also not only encourage toxic algae blooms but also encourage warm-water parasites like *Ceratomyxa shasta* and *Parvicapsula minibicornis*, which are fatal to many juvenile salmon, resulting in the mortality equivalent of a major fish kill nearly every year, even far below the dams. Currently these diseases result in high rates of juvenile salmonid mortality -- as high as 90% in some studies (see PCFFA/IFR Scoping Comments 23 February 2009, Attachments 1 (Rode), sec. 5.4.1 (pp. 12-14); Attachment 2 (Kann) on toxic algae studies; Attachments 15 and 16 on the prevalence of fish diseases in juvenile salmonids just below the dams; and the FERC FEIS pp. 3-304 through 3-312).[14]

- Warmed river waters caused by the KHP also stress both adults and juveniles salmon generally, making them much more susceptible to both predators and fish pathogens even far downriver from the dams. Water temperatures consistently above 20° Centigrade (68° Fahrenheit) are fatal to salmon. Juvenile salmon are even more stressed by warm water temperatures than adults. The U.S. Environmental Protection Agency recommends temperature limits for the protection of various life stages of Chinook salmon, including that maximum seven-day floating average water temperatures not exceed 13° C. for spawning times. The KHP has directly changed the hydrology, thermal mass and temperature profiles vs. time of the river below it so that "water temperatures in the mainstem river below Iron Gate Dam are cooler in the spring by up to 5° C. and warmer in late summer and fall by up to 5° C. than they would otherwise be, absent the reservoirs" (see Attachment 1 (Rode), Sec.5.4.1, pg. 13 and Figure 5.4.1-1 (pg. 23); see also FERC FEIS, pp. 2-208 to 2-216). Additional water temperature modeling prepared for the KHSA FEIS/FEIR process confirmed this KHP-driven temperature shift.

- Blockage of access by the KHP to the upper river has dramatically changed the species composition of the river's salmonid runs greatly, as well as their seasonal migration timing. Formerly, Spring-run Chinook were the dominant stocks in the river, while today it is Fall-run Chinook. Steelhead runs, also once abundant above the dams, have now been severely limited to below Iron Gate dam and have nearly disappeared. Coho are greatly reduced in number to the point of federal and state ESA listings, and some stocks of salmon (such as pink salmon) that were once found in the Klamath are now presumed extinct (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 1 (Rode), Sec. 4.1.1, pp. 3-5; see also FERC FEIS pp. 2-208 to 2-212).

(2) Changed River Ecosystems: The synergistic combination of decades of poor water quality and altered river flows caused by the dams have dramatically changed the riverine ecosystems in many ways. These changes need to be examined carefully as part of the EIR analysis. Some (but not all) of these impacts are delineated in many places in the FERC FEIS in Section 3.0, and confirmed in the KHSA FEIS/FEIR in various studies.

(3) Changed River Morphology: Numerous changes to the historical morphology of the river have also been caused by the dams, including reductions of the number of "flood event" flows that typically disturbed the river gravel beds and stream edge riparian vegetation more frequently prior to construction of the dams. These changes have also resulted in impacts to lower river fisheries by

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[14] "The Klamath Hydroelectric Project has likely contributed to conditions that foster disease losses in the lower Klamath River by (1) increasing the density of spawning adult fall Chinook salmon downstream of Iron Gate Dam; (2) promoting the development of attached algae beds that provide favorable habitat for the polychaete alternate host for *C. shasta* and *P. minibicornis*; and (3) contributing to water quality conditions that increase the stress level of juvenile and adult migrants and increase their susceptibility to disease." (FERC FEIS, pg. 3-309)

reducing natural riparian scouring, which in turn allows more growth of permanent stream edge vegetation, which in turn reduces edge habitat necessary for juvenile salmonids during their early rearing periods. These impacts are discussed in detail in the FERC FEIS, particularly at pp. 3-27 through 3-57.

(4) Spawning Gravel Impoverishment Below the Dams: The KHP dams also trap and hold back natural gravel-rich sediments, thereby impoverishing salmon spawning gravel beds for as much as 50 miles downriver of Iron Gate Dam.[15] This greatly limits the ability of both Chinook and coho salmon (as well as steelhead) to spawn in the river at all, as well as pushes them out of some of their best remaining habitat (see FERC FEIS, pp. 3-41 through 3-51 inclusive). This KHP-driven impact has doubtless contributed greatly to salmon declines in the lower Klamath River over many decades, even well below the dams. This is also an additional fisheries impact above and beyond that impact produced by simple blockage of salmonids from their once-occupied spawning and rearing habitat above the dams, which were built without adequate fish passage.

(5) Synergistic Causal Links Between Dams and Virulent Lower River Fish Pathogens: Poor water quality and altered river morphology produced by the Klamath Hydropower Project (KHP), particularly by both in synergistic combination, also contribute to higher than normal incidence of various fish diseases such as *Ceratomyxa shasta* and *Parvicapsula minibicornis*. Both these virulent warm-water parasites are simply more active (and thus juvenile exposures more frequent and more likely to be fatal) in the warmer river waters that now occur every summer for longer periods than historically occurred. Juvenile fish are especially vulnerable to these virulent pathogens. When juvenile salmonids contract either of these virulent fish diseases it is frequently fatal, even more so when juvenile fish (as is all too common) contract both. Fish already stressed by higher than normal water temperatures are that much more vulnerable to such infections.

Among other synergistic casual factors, the dams first impoverish natural spawning gravel recruitment as well as reduce the number of natural high flow (flooding) events in ways that prevent natural gravel from rolling rapidly downriver as normally would have occurred. Rapidly moving gravel naturally cleans itself (and large portions of the river bed) of algae, and thus reduces the growth and prevalence of the algal species that harbor (and are the major food sources) for the polychaete worm *Manayunkia speciosa* that is the alternative disease vector for *Ceratomyxa shasta.* In other words, less gravel with fewer cleansing flows results in far more algal growth, which harbors more polychaete worms which carry more *C. shasta* spores, which then leads to much greater *C. shasta* exposures of juvenile salmonids than would otherwise naturally have occurred. The *P. minibicornis* pathogen has a similar complex lifecycle.

Additionally, cumulative changes in the annual water thermograph have meant lower river water temperatures in the spring, which have delayed juvenile salmon growth in early springtime to the point where they out-migrate today *several weeks later than historically occurred*, when early springtime river temperatures are typically much warmer. Both growth and timing of out-migration as smolts is affected by higher ambient water temperatures:

> "The cumulative effect of delayed spawning in the fall with reduced fry growth rates in the

[15] "[W]e conclude that a sediment deficit could easily exist to the confluence with the Scott River (RM 143)." FERC FEIS, pg. 3-49.

> spring is that rearing and outmigration are now generally occurring at a later date than would have occurred pre-KHP, thus subjecting these fish to even greater temperature and disease exposure (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 1 (Rode), pp. 13-14).

Likewise, the larger thermal mass of the reservoirs causes water to warm faster in late spring and to remain at higher temperatures for longer periods of time throughout the summer and fall. These earlier, warmer waters cause *Ceratomyxa shasta* spores to emerge earlier – causing more and longer overlap between juvenile fish remaining later and pathogens emerging earlier today than historically occurred. Thus more juvenile salmon are now in the river when *C. shasta* spores emerge and these spores are more contagious – resulting today in *far* greater juvenile mortalities than normally occurred from this fish pathogen prior to dam construction. Juvenile Chinook are especially susceptible to *C. shasta*, and *once infected nearly all will die* before reaching adulthood. These disease impacts of the KHP are included in the FERC FEIS analysis, particularly at pp. 3-304 through 3-315).

Such a large portion of these juveniles runs are now infected annually that fish pathologists recently observed that:

> "Depending on the juvenile Klamath River salmon population size and smolt to adult return ratio, the effective number of adult salmon lost to *C. shasta* as juveniles could rival the 33,000+ adult salmon lost in the 2002 Klamath River Fish Die-off." (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 15, Summary pg. 1).

The reference to the "2002 die-off" is to the largest adult fish kill ever recorded in the Klamath, said to be the worst in U.S. history, in which it was ultimately determined that more than 78,000 adult fish died before they could spawn as they tried to travel upriver. The loss of nearly this entire year-class of adult spawners devastated the west coast salmon fishery, resulting in far fewer eggs being laid and thus fewer juveniles outmigrating in 2003, and this eventually resulted in so few harvestable adults coming back in 2006 that the Secretary of Commerce declared a Klamath fishery disaster in 2006 and imposed widespread closures (see PCFFA/IFR Scoping Comments 23 February 2009, Attachments 12 and 13). Economic damages to the west coast salmon fishing industry from the 2006 were estimated at over $100 million, and Congress appropriated $60.4 million in disaster assistance to these affected fishing families and communities.

Adult fish kills make national headlines, but massive *juvenile* fish kills are silent and mostly hidden – but have economic impacts that may be just as devastating. The disease-caused equivalent of one of these types of major fish kills is apparently happening *nearly every year*, but instead of happening to the spawning adults it happens to the juvenile salmon populations whose wholesale demise is much harder to directly observe (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 1 (Rode), Sec. 7.0, pp. 15- 17; Attachments 15 and 16 for fish pathogen surveys during 2004 and 2007). As seen above, there is a direct causal link between changes created in the river from the Klamath Hydroelectric Project (KHP) and these nearly annual major fish kills.

SOCIO-ECONOMIC IMPACTS OF KLAMATH SALMON DECLINES ON FISHING-DEPENDENT COASTAL COMMUNITIES

(1) Original Populations of Salmon on the Klamath: Before European development of the

Klamath River, there were an estimated 660,000 to 1.1 million adult salmon returning to the Klamath River, with an average of about 880,000, predominately spring-run Chinook, returning each year to spawn (see *Estimates of Pre-Development Klamath River Salmon Run Size*, PCFFA/IFR Scoping Comments 23 February 2009, Attachment 4). Salmonids were also historically widely distributed throughout the basin, with some species such as steelhead abundant well above Upper Klamath Lake (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 3 Hamilton, et al.).[16]

Today's river water quality conditions are so degraded, and loss of habitat through dam blockage and other factors so devastating, that salmonid runs in the Klamath basin (including both wild and hatchery fish) are now only about 12% of what they once were, averaging only about 105,000 adult returns over the time frame of 1978-2007, but the majority of even these are hatchery fish in origin.

This means that the wild fish runs still remaining (i.e., fish produced in the wild and not dependent on hatcheries for any portion of their lifecycle) are considerably *less* than 12% of their historic runs size (probably about 6%), though such estimates vary. ESA-listed coho salmon are down to less than 1-2% of their historic abundance in the basin, and were never as abundant as Chinook, which is why they are now federally and state protected.[17]

Prior to dam construction, the predominant salmonid population above the current location of Iron Gate Dam were the Spring-run Chinook, which may have historically outnumbered Fall-run Chinook in total numbers throughout the basin.[18] Today by far the dominant population is Fall-run Chinook, with Spring-run Chinook (which depended upon habitat now mostly blocked by the dams) nearly extirpated in the river except for a few remnant populations spawning in the Salmon River and just below Iron Gate Dam. Since steelhead depended upon upper river habitat (now above the dams) more than other salmonids, steelhead too are greatly reduced in numbers in the Klamath Basin except in portions of the Trinity River, the Klamath's major tributary.

Two other species of salmonids known to exist in the river before the KHP dams blocked it were chum salmon (*O. keta*) and pink salmon (*O. gorbuscha*). However, today chum salmon are extremely rare in the Klamath (and thought to be functionally extinct) and pink salmon, once thought relatively abundant, are extinct.

Thus the very existence of the Klamath Hydropower Project (KHP) dams has dramatically changed the anadromous species composition as well as run timing for all the salmonid species in the entire Klamath River. This has adversely affected the ability of these species and sub-species to remain viable and to respond to changed environmental conditions. We do not believe that these fundamental impacts result from the very existence of the four KHP main dams, and cannot be mitigated nor reversed without four-dam removal.

(2) What Is the Value of a Restored Klamath River Salmon Fishery? The present net economic value of a restored pre-development sized Klamath Basin salmon fishery can also be estimated,

[16] The term "salmonids" is a biological category which includes closely related members of the fish genus *Oncorhynchus* such as Chinook (*O. tshawtscha*), and coho (*O. kisutch*) salmon, as well as closely related anadromous steelhead (*O. mykiss gairdneri*) and other species.
[17] See PCFFA/IFR Scoping Comments 23 February 2009, Attachment 1, Expert Report of Mike Rode, Figure 4.1.1-1 (pg. 21).
[18] See FERC FEIS pp. 2-208 to 2-212.

depending on discount rate assumed. At an assumed discount rate of 3%, the net present economic value of this fishery would have been between $2.634 and $4.347 *billion* dollars, for a net present economic value to the regional economy of just over $3.49 billion dollars (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 4, Table 4). Other independent studies, using very different methodologies, have come to similarly large value numbers (see PCFFA/IFR Scoping Comments 23 February 2009, USGS Aaron Douglas study, Attachment 5).

Today, even with stringent fisheries management and at least 20 years of targeted habitat restoration efforts, the biological carrying capacity of the Klamath Basin is still so seriously eroded that from 1978-2002, the average Fall-run Chinook run size has been only 85,855 – just 9.7% of historic abundances. Subtracting hatchery-raised spawners from these totals gives only 60,723 natural fall Chinook spawners returning, on average, during this time period – *just 6.9% of the historic run size* (see FERC FEIS, pg. 3-195 (Table 3-48)). And this is for the most *abundant* stock – the Fall-run Chinook. This does not count other species, particularly coho salmon, that are so depressed they require ESA protection,[19] nor does it count Spring-run Chinook, once the dominant run throughout the upper basin, that have today been all but extirpated by the Klamath Hydroelectric Project (KHP) dams.

Assuming (as a rough estimate) that a proportional reduction from pre-development to current run sizes (even counting hatchery fish as partial mitigation) would create a proportional decrease in harvest and thus fishery values, with all other factors kept the same, then the value *reduction* of the present day Klamath fishery would be a 100.0% - 9.7% = 90.3 % reduction in harvest capacity today from historic capacity. *This means that the net loss of net economic value of the Klamath salmon fishery to the regional economy – in large part caused by the Klamath dams – would be calculated as a loss of value of $3.15 billion dollars.* This may be how much the Klamath dams have directly cost the regional fishing-based economy. This does not even begin to count secondary economic costs due to "weak stock management" that requires widespread ocean coastal fishing closures, such as we experienced in 2006, that can hit ocean fishing ports far to the north and south of the Klamath over more than 700 miles of coastline.[20]

While the impact of the Klamath Project dams is certainly not the only impact on these stocks or their habitat, it is almost certainly the single largest impact, as well as one of the few impacts we have some real control over, through FERC relicensing.

A major impact of the Klamath Dams is that when the losses of Klamath Fall-run Chinook are high, this can trigger "weak stock management" closures of ocean fisheries all up and down the coast. Under the federal Magnuson-Steven Act "Salmon Fishery Management Plan," the Klamath Fall-run Chinook are the key stock around which all other harvest opportunities are regulated in California, Oregon and Washington. Since both weak and strong stocks intermingle in the ocean, all ocean fisheries must be halted – even on otherwise abundant stocks from other river systems – whenever intermingling Klamath Fall-run Chinook drop below a certain level, or there would be normal harvest impacts that would bring them below the "minimum spawner floor" of 35,000 adults returning to spawn in the river. This 35,000 minimum spawner floor is the minimum number of spawning adults *absolutely necessary*

[19] Coho salmon in the Klamath Basin are estimated to be at between 1-2% of historic abundance, and are both federally and state listed under the Federal and California Endangered Species Acts.

[20] See FERC FEIS pp. 2-230 to 3-241for a more extensive discussion of the "weak stock management" problem and how it causes extensive coastal ocean fishing closures whenever Klamath Fall-run Chinook are in very low abundance.

to perpetuate the species to the next generation. Fishery managers must diligently restrict total cumulative harvest impacts on the Klamath Fall-run Chinook to always make sure at least the 35,000 "minimum spawner floor" can be met each year.[21] To put these limits into perspective, the "minimum spawner floor" goal of at least 35,000 returning spawners is just 4% of the 880,000 estimated annual average historic run size.

This situation also appears to be worsening. Poor in-river conditions and disease problems are so pervasive in the Klamath River that fishery managers are now hard pressed to achieve the "spawner floor" of 35,000 returning Klamath adult Fall-run Chinook, *even with zero fishing impacts*. For instance, the ocean commercial fishery in 2006 suffered through a nearly total closure (from near Monterey, CA to the OR-WA border) to prevent as much impact as possible on Klamath Fall-run Chinook that might intermingle with otherwise abundant stocks. Economic losses to California and Oregon fishing-dependent economies in 2006 alone were estimated at more than $100 million. Congress ultimately appropriated $60.4 million in direct disaster assistance to these communities.[22]

With improvements in water quality from dam removal, a large part of the value of the Klamath fishery could be restored, giving fish access once again to hundreds of miles of historic spawning and rearing habitat and improving juvenile survival throughout the system because of better water quality. As noted in the FERC FEIS itself:

> "Huntington (2006) estimates that there are 355.6 miles of existing stream habitat that is currently or was recently capable of supporting anadromous salmonids in tributaries to Upper Klamath Lake and another 70.4 miles that he considers recoverable within the next 30 to 50 years (Table 3-67). Although much of this habitat has been degraded, substantial portions in the Wood and Williamson river systems are considered to be in good condition (Huntington et al., 2006), and habitat conditions are expected to improve over time, due to numerous ongoing restoration efforts in the upper basin (FWS, 2006c)." FERC FEIS pg. 3-284.

Huntington (2004) estimated that the historic returns of adult Chinook salmon to areas upstream of Upper Klamath Lake were between 149,734 and 438,023 fish per year, and were most likely in the lower end of this range (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 9).

Huntington (2006) (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 10) later

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[21] Since 2006 a minor amendment to the Pacific Fishery Management Council's *Salmon Fishery Management Plan* (Amendment 15) has been formally adopted to allow, in some years, a *de minimus* impact exception to the 35,000 minimum spawner floor to avoid massive closures such as occurred in 2006, but this exception is still very narrow and only applies to truly *de minimus* impacts that must be made up later. Otherwise ocean salmon fishery management remains the same as in 2006, i.e., it is largely still controlled by the abundance of Klamath Fall-rim Chinook.

[22] Board Staff heard it stated several times in the Yreka Scoping Hearing (on 1/26/16) that the Klamath salmon are coming back now in "record numbers," usually asserted as a defense against the need for dam removal. This is a complete fabrication. The so-called "large runs" of recent years in the Klamath only look good by comparison with very low runs of 2005-2007 which, had that continued as the long-term trend, would have led to their ultimate extinction. Current runs are typically only about 10-15% of historic, pre-development runs sizes, at least half of which are artificially produced hatchery fish in origin, and have also been supported by several years of unusually good ocean conditions. In some years (2006 being the most recent example) fisheries managers cannot maintain even the "minimum spawner floor" of 35,000 adult Fall-run Chinook, which is just 4% of the historic run size and is the minimum number of spawners necessary just to replace that generation.

amended his estimates, after additional field research, to say that the upper basin habitat could support an additional run of 111,230 Chinook salmon once fish passage is restored, acknowledging that this was a conservative estimate. Once problems with poor water quality, high water temperatures and conditions that encourage various fish parasites are also cured by dam removal, juvenile survival rates in the lower river would also improve, therefore allowing more fish to survive to adulthood and return as harvestable adults.

In September 2011, as part of the KHSA NEPA/CEQA process, similar estimates of improvements in salmon runs in the Klamath Basin that would likely occur with four-dam removal of the KHP were also made, concluding that the average annual Klamath salmon Fall-run Chinook size would nearly double after four-dam removal. See *Forecasting the Response of Klamath Basin Chinook Populations to Dam Removal and Restoration of Anadromy versus No Action*, by Noble Hendrix, available at: http://klamathrestoration.gov/sites/klamathrestoration.gov/files/EDRRA%20Report%20Hendrix%2012.15..11.pdf.

Other studies have concluded that if water quality were improved by removal of the dams, and given access to the additional habitat above the dams, it is therefore highly likely that an additional 100,000 adult Fall-run Chinook would come back to the river after only a few fish generations. Assuming only a 50% harvest rate on these adult returns, this means an additional 50,000 fish might be available for some form of harvest as a result of dam removal. Then turning to PCFFA/IFR Scoping Comments 23 February 2009, Attachment 6, Table 3 (from Meyer Resources, (1984)), with the numbers updated to 2015 dollars[23] for the annual economic benefits to the regional economy per 50,000 additional harvested adult fish, in market benefits *only* (to be conservative) this would mean an additional economic benefit to the regional economy of:

Low Value: $396,940 per 1,000 fish x 50 = $19,847,000 in restored economic benefits

This would likely be a low or conservative value of the average additional annual economic personal impact benefits that would accrue to the fishing-based and regional economy from four-dam removal and subsequent water quality improvements (i.e., resulting in increased salmonid survival rates as well as larger populations).

It should be particularly noted that this conservative estimate of salmon harvest economic benefits which could be readily derived from Klamath dam removal *exceeds* the "annual net benefits" of *all* of the FERC FEIS options except for the "no action" alternative, which of course is not a legal option. With an incremental annual average increase of personal income impacts from restored fisheries conservatively estimated at $19,847,000, this is also more than enough to offset the FERC-estimated annual costs of the Four-Dam Removal Option of -$13,186,870 (see FERC FEIS, pg. 4-2 (Table 4-3)) [which when converted from 2006 to 2015 dollars = -$15,494,570), *by more than $4.35 million/year*.

In other words, using FERC Staff's own FEIS cost estimates, it appears that the most economically beneficial course to follow for society as a whole is to remove all four of the KHP hydropower dams (Iron Gate, CopCo 1 & 2 and J.C. Boyle) in order to restore the lost but very valuable salmon and steelhead fisheries these dams originally destroyed.

[23] Using the standard CPI adjustment of 2.28 to convert 1984 dollars to 2015 dollars. CPI adjustments can be easily calculated on the Internet at: http://data.bls.gov/cgi-bin/cpicalc.pl.

It should be noted, however, that these restored Klamath fishery economic benefits could only be fully achieved under a full KHP "Four Dam Removal" option. Anything *less* than a full removal of the KHP dams would mean some dams (and reservoirs) still in place, and this would still mean: (1) significant continued fish mortalities due to artificial fish passage as opposed to full volitional free passage in a restored river, since no artificially engineered fish passage system is perfect; (2) remaining large thermal barriers and other problems for salmon migration in the reservoirs behind the dams because reservoirs would still heat up, adding to salmonid stress, encouraging warm-water reservoir predators, and decreasing resistance to diseases; (3) remaining good growing conditions for toxic and other species of algae with all their associated multiple water quality problems.

The above "restored fishery benefits" numbers are also conservative figures in that they exclude *all* non-market benefits. They also exclude other and potentially *much* greater economic benefits to commercial ocean salmon fishermen which would accrue simply by having more fish in the system and thus being able to meet the "spawner floor" of 35,000 minimum escapement requirements far more frequently – thus eliminating current severe restrictions such as we saw in 2005, and worse in 2006, on ocean commercial fishermen that are triggered by Klamath salmon populations declines, and thus allowing fishermen far more access to otherwise abundant intermingling oceans stocks from other basins, primarily from the California Central Valley hatcheries.

The KHSA NEPA/CEQA analysis confirmed the restored commercial salmon fishery benefits that would likely accrue from four-dam removal of the KHSA, calculating roughly comparable additional benefits in terms of net increases in commercial fishery income and number of fishery-related jobs, and also concluding that under KHP four-dam removal scenarios the chances of widespread, Klamath-driven commercial fisheries closure caused by inability to maintain the 35,000 minimum spawner floor for returning Klamath River spawning Fall-run Chinook would be greatly decreased. See KHSA NEPA/CEQA report Commercial Fishing Economics Technical Report, by Cynthia Thomson, Updated 31 August 2012, which is enclosed with these comments as ATTACHMENT C.

Fewer fishery restrictions of the sort that required a 90% ocean fishery closure in 2006 and a 60% ocean fishery closure in 2005 over more than 700 miles of Northern California and Oregon coastline has great economic value to the west coast salmon fleet. Had these additional Klamath fish been available during those years, there would have been no question about meeting the "spawner floor," and this would have saved the coastal commercial fishing industry from draconian closures that cost their coastal communities well over $100 million in economic losses and damages -- all caused by mandatory Klamath-driven closures because of very low in-river survival rates, in turn caused in some large part because of long-term KHP-induced adverse ecological changes in the river.

Some of the potential economic "restored fishery benefits" that may accrue to in-river sportsfishing businesses (particularly within Siskiyou County) from a restored upper basin salmon fishery after dam decommissioning have also been delineated in the recent study, *Preliminary Economic Assessment of Dam Removal: The Klamath River* (January 31, 2006), by Sarah A. Kruze and Astrid Scholz (Kruze, S. A. and A. Scholz (2006)) (see PCFFA/IFR Scoping Comments 23 February 2009, Attachment 8), in which the authors have estimated additional fisheries economic benefits of up to $140 million annually from KHP four-dam decommissioning. Similar types of estimates were made for the KHSA NEPA/CEQA process and are available at: www.klamathrestoration.gov under Technical Studies and Reports (Economics).

Additional ecological benefits of KHP four-dam removal might also include adding an addition of 10% or more to existing ESA-listed coho habitat, making them far more viable and resistant to extinction, and finally moving them toward future recovery. This benefit was acknowledged in a Ruling in the EPAct Hearings by Judge McKenna as Finding 7-16:

> "Over time, access to habitat above Iron Gate Dam would benefit the Coho salmon population by: a) extending the range and distribution of the species thereby increasing the Coho salmon's reproductive potential; b) increase genetic diversity in the Coho stocks; c) reduce the species vulnerability to the impacts of degradation; and d) increase the abundance of the Coho population.[24]

Reduced need for restrictive ESA-driven land use regulation also has great value (though exact amounts are hard to quantify) to local landowners in terms of fewer land and water use restrictions, etc., and the hope of coho recovery and eventual delisting.

In general, neither the PacifiCorp Application nor the FERC FEIS adequately assess or evaluate the probable economic *benefits* of a restored fishery that would accompany the dam removal options, nor does it adequately assess the *severe economic damages* perpetually being suffered by coastal ocean fishing-dependent communities because of lack of Klamath fish – a lack caused in large part by the KHP dams. Many Economists have criticized that sort of one-sided consideration, where the "costs of doing nothing," i.e., the costs of the *status quo*, are systematically ignored in the costs-benefits analysis by assuming them to be part of the baseline. This is logically inappropriate. When considering environmental costs vs. benefit, <u>all</u> the benefits of <u>all</u> actions, as well as <u>all deficits</u> of <u>all</u> actions (including the environmental and social costs of merely maintaining the *status quo*), should be <u>considered together</u> for this to be a legitimate costs-benefits analysis (see ATTACHMENTS A & B to these comments concerning proper Economics methodology for such a socio-economic analysis). The fact is, the <u>costs to society</u> of the KHP's negative ecological impacts, and their related adverse socio-economic impacts, has been very much greater than the minimal value of the mere 82 megawatts of power on average that the four KHP power dams combined typically generate – which also amounts to less than 2% of PacifiCorp's total generation capacity.

One way to measure those KHP-related economic loses, and to ascertain the magnitude of these salmon declines, is to look at the recent history of salmon landings into what were once the most productive salmon ports in the lower 48 states – the salmon ports within the Klamath Management Zone (KMZ). We have done so in our Scoping Comments of 23 February 2009, Attachment 7, which is separately submitted. In summary, landings averaged over the years (1976-1980) as compared landings in these same port areas averaged over 2001-2004[25] shows huge declines during this time frame, as

[24] Evidence in the record cited by the ALJ in that Ruling was: *Aug. 23, 2006 Transcript at 163:1-2; Aug. 25, 2006 Transcript at 107:5-20; NGO Ex. 27 at 3:11-4:7 (allowing access to additional habitat does not decrease the size of the population existing below Iron Gate Dam); Yurok-Hillemeir Direct Testimony-NMFS/FWS Issue 7 at 5:7-8 (access to project area is one of the quickest ways to increase population abundance), 6:4-22; CDFG-Pisano-Ex. 1 at 5, 11:18-12:23; NMFS/FWS-Issue 7-Simondet-Ex. 1 at 5:21-6:15; NMFS/FWS-Issue 7-Williams-Ex. 1 at 6:15- 19, 7:15-9:22 (explaining that additional spatial structure reduces species vulnerability to changing environmental conditions); HVT-Franklin-Ex. 1 at 6:16-7:12 (explaining that diverse habitat leads to populations adapted to diverse life history forms and greater viability for the species); NGO ex. 4 at 11:15-28*. These documents are hereby incorporated into these comment by reference.

[25] To create a representative baseline for landing numbers by port, fishery managers always average over several years to eliminate sometimes large annual variations.

follows:

SALMON FISHERY LOSSES BY PORT AREA OVER TIME

(Average of Years 1976-1980 as compared to Average of 2001-2004 landings)

	Eureka (CA)	Crescent City (CA)	Brookings (OR)
Port Area:			
Decline (%) of Fishery:	**= 97% LOSS**	**= 87% LOSS**	**= 82% LOSS**

These precipitous losses started within a few short (3-year long) salmon generations shortly after the completion of Iron Gate Dam, the last dam in the KHP series of dams, in 1962. See also the FERC FEIS at pg. 3-235 (Table 3-55), and also the PacifiCorp *Final License Application (FLA), Socioeconomic Resource Final Technical Report*, pgs. 2-108 to 2-114 for landing loss figures to the same effect. Similar numbers as occurred on average during the 2001-2004 period prevail today in those once highly productive ports.

These absolute salmon landing losses have been *economically devastating* for these Northern California and Southern Oregon coastal port economies, translating into thousands of lost jobs, fishermen forced to relocate with their families in order to find work or to sell their boats and quit fishing, fragmented fishing-dependent communities and the fleeing of processors, ice plants, fuel depots and other allied infrastructure businesses from these communities over the last 40 years. *If even a small portion of these losses is directly or indirectly attributable to poor water quality problems, or to disease problems exacerbated by the dams, then it is far more beneficial to society as a whole to remove the Klamath dams than to keep them, knowing their economic and social costs to these many coastal communities.*

And these losses above are those suffered by the commercial salmon fishing fleet only. They do not include separate but also very large economic losses to recreational fishing-dependent small businesses throughout the lower river, nor to Tribal communities for the loss of both a source of revenues as well as a basic subsistence fishery that supports those communities and their ancient, salmon-centered cultures. *The combined cumulative socioeconomic losses to all these fisheries and all these fishing-dependent communities greatly exceeds any potential future economic benefits from hydropower production at the dams.*

In recognition of this fact, the Pacific Fishery Management Council (PFMC), which manages all ocean salmon fisheries in federal waters under the Magnuson-Stevens Fishery Management and Conservation Act (16 U.S. C. §1801 et seq.), formally endorses Klamath Project "Four-Dam Removal" as its recommended option for restoring damaged Klamath fisheries, and so noted in a letter to FERC dated April 24, 2006:

> "The value of ocean fisheries is high when Klamath natural Chinook are abundant, but can be much lower when Klamath fish constrain the catch of other healthy stocks. The Council estimates that between 1970 and 2004, the average annual personal income impacts of the

> recreational and commercial ocean salmon fishery in the area where Klamath fish are found amounted to $92 million. The constraints on the fishery in 2006 caused by the need to protect Klamath River natural fall Chinook are expected to reduce the value of this fishery to less than $33 million. In contrast, the Klamath hydropower project produces 163 megawatts with an annual net economic value of $16.3 million. NMFS notes that the 'generating capacity provided through continued Project operations is nominal ... relative to the watershed level of benefits to aquatic resources and regional and national priorities for restoring anadromous salmonids.'...
>
> "The Council believes the proposed relicensing of this project will have substantial adverse impacts on EFH [Essential Fish Habitat] in the Klamath River. The project causes harm to salmon habitat; to the health of fish stocks; to commercial, recreational, and tribal fisheries; and to fishing communities along the Oregon and California coasts and in the Klamath River basin. Consequently, the Council recommends that FERC order the immediate decommissioning and removal of the four lower Klamath River dam structures and full restoration of habitat affected by the dams and reservoirs. "

A copy of this PFMC letter has been filed in the FERC docket and is enclosed as Attachment 17 to the PCFFA/IFR Scoping Comments of 23 February 2009, separately refiled. It will also be resubmitted separately for this Record.

(3) Market Impacts of Poor Klamath Salmon Quality: The Klamath River-origin salmon are known in the fishing industry to be of increasingly poor quality due to distinctive "green algae" taste created by the salmon's exposure to excessive algae in the river. There was oral testimony in the record of the 2009 Scoping Hearings to that effect. While hard to quantify, this does adversely affect coastal and other markets for salmon, and many processors now avoid purchasing salmon caught in the Klamath River for that reason.

There are also several recent studies, including one by the State Water Board itself, showing that Klamath River adult salmon are accumulating the potent blue-green algae liver toxin microcystin in their livers and flesh, making their use for human consumption increasingly problematical. Many of those more recent studies will be provided in the Scoping comments of the Karuk Tribe.

TEMPERATURE AND OTHER KLAMATH WATER QUALITY PROBLEMS WILL BE EXACERBATED BY REGIONAL CLIMATE CHANGE

(1) Water Temperatures in the Klamath River Have Been Steadily Increasing Due To Global Climate Change. Recent studies show that Klamath River average water temperatures have been gradually, over the last several decades, increasing consistent with current projects of overall regional climate change. Bartholow (2005) found a high probability (95% confidence interval) of an 0.5o C./decade upward average summer water temperature trend and that the "season of high temperatures that are potentially stressful to salmonids has lengthened by 1 month over the period studied, and the average length of main-stem river with cool summer temperatures has declined by about 8.2 km/decade." (see Attachment 14). It is important to note that this adverse water temperature impact is above and *added* to anthropogenic temperature increases caused by the KHP. Since these higher water temperature impacts are apparently related to overall regional average temperature and climate changes of the sort projected to continue (and accelerate) for the foreseeable future over the next 30-50 years, these are foreseeable "global warming" impacts that must also be taken into account as cumulative and foreseeable future impacts under CEQA.

This makes a "Precautionary Approach" to keeping water temperatures in the river as low as possible essential. Reducing *all* anthropogenic heat sources – such as the warm water sinks of the reservoirs – is thus even *more* important, especially given these potential global warming problems which will add ever more additional temperature stress to river ecosystems as well as salmonids throughout the Klamath Basin in the future.

The outflow from Iron Gate Fish Hatchery is identified as a **point source** by the Water Board in the *Klamath Mainstem TMDL Action Plan*. The following excerpt from the Klamath Mainstem TMDL, Section II-B, refers to Iron Gate Fish Hatchery as a point source for pollution. It also refers to the TMDL load allocation at Stateline, which is below part of the KHP operations, Keno and J.C. Boyle dams:

> "The Iron Gate Fish Hatchery is the one point-source heat load in the Klamath River watershed. The interstate water quality objective for temperature prohibits the discharge of thermal waste to the Klamath River, and therefore the waste load allocation for Iron Gate Hatchery is set to zero, as monthly average temperatures."
>
> And,
>
> "The Klamath River TMDL relies on an implicit margin of safety. The intrastate water quality objective for temperature allows for increases of up to 5^{o} F if beneficial uses of water are not adversely affected…. The seasonable variation is accounted for in the load allocations for temperature…which do not allow for temperature increases during any part of the year."

Section IV-C states:

> "Achievement of the nutrient and organic matter allocation and the tributary nutrient and organic matter allocations will not result in compliance with the DO and temperature load allocations within Copco 1, Copco 2, and Iron Gate Reservoirs during periods of thermal stratification. Therefore additional dissolved oxygen load allocations are assigned to the reservoirs for the period of May through October to ensure compliance with the SSOs for DO and temperature objectives within the reservoirs, and ensure support of the cold freshwater habitat (COLD) beneficial use."[26]

(2) Foreseeable Future Impacts Also Adversely Affecting Water Quality: Foreseeable future impacts also include drought and reduced flows from Upper Klamath Basin, etc., as well as changes in climate.

The Upper Klamath Basin is naturally arid, with an average rainfall in downtown Klamath Falls, OR

[26] The *Klamath Mainstem TMDL Action Plan*, is available at: http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/100927/03_BasinPlanLanugage_Klamath_Lost.pdf. [Note: the word "Lanugage" is correct in this URL and is not misspelled except in the original URL]

of only about 12 inches/year. Droughts below these already low average rainfall amounts are also not only frequent, but projected under climate change scenarios to be increasing in both number and severity. All water quality parameters must therefore be calculated so as to be achievable *even in the increasingly frequent drought and dry years.* Otherwise, major portions of the basin's aquatic resources – including its economically and culturally irreplaceable salmon runs – could "wink out" because of serious water quality problems occurring during any prolonged drought, and would then be extinct when conditions improved – which could be way too late. Again, a Precautionary Approach requires that water quality standards must be satisfied in poor rainfall years as well and in wet years.

(3) The "We Must Keep This Green Power" Fallacy: Some opponents of dam removals generally have argued that removing the Klamath Dams eliminates renewable (i.e., non-carbon) power production, supposing their power would be replaced entirely with fossil fuel energy sources. This is a false argument! First off, the reality is that all four dams combined do not generate all that much power. Although the whole Klamath Hydroelectric Project is technically rated for maximum power generation of about 169 megawatts (MW), these dams cannot run at maximum capacity 24/7, especially during summers when turbine flows are lowest. The entire Project combined actually generated only about 82 MW of power on average over the past 50 years, according to FERC records.[27]

And also according to estimates by FERC, even after all the expensive retrofitting to meet modern standards for relicensing, these dams would then only generate about 61 MW of power on average -- *about 26% less than they do today*.[28] Relicensing thus means spending a great deal of money for what is actually very little power. In fact, FERC estimated in its 2007 Final Environmental Impact Report (FEIS) on relicensing that even if fully relicensed, the required retrofitting would be so expensive that these dams would then operate *at more than a $20 million/year net loss*.[29]

As to replacement power, Pacific Power has already legally committed to bringing more than 1,400 MW of brand new, cost-effective renewable power online by 2015.[30] The company has apparently exceeded that goal. This is *17 times more* power than the four Klamath dams generate all together. Adding an additional 82 MW of cost-effective and clean (i.e., non-carbon based) replacement power to its grid after 2020, as it intends to do under the KHSA, would be an almost trivial task by comparison. There are many options for the replacement of this power from comparable carbon-free or renewable sources by 2020.[31]

MITIGATION MEASURES

CEQA calls for a detailed analysis of both impacts and mitigation measures. In this Application

[27] The November, 2007 FERC Final EIS ("FERC FEIS") is available online at: http://elibrary.ferc.gov/idmws/File_list.asp?document_id=13555784 or found by a FERC docket search at www.ferc.gov, Docket No. P-2082-027 posted November 16, 2007, Document No. 20071116-4001. This number is taken from FERC FEIS, pg. 1-1, as 716,800 MWh, which divided by hours per year (24 hrs./day X 365.25 days/year) = 81.77 MW actual output, rounded to 82 MW – less than 2% of PacifiCorp's total power production.
[28] FERC FEIS, Sec. 4.4, pg. 4-4 of 533,879 MWh = 60.90 MW relicensed output, rounded to 61 MW.
[29] FERC FEIS (Nov. 2007), Table 4-3 on pg. 4-2.
[30] See for instance, *Final Order*, Measure 41, in CPUC Docket A05-07-010.
[31] A single modern wind turbine, for instance, can generate up to 6 MW of power and it would take fewer than 55 such wind turbines, even at a very conservative 25% efficiency, to *completely replace* the total amount of "green power" these four dams now generate – and only 41 such wind turbines to replace the 61 MW after any hypothetical relicensing. A single modern "wind farm" may contain hundreds of such wind turbines.

there is actually very little mitigation proposed, and what little there is mainly relies on proposed further studies and project planning, despite the long length of the permit. This qualifies as deferred mitigation. As demonstrated in *Sundstrom v. County of Mendocino* (1988) 202 Cal.App.3d 296 deferred mitigation is not legal under CEQA. This was recently held up in *Madera Oversight Coalition, Inc. v. County of Madera* (2011) 199 Cal.App.4th 48 where the court found "the plain, unambiguous language" of the mitigation measure violated CEQA and "The post certification verification procedure [is contrary to law and] allows for an environmental decision to be made outside an arena where public officials are accountable." In both cases there was no permit issued. It is inappropriate to issue a long-term permit on the basis of mere studies of potential future mitigation whose efficacy is highly speculative.

We request that the Board use the CEQA process to protect beneficial uses by requiring concrete and effective reservoir management, including mitigations that incorporate and are designed to meet TMDL standards and all other needed water quality requirements. We also request that the needs of migrating salmon and other fisheries be fully considered in these mitigations. If water quality pollution cannot be mitigated, then the Board has no choice but to deny a permit.

We do not believe that any conceivable combination of water quality mitigation measures will be effective in the KHP to bring water quality standards in compliance with the law – at least not short of *enormously* expensive reconstructions that would cause the Project to cost far more than it can ever generate in revenues or economic benefits. We therefore support denial of a 401 Certification for FERC relicensing, and support ultimate dam removal supervised by FERC – either through a negotiated Settlement or a FERC decommissioning order. We believe that the economics and the science are both now clear that these dams at least are no longer cost effective, that they will do far more environmental and economic harm, even if FERC relicensed, than can be offset or justified by any of their likely economic benefits, and that the best option for these dams is that they be decommissioned and their structures removed from the river, allowing PacifiCorp to invest its saved resources in more efficient renewable energy facilities elsewhere.

If the 401 Certification Application is denied and this process formally moves toward ultimate removal, the question then becomes only what interim measures should be imposed between now and dam removal to try to mitigate as much as possible the harms these dams will still do prior to their removal.

(1) Potential Mitigation Measures: The PacifiCorp Application is strangely silent about how it will meet federal Federal Power Act (FPA) Sec. 18 requirements for volitional fish passage, in spite of the fact that those Sec. 18 measures have already survived a PacifiCorp appeal and must now be included in any future FERC license. This is a serious deficiency in the Application, and sufficient cause in and of itself for denial of this particular Application, although without prejudice should PacifiCorp resubmit a new Application dealing with these issues.

Reduced ramping rates and peaking flows at J.C. Boyle and appropriate fish screens and other mitigation measure in accordance with the NMFS, FWS and BLM "Mandatory Prescriptions" and recommendations should be among the required mitigation measures, as well as other measures in addition to those FWS and BLM Mandatory Prescriptions. In the event that PacifiCorp agrees to surrender its FERC license for the KHP and move toward dam removal, these Sec. 18 mitigation measures should also be imposed (to the extent feasible and practicable) until such time as PacifiCorp formally submits a FERC license surrender application and begins the process of dam removal. These and other interim mitigation measures should be scaled up in accordance with how long a delay dam removal will take. They should also become conditions to the current FERC license by way of an amendment to that license, so that they continue in full force and effect throughout all future one-year license extensions.

In the event of dam removal, various mitigation measures to reduce sediment loads expected to be released by dam removal should also be imposed to minimize adverse (though temporary) impacts from these sediment releases, particularly on in-river fish. Simultaneous dam removal and sediment discharges should be preferred over sequential releases, as this minimizes total number and duration of fish exposure times to high levels of sediment. A single high level sediment surge that may impact a single year-class is much less destructive to lower river salmon runs than several smaller (but still fatal) sediment surges poorly timed that impact multiple year-classes. Numerous dam removal mitigation measures are contained and fully analyzed in the KHSA FEIS/FEIR, and should be required of PacifiCorp in any future dam removal permits.

Trap and haul programs as proposed by PacifiCorp will not work in the Klamath – they would only move smolts from one toxic part of the river to another toxic part. Juveniles will die under such conditions wherever they are placed, plus artificial transportation itself creates intense stresses on juvenile salmon that greatly decrease their chances for survival.

There is some value to retaining Keno Dam intact – with, of course, installation of appropriate fish passage facilities for salmonids and other species – because of the unique flow regulation capacity of that dam, and because some 91 small irrigation and domestic water system intakes are supported by its reservoir. But as long as PacifiCorp owns this dam, it is responsible for its impacts. Mandatory mitigation measures at Keno Dam by way of 401 Certification should involve upgrades to existing poorly functioning fish passage facilities to adapt that structure to both salmonids and to lamprey. Various water quality mitigation measures should also be imposed as appropriate at Keno Dam and Keno reservoir as a pre-requisite to any exclusion from the next FERC license or any future transfer by PacifiCorp. Given that Keno is part of the current FERC license, PacifiCorp cannot just leave it in place as is, especially given the many water quality problems it creates. Just continuing the current *status quo* for Keno Dam indefinitely is not acceptable.

(2) Likely Failure of Permanent Mitigation Measures: It is important to also note that even with fish passage installed in retained (but retrofitted) dams, there will still be some unavoidable dam-related mortalities at each fish passage bottleneck. This is particularly true for juveniles migrating downstream, which may also become physically entrained in fish screens or lost in the power turbines that would still be running with the dams in place under either a new FERC license, or until such time under a license surrender that the dams could be decommissioned and removed. These are impacts which must also be analyzed under CEQA, including those types of impacts at dams in Oregon which may adversely affect water quality at California's border inflows.

No artificially engineered fish passage system can ever be as efficient in passing fish as a healthy and free-flowing river corridor. This is important to remember in any analysis of the environmental consequences of dams remaining in place.

PacifiCorp has failed to fully mitigate for the fisheries losses caused by the KHP in a variety of ways, including lack of support for hatchery programs at Iron Gate Dam, including abandoning mitigation measures for spring Chinook. These failures are discussed in Mike Rode's Expert Report enclosed as PCFFA/IFR Scoping Comments 23 February 2009, Attachment 1.

In Summary: Dam removal is the only effective option to solve the many water quality problems that occur in the dam. Full "Four Dam Removal" should be analyzed in great detail. Although J.C. Boyle and Keno Dams are physically located in Oregon, nevertheless under CEQA the State of Oregon can and should analyze both their impacts on lower river water quality in California, as well the impacts (positive and negative) on water quality in Oregon expected from their removal.

*****

Thank you for the opportunity to comment on this process. Please include these written comments and Attachments in the public record for this proceeding. And please call me if there are any questions about this submission, or if any part of it is not readable and printable.

Sincerely,
Glen H. Spain
Glen H. Spain, J.D.
NW Regional Director For PCFFA and IFR

Vivian Helliwell
Vivian Helliwell
PCFFA Watershed Conservation Director

ATTACHMENTS:
A – Economists Letter 1 (9 September 1998)
B -- Economists Letter 2 (3 December 2003)
C – *Commercial Fishing Economics Technical Report* (KHSA NEPA/CEQA Analysis), by Cynthia Thomson (31 August 2012 Update). Also available at: www.klamathrestoration.gov under Technical Reports (Economics).
D – Letter to FERC from the Pacific Fishery Management Council (PFMC), dated 24 April 2006 regarding the Klamath Hydropower Project (sent separately).

Also sent separately for refiling in this Docket are the PCFFA/IFR Scoping Comments Dated 23 February 2009, with Attachments.

ATTACHMENT A – Economists Letter 1 (9 September 1998)

09 September 1998

Governor John A. Kitzhaber
State Capitol Building
Salem, Oregon 97310

Governor Tony Knowles
Office of the Governor
P.O. Box 110001
Juneau, Alaska 99811

Governor Gary Locke
Office of the Governor
P.O. Box 40002
Olympia, Washington 98504-0002

Governor Pete Wilson
State Capitol Building
Sacramento, California 95814

Premier Glen Clark
Office of the Premier
Room 156, West Annex
Parliament Buildings
Victoria, BC V8V 1X4 Canada

Dear Governors Kitzhaber, Knowles, Locke, and Wilson, and Premier Clark:

Decisions regarding the management of Pacific salmon, many of which are experiencing deep declines in numbers, can affect a vast landscape along the western edge of North America and markedly influence the region's future economy. With this letter, we hope to help lay the foundation for the public debate over the economic aspects of these decisions.

Most of the discourse on the economic issues of salmon recovery has focused too narrowly, concentrating almost exclusively on the costs of recovery. Costs are indeed important, but they tell only part of the economic story. We encourage you and the members of your Administrations to adopt a broader perspective and consider the full range of economic consequences of salmon-management decisions. Toward this end, we recommend that you examine and weigh all these factors:

* Costs, Benefits, and Net Benefits.

Salmon recovery will generate economic benefits as well as costs. To understand the net benefit (a net cost if negative) to the economy as a whole, one must consider the effects on the production of all goods and services. The effects on goods and services that are traded in markets, such as commercial salmon, timber production, and agricultural production, should receive the same consideration as those, such as recreational fishing, clean streams, and biodiversity, that are not. A full accounting must be provided of the true value of each affected good or service, taking into account the market price, where appropriate, as well as all factors, such as subsidies, taxes, and environmental externalities, that distort the level of supply or demand. Some of the benefits and costs will manifest themselves in the immediate vicinity of the resources affected by salmon recovery, while others will manifest themselves at greater distances.

* Jobs, Incomes, and Transitions.

Salmon recovery will have diverse impacts on labor markets, increasing some demands for labor and decreasing others. It also may affect the spatial distribution of the supply of labor by influencing the location decisions of some households. To understand the resulting impacts on jobs and incomes, one must consider the salmon-related changes in demand and supply against the backdrop of the markets' ability to adjust. One should examine both the overall change in jobs and incomes as well as the transitions for affected workers, their families, and their communities.

* Distribution of Economic Consequences.

The positive and negative effects of salmon recovery will not be distributed equally. Identifying the winners and losers can create opportunities to explore options for breaking political gridlock–by clarifying mechanisms, for example, for the winners to provide some compensation to the losers.

* Rights and Responsibilities.

Owners of natural resources affected by salmon-recovery measures have both rights regarding their use of these resources and responsibilities not to exercise these rights in ways that unreasonably restrict the rights of others. This is true of both private- and public-property owners. To understand the costs and benefits associated with salmon recovery, one first must have a clear understanding of the relevant rights and responsibilities, because society might assign very different values to two recovery actions that are otherwise identical but one restricts a property owner's rights and the other forces it to comply with its responsibilities.

* Uncertainty and Sustainability.

Nobody can eliminate the uncertainty regarding how salmon-recovery decisions will affect salmon populations and the economy, and it is inevitable that some decisions will not yield the desired outcomes. Reversing undesired outcomes is always costly, however, some outcomes are less costly to reverse than others. Some, of course, are irreversible. To understand the full economic consequences of salmon-recovery decisions, one should consider the potential reversal costs if the decision should yield undesired outcomes.

* Looking Beyond Salmon.

To understand the full consequences of salmon recovery, one must look beyond those tied to the salmon, themselves, and examine those linked to the productivity and use of the surrounding ecosystem. Changes in ecosystem productivity may occur through the restoration of the ecological functions of salmon-bearing streams and the surrounding watersheds that will accompany salmon recovery. Changes in the use of the resources of the larger ecosystem may have both positive and negative effects on the economy.

We hope you will consider the factors outlined here, and use this outline to improve the public's understanding of the full economic consequences of salmon recovery.

Sincerely,

W. Ed Whitelaw
University of Oregon/ECONorthwest

Ernest Niemi
ECONorthwest

And the following co-signing economists:

Russ Beaton, Willamette University
Peter Berck, University of California Berkeley
Bruce Blonigen, University of Oregon
Peter Bohmer, Evergreen College
Richard Brinkman, Portland State University
Gardner Brown, University of Washington
Walt Butcher, Washington State University
Kevin Calandri, California State University Sacramento
Arthur Caplan, Weber State University
Ken Casavant, Washington State University
Laura Connolly, Oregon State University
Jeffrey Connor, Oregon State University
Robert Curry, California State University Sacramento
Elizabeth E. Davis, Oregon State University
Robert Deacon, University of California Santa Barbara
David Donaldson, University of British Columbia
Bryan Ellickson, University of California Los Angeles
Mark Evans, California State University Bakersfield
Anthony Fisher, University of California Berkeley
David E. Gallo, California State University Chico
Alan Gin, University of San Diego
Eban Goodstein, Lewis & Clark College
Lawrence Goulder, Stanford University
Theodore Groves, University of California San Diego
A.R. Gutowsky, California State University Sacramento
Steve Hackett, Humboldt State University
Brent Haddad, University of California Santa Cruz
Dan Hagen, Western Washington University
Darwin C. Hall, California State University Long Beach
Jane Hall, California State University Fullerton
Robert Halvorsen, University of Washington
Bill Harbaugh, University of Oregon
Martin Hart-Landsberg, Lewis & Clark College
Stephen E. Haynes, University of Oregon
John F. Henry, California State University Sacramento
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Richard B. Howarth, Dartmouth
Lovell S. Jarvis, University of California Davis
Desmond Jolly, University of California Davis
Mary King, Portland State University
Van Kolpin, University of Oregon
B. Y. Lee, University of Oregon
Cathleen Leue, University of Oregon
Peter Lund, California State University Sacramento
Bruce Mann, University of Puget Sound
Carlos Martins-Filho, Oregon State University
Ray Mikesell, University of Oregon
Andrew Narwold, University of San Diego
Noelwah Netusil, Reed College
Roger Noll, Stanford University
Dale O'Bannon, Lewis & Clark College
Arthur O'Sullivan, Oregon State University
Steve Polasky, Oregon State University
Thomas Potiowsky, Portland State University
Tom Power, University of Montana
R. Bruce Rettig, Oregon State University
Alan Richards, University of California Santa Cruz
Robert J. Rooney, California State University Long Beach
Tony Rufolo, Portland State University
Linda Shaffer, California State University Fresno
Barry N. Siegel, University of Oregon
Emilson Silva, University of Oregon
Ross Singleton, University of Puget Sound
Chuck Skoro, Boise State University
David Starrett, Stanford University
Kate Stirling, University of Puget Sound
Joe Story, Pacific University
Rod Swanson, University of California Riverside
Paul Thorsnes, Grand Valley State University, Michigan
Victor Tremblay, Oregon State University
Charles Vars, Oregon State University
John F. Walker, Portland State University
Norm Whittlesey, Washington State University
Yung Yang, California State University
Ross Youmans, Oregon State University
Zenon X. Zygmont, Western Oregon University

Note: Affiliations are for informational purposes and do not imply consent by organizations.

cc: David Anderson, Minister, Fisheries and Oceans, Canada
Will Stelle, National Marine Fisheries Service

ATTACHMENT B -- Economists Letter 2 (3 December 2003)

December 3, 2003

A Letter from Economists to President Bush and the Governors of Eleven Western States Regarding the Economic Importance of the West's Natural Environment.

To:

President George W. Bush
The White House
1600 Pennsylvania Avenue NW
Washington, DC 20500

The Honorable Dave Freudenthal, Governor of Wyoming
State Capitol Building
Cheyenne, WY 82002-0010

The Honorable Kenny Guinn, Governor of Nevada
State Capitol
101 North Carson Street
Carson City, NV 89701

The Honorable Dirk Kempthorne, Governor of Idaho
700 West Jefferson, 2nd Floor
P.O. Box 83720
Boise, Idaho 83720-0034

The Honorable Ted Kulongoski, Governor of Oregon
160 State Capitol
900 Court Street
Salem, Oregon 97301-4047

The Honorable Gary Locke, Governor of Washington
PO Box 40002
Olympia, WA 98504-0002

The Honorable Judy Martz, Governor of Montana
P.O. Box 0801
204 State Capitol
Helena, MT 59620-0801

The Honorable Janet Napolitano, Governor of Arizona
1700 West Washington
Phoenix, AZ 85007

The Honorable Bill Owens, Governor of Colorado
136 State Capitol
Denver, CO 80203-1792

The Honorable Bill Richardson, Governor of New Mexico
Office of the Governor
Room 400, State Capitol Building
Santa Fe, NM 87501

The Honorable Arnold Schwarzenegger, Governor of California
State Capitol Building
Sacramento, CA 95814

The Honorable Olene Walker, Governor of Utah
210 State Capitol
Salt Lake City, UT 84114

Dear Mr. President;
Dear Governor Freudenthal;
Dear Governor Guinn;
Dear Governor Kempthorne;
Dear Governor Kulongoski;
Dear Governor Locke;
Dear Governor Martz;
Dear Governor Napolitano;
Dear Governor Owens;
Dear Governor Richardson;
Dear Governor Schwarzenegger;
Dear Governor Walker:

We are economists, and we are writing to express our concern about federal and state actions that harm the West's natural environment and, as a result, the economic outlook for this region's workers, families, firms, and communities.

The West's natural environment is, arguably, its greatest, long-run economic strength. The natural landscapes of the western states, with wide open spaces, outdoor recreational opportunities, and productive natural-resource systems underlie a quality of life that contributes to robust economic growth by attracting productive families, firms, and investments. The West's natural environment, however, faces serious challenges that threaten to undermine its contribution to the economy. These include air and water pollution, urban sprawl, the extension of roads and other development into roadless public lands, and fragmentation of habitat for native fish and wildlife.

The economic importance of the West's natural environment is widely recognized. Last year, for example, the Western Governors' Association, recognizing that "There is a lot at stake," reaffirmed its adoption of the Enlibra Principles for guiding policy and decision-making regarding natural resources and the environment.[1]

The seventh of these principles is, "Recognition of Benefits and Costs – Make Sure All Decisions Affecting Infrastructure, Development and Environment are Fully Informed."[2] We endorse this principle, and we commend each of you for your commitments to apply it to the actions of your administration. Despite your commitments, however, many state and federal actions are causing additional environmental degradation, increasing the risks of future degradation, or slowing efforts to reverse past degradation. These actions harm the economy—across the West and in each of the states. They diminish the economic well-being of many residents, divert natural resources from their highest and best use, reduce the

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[1] Western Governors' Association, "Principles for Environmental Management in the West." http://www.westgov.org./wga/policy/02/enlibra_07.pdf. p. 2.

[2] Ibid. p. 6.

environmental amenities that are essential ingredients of the West's quality of life, and pass to future generations the costs of cleaning up this generation's environmental messes.

We ask each of you to renew and strengthen your efforts to secure for the West both a healthy environment and a prosperous economy. Toward this end, we ask you to initiate a review of your administration's actions affecting the environment and the economy. This review should:

- Identify actions having a significant impact on the environment and fully describe the benefits and costs of each.
- Reinforce those actions that strengthen the economy by protecting or restoring environmental quality.
- Arrest those actions that damage the economy by degrading the environment.

In the remainder of this letter we describe the linkage between environmental quality and economic prosperity, identify some of the environmental policies and activities harmful to western economies, and express eight principles for capitalizing on the environment-economy linkage.

Environmental Quality Is a Major Source of the West's Long-Run, Economic Strength

In the distant past, the West's natural resources were widely abundant and important to the economy primarily when they were converted into something else. We converted forests, mineral deposits, and streams into lumber, metals, and hydroelectricity; valleys, wetlands, and hillsides into agricultural and urban landscapes; and land, water and air into waste repositories.

Today, conditions have changed.

Some important elements of the environment are scarcer. The population and distribution of many native species have diminished markedly. Similarly, the supplies of roadless lands, free-flowing rivers, and unexploited marine areas have diminished and, although there have been some notable improvements recently, much of the West's air and water remains degraded.

The structure of the western economy has changed. Though still important, extractive industries (logging, mining, and commercial fishing) and agriculture now play a smaller economic role because their ability to generate new jobs and higher incomes has declined. Across most of the West, a community's ability to retain and attract workers and firms now drives its prosperity. But if a community's natural environment is degraded, it has greater difficulty retaining and attracting workers and firms.

The economic costs of environmental degradation are rising. As the West's population increases, so too do the damages (current and future) from exposure to hazardous pollution and the degradation of environmental amenities. As their habitats shrink, many native species face an increased risk of extinction. Reversing this trend becomes more expensive over time. As ecosystems are degraded, they provide fewer economically valuable services, such as cleansing the water in streams, and communities therefore must provide replacement services with water-treatment plants and other costly investments.

The economic benefits of protecting and restoring environmental quality are large and increasing. As the West's population increases, the West enjoys greater economic benefits by avoiding exposure to hazardous pollution, maintaining scenic natural vistas, extending the availability of recreational opportunities in clean environments and on public lands, and sustaining the existence of undeveloped lands and healthy ecosystems.

Misleading price signals slow economic growth. Inefficient pricing of many natural resources encourages waste and diminishes economic productivity by allocating resources to low-value uses, while higher-value uses languish. Subsidies to irrigation, logging, public-land ranching, and mining prop up activities that would not take place under efficient, market conditions. Underpricing of urban roads, municipal-industrial water, and pollution emissions sends false signals regarding the true cost of urban sprawl, and the true value of free-flowing streams, and clean air and water.

Climate change poses significant economic risks. Global warming threatens to alter winter snow fall in the West's mountains, increasing the risk that runoff in important rivers will fall short of summer demands for water; raise sea levels, increase the risk of coastal flooding, change the distribution of habitats, and increase the risk of extinction for some threatened and endangered species.

As these and related changes evolve, the economic health of western communities increasingly will depend on the health of the environment. Long-run prosperity will derive from efficient, effective efforts to conserve increasingly scarce environmental resources, protect high-quality natural environments, reverse past environmental degradation, and manage congestion in both urban areas and on public lands with high recreational use. Resource-management policies and economic-development activities that significantly compromise the environment will likely do more economic harm than good.

Many Current Policies and Activities Degrade or Threaten the West's Environment and Jeopardize the West's Prosperity

Numerous governmental policies and activities affecting the West's natural resources, which purportedly help the West's economies, are doing just the opposite. Here are a few examples:

Inadequate investment in parks. The federal government has failed to maintain the infrastructure and environmental quality of national parks. State and local governments have done the same with their own parks. These failures have weakened the West's economies by reducing the attractiveness of nearby communities to workers and firms and by eroding the foundation for the outdoor recreation and tourism industries.

Reduced protection for roadless public lands. By opening roadless lands to vehicular traffic, mining, logging, grazing, and other development, usually at a net cost to the US taxpayer, the federal government has expanded the supply of that which is already plentiful and common at the expense of that which is increasingly scarce and unique. Such actions fail to account for the benefits non-motorized visitors receive from these lands and for the loss of the considerable economic benefits—recreation, high-quality water, wildlife habitat, spiritual values, and more—that public lands provide when they are undeveloped. The loss of these benefits undermines one of the cornerstones of economic strength for communities throughout the West.

Slow action to conserve threatened and endangered species. Congress has failed to provide adequate funding, and federal agencies have dragged their feet when called upon to conserve threatened and endangered species. These actions jeopardize the economic outlook for western communities by increasing the risks to species with high economic value, protecting inefficient and often subsidized activities harmful to both the species and the economy, and raising the ultimate costs of conserving the species.

Slow clean-up of polluted sites. Federal agencies have not requested and Congress has not provided adequate funding to clean-up Superfund sites promptly. Some state and local governments have slowed the clean-up process. Delayed clean-up of these sites harms the economy by extending westerners' exposure to hazardous materials, diminishing the value of nearby properties, impeding economic-development activities near polluted sites, and giving polluters additional incentives to pollute in the future.

Ineffective response to risks of global warming. Current research results are sufficiently robust to conclude that global warming poses significant economic risks to the West, including increases in coastal flooding, more frequent severe storms, and reductions in snowpack resulting in lower summer flows of important rivers and streams. These risks are perpetuated and strengthened by the failure of Congress and the White House to take decisive action to curb emissions of carbon dioxide and other global greenhouse gases.

Inefficient management of public forests. Federal and state forest managers emphasize the production of logs, forage, minerals, and other commodities without fully accounting for adverse impacts on services, such as recreation, provision of clean water in streams, sequestration of carbon, and the existence of roadless lands. These actions reduce the overall value of goods and services derived from public forests.

Lack of appropriate incentives for resource conservation. With subsidies and inefficient pricing, federal, state, and local policies encourage waste and discourage conservation by hiding from consumers the full costs of resource-intensive activities, such as exploration for oil and gas, irrigation, public-land grazing, and congestion on urban roadways and at public-land recreation sites.

Unreasonable exemptions from environmental review. Federal resource managers have granted exemptions for military operations, logging, exploration for oil and gas, operation of motor vehicles on roadless public lands, the use of some pesticides, the emission of air pollution, and other activities. Also, de facto exemptions occur when federal and state agencies fail to enforce environmental laws. The economy is harmed when activities are allowed to proceed even though their economic costs outweigh their benefits.

Unnecessarily divisive approaches to economic/environmental issues. The costs—to individual workers, families, firms, communities, and the economy as a whole—of the changing relationship between the economy and the environment are worsened by federal, state, and local actions that promote misunderstanding and divisiveness rather than cooperative problem-solving. Especially divisive and costly are proposals and decisions that presume the economic benefits of an increase in an extractive, agricultural, or development activity necessarily exceed the costs, even when the evidence indicates otherwise. Recent examples include proposals or decisions to:

- Encourage road development, vehicular traffic, and other development on lands with roadless or wilderness qualities, including national parks, national forests, and lands administered by the Bureau of Land Management.
- Promote energy consumption rather than conservation.
- Relax restrictions on emissions of water and air pollution.
- Forgo U.S. leadership of efforts to shape a prompt, efficient and global response to climate-change risks.
- Relax restrictions on the use of or exposure to potentially harmful substances.

We Encourage You to Adopt Initiatives that Promote Both a Healthy Environment and a Healthy Economy

We ask each of you to initiate a review of the economic effects of actions taken by your administration that have a significant impact on the environment. The primary objective of this review should be to identify and correct those actions that are harming the economy by degrading the environment. It also should highlight the merits of those actions beneficial to both the environment and the economy. We urge you to act promptly.

We also urge you to implement appropriate policies and procedures to increase the likelihood that future governmental actions will capitalize on and reinforce the evolving relationship between the West's environment and its economy. These initiatives should incorporate these eight principles:

Principle #1: Environmental protection has economic benefits as well as economic costs. It has positive as well as negative impacts on jobs and incomes.

Principle #2: Some economic interests in natural resources are mostly local but, increasingly, the interests are broader in geographic scope: regional, national, and even global.

Principle #3: To discourage waste, prices for the use of environmental resources should reflect the full costs and benefits to the economy, exclusive of subsidies.

Principle #4: Given their stewardship responsibilities regarding the environment, it is appropriate for governments to encourage or undertake activities that protect the environment and to discourage or prohibit those that do not. It is also appropriate for government to own and use land and water resources to protect the environment and to support others who desire to own and use resources for the same purpose.

Principle #5: Governments should continually seek to improve the efficiency of their environmental- and resource-management programs without compromising their responsibilities. These programs may include a mixture of regulations, incentives, and public ownership of resources. They should aim to bring about as high a level of environmental quality as possible for a given expenditure.

Principle #6: To understand the full, potential economic consequences of a pending resource-management decision, one should consider the potential reversal costs if the decision should yield undesirable outcomes.

Principle #7: The benefits and costs of environmental protection and degradation fall unevenly on different groups. Anticipating and mitigating these effects can reduce the controversies over the West's environment and economy. Having the winners compensate the losers, for example, could serve this principle.

Principle #8: Owners of natural resources have both rights and responsibilities. Both private- and public-property owners have rights to use their properties in ways that do not unreasonably harm others or restrict their rights. Clarifying and respecting the rights of all parties—including future generations—affected by the uses of environmental resources remains a necessary condition for effective environmental management.

Conclusion

We are not saying that resource-intensive industries (agriculture, timber, commercial fishing, and mining) do not play an important role in the West's economies. They are important today, and we expect they will remain important in the future.

We are not saying that the shift away from industries and activities harmful to the environment will not hurt some workers, families, and communities. It has in the past and it will in the future.

We are not saying that protecting and improving the environment can be accomplished without costs, nor are we saying that governmental entities should disregard such costs. To the contrary, we are calling for consideration of the full range of costs and benefits of policies, decisions, and activities that affect the western environment and, hence, its economy.

We are not saying that no progress is being made in capitalizing on the link between environmental health and economic prosperity. Many private-sector firms and public agencies have taken actions to reduce their negative impact on the environment and found that they saved money.

Rather, we are saying that nearly all communities in the West will find they cannot have a healthy economy without a healthy environment. Moreover, there exist many opportunities in the West to improve both the environment and the economy, for example, the elimination of inefficient subsidies would make more money available for other public services or to reduce debt. The longer these opportunities languish, the fewer will be the West's jobs, the lower its incomes, and the poorer its communities. Conversely, the sooner we seize these opportunities, the sooner the West will enjoy more jobs, higher incomes, and greater prosperity.

We are saying that the economic pressures to arrest and reverse environmental degradation will increase. Those who promise that workers, firms, and communities tied to environmentally harmful activities can avoid these pressures if only the environmental laws, such as the Endangered Species Act, were set aside raise false hopes. The pressures are independent of specific laws. Even if such laws are repealed, the costs of environmentally harmful activities will continue to rise and jeopardize the economic outlook for affected communities. Public officials can best promote long-run economic prosperity in the West by encouraging efficient transitions away from harmful activities toward those beneficial to both the environment and the economy.

We are requesting that you recognize the important role the environment plays in western economies and take the steps we've identified to strengthen these economies by protecting and enhancing the quality of the region's natural environment.

Sincerely and respectfully,

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ATTACHMENT C – *Commercial Fishing Economics Technical Report* (KHSA NEPA/CEQA Analysis), by Cynthia Thomson (31 August 2012 Update). Also available at: www.klamathrestoration.gov under Technical Reports (Economics).

Commercial Fishing Economics Technical Report

For the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon

Prepared by
Cynthia Thomson

NOAA National Marine Fisheries Service
Southwest Fisheries Science Center
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Santa Cruz, California

31 August 2012

Abbreviations and Acronyms

DPV	Discounted Present Value
DRA	Dam Removal Alternative
EDRRA	Evaluation of Dam Removal and Restoration of Anadromy
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FMP	Fishery Management Plan
IGD	Iron Gate Dam
IMPLAN	Impact Analysis for Planning
KBRA	Klamath Basin Restoration Agreement
KMZ	Klamath Management Zone
KMZ-CA	Klamath Management Zone – California
KMZ-OR	Klamath Management Zone – Oregon
KRFC	Klamath River Fall Chinook
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAA	No Action Alternative
NED	National Economic Development
NMFS	National Marine Fisheries Service
PFMC	Pacific Fishery Management Council
RED	Regional Economic Development
SONCC	Southern Oregon Northern California Coast
SRFC	Sacramento River Fall Chinook
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USWRC	U.S. Water Resources Council

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I. Introduction

In accordance with the terms of the Klamath Hydroelectric Settlement Agreement and contingent on Congressional authorization, the Secretary of the Interior – in consultation with the Secretary of Commerce – will make a determination regarding whether removal of four Klamath River dams (Iron Gate, Copco 1, Copco 2 and J.C. Boyle) owned by the utility company PacifiCorp advances restoration of salmonid fisheries and is in the public interest. One of the fisheries potentially affected by the Secretarial Determination is the ocean commercial salmon fishery. This report analyzes the economic effects on that fishery of three alternatives that will be considered by the Secretary:

- Alternative 1 – No Action: This alternative involves continued operation of the four dams under current conditions, which include no fish passage and compliance with Biological Opinions by the U.S. Fish and Wildlife Service (USFWS) and NOAA National Marine Fisheries Service (NMFS) regarding the Bureau of Reclamation's Klamath Project Operation Plan.
- Alternative 2 – Full Facilities Removal of Four Dams: This alternative involves complete removal of all features of the four dams, implementation of the Klamath Basin Restoration Agreement (KBRA 2010), and transfer of Keno Dam from PacifiCorp to the U.S. Department of the Interior (USDOI).
- Alternative 3 – Partial Facilities Removal of Four Dams: This alternative involves removal of selected features of each dam to allow a free flowing river and volitional fish passage for all anadromous species. Features that remain in place (e.g., powerhouses, foundations, tunnels, pipes) would be secured and maintained in perpetuity. The KBRA and transfer of Keno Dam are also part of this alternative.

Throughout this report, Alternative 1 is referred to as the no action alternative and Alternatives 2 and 3 as the action alternatives.

Section II describes existing conditions in the ocean commercial (troll) fishery and Section III describes the biological sources of information underlying the economic analysis of fishery effects. Sections IV and V respectively analyze the alternatives in terms of two 'accounts' specified in guidelines provided by the U.S. Water Resources Council (USWRC 1983): Net Economic Development (NED) and Regional Economic Development (RED). NED pertains to analysis of economic benefits and costs from a national perspective and RED pertains to analysis of regional economic impacts in terms of jobs, income and output. Sections VI summarizes results and conclusions of the previous sections, and Section VII provides a list of references cited in the report. Appendices A-B supplement the report with additional technical information.

II. Existing Fishery Conditions

The particular salmon stocks influenced by the no action and action alternatives are the two component populations of the Upper Klamath-Trinity Evolutionarily Significant Unit (ESU)[1] (Klamath River fall and spring Chinook) and the Southern Oregon Northern California Coast (SONCC) coho ESU. These stocks generally limit their ocean migration to the area south of Cape Falcon. The area south of Falcon is divided into six fishery management areas: Monterey,

[1] An Evolutionarily Significant Unit is a population or group of populations that is reproductively isolated and of substantial ecological/genetic importance to the species (Waples 1991).

San Francisco, Fort Bragg, Klamath Management Zone (KMZ), Central Oregon, and Northern Oregon. For purposes of this analysis, the KMZ (which straddles the Oregon-California border) is divided at the border into two areas: KMZ-OR and KMZ-CA (Figure II-1). To the extent possible, the effects of the alternatives are analyzed separately for each area (including KMZ-OR and KMZ-CA).

Figure II-1. Ocean salmon management areas south of Cape Falcon, Oregon (graphic by Holly Davis).

SONCC coho and Klamath Chinook co-mingle with other salmon stocks in the ocean commercial fishery. The Pacific Fishery Management Council (PFMC) manages such 'mixed stock' fisheries on the principle of 'weak stock management' whereby harvests of healthier stocks are constrained more by the need to protect weaker stocks than by their own abundance (see Appendix A for detailed description of PFMC management).[2] The implications of weak stock management as it relates to SONCC coho and Klamath Chinook are as follows.

- PFMC-managed ocean fisheries south of Cape Falcon are subject to consultation standards for two Chinook and four coho ESUs listed under the Endangered Species Act (ESA) – including the SONCC coho ESU (listed in 1997). To meet consultation standards for the

[2] See Appendix A for a description of PFMC salmon management.

coho ESUs, the PFMC has banned coho retention in the troll fishery in KMZ-CA and KMZ-OR since 1990 and in all other management areas south of Cape Falcon since 1993 (with the exception of limited fisheries in 2007 and 2009 in Central and Northern Oregon).

- The major salmon stocks targeted by ocean fisheries south of Cape Falcon are Sacramento River fall Chinook (SRFC) and Klamath River fall Chinook (KRFC). For most of the past three decades, KRFC has been more constraining on the troll fishery than SRFC. Because SRFC and KRFC intermix in the troll harvest, regulations devised to limit harvest of KRFC necessarily constrain SRFC harvest as well to levels below what would have been allowed in the absence of the KRFC constraint.

Figure II-2 describes harvest trends over the past 30 years. Troll harvests south of Cape Falcon declined markedly from the 1980s to the 1990s. A number of factors contributed to that decline – e.g., the more conservative harvest control rule for KRFC adopted in 1989, implementation of weak stock management policies in the 1990s, the spate of ESA listings that occurred during the 1990s, and the 50-50 tribal/non-tribal allocation of Klamath-Trinity River salmon implemented in 1993. These regulatory changes were compounded by drought and El Niño conditions during 1991-92 and 1997-98 that contributed to low Chinook and coho returns and prompted major fishery restrictions during the 1990s. The 1990s were followed by a period of more stable, moderate harvests during 2001-05. During 2006-10 landings fell to record low levels due to low KRFC abundance in the mid-2000s and record low SRFC abundance in the late 2000s. The lack of coho landings since 1993 is due to the non-coho retention policy adopted in that year (Appendix A).

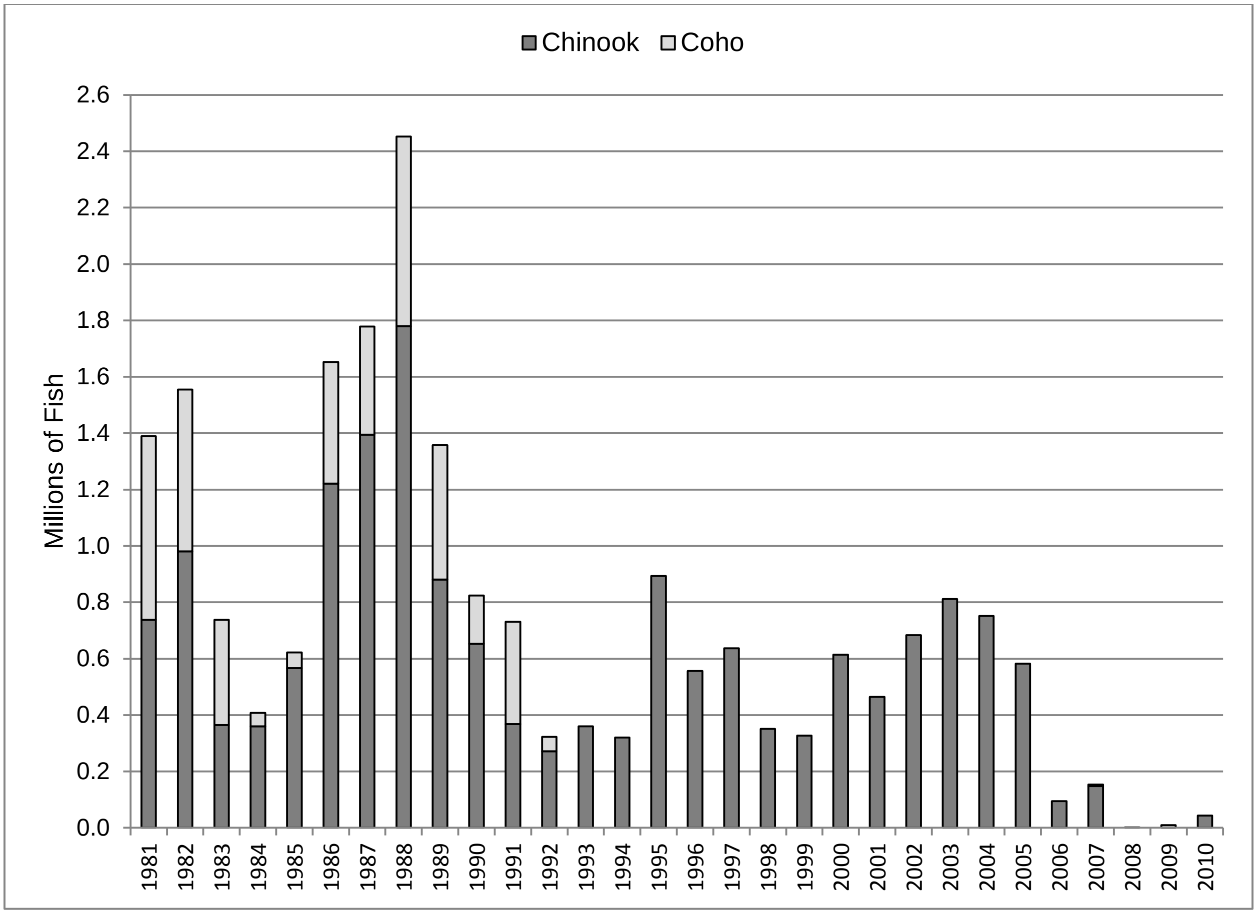

Figure II-2. Landings of troll-caught Chinook and coho south of Cape Falcon, Oregon (millions of fish), 1981-2010 (sources: PFMC 1990, 1991, 1998, 2009, 2010, 2011b).

Tables II-1 and II-2 summarize trends in troll landings (numbers and pounds of fish) by management area. Landings are generally highest in San Francisco and lowest in KMZ-CA and KMZ-OR. Landings reductions began occurring in KMZ-CA and KMZ-OR in the mid-1980s to address conservation concerns for KRFC; low landings remain a persistent features in those areas. The precipitous decline in landings after 2005 was felt in all areas.

Table II-1. Landings of troll-caught Chinook and coho (# fish), 1981-2010, by management area

	Management Area							
Year(s)	*Monterey*	*San Fran*	*Ft Bragg*	*KMZ-CA*	*KMZ-OR*	*CentralOR*	*NorthOR*	*Total*
81-85Avg	85,260	186,680	124,320	124,020	61,320	170,560	190,200	942,360
86-90Avg	146,460	360,480	278,380	56,120	33,920	385,940	351,700	1,613,000
91-95Avg	137,720	205,480	14,760	1,540	1,000	36,820	128,240	525,560
96-00Avg	156,305	195,662	12,529	3,505	3,542	36,042	89,479	497,065
01-05Avg	64,827	210,228	96,466	12,401	5,245	117,529	151,698	658,393
06-10Avg	5,330	24,806	7,906	1,752	1,188	7,736	11,598	60,315
2001	35,940	136,630	14,993	5,523	3,599	72,272	195,001	463,958
2002	69,980	242,872	65,336	13,467	6,803	122,174	162,415	683,047
2003	36,099	202,876	248,875	4,044	5,072	132,156	182,066	811,188
2004	64,707	298,229	107,259	31,915	8,484	140,142	100,965	751,701
2005	117,408	170,531	45,869	7,054	2,266	120,900	118,044	582,072
2006	11,204	47,689	10,835	0	738	1,979	21,759	94,204
2007	14,009	75,254	16,116	8,762	4,097	24,096	11,393	153,727
2008	0	0	0	0	236	208	76	520
2009	0	0	0	0	0	979	8,738	9,717
2010	1,435	1,086	12,577	0	869	11,418	16,022	43,407

Sources: PFMC 1990, 1991, 1998, 2009, 2010, 2011b.

Table II-2. Landings of troll-caught Chinook and coho (1000s of pounds dressed weight), 1981-2010, by management area

	Management Area							
Year(s)	*Monterey*	*San Fran*	*Ft Bragg*	*KMZ-CA*	*KMZ-OR*	*CentralOR*	*NorthOR*	*Total*
81-85Avg	748	1,849	1,218	967	495	1,140	1,080	7,497
86-90Avg	1,601	3,700	2,434	624	537	2,765	2,259	13,921
91-95Avg	1,350	1,949	194	31	32	339	869	4,764
96-00Avg	1,699	2,155	146	37	92	435	861	5,425
01-05Avg	756	2,704	1,268	149	204	1,124	1,605	7,809
06-10Avg	54	318	163	24	40	86	156	841
2001	418	1,735	192	64	152	776	1,898	5,235
2002	912	3,060	872	162	218	1,223	1,722	8,169
2003	498	2,753	3,096	45	142	1,353	1,890	9,777
2004	853	3,712	1,292	373	267	1,214	1,256	8,967
2005	1,098	2,258	889	102	239	1,054	1,259	6,899
2006	87	684	273	0	45	56	290	1,435
2007	165	888	357	115	101	246	160	2,032
2008	0	0	0	0	8	0	20	28
2009	0	0	0	0	5	5	82	92
2010	20	16	187	4	43	122	226	618

Sources: PFMC 1990, 1991, 1998, 2001, 2011b.

Table II-3 summarizes trends in salmon ex-vessel revenue[3] by management area. Revenues (like landings) are generally highest in San Francisco and lowest in KMZ-CA and KMZ-OR. Revenues are influenced by ex-vessel prices[3] as well as landings. Price declines during 1981-2002 accentuated the landings declines that occurred during the 1980s and 1990s; price increases since 2003 have tended to offset (albeit modestly) the landings declines that occurred after 2005.

[3] Ex-vessel revenue pertains to the value of fish landed dockside and ex-vessel price to the price received by fishermen for those landings.

Table II-3. Ex-vessel value of troll-caught Chinook and coho ($1000s, base year=2012), 1981-2010, by management area

	Management Area							
Year(s)	*Monterey*	*San Fran*	*Ft Bragg*	*KMZ-CA*	*KMZ-OR*	*CentralOR*	*NorthOR*	*Total*
81-85Avg	3,671	9,170	5,881	4,536	2,426	4,637	3,965	34,286
86-90Avg	7,003	16,751	10,884	2,736	2,219	10,983	8,128	58,703
91-95Avg	4,095	6,097	670	104	98	899	2,349	14,312
96-00Avg	3,755	4,912	340	81	217	1,038	1,950	12,292
01-05Avg	2,129	7,422	3,371	440	608	3,206	4,280	21,456
06-10Avg	307	1,797	925	134	243	500	834	4,740
2001	1,051	4,362	483	161	311	1,586	3,878	11,831
2002	1,766	5,927	1,689	314	420	2,354	3,309	15,778
2003	1,164	6,432	7,233	105	342	3,260	4,539	23,076
2004	2,912	12,672	4,411	1,273	1,096	4,982	5,096	32,442
2005	3,754	7,719	3,039	349	872	3,846	4,577	24,156
2006	497	3,911	1,561	0	275	342	1,757	8,344
2007	925	4,981	2,002	645	607	1,451	789	11,400
2008	0	0	0	0	62	0	150	212
2009	0	0	0	0	27	11	188	226
2010	114	91	1,063	23	245	696	1,286	3,517

Sources: PFMC 1990, 1991, 1998, 2001, 2011b.

The effects of the coho non-retention policy implemented in the KMZ in 1990 and in all other areas south of Cape Falcon in 1993 have been disproportionately felt in Oregon. To illustrate this point, in the five years prior to implementation of this policy (1985-89), coho dependence was most pronounced (both absolutely and as a proportion of total salmon landings) in Central and Northern Oregon. This dependence is somewhat higher when considered in terms of numbers of fish rather than pounds, as weight per fish is lower for coho than Chinook (Table II-4).

Table II-4. Average annual harvest of troll-caught Chinook and coho during 1985-1989 – pounds, numbers of fish, and percent of total pounds and fish consisting of coho, by management area.

	1000s of Pounds Dressed Weight			*Number of Fish*		
Management Area	*Chinook*	*Coho*	*Coho as % of Total Lbs*	*Chinook*	*Coho*	*Coho as % of Total Fish*
Monterey	1,403	3	0.002	124,560	500	0.004
San Francisco	3,685	26	0.007	345,360	4,120	0.012
Fort Bragg	2,532	124	0.051	266,420	22,440	0.083
KMZ-CA	537	63	0.106	45,740	9,700	0.179
KMZ-OR	444	65	0.110	29,580	5,140	0.097
Central OR	2,119	643	0.217	249,400	129,700	0.318
Northern OR	1,072	1,114	0.448	107,800	231,960	0.597

Sources: PFMC 1990, 1991, 1998, 2001, 2011b.

III. Biological Assumptions

The economic effects of the no action and action alternatives on the troll fishery are largely driven by the effects on fish populations. This section discusses the biological effects of the alternatives on the SONCC coho ESU and Klamath River fall and spring Chinook.

III.A. SONCC Coho

The status of SONCC coho is discussed here in the context of NMFS' viability criteria and conclusions of the Biological Subgroup for the Secretarial Determination and an Expert Panel convened in December 2010 to evaluate the effects of the alternatives on steelhead and SONCC coho.

The SONCC coho ESU consists of 28 coho population units that range from the Elk and Rogue Rivers in southern Oregon to the Eel River in Northern California, including the coho populations in the Klamath Basin. NMFS' framework for assessing the biological viability of the SONCC coho ESU involves categorization of these component populations into seven diversity strata that reflect the environmental and genetic diversity across the ESU. Risk of extinction is evaluated on the basis of measurable criteria that reflect the biological viability of individual populations, the extent of hatchery influence, and the diversity and spatial structure of population units both within and across diversity strata (Williams *et al*. 2008).

The Klamath diversity stratum includes five population units, three of which (Upper Klamath, Shasta, Scott) are potentially affected by the action alternatives. According to the Biological Subgroup, "None of the population units of Klamath River coho salmon is considered viable at this point in time" (Hamilton *et al*. 2011, p 89) and "…all five of these Population Units have a high risk of extinction under current conditions" (Hamilton *et al*. 2011, p 90).

According to the Coho/Steelhead Expert Panel, adverse effects of dam removal on coho would likely be short-lived:

> "The short-term effects of the sediment release … will be injurious to upstream migrants of both species [coho and steelhead]…. However, these high sediment concentrations are expected to occur for periods of a few months in the first two years after the beginning of reservoir lowering and sediment flushing. For a few years after that period, suspended sediment concentrations are expected to be higher than normal, especially in high flow conditions, but not injurious to fish (Dunne *et al*. 2011, pp 18-19).

The Expert Panel noted the likely continuation of poor coho conditions under the no action alternative and a modest to moderate response of coho under the action alternatives (the moderate response being contingent on successful KBRA implementation):

> "Although Current Conditions will likely continue to be detrimental to coho, the difference between the Proposed Action and Current Conditions is expected to be small, especially in the short term (0-10 years after dam removal). Larger (moderate) responses are possible under the Proposed Action if the KBRA is fully and effectively implemented and mortality caused by the pathogen *C. shasta* is reduced. The more likely small response will result from modest increases in habitat area usable by coho with dam removal, small changes in conditions in the mainstem, positive but unquantified changes in tributary habitats where most coho spawn and rear, and the potential risk for disease and low ocean survival to offset gains in production in the new habitat. Very low present population levels and low demographic rates indicate that large improvements are needed to result in moderate responses. The high uncertainty in each of the many individual steps involved for improved survival of coho over their life cycle under the Proposed Action results in a low likelihood of moderate or larger responses….Nevertheless, colonization of the Project Reach between

Keno and Iron Gate Dams by coho would likely lead to a small increase in abundance and spatial distribution of the ESU, which are key factors used by NMFS to assess viability of the ESU" (Dunne *et al*. 2011, p ii).

The Biological Subgroup also notes the benefits of the action alternatives on coho viability:

> "Reestablishing access to historically available habitat above IGD will benefit recovery of coho salmon by providing opportunities for the local population and the ESU to meet the various measures used to assess viability (e.g., abundance, productivity, diversity, and spatial structure (Williams *et al*., 2006). Thus there would be less risk of extinction when more habitat is available across the ESU" (Hamilton *et al*. 2011, p 92).

The action alternatives are expected to improve the viability of coho populations in the Klamath Basin and advance the recovery of the SONCC coho ESU. However, since the action alternatives do not include coho restoration actions outside the Klamath Basin, they alone will not bring about the conditions that would warrant de-listing of the SONCC coho ESU throughout the species range. The potential for coho harvest under the no action and action alternatives is evaluated in the context of this conclusion.

III.B. Klamath River Spring and Fall Chinook

Biological effects of the no action and action alternatives on Klamath River Chinook are evaluated on the basis of two models – the Evaluation of Dam Removal and Restoration of Anadromy Model (Hendrix 2011) and a habitat-based model (Lindley and Davis 2011) – and conclusions of the Biological Subgroup (Hamilton *et al*. 2011) and an Expert Panel convened in January 2011 to evaluate the effects of the alternatives on Klamath River Chinook (Goodman *et al*. 2011).

III.B.1. Evaluation of Dam Removal and Restoration of Anadromy (EDRRA) Model

The Evaluation of Dam Removal and Restoration of Anadromy (EDRRA) model (Hendrix 2011) is a simulation model that provides 50-year projections of Klamath Chinook escapement, as well as separate harvest projections for the ocean troll, ocean recreational, inriver recreational and tribal fisheries under the no action alternative and dam removal alternatives (denoted as NAA and DRA respectively by Hendrix). Projections from the EDRRA model begin in 2012 (the year of the Secretarial Determination) and span the period 2012-61. The harvest projections for the DRA reflect the following assumptions: (i) active introduction of Chinook fry to the Upper Basin beginning in 2011, (ii) short-term effects on Chinook of sedimentation associated with dam removal, (iii) gains in the quantity and quality of salmonid habitat associated with dam removal and KBRA, and (iv) loss of Iron Gate as a production hatchery in 2028.

The 50-year escapement and harvest projections provided by the model were each iterated 1000 times to capture the influence of uncertainties in model inputs on model outputs. The harvest projections pertain to Klamath/Trinity River Chinook and do not distinguish between spring and fall runs. Klamath/Trinity Chinook harvest (all fisheries combined) is estimated for each simulated year on the basis of the KRFC harvest control rule recommended by the PFMC to NMFS in June 2011 as part of a pending amendment to the Pacific Salmon FMP (Figure III-1). As an added constraint, the model also caps the forecast harvest rate for age-4 KRFC in the ocean fishery at 16 percent to address the consultation standard for California Coastal Chinook (listed as ‘threatened’ in 1999 – see Appendix A).

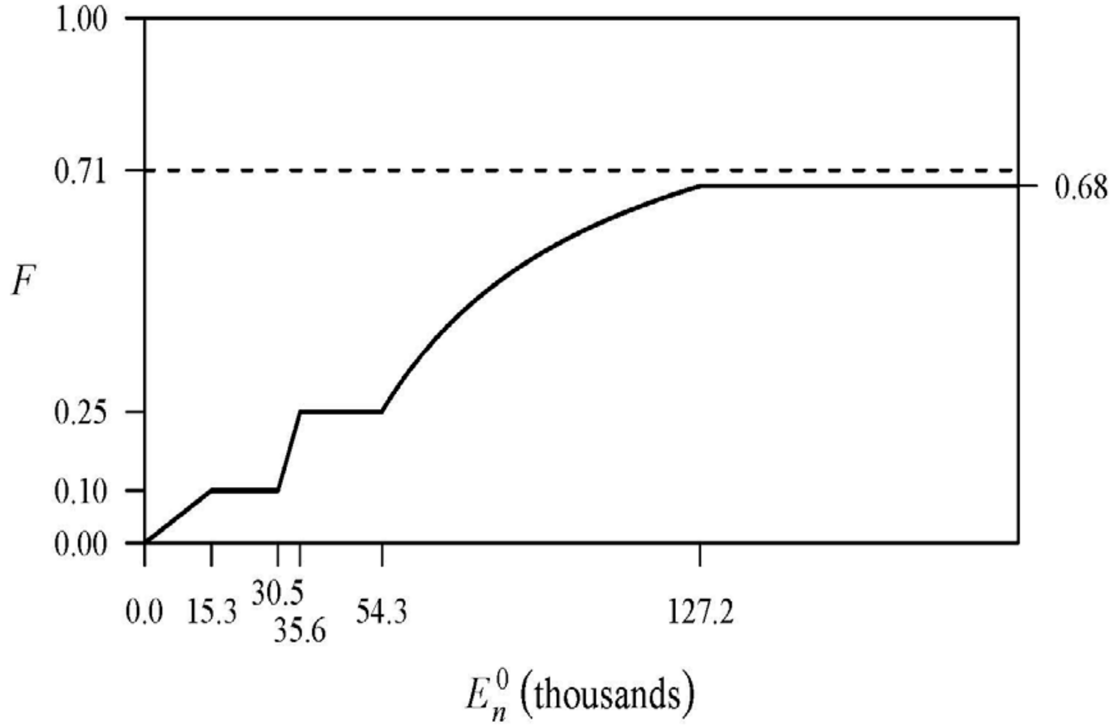

Figure III-1. Harvest control rule used in the EDRRA model (E_n^0 = natural area adult escapement in the absence of fisheries, F = exploitation rate) (graphic by Michael Mohr, NMFS).

As reflected in Mohr (in prep) and consistent with PFMC practice, the model distributes the allowable harvest among fisheries as follows: 34.0 percent to the ocean commercial fishery, 8.5 percent to the ocean recreational fishery, 7.5 percent to the inriver recreational fishery (up to a maximum of 25,000 fish – with any surplus above 25,000 allocated to escapement), and 50.0 percent to tribal fisheries. The 50 percent tribal share is a ‘hard’ allocation specified by the Department of the Interior (USDOI 1993) on behalf of the Yurok and Hoopa Valley Tribes. The distribution of the remaining 50.0 percent among the three non-tribal fisheries represents customary practice rather than mandatory conditions (Appendix A).

Table III-1 summarizes model results for the entire 50-year projection period (2012-61) and for the following subperiods: (i) 2012-20 (pre-dam removal, hatchery influence); (ii) 2021-32 (post-dam removal, continued hatchery influence), and (iii) 2033-61 (post-dam removal, no hatchery influence).[4]

[4] The model assumes that Iron Gate would cease to operate as a production hatchery in 2028. Hatchery influence on the fishery would continue for another 3-4 years (the length of the life cycle of the last year class released from the hatchery).

Table III-1. EDRRA model results for the troll fishery under the no action alternative (NAA) and dam removal alternative (DRA)[1]

	Time Period			
Model Results	*2012-61*	*2012-20*	*2021-32*	*2033-61*
50th percentile harvest: % diff between NAA and DRA[1]	+43%	+7%	+60%	+47%
5th percentile harvest: % diff between NAA and DRA[1]	-57%	-77%	-46%	-55%
95th percentile harvest: % diff between NAA and DRA[1]	+725%	+421%	+821%	+780%
Average # years when DRA harvest > NAA harvest: % diff between NAA and DRA[2]	70%	54%	78%	71%
Average # years when pre-harvest adult natural spawning escapement ≤ 30,500: % diff between NAA and DRA[3]	-66%	-4%	-79%	-80%

[1] Source: EDRRA model outputs provided by Hendrix (2011). Derivation provided in Appendix B.1.b.
[2] Derivation provided in Appendix B.3.
[3] Derivation provided in Appendix B.4.
2012-61: 50-year projection period
2012-20: pre-dam removal
2021-32: post-dam removal, hatchery influence
2033-61: post-dam removal, no hatchery influence

The EDRRA model assumes that ocean abundance is known without error and that the harvest control rule exactly achieves the escapement objective (Hendrix 2011). Given that the absolute harvest projections provided by the model are an idealized version of real world conditions, model results are best considered in terms of relative rather than absolute differences between alternatives. The average percent difference between EDRRA's 50th percentile harvest projections for the NAA and DRA is +43 percent for the troll fishery. The annual increase varies by subperiod, with harvest increasing by +7 percent prior to dam removal (2012-2020), peaking at +60 percent during the 12 years after dam removal when the fishery is still influenced by hatchery production (2021-32), then diminishing somewhat to +47 percent during 2033-61 after hatchery influence dissipates in 2032 (Table III-1).

EDRRA model results indicate that the 5th percentile harvest value for the DRA is 57 percent lower than the 5th percentile value for the NAA and that the 95th percentile harvest value is 725 percent higher; that is, the DRA harvest distribution is positively skewed and exhibits a high degree of overlap with the NAA harvest distribution. The EDRRA model also provides information regarding the percent of simulated years in which DRA harvest exceeds NAA harvest (50 percent indicating no difference between the two alternatives). These paired comparisons were made possible by applying the parameter draws associated with each iteration of the simulation to both the NAA and DRA. The results in Table III-1 indicate virtually no difference between the alternatives during 2012-20 (54 percent) but higher harvests under DRA in the two subsequent subperiods (2021-32 and 2033-61) in a notable majority of years (78 percent and 71 percent respectively).

The harvest control rule incorporated into the EDRRA model (Figure III-1) limits the exploitation rate to 10 percent or less when pre-harvest escapements fall below 30,500 adult natural spawners. Escapements this low would likely be accompanied by major regulatory restrictions and adverse economic conditions for the fishery. Such conditions occur in 66 percent fewer years under the DRA than the NAA – with the greatest declines (-79 percent during 2021-32, -80 percent during 2033-61) occurring in the post-dam removal years (Table III-1).

III.B.2. Biological Subgroup

According to the Biological Subgroup, the action alternatives are expected to provide habitat favorable to spring Chinook:

> "If dams were removed it is reasonable to expect reestablished spring-run Chinook salmon to synchronize their upstream migration with more natural flows and temperatures. The removal of Project reservoirs would also contribute important coldwater tributaries (e.g., Fall Creek, Shovel Creek) and springs, such as the coldwater inflow to the J.C. Boyle Bypassed Reach, to directly enter and flow unobstructed down the mainstem Klamath River, thereby providing thermal diversity in the river in the form of intermittently spaced patches of thermal refugia. These refugia would be useful to migrating adult spring-run Chinook salmon by extending opportunities to migrate later in the season. The thermal diversity would also benefit juvenile salmon" (Hamilton *et al*. 2011, p 87).

III.B.3. Lindley/Davis Habitat Model

The Lindley/Davis habitat model focuses on potential Chinook escapement to the Upper Basin above Iron Gate Dam (IGD). The analytical approach involved compilation of escapement and watershed attribute data for 77 fall and spring Chinook populations in various watersheds in Washington, Oregon, Idaho and Northern California, and comparison of those attribute sets with the attributes of Upper Basin watersheds. Based on their analysis, the authors concluded that Upper Basin attributes fall well within the range of spring bearing watersheds.

According to Lindley and Davis:

> "Our model predicts a fairly modest increase in escapement of Chinook salmon to the Klamath basin if the dams are removed. The addition of several populations of spring-run Chinook salmon with greater than 800 spawners per year to the upper Klamath would significantly benefit Klamath Chinook salmon from a conservation perspective, in addition to the fishery benefits….The last status review of the UKTR [Upper Klamath and Trinity Rivers] ESU expressed significant concern about the very poor status of the spring-run component of the ESU (Myers *et al*. 1998). Viable populations of spring-run Chinook salmon in the upper Klamath would increase the diversity and improve the spatial structure of the ESU, enhancing its viability (McElhaney *et al*., 2000) and improving the sustainability of the ESU into the uncertain future" (Lindley and Davis 2011, p 13).

III.B.4. Chinook Expert Panel

The Chinook Expert Panel concluded that "The Proposed Action offers greater potential for increased harvest and escapement of Klamath Chinook salmon than the Current Conditions" (Goodman *et al*. 2011, p 16). More specifically, the Panel noted that

> ”…a substantial increase[5] in Chinook salmon is possible in the reach between Iron Gate Dam and Keno Dam. A modest or substantial increase in Chinook upstream of Keno Dam is less certain. Within the range of pertinent uncertainties, it is possible that the increase in Chinook salmon upstream of Keno Dam could be large, but the nature of the uncertainties precludes attaching a probability to the prediction by the methods and information available to the Panel. The principal uncertainties fall into four classes: the wide range of variability in salmon runs in near-pristine systems, lack of detail and specificity about KBRA, uncertainty about an institutional framework for implementing KBRA in an adaptive fashion, and outstanding ecological uncertainties in the Klamath system that appear not to have been resolved by the available studies to date” (Goodman *et al*. 2011, p 7).

With regard to spring Chinook, the Panel noted:

> “The prospects for the Proposed Action to provide a substantial positive effect for spring Chinook salmon is much more remote than for fall Chinook. The present abundance of spring Chinook salmon is exceptionally low and spawning occurs in only a few tributaries in the basin. Under the Proposed Action, the low abundance and productivity (return per spawner) of spring Chinook salmon will still limit recolonization of habitats upstream of IGD. Intervention would be needed to establish populations in the new habitats, at least initially. Harvests of spring Chinook salmon could occur only if spring Chinook salmon in new and old habitats survive at higher rates than at present. Therefore, habitat quality would need to be higher than at present, and KBRA actions would need to greatly improve survival of existing populations of spring Chinook salmon. Factors specifically affecting the survival of spring Chinook salmon have not been quantified” (Goodman *et al*. 2011, p 25).

IV. Commercial Fishing Economic Value for Benefit-Cost Analysis (NED Account)

IV.A. Methodology and Assumptions

The economic analysis provided here assumes that the troll fishery will continue to be constrained by consultation standards associated with ESA listings and that KRFC will continue to be a binding constraint in most areas south of Cape Falcon. This has been the case in most years since the PFMC initiated its weak stock management policy in the early 1990s. Notable exceptions occurred in the late 2000s, when abundance of SRFC fell to record low levels and SRFC became the binding constraint on the troll fishery in all areas south of Cape Falcon. However, as indicated in Appendix A, it is not clear whether such low SRFC abundances signal a future pattern of persistent low abundances, are part of a cyclical pattern, or are events that may recur on a rare or occasional basis.

[5] The Panel defined the term ‘substantial increase’ to mean ‘a number of fish that contributes more than a trivial amount to the population’ and cited 10 percent of the average number of natural spawners or 10,000 fish as a rough approximation to what they mean by ‘substantial’. As indicated in their report, “The Panel does not suggest that this figure is a likely increase or a minimum increase that is expected. It is only used as a benchmark for our discussions and to provide a basis for interpreting our response to the question” (Goodman *et al*. 2011, p 7, footnote 3).

IV.A.1. SONCC Coho

As indicated in Section II.A, the SONCC coho ESU is listed as ‘threatened’ under the ESA. This ESU includes coho populations both inside and outside the Klamath Basin. The action alternatives are expected to increase the viability of Klamath River coho populations and advance recovery of the ESU (Hamilton *et al*. 2011, Dunne *et al*. 2011). However, since the action alternatives do not include coho restoration outside the Klamath Basin, they alone will not create conditions that would warrant de-listing of the SONCC coho ESU throughout its range. Thus, while they are expected to provide long term, positive biological effects, the action alternatives are not likely to affect the availability of coho to the troll fishery.

IV.A.2. Klamath River Spring and Fall Chinook

The EDRRA model (Hendrix 2011) is the basis for the quantitative projections of harvest, gross revenue and net revenue used to compare the no action and action alternatives. These variables were estimated as follows:[6]

(i) As indicated in Section III.B.1, the absolute harvest projections provided by the EDRRA model reflect idealized rather than real world conditions. Thus model results are best considered in terms of relative rather than absolute differences between alternatives. To anchor EDRRA projections to the real world, average annual troll harvest of Klamath Chinook during 2001-05 (35,778 fish, according to PFMC 2011b) was used to characterize the no action alternative. Annual harvest under the DRA (51,082 fish) was estimated by scaling average 2001-05 harvest upward, based on the difference between EDRRA’s 50th percentile harvest projections for the NAA and DRA (+43 percent, according to Table III-1). The years 2001-05 were selected as the base period for the following reasons: KRFC fell within a moderate range of abundance during those years (Figure A-3); abundance of SRFC (which is targeted along with KRFC in the troll fishery south of Cape Falcon) also fell within a moderate range (Figure A-4); and management constraints and policies that are likely to continue into the future – e.g., policies established in the 1990s to protect weaker stocks (including ESA-listed stocks), the 50-50 tribal/non-tribal harvest allocation – were well established by that time. Record low fishery conditions experienced after 2005 made those years unsuited for base period characterization.[7]

(ii) Harvest of Klamath River Chinook varies by management area due to factors such as the biological distribution of the stock and fishery regulations. To reflect the influence of these factors, annual average Klamath Chinook harvest projected under the no action and action alternatives was distributed among management areas, based on the relative geographic distribution of KRFC harvests experienced in the troll fishery during the 2001-05 base period (data source: Michael O’Farrell, NMFS).[8]

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[6] See Appendix B for more details regarding the methods and assumptions underlying the harvest and revenue projections for each alternative.

[7] The decades prior to the 2000s were also deemed unsuitable for characterizing the no action alternative. The 1980s pre-date current weak stock management policies. The 1990s was a period of adjustment to constraints that are expected to continue into the future (e.g., consultation standards for ESA-listed stocks, 50-50 tribal/non-tribal allocation) and also includes years of unusually low landings.

[8] Distribution of troll harvests of KRFC during 2001-05 was as follows: Monterey 4.7 percent, San Francisco 34.4 percent, Fort Bragg 17.9 percent, KMZ-CA 4.3 percent, KMZ-OR 1.9 percent, Central Oregon 27.8 percent, Northern Oregon 9.0 percent.

(iii) In San Francisco, Fort Bragg, KMZ-CA, KMZ-OR and Central Oregon, KRFC is managed as a 'constraining stock'; that is, the amount of Chinook harvest (all stocks) made available to the troll fishery is contingent on the allowable harvest of KRFC. To estimate average annual Chinook harvest (all stocks) attributable to the availability of Klamath Chinook in each of these areas, average annual Klamath Chinook harvest projected for each area under the no action and action alternatives was divided by an area-specific expansion factor – calculated as the average ratio of annual Klamath Chinook harvest to annual Chinook harvest (all stocks) during 2001-05 (data source: Michael O'Farrell, NMFS). For Monterey and Northern Oregon, Klamath Chinook is not a constraining stock except in years of very low Klamath Chinook abundance. For these latter two areas, the expansion factor was set equal to 1.000 to reflect the fact that Klamath Chinook availability in these areas does not affect the troll fishery's access to other stocks; thus Klamath Chinook harvest is treated as a simple addition to total harvest under the no action and action alternatives.[9]

(iv) Total Chinook harvest (all stocks) in each area attributable to the availability of Klamath Chinook was converted from numbers of fish to pounds dressed weight, based on the 2001-05 mean weight of troll-caught Chinook south of Cape Falcon (11.9 pounds according to PFMC 2011b).

(v) Total Chinook harvest (all stocks) was converted from pounds to gross revenue, based on the 2004-05 average ex-vessel price of troll Chinook landings south of Cape Falcon ($3.59 per pound dressed weight according to PFMC 2011b, calculated in 2012 dollars). This average price was calculated based on fishery data for 2004-05 – a period when prices reflect recent consumer preferences and more normal fishery conditions than 2006-10 (Appendix B.1.c).

(vi) The economic value of the fishery was measured in terms of net revenue (gross revenue minus trip expenses). Net revenue was estimated as 81.3 percent of gross ex-vessel revenue – based on survey data indicating that salmon troll trip costs (fuel, food/crew provisions, ice, bait) comprise 18.7 percent of gross revenue (source: Jerry Leonard, NMFS).

Harvest projections provided by the EDRRA model do not differentiate between spring and fall Chinook. However, actual harvest opportunities may differ somewhat by fishery – depending on the extent to which the harvestable surplus includes spring Chinook. The Biological Subgroup indicates that the action alternatives will result in expansion and restoration of habitat beneficial to spring Chinook. The Lindley/Davis model anticipates positive conservation benefits in terms of returning spring Chinook to Upper Basin watersheds and enhancing the viability of the Klamath/Trinity Chinook ESU, as well as modest fishery benefits. The Chinook Expert Panel indicates that a 'substantial increase' in Chinook between IGD and Keno Dam is possible but is more cautious regarding the possibility of successful Chinook introduction above Keno Dam and benefits to spring Chinook (Section III.B). The Biological Subgroup, Lindley/Davis and Expert Panel results are used here to qualify and expand on the EDRRA results by considering what the

[9] The expansion factors used in the analysis are as follows: Monterey 1.000, San Francisco 0.058, Fort Bragg 0.065, KMZ-CA 0.199, KMZ-OR 0.107, Central Oregon 0.062, Northern Oregon 1.000.

availability of modest amounts of spring Chinook in the harvestable surplus might mean for the troll fishery.

IV.B. Alternative 1 – No Action
IV.B.1. SONCC Coho

As indicated in Section II, coho retention has been prohibited in the troll fishery south of Cape Falcon since 1993 to meet consultation standards for SONCC coho and three other coho ESUs listed under the ESA. Little improvement in the status of the SONCC coho ESU is expected under Alternative 1. Thus current fishery prohibitions on coho retention are likely to continue into the future under this alternative.

IV.B.2. Klamath River Spring and Fall Chinook

Under Alternative 1, annual Klamath Chinook harvest is 35,778 fish and annual Chinook harvest (all stocks) attributable to the availability of Klamath Chinook is 491,100 fish. In all areas except Monterey and Northern Oregon, total Chinook harvest (all stocks) is higher than Klamath Chinook harvest, due to the use of expansion factors to account for total harvest of all stocks associated with the availability of Klamath Chinook. In Monterey and Northern Oregon, Klamath Chinook is not a constraining stock; that is, increases in Klamath Chinook harvest represent a simple addition to total harvest and do not yield benefits in terms of increased access to other stocks.[10] Average annual gross and net revenue under Alternative 1(all areas) are $21.0 million and $17.1 million respectively (Table IV-1).

Table IV-1. Projected average annual ocean troll harvest of Klamath Chinook and total Chinook (all stocks) attributable to Klamath Chinook abundance, and associated gross and net revenues under Alternative 1 – by management area.[1]

Management Area	*# Klamath Chinook*	*# Chinook (All Stocks)*	*Gross Revenue (2012$)*	*Net Revenue (2012$)*
Monterey	1,671	1,671	71,367	58,021
San Fran	12,312	213,608	9,125,553	7,419,075
Fort Bragg	6,413	98,382	4,202,992	3,417,033
KMZ-CA	1,530	7,691	328,574	267,131
KMZ-OR	667	6,247	266,894	216,985
Central OR	9,963	160,274	6,847,058	5,566,658
Northern OR	3,223	3,223	137,696	111,946
Total	35,778	491,097	20,980,134	17,056,849

[1] Calculations based on methodology discussed in Section IV.A.2.

It is also important to note that troll harvest of Klamath Chinook consists almost exclusively of fall run fish. This stock composition is expected to persist into the future under Alternative 1.

[10] It is important to note that total Chinook harvest (all stocks) and gross revenues reported in Table IV-1 pertain only to harvest and revenues that are attributable to the availability of Klamath Chinook. Because Klamath Chinook is not normally a constraining stock (i.e., does not affect access to other stocks) in Monterey and Northern Oregon, harvest and revenues in those areas attributable to Klamath Chinook (Table IV-1) are much less than actual harvest and revenues during the 2001-05 base period (Tables II-1 and II-3).

IV.C. Alternative 2 – Full Facilities Removal of Four Dams
IV.C.1. SONCC Coho

Alternative 2 is expected to improve the viability of coho populations in the Klamath stratum of the SONCC coho ESU but is unlikely to lead to de-listing, since the ESU also includes stocks outside the Klamath Basin whose viability is not affected by this action (Section III.A). Thus Alternative 2 will yield little change in coho harvest opportunities. Coho retention will likely continue to be prohibited in the California and Oregon troll fisheries south of Cape Falcon.

IV.C.2. Klamath River Spring and Fall Chinook
IV.C.2.a. Effects on Annual Harvest and Gross and Net Revenue

Under Alternative 2, annual average salmon harvest is projected to include 51,082 Klamath Chinook and 701,162 total Chinook (all stocks). In all areas except Monterey and Northern Oregon, total Chinook harvest (all stocks) is higher than Klamath Chinook harvest, due to the use of expansion factors to estimate total harvest of all stocks attributable to the availability of Klamath Chinook in those areas. In Monterey and Northern Oregon, increases in Klamath Chinook harvest represent a simple addition to total harvest and do not yield benefits in terms of increased access to other stocks.[11] Associated gross and net revenues (all areas) are $30.0 million and $24.4 million respectively. Average annual net revenue is higher under Alternative 2 (relative to Alternative 1) by $7.3 million (Table IV-2).

Table IV-2. Projected average annual ocean troll harvest of Klamath Chinook, total Chinook (all stocks) attributable to Klamath Chinook abundance, and gross and net revenues under Alternative 2, and change in net revenue from Alternative 1 – by management area.

Management Area	*# Klamath Chinook*[1]	*# Chinook (All Stocks)*[1]	*Gross Revenue (2012$)*[1]	*Net Revenue (2012$)*[1]	*Change in Net Revenue*[2]
Monterey	2,385	2,385	101,894	82,840	24,819
San Fran	17,578	304,979	13,028,998	10,592,576	3,173,501
Fort Bragg	9,156	140,465	6,000,817	4,878,665	1,461,632
KMZ-CA	2,184	10,981	469,121	381,396	114,265
KMZ-OR	952	8,920	381,058	309,800	92,815
Central OR	14,225	228,831	9,775,879	7,947,790	2,381,132
Northern OR	4,602	4,602	196,595	159,831	47,885
Total	51,082	701,162	29,954,363	24,352,897	7,296,049

[1] Calculations based on methodology described in Section IV.A.2.
[2] Difference in net revenue between Alternative 2 (column 5 of this table) and Alternative 1 (column 5 of Table IV-1).

[11] It is important to note that total Chinook harvest (all stocks) and gross and net revenues reported in Table IV-2 pertain only to harvest and revenues that are attributable to the availability of Klamath Chinook. Because Klamath Chinook is not normally a constraining stock (i.e., does not affect access to other stocks) in Monterey and Northern Oregon, harvest and revenues attributable to Klamath Chinook in those areas are likely much less than actual total harvest and revenues (all stocks) that would occur under the Klamath Chinook conditions projected for Alternative 2.

To the extent that spring Chinook production increases sufficiently to provide a harvestable surplus, the EDRRA projections (which include but do not distinguish between spring and fall Chinook) may over-estimate troll harvest. The reason for this has to do with the timing of the run relative to the timing of the fishery. Specifically, the troll fishery north of Point Arena, California opens on April 1; the troll fishery south of Point Arena (which includes the San Francisco and Monterey management areas) does not open until May 1 to meet the consultation standard fodr ESA-listed Sacramento River winter Chinook (PFMC 2011). Given this season structure, the harvest potential of spring Chinook may be limited for the troll fishery, as a large portion of the spring run will have returned to the river by the time the season opens.

IV.C.2.b. Discounted Present Value of Change in Net Revenue

Figure IV-1 depicts the annual trajectory of net revenues for Alternatives 1 and 2 during 2012-61. These annual values were derived by multiplying average annual net revenue (all areas) associated with each alternative (Tables IV-1 and IV-2 respectively) by an annual adjustment factor that reflects the variation in annual Klamath Chinook harvest relative to mean 2012-61 harvest – as projected by the EDRRA model (Appendix B.2). As indicated in Figure IV-1, the difference between the two alternatives diverges considerably after dam removal.

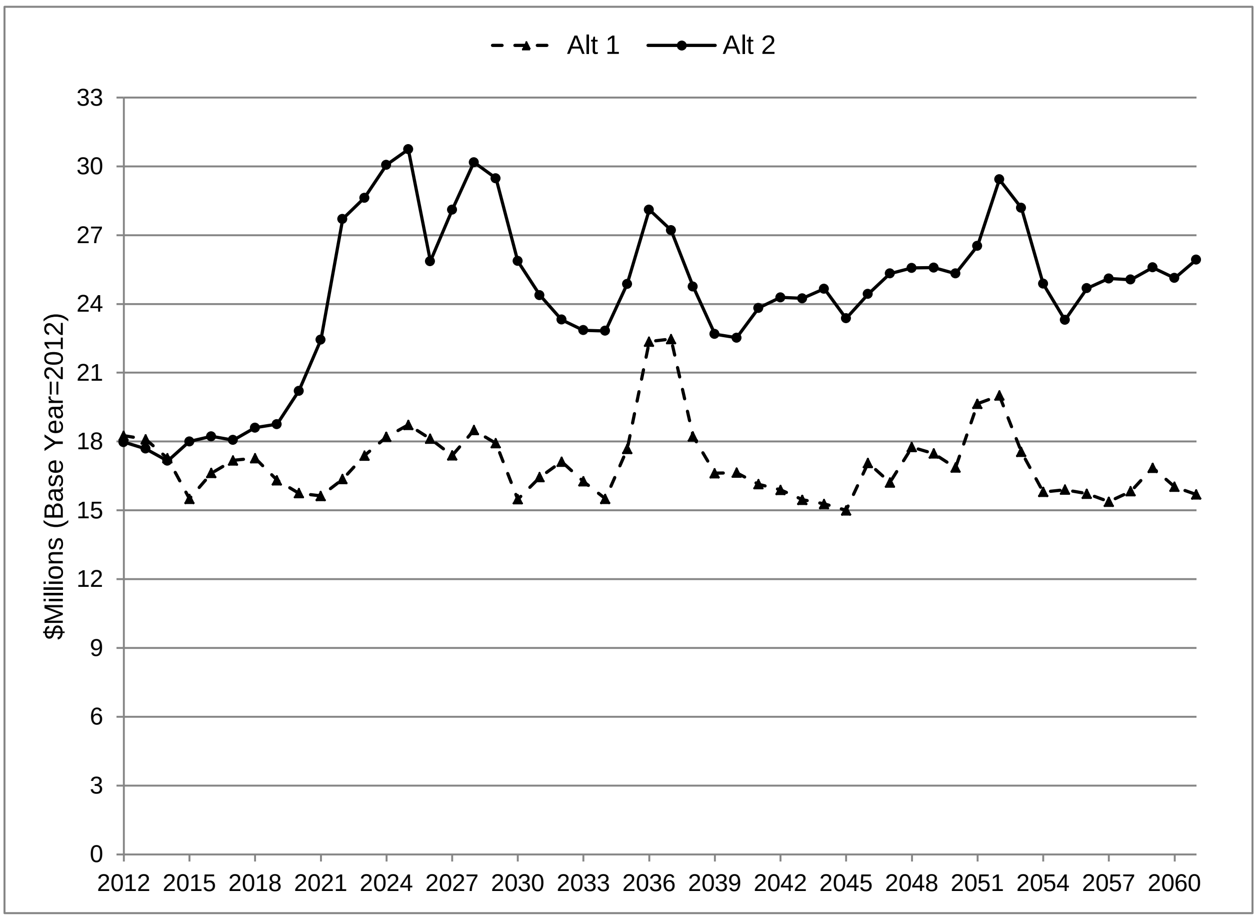

Figure IV-1. Projected annual net revenue under Alternatives 1 and 2 during 2012-61 (calculated according to the methodology described in Appendix B-2).

Results of the NED analysis provided here are also included in two summary reports (Reclamation 2011a, 2011b) that describe all quantifiable economic benefits and costs in terms of discounted present value (DPV). Discounting is based on the premise that benefits that occur more immediately are preferred to benefits that occur farther into the future. Discounting has the effect of attaching progressively smaller weights to changes in net economic value that occur later in the time series, with diminution of these weights becoming more rapid at higher discount rates. The discount rate used in the NED analysis is 4.125 percent, the rate prescribed at the time of the analysis for Federal water resources planning (Reclamation 2010).

DPV for the troll fishery was calculated by applying a discount factor to each of the annual net revenue estimates provided in Figure IV-1, then summing the results (Appendix B-2). Table IV-3 provides estimates of DPV associated with the prescribed 4.125 percent rate and several rates lower and higher than 4.125 percent (including 0.000 percent – no discounting). DPV associated with the 4.125 percent discount rate is $134.5 million, which is 37 percent of the undiscounted present value (discount rate of 0.000 percent) and twice the value of DPV associated with the 8.000 percent discount rate.

Table IV-3. Discounted present value of the increase in net revenue under Alternative 2 relative to Alternative 1 (2012$), calculated to illustrate the sensitivity of the estimates to alternative discount rates.

Discount Rate	*Discounted Present Value (2012$)*
0.000%	364,801,854
2.000%	216,684,556
4.125%	134,494,901
6.000%	93,378,408
8.000%	66,327,564

Calculations based on methodology described in Appendix B.2.

Figure IV-2 depicts the stream of the annual discounted changes in net revenue that were summed to derive the DPV estimate associated with each of the discount rates in Table IV-3. As indicated in the figure, changes in net revenue are relatively insensitive to the choice of discount rate in the first decade of the time series but can diverge rather widely in subsequent decades. The differences in the DPV estimates shown in Table IV-3 are influenced by the fact that changes in net revenue under Alternative 2 do not increase appreciably until after dam removal, which does not occur until close to the end of the first decade of the projection period 2012-61.

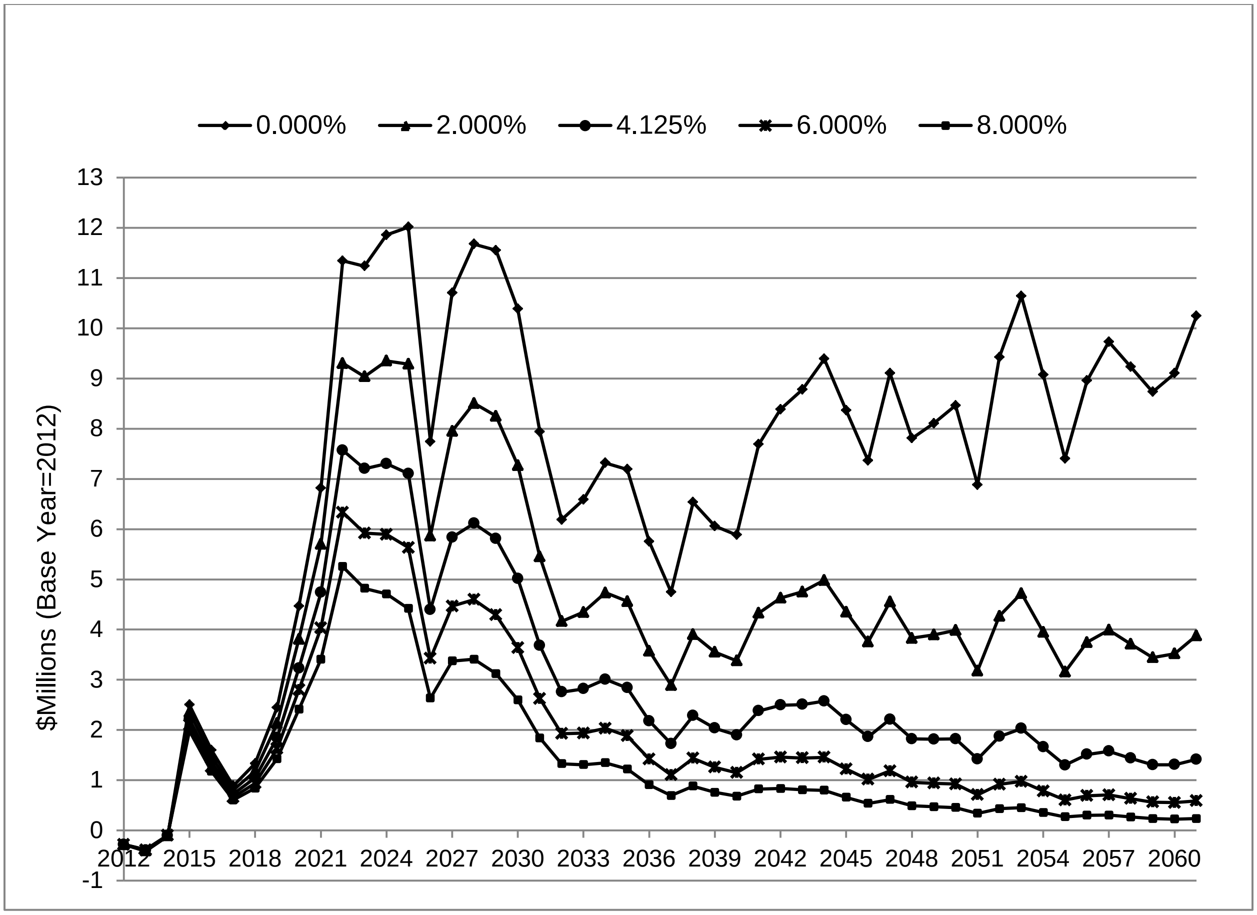

Figure IV-2. Annual discounted value of the change in net revenue under Alternative 2 relative to Alternative 1 (2012$) during the projection period 2012-61, calculated on the basis of alternative discount rates of 0% (no discounting), 2%, 4.125%, 6%, and 8%.

IV.C.2.c. Effects at Low Levels of Abundance

Economic effects pertain not only to how harvest opportunity is affected on an average basis but also under more unusual conditions. As indicated in Figure III-1, the KRFC harvest control rule adopted by the PFMC in June 2011 limits the exploitation rate to 10 percent or less when pre-harvest escapements fall below 30,500 adult natural spawners. Escapements this low would be accompanied by adverse economic conditions that are reminiscent of the situation in 2006, when actions to protect KRFC required major reductions in harvest of all salmon stocks in all areas south of Cape Falcon (including Monterey and Northern Oregon, where KRFC does not normally constrain harvest of other stocks). Salmon troll landings and revenues were 18 percent and 39 percent respectively of their 2001-05 average values (Tables II-2 and II-3), and $60.4 million in Commercial Fishery Disaster Assistance was provided to affected businesses and communities. Results of the EDRRA model indicate that pre-harvest escapements below 30,500 would occur in 66 percent fewer years under Alternative 2 than Alternative 1, with the greatest decline (-79 percent) occurring in the post-dam removal years (Table III-1). While the quantitative economic results provided in Sections IV.C.2.a and IV.C.2.b pertain to how the action alternatives would affect fishery conditions at moderate levels of abundance, it is important to note that Alternative 2 will also reduce the incidence of low abundances and associated adverse effects on the troll fishery.

IV.D. Alternative 3 – Partial Facilities Removal of Four Dams

Alternative 3 is intended to provide the same habitat conditions as Alternative 2 – i.e., fish passage unencumbered by dams and a free-flowing river, as well as benefits of the KBRA. Therefore the effects of this alternative on salmon populations and the salmon troll fishery are expected to be the same as Alternative 2.

V. Commercial Fishing Expenditures for Regional Economic Impact Analysis (RED Account)

V.A. Methodology and Assumptions

Regional economic impacts pertain to effects of the no action and action alternatives on employment, labor income and output in the regional economy. These impacts include: direct effects on the economy as trollers spend their revenues on labor shares and payments to support businesses that provide food/crew provisions, fuel, ice, boat maintenance/repair, moorage, and the like; indirect effects as payments by fishery support businesses to their vendors generate additional economic activity; and induced effects associated with changes in household spending by workers in all affected businesses. Estimation of this so-called multiplier effect is based on assumptions such as constant returns to scale, no input substitution, no supply constraints, and no price or wage adjustments. Thus regional impacts as estimated here are more suggestive of the economy's short-term response rather than long-term adjustment to infusions of money into the economy.

Regional impacts were estimated using Impact Analysis for Planning (IMPLAN) software and data and are based on the makeup of the economy at the time of the underlying IMPLAN data (2009). The applicability of the impacts thus estimated to any particular year of the 50 year study period is affected by the extent to which the underlying economy in that year deviates from the economy in 2009. The employment impacts include full time, part time, and temporary positions. These impacts may not be fully realized to the extent that businesses deal with changes in demand by adjusting the workload of existing employees or increasing their use of capital relative to labor rather than hiring new employees.

The regional economic analysis provided here is based on average annual gross revenues projected for the no action and action alternatives. About 99 percent of revenues from Chinook harvest (all stocks) that are attributable to the availability of Klamath Chinook is concentrated in five of the seven management areas under the no action and action alternatives (Tables IV-1 and IV-2). Thus the regional economic analysis focuses on those five areas: San Francisco (San Mateo, San Francisco, Marin and Sonoma Counties), Fort Bragg (Mendocino County), KMZ-CA (Humboldt and Del Norte Counties), KMZ-OR (Curry County), and Central Oregon (Coos, Douglas and Lane Counties). Revenues spent in the region and the multipliers used to estimate the impacts of these expenditures will vary, depending on how the affected region is defined. Thus regional impacts will differ, depending on whether impacts are (i) estimated separately for each of the five areas or (ii) estimated for a single study area defined as the aggregation of all five areas. Because the impacts provided here were estimated in the manner of (i), summing those impacts across areas will not provide an accurate estimate of the impacts in all areas combined. More detailed documentation of the methods used to estimate regional impacts is provided in Reclamation (2011a).

V.B. Alternative 1 – No Action

Table V-1 describes average annual gross revenue in each of the five management areas covered by the regional economic analysis. These revenue estimates were used in conjunction with IMPLAN software and data to analyze the regional impacts of Alternative 1 in each area.

Table V-1. Average annual gross revenue under Alternative 1, by management area[1]

Management Area	*Gross Revenue (2012$)*
San Francisco	9,125,553
Fort Bragg	4,202,992
KMZ-CA	328,574
KMZ-OR	266,894
Central Oregon	6,847,058

[1] Extracted from Table IV-1.

The associated impacts of Alternative 1 on employment, labor income and output are shown in Table V-2 by management area. Consistent with the revenue pattern (Table V-1), impacts are highest in San Francisco and lowest in KMZ-CA and KMZ-OR.

Table V-2. Annual regional economic impacts associated with average annual gross revenue projected for Alternative 1, by management area

San Francisco			
Impact Type	*Employment (Jobs)*	*Labor Income ($Millions)*	*Output ($Millions)*
Direct	480.0	4.27	9.13
Indirect	8.0	0.56	2.70
Induced	22.0	1.27	3.69
Total	**510.0**	**6.10**	**15.52**
Fort Bragg			
Impact Type	*Employment (Jobs)*	*Labor Income ($Millions)*	*Output ($Millions)*
Direct	150.0	1.98	4.20
Indirect	1.4	0.07	0.18
Induced	10.6	0.40	1.24
Total	**162.0**	**2.45**	**5.62**
KMZ-CA			
Impact Type	*Employment (Jobs)*	*Labor Income ($Millions)*	*Output ($Millions)*
Direct	43.0	0.15	0.33
Indirect	0.1	0.01	0.02
Induced	0.9	0.03	0.10
Total	**44.0**	**0.19**	**0.45**
KMZ-OR			
Impact Type	*Employment (Jobs)*	*Labor Income ($Millions)*	*Output ($Millions)*
Direct	25.0	0.13	0.27
Indirect	0.1	0.00	0.01
Induced	0.5	0.02	0.05
Total	**25.6**	**0.15**	**0.33**

Central Oregon			
Impact Type	*Employment (Jobs)*	*Labor Income ($Millions)*	*Output ($Millions)*
Direct	293.0	3.21	6.85
Indirect	4.1	0.17	0.46
Induced	21.8	0.77	2.24
Total	**318.9**	**4.15**	**9.55**

Source: Reclamation 2011b, presented in 2012 dollars.
Employment measured in number of full time, part time and temporary jobs. Labor income is dollar value of total payroll (including benefits) for each industry in the analysis area plus income received by self-employed individuals in the analysis area. Output represents dollar value of industry production.

V.C. Alternative 2 – Full Facilities Removal of Four Dams

Table V-3 describes average annual gross revenue in each of the five management areas covered by the regional economic analysis. The changes in gross revenue from Alternative 1 to Alternative 2 was used in conjunction with IMPLAN software and data to estimate the regional impacts associated with Alternative 2.

Table V-3. Average annual gross revenue under Alternative 2 and change from Alternative 1 – by management area.

Management Area	*Gross Revenue (2012$)*[1]	*Change from Alternative 1*[2]
San Francisco	13,028,998	3,903,445
Fort Bragg	6,000,817	1,797,825
KMZ-CA	469,121	140,547
KMZ-OR	381,058	114,164
Central Oregon	9,775,879	2,928,821

[1] Extracted from Table IV-3.
[2] Difference in gross revenue between Alternative 2 (column 2 of this table) and Alternative 1 (Table V-1).

The impacts of the increase in troller revenues under Alternative 2 on employment, labor income and output are shown in Table V-4 for each management area. The increases in employment, labor income and output relative to Alternative 1 are 42 to 43 percent in each area.

Table V-4. Change in annual regional economic impacts associated with average annual increase in ex-vessel revenue under Alternative 2 relative to Alternative 1, by management area.

San Francisco						
Impact Type	*Employment*		*Labor Income*		*Output*	
	Jobs	*% change from Alt 1*	*$Millions*	*% change from Alt 1*	*$Millions*	*% change from Alt 1*
Direct	205.0		1.79		3.90	
Indirect	3.5		0.24		1.15	
Induced	9.3		0.53		1.55	
Total	**217.8**	**42.7**	**2.56**	**42.0**	**6.6**	**42.6**
Fort Bragg						
Impact Type	*Employment*		*Labor Income*		*Output*	
	Jobs	*% change from Alt 1*	*$Millions*	*% change from Alt 1*	*$Millions*	*% change from Alt 1*
Direct	64.0		0.85		1.80	
Indirect	0.5		0.03		0.08	
Induced	4.5		0.17		0.53	
Total	**69.0**	**42.7**	**1.05**	**42.8**	**2.41**	**42.8**
KMZ-CA						
Impact Type	*Employment*		*Labor Income*		*Output*	
	Jobs	*% change from Alt 1*	*$Millions*	*% change from Alt 1*	*$Millions*	*% change from Alt 1*
Direct	18.0		0.06		0.14	
Indirect	0.1		0.00		0.01	
Induced	0.4		0.01		0.04	
Total	**18.5**	**41.7**	**0.07**	**42.0**	**0.19**	**42.6**
KMZ-OR						
Impact Type	*Employment*		*Labor Income*		*Output*	
	Jobs	*% change from Alt 1*	*$Millions*	*% change from Alt 1*	*$Millions*	*% change from Alt 1*
Direct	11.0		0.05		0.11	
Indirect	0.0		0.00		0.00	
Induced	0.2		0.01		0.02	
Total	**11.2**	**43.8**	**0.06**	**42.8**	**0.13**	**42.8**
Central Oregon						
Impact Type	*Employment*		*Labor Income*		*Output*	
	Jobs	*% change from Alt 1*	*$Millions*	*% change from Alt 1*	*$Millions*	*% change from Alt 1*
Direct	125.0		1.35		2.93	
Indirect	1.8		0.07		0.20	
Induced	9.1		0.32		0.94	
Total	**135.9**	**42.6**	**1.74**	**42.0**	**4.07**	**42.6**

Source: Reclamation 2011b, presented in 2012 dollars.

Employment measured in number of full time, part time and temporary jobs. Labor income is dollar value of total payroll (including benefits) for each industry in the analysis area plus income received by self-employed individuals in the analysis area. Output represents dollar value of industry production.

V.D. Alternative 3 – Partial Facilities Removal of Four Dams

Alternative 3 is intended to provide the same habitat conditions as Alternative 2 – i.e., fish passage unencumbered by dams and a free-flowing river, as well as benefits of the KBRA. Therefore the effects of this alternative on salmon populations and the salmon troll fishery are expected to be the same as Alternative 2.

VI. Summary and Conclusions

The particular salmon stocks influenced by the no action and action alternatives are the SONCC coho ESU (which is listed under the ESA) and Klamath River fall and spring Chinook. Economic effects of the no action and action alternatives on the troll fishery as they relate to these stocks are as follows:

SONCC coho ESU: Coho retention has been prohibited in the troll fishery south of Cape Falcon since 1993 to meet consultation standards for SONCC coho and three other coho ESUs listed under the ESA. Little improvement in the status of the SONCC coho ESU is expected under the no action alternative. Thus current fishery prohibitions on coho retention are likely to continue into the future under this alternative. The action alternatives are expected to yield similar improvements in the viability of Klamath coho populations and advance the recovery of the SONCC coho ESU, but are unlikely to lead to de-listing since the ESU also includes stocks outside the Klamath Basin whose viability is not affected by this action. Thus coho retention will likely continue to be prohibited in the California and Oregon troll fisheries south of Cape Falcon under these alternatives.

Klamath River Chinook

- *Economic benefits:* Under the no action alternative, average annual troll harvest of Klamath Chinook is estimated to be similar to what it was during 2001-05 (35,778 fish). Reflecting the constraining influence of Klamath Chinook on the availability of Chinook (all stocks) in the San Francisco, Fort Bragg, KMZ-CA, KMZ-OR and Central Oregon management areas, Klamath Chinook harvest of 35,778 provides the opportunity for the troll fishery to harvest 491,100 Chinook (all stocks) south of Cape Falcon, Oregon. Average annual net revenue associated with such harvest is $17.1 million.

  Under the action alternatives, annual salmon troll harvest is estimated to increase by an average of 43 percent over the 2012-61 projection period. Average annual harvest under these alternatives is projected to include 51,082 Klamath Chinook and 701,162 total Chinook (all stocks), with associated net revenue of $24.4 million. The increase in annual net revenue under the action alternatives relative to no action is $7.3 million. The discounted present value of this increase over the 2012-61 period is $134.5 million (based on a discount rate of 4.125 percent).

  The harvest control rule underlying the Klamath Chinook harvest projections limits the exploitation rate to 10 percent or less in years when pre-harvest escapements fall below 30,500 adult natural spawners. Escapements this low would likely be accompanied by major regulatory restrictions and adverse economic conditions similar to what was experienced in 2006. Such low escapements would occur in 66 percent fewer years under the action alternatives, with the greatest decline (-79 percent) occurring in the post-dam removal years.

- *Economic impacts:* Regional economic impacts associated with the no action and action alternatives are largely concentrated in the five management areas where Klamath Chinook is the constraining stock. Regional impacts associated with the $20.8 million in gross revenue generated in those five areas under the no action alternative vary widely by area. For San Francisco, Fort Bragg and Central Oregon, annual impacts (depending on the area) include 162 to 510 jobs, $2.45 million to $6.10 million in labor income, and $5.62 million to $15.52 million in output. For KMZ-CA and KMZ-OR, annual impacts include 26 to 44 jobs, $0.15 million to $0.19 million in labor income, and $0.33 million to $0.45 million in output.

  The additional $8.9 million in gross revenue in the same five areas under the action alternatives generates regional impacts that vary widely by area. For San Francisco, Fort Bragg and Central Oregon, annual impacts (depending on the area) include an additional 69 to 218 jobs, an additional $1.05 million to $2.56 million in labor income, and an additional $2.41 million to $6.6 million in output. For KMZ-CA and KMZ-OR, the annual impacts include an additional 11 to 19 jobs, an additional $0.06 million to $0.07 million in labor income, and an additional $0.13 million to $0.19 million in output.

Main areas of uncertainty in this analysis include natural variability in biological and environmental parameters, uncertainty regarding future harvest management policies, and uncertain ex-vessel prices (which are affected by global supply and demand for farmed as well as wild salmon).

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Appendix A. Salmon Fishery Management

In 1976 the U.S. Congress implemented the Magnuson Fishery Conservation and Management Act (now the Magnuson-Stevens Fishery Conservation and Management Act or MSFCMA), which established eight regional fishery management councils whose mandate was to phase out foreign fishing and manage domestic fisheries in the U.S. Exclusive Economic Zone (EEZ).[12] The Pacific Fishery Management Council (PFMC) is the entity responsible for management of EEZ fisheries off the coasts of Washington, Oregon and California.   The PFMC implemented the Pacific Coast Salmon Fishery Management Plan (FMP) in 1978. The FMP addresses management needs of multiple salmon stocks that originate in rivers along the Pacific coast. The PFMC manage the troll fishery south of Cape Falcon with regulations such as area closures, season closures, gear restrictions, minimum size limits, vessel landing limits, stock retention prohibitions , mark-selective fishing, and quotas.[13]

The major salmon species harvested in the south-of-Falcon fishery are Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*). The area south of Falcon is divided into six management areas: Monterey, San Francisco, Fort Bragg, Klamath Management Zone (KMZ), Central Oregon, and Northern Oregon. For purposes of this analysis, the KMZ (which straddles the Oregon-California border) is divided at the border into two areas: KMZ-OR and KMZ-CA.

Management of the troll fishery is complicated by the fact that multiple salmon stocks with different conservation objectives mix in the ocean harvest. These 'mixed stock' fisheries are managed on the general principle of 'weak stock' management, whereby harvest opportunity for more abundant stocks is constrained by the need to meet conservation objectives for weaker stocks.

PFMC management reflects conservation objectives for targeted stocks, consultation standards for weak stocks, and harvest allocation requirements (PFMC 2011b):

- *Targeted stocks:*   For ocean fisheries south of Cape Falcon, the major targeted stocks are Sacramento River fall Chinook (SRFC) and Klamath River fall Chinook (KRFC). Conservation objectives for these stocks[14] are as follows:
    - In 1989, following a period of sizeable KRFC harvests, low KRFC escapements and a major El Niño in 1982-83, the PFMC adopted more conservative harvest policies for KRFC, including a return of 34-35 percent of adult natural spawners and an escapement floor of 35,000 adult natural spawners (Klamath River Technical Team 1986, PFMC 1988). Figure A-1 depicts KRFC escapements during 1978-2010 relative to the

[12] The EEZ includes waters that extend 3-200 miles from the U.S. coast.

[13] A mark selective fishery is a fishery in which hatchery fish are marked in a visually identifiable manner (e.g., by clipping the adipose fin), thereby allowing fishermen to selectively retain marked fish and release unmarked (wild) fish.

[14] The conservation objectives for KRFC and SRFC discussed here are intended to facilitate interpretation of historical fishery trends. In June 2011 the PFMC recommended modifications to these objectives to address new requirements of the MSFCMA; these changes will likely become effective in 2012.

escapement floor that was in effect during 1989-2006. In 2007 the floor was increased to 40,700 to help rebuild KRFC after the stock collapsed in 2006.[15]

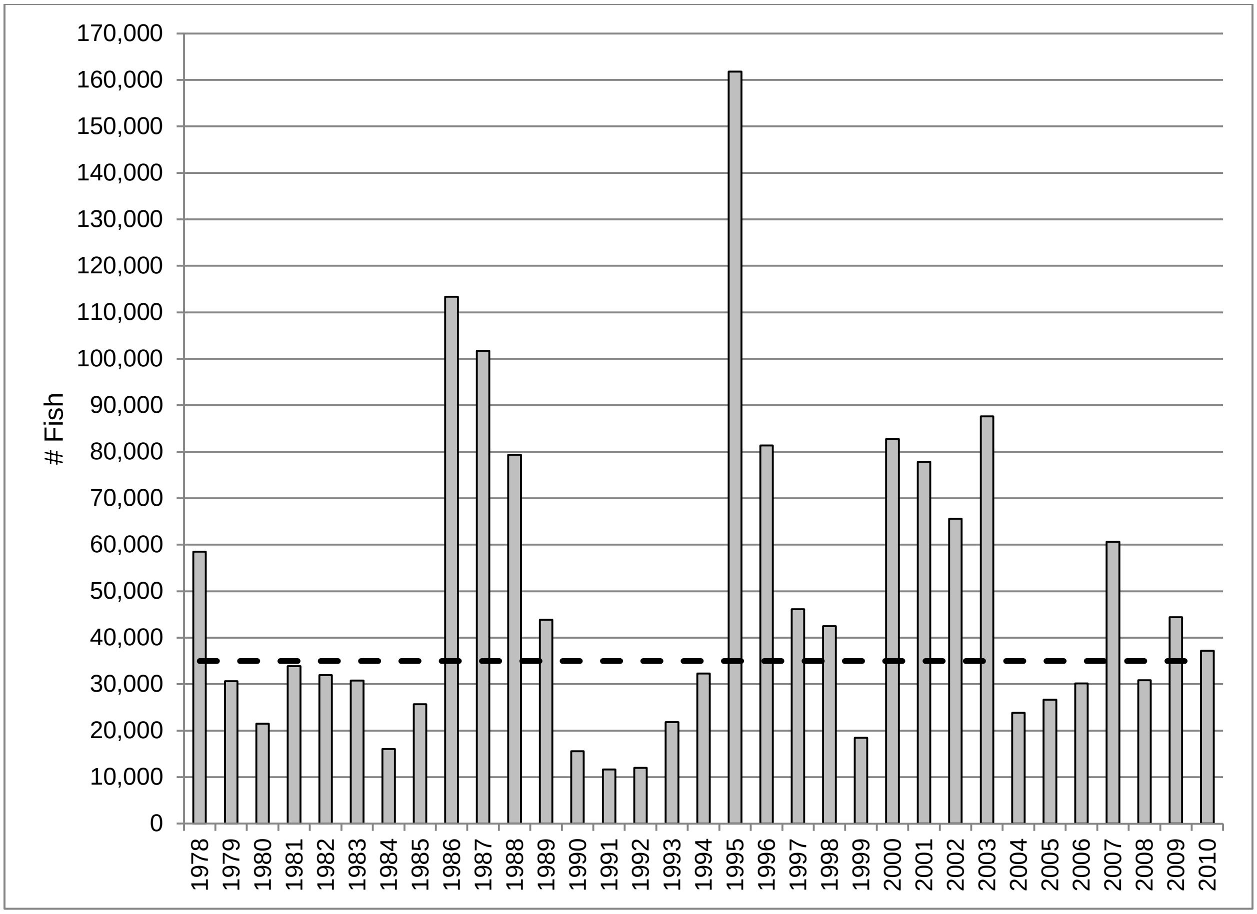

Figure A-1. Klamath River adult natural spawner escapement, 1978-2010. Dotted line represents 35,000 escapement floor in effect during 1989-2006 (source: PFMC 2011a)

- The conservation objective for SRFC is a spawner escapement goal of 122,000-180,000 hatchery and natural area adults. Figure II-2 depicts SRFC escapements during 1978-2010 relative to the escapement goal, which has been in effect since 1978.

[15] The escapement floor returned to 35,000 in 2011, when KRFC was classified as rebuilt (PFMC 2012).

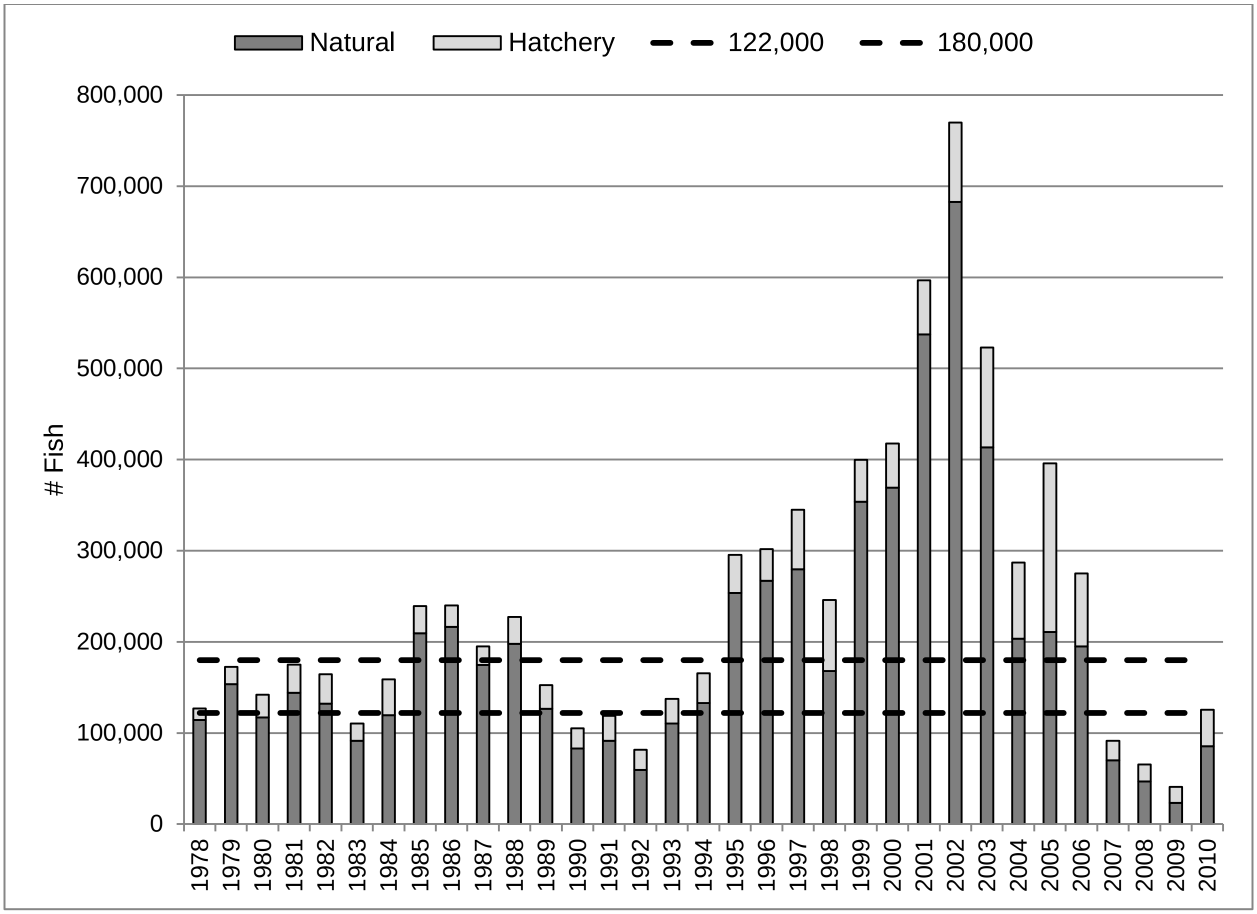

Figure A-2. Sacramento River adult spawner escapement (natural + hatchery), 1978-2010. Dotted lines represent PFMC escapement goal of 122,000-180,000 (source: PFMC 2011a).

- *Stocks listed under the Endangered Species Act (ESA):* The PFMC is bound by consultation standards for six ESA-listed Chinook and coho stocks that occur in the ocean fishery south of Cape Falcon.[16]
  - Sacramento River winter Chinook was listed as 'threatened' in 1989 and reclassified as 'endangered' in 1994. The current consultation standard includes area, season and size limit restrictions for ocean commercial and recreational fisheries from Point Arena, California to the U.S./Mexico border.
  - Central California Coast coho was listed as 'threatened' in 1996 and reclassified as 'endangered' in 2005. The consultation standard is a ban on coho retention in all commercial and recreational fisheries in California.
  - SONCC coho was listed as 'threatened' in 1997. The consultation standard caps the marine exploitation rate on Rogue/Klamath River hatchery coho at 13 percent.
  - Oregon Coastal Natural (OCN) coho was listed as 'threatened' in 1998, de-listed in 2006 following a NMFS update of all its listing determinations, and re-listed in 2008 after the de-listing was successfully challenged in Court. OCN coho is managed on the basis of exploitation rates that vary with habitat production potential (freshwater and marine) –

[16] A seventh stock – Central Valley spring Chinook – was listed as 'threatened' in 1999. NMFS determined that PFMC-managed fisheries presented 'no jeopardy' to this stock.

measured by parent spawner status and smolt-to-adult marine survival (PFMC 1999, OCN Work Group 2000).
  - California Coastal Chinook was listed as 'threatened' in 1999. Using KRFC as an indicator stock, the consultation standard for California Coastal Chinook caps the forecast harvest rate for age-4 KRFC in the ocean fishery at 16 percent.
  - Lower Columbia Natural coho was listed as 'threatened' in 2005. The consultation standard is a maximum exploitation rate of 15 percent (marine and Columbia River combined).

- *Stock rebuilding:* The PFMC designates a 'conservation alert' when a stock is forecast to not meet its conservation objective in a single year and an 'overfishing concern' when this happens in three consecutive years. A conservation alert may warrant precautionary management in the year of the alert, while an overfishing concern (which is more indicative of a downward trend) may require a longer-term management strategy – including a stock rebuilding plan (PFMC 2003).

- *Allocation:* In 1993, the Department of the Interior, Office of the Solicitor issued an opinion requiring that 50 percent of Klamath-Trinity River salmon be reserved for the Yurok and Hoopa Valley Tribes (USDOI 1993). This was considerably higher than the 30 percent tribal reserve that was in effect during 1987-91 (Pierce 1998) and required reduced allocations to non-tribal fisheries. The 50-50 tribal/non-tribal allocation remains in effect today.

Table A-1 identifies periods of particularly stringent troll regulations associated with low coho and/or Chinook abundances. The table illustrates the long-term nature of non-retention policies to protect coho and the frequency of fishery closures, which tend to occur when Chinook abundance is also low.

Table A-1. Years of no coho retention (NoCoho), closure of both Chinook and coho fisheries (Closure), and closure of Crescent City portion of KMZ-CA (ClosureCC)[1] in the troll fishery south of Cape Falcon, 1990-2010, by management area.

Year	*Management Area*				
	SanFran & Monterey	*Ft Bragg*	*KMZ-CA*	*KMZ-OR*	*CentralOR & North OR*
1990			NoCoho	NoCoho	
1991			NoCoho, ClosureCC	NoCoho	
1992		Closure	Closure	Closure	
1993	NoCoho	NoCoho	Closure	Closure	NoCoho
1994	NoCoho	NoCoho	Closure	NoCoho	NoCoho
1995	NoCoho	NoCoho	Closure	NoCoho	NoCoho
1996	NoCoho	NoCoho	NoCoho	NoCoho	NoCoho
1997-98	NoCoho	NoCoho	NoCoho, ClosureCC	NoCoho	NoCoho
1999-05	NoCoho	NoCoho	NoCoho	NoCoho	NoCoho
2006	NoCoho	NoCoho	Closure	NoCoho	NoCoho,
2007	NoCoho	NoCoho	NoCoho	NoCoho	
2008	Closure	Closure	Closure	NoCoho	NoCoho
2009	Closure	Closure	Closure	Closure	
2010	NoCoho	NoCoho	Closure	NoCoho	NoCoho

Sources: PFMC 1998, 2009. 2010, 2011b.

[1] KMZ-CA includes Crescent City and Eureka-area ports.

Circumstances underlying the regulatory restrictions identified in Table A-1 are as follows:

- Periods of drought and El Niño conditions during 1991-92 and 1997-98 contributed to low Chinook and coho returns and prompted major fishery restrictions during the 1990s – including Commercial Fishery Disaster Assistance in 1994 ($15.7 million), 1995 ($13.0 million) and 1998 ($3.5 million) (pers. comm. Stephen Freese, NMFS). Actions taken by the PFMC to deal with the persistent decline in coho stocks included a ban on coho retention in KMZ-CA and KMZ-OR since 1990 and in all other management areas south of Cape Falcon since 1993, with the exception of limited fisheries in 2007 and 2009 in Central and Northern Oregon.
- Fishery closure (all stocks) generally occurs when overfishing concerns for SRFC and/or KRFC occur in conjunction with the prohibition on coho retention. During 1990-92, KRFC and SRFC failed to reach their respective conservation objectives – triggering an overfishing concern for both stocks (Klamath River Fall Chinook Review Team 1994, Sacramento River Fall Chinook Review Team 1994). Major fishery restrictions including closures in Fort Bragg in 1992, KMZ-CA during 1992-95, and KMZ-OR during 1992-93.
- During the prolonged drought in the 2000s, KRFC failed to achieve its conservation objective for three consecutive years (2004-06). Subsequent fishery restrictions – including closure of KMZ-CA in 2006 – prompted $60.4 million in Commercial Fishery Disaster Assistance in 2007 (Upton 2010). The PFMC also increased the adult natural spawner escapement floor from 35,000 to 40,700 as a rebuilding strategy.
- Failure of SRFC to achieve its conservation objective during 2007-09 triggered an overfishing concern (Lindley *et al.* 2009). Historically unprecedented restrictions were imposed on the troll fishery (including complete closure of the California fishery in 2008-09. Congress appropriated $170 million in Commercial Fishery Disaster Assistance, of which $117 million was disbursed in 2008 and $53 million in 2009 (Upton 2010; pers. comm. Stephen Freese, NMFS).

It is important to note that KRFC natural spawner escapement – as depicted in Figure A-1 above – does not necessarily reflect stock abundance. Ocean abundance of adult KRFC includes the number of fish that migrate to the ocean and (i) are harvested in ocean or inriver fisheries, (ii) contribute to natural or hatchery escapement, (iii) remain unharvested in the ocean, or (iv) are subject to natural mortality or non-retention (hooking and dropoff) mortality.[17] Figure A-3 provides ocean abundance estimates – decomposed into ocean and inriver harvest and an 'All Else' component that includes items (ii) through (iv) above.[18] The size of the individual components of Figure A-3 depends on factors such as the extent of hatchery production, ocean and inriver conditions, and fishery regulations.

[17] Natural mortality is the mortality associated with factors such as disease and non-human predation. Hooking mortality pertains to fish that die after being hooked and released. Dropoff mortality pertains to fish that die after being dropped from the fishing gear as a result of such encounters with the gear.
[18] The escapements depicted in Figures A-1 and A-3 are not comparable. Figure A-1 includes natural escapement only, while Figure A-3 includes both natural and hatchery escapement.

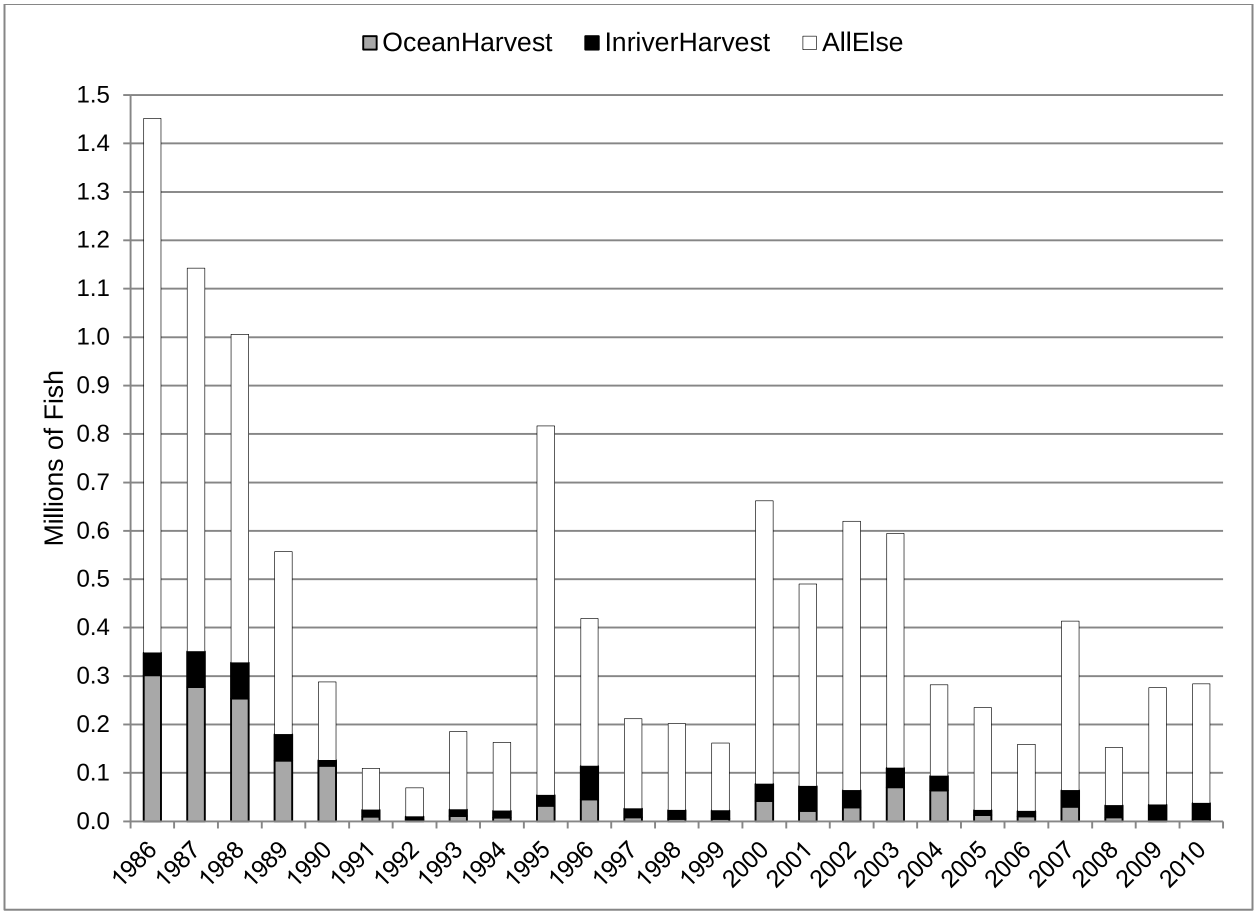

Figure A-3. Klamath River fall Chinook ocean abundance (millions of fish), 1986-2010 (source: PFMC 2011a).

Figure A-4 depicts ocean abundance of SRFC in terms of two major components (harvest and escapement).[19] Because estimates are not available for all components of abundance, the SRFC estimates in Figure A-4 should be viewed as indices rather than absolute estimates of abundance. As was the case with KRFC, the pattern of SRFC abundance in Figure A-4 differs considerably from the escapement pattern in Figure A-2.

[19] The escapement portion of Figure A-4 is comparable to escapement as depicted in Figure A-2, as both figures include both natural and hatchery escapement.

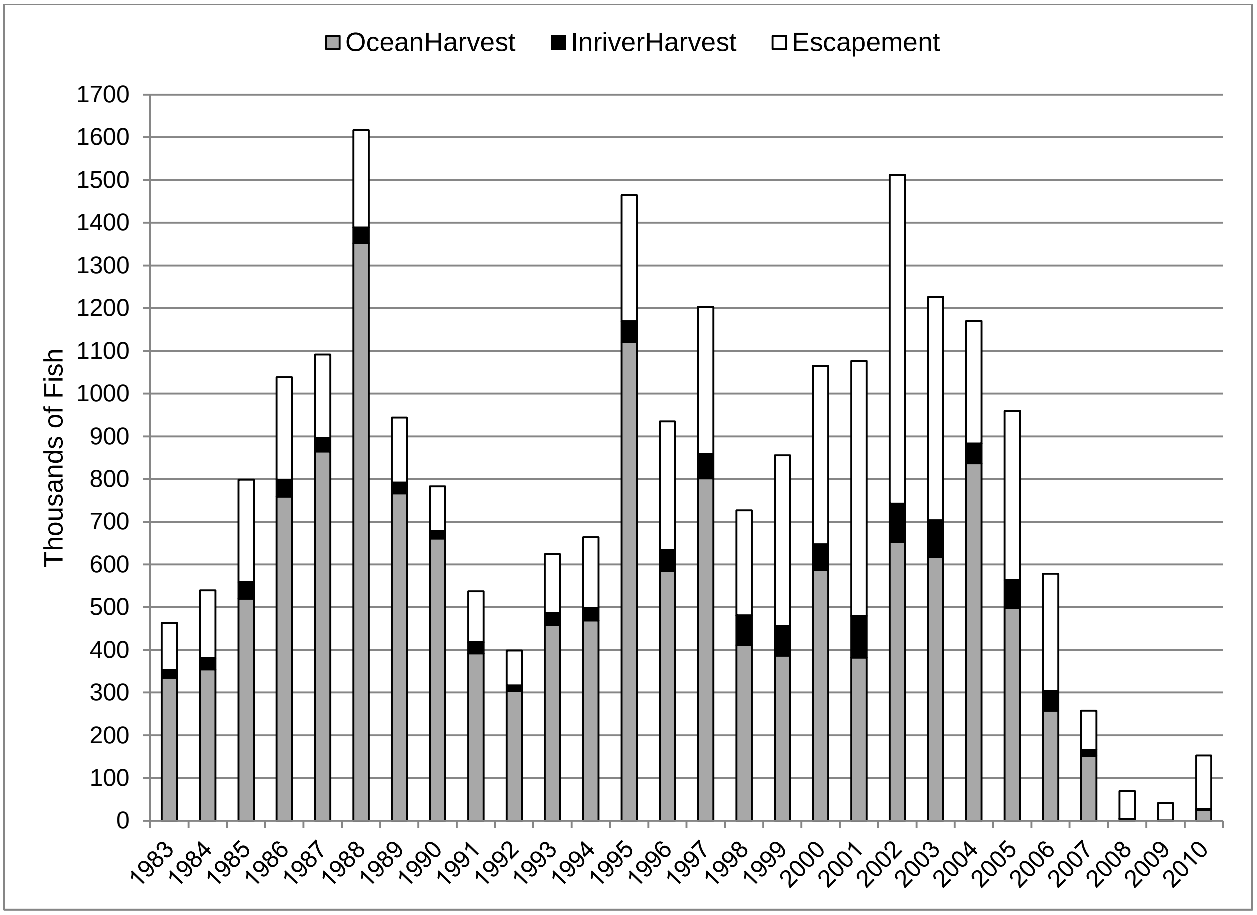

Figure A-4. Sacramento River fall Chinook ocean abundance index (1000s of fish), 1983-2010 (source: PFMC 2011a).

Escapement as a proportion of the SRFC abundance index increased from an annual average of 21 percent during 1981-95 to 40 percent during 1996-2007 to 91 percent during 2008-10 – reflecting the effect of more conservative harvest policies over time (Figure A-4). The 91 percent estimate reflects the effects of stringent fishery regulations associated with record low stock conditions during 2008-10. It is not clear whether the record low SRFC abundances experienced in recent years signal a future pattern of persistently low abundances, are part of a cyclical pattern, or are events that may recur on a rare or occasional basis.

Appendix B. Some Methodologies Used to Quantify Economic Effects of No Action and Action Alternatives

This appendix provides documentation of how EDRRA model projections were used in combination with fishery data to quantify the economic effects of the no action and action alternatives on the troll fishery.

B.1. Estimation of Annual Harvest and Gross and Net Revenue

Table B-1 describes the equations used to estimate Klamath Chinook harvest, total Chinook harvest (all stocks), and gross and net revenues under the no action and action alternatives. The net revenue estimates are inputs in the Net Economic Development (NED) analysis (Section IV); the gross revenues are inputs in the Regional Economic Development (RED) analysis (Section V). Numeric values of the parameters that appear in Table B-1 (α_i , $EXPAND_i$, LBFISH, PRICE, PCTREV) are provided in Table B-2. Derivation of the variable PCTHARV (row #1 of Table B-1) is discussed in Appendix B.1.b. Derivation of the variable PRICE (row #5 of Table B-1) is discussed in Appendix B.1.c.

B.1.a. Equations and Parameter Values

Table B-1. Equations used to project average annual troll harvest of Klamath Chinook and total Chinook and associated gross and net revenues, by management area i and year t (2012-61), under no action alternative (NAA) and dam removal alternative (DRA).

#	*No-action alternative (NAA/Alternative 1)*	*Dam removal alternative (DRA/Alts 2 and 3)*
1	$KLAMCHNK^{NAA} = KLAMCHNK_{mean(01\text{-}05)}$	$KLAMCHNK^{DRA} = KLAMCHNK^{NAA} \times PCTHARV$
2	$KLAMCHNK_i^{NAA} = \alpha_i \times KLAMCHNK^{NAA}$	$KLAMCHNK_i^{DRA} = \alpha_i \times KLAMCHNK^{DRA}$
3	$TOTCHNK_i^{NAA} = KLAMCHNK_i^{NAA} / EXPAND_i$	$TOTCHNK_{i,}^{DRA} = KLAMCHNK_{i,}^{DRA} / EXPAND_i$
4	$TOTCHNKLB_i^{NAA} = TOTCHNK_i^{NAA} \times LBFISH$	$TOTCHNKLB_i^{DRA} = TOTCHNK_i^{DRA} \times LBFISH$
5	$GROSSREV_i^{NAA} = TOTCHNKLB_i^{NAA} \times PRICE$	$GROSSREV_i^{DRA} = TOTCHNKLB_i^{DRA} \times PRICE$
6	$NETREV_i^{NAA} = GROSSREV_i^{NAA} \times PCTREV$	$NETREV_i^{DRA} = GROSSREV_i^{DRA} \times PCTREV$

Note: Variables with subscripts NAA and DRA pertain to outputs of the economic analysis. Variables with asterisked versions of these superscripts (NAA* and DRA*) pertain to outputs of the EDRRA model.

$KLAMCHNK^{NAA}$ = average annual troll harvest of Klamath River Chinook under NAA (# fish, all areas).
$KLAMCHNK_{mean(01\text{-}05)}$ = average troll harvest of Klamath River Chinook during 2001-05 (# fish, all areas).
$KLAMCHNK^{DRA}$ = average annual troll harvest of Klamath River Chinook under DRA (# fish, all areas).
PCTHARV = percent increase in Klamath Chinook harvest under DRA, as projected by EDRRA model (see Appendix B.1.b).

$KLAMCHNK_i^{NAA}$ = annual harvest of Klamath River Chinook (# fish) in area i under NAA.
$KLAMCHNK_i^{DRA}$ = annual harvest of Klamath River Chinook (# fish) in area i under DRA.
α_i = proportion of troll-caught Klamath River Chinook harvest occurring in area i under NAA and DRA (see Table B-2)

$TOTCHNK_i^{NAA}$ = annual Chinook harvest (# fish, all stocks) in area i under NAA
$TOTCHNK_i^{DRA}$ = annual Chinook harvest (# fish, all stocks) in area i under DRA
$EXPAND_i$ = expansion factor used to project Chinook harvest (all stocks) associated with access to Klamath Chinook in each area i under NAA AND DRA (see Table B-2)

$TOTCHNKLB_i^{NAA}$ = annual Chinook harvest (# pounds dressed weight, all stocks) in area i under NAA
$TOTCHNKLB_i^{DRA}$ = annual Chinook harvest (# pounds dressed weight, all stocks) in area i under DRA
LBFISH = average pounds dressed weight per Chinook (see Table B-2)

$GROSSREV_i^{NAA}$ = annual gross ex-vessel revenue (all stocks, 2012$) in area i under NAA
$GROSSREV_i^{DRA}$ = annual gross ex-vessel revenue (all stocks, 2012$) in area i under DRA
PRICE = ex-vessel price per pound dressed weight (2012$) (see Table B-2)

$NETREV_i^{NAA}$ = annual net revenue (all stocks, 2012$) in area i under NAA
$NETREV_i^{DRA}$ = annual net revenue (all stocks, 2012$) in area i under DRA
PCTREV = net revenue as percent of gross revenue (see Table B-2)

Table B-2. Parameter values used to estimate Klamath Chinook and total Chinook harvest (all stocks), and gross and net revenue by management area under the no-action and action alternatives.

	Management Area						
Parameter	*Monterey*	*SanFran*	*FtBragg*	*KMZ-CA*	*KMZ-OR*	*CentralOR*	*NorthernOR*
α_i	0.047	0.344	0.179	0.043	0.019	0.278	0.090
$EXPAND_i$	1.000	0.058	0.065	0.199	0.107	0.062	1.000
LBFISH	11.9	11.9	11.9	11.9	11.9	11.9	11.9
PRICE	3.59	3.59	3.59	3.59	3.59	3.59	3.59
PCTREV	0.813	0.813	0.813	0.813	0.813	0.813	0.813

α_i = proportion of Klamath River Chinook harvested by troll fishery in management area I, estimated using 2001-05 fishery data (data source: Michael O'Farrell, NMFS).

$EXPAND_i$ = ratio of Klamath Chinook harvest to total Chinook harvest (all stocks) in management area i, estimated using 2001-05 fishery data (data source: Michael O'Farrell, NMFS).

LBFISH = mean weight (pounds dressed weight) per troll-caught Chinook south of Cape Falcon during 2001-05 (data source: PFMC 2011b).

PRICE = mean ex-vessel price per pound dressed weight of troll-caught Chinook south of Cape Falcon, estimated using 2004-05 fishery data (data source: PFMC 2011b).

PCTREV = estimated percent of gross salmon troll revenue remaining after payment of trip expenses (source: Jerry Leonard, NMFS)

B.1.b. Derivation of PCTHARV

The percent increase in Klamath Chinook harvest between the NAA and DRA projected by the EDRRA model (PCTHARV) was estimated by Hendrix (2011) as follows:

$$PCTHARV=1/T \sum_{t=1,\ldots,T} \{Median_{t,j=1,\ldots,1000} [(KLAMCHNK_{t,j}^{DRA*} - KLAMCHNK_{t,j}^{NAA*})/ KLAMCHNK_{t,j}^{NAA*}]\} \quad [B1]$$

where

$KLAMCHNK_{t,j}^{NAA*}$ = troll harvest of Klamath Chinook projected for year t and iteration j under the NAA by the EDRRA model;

$KLAMCHNK_{t,j}^{DRA*}$ = troll harvest of Klamath Chinook projected for year t and iteration j under the DRA by the EDRRA model;

the term in [ ] is the percent difference between DRA harvest and NAA harvest projected by the EDRRA model for each iteration j=1,…,1000 and year t=1,..,T;

$Median_{t,j=1,\ldots,1000}$ [ ] is the median of the 1000 values of [ ] generated for year t;

$1/T \sum_{t=1,\ldots,T}$ {$Median_{t,j=1,\ldots,1000}$ [ ]} is the mean of the median values of [ ], calculated over the years t=1.,…,T.

B.1.c. Derivation of PRICE

Over the past three decades, ex-vessel salmon prices have been heavily influenced by national and international market conditions. The relatively low prices of farmed salmon and the rapid increase in farmed salmon imports since the 1980s (Figure B-1) contributed to declining prices for both west coast and Alaska salmon (Figure B-2). The reversal of this trend, which began in 2002, is attributed to a number of factors, including increasing prices of farmed salmon compounded by growing consumer differentiation between wild and farmed salmon.

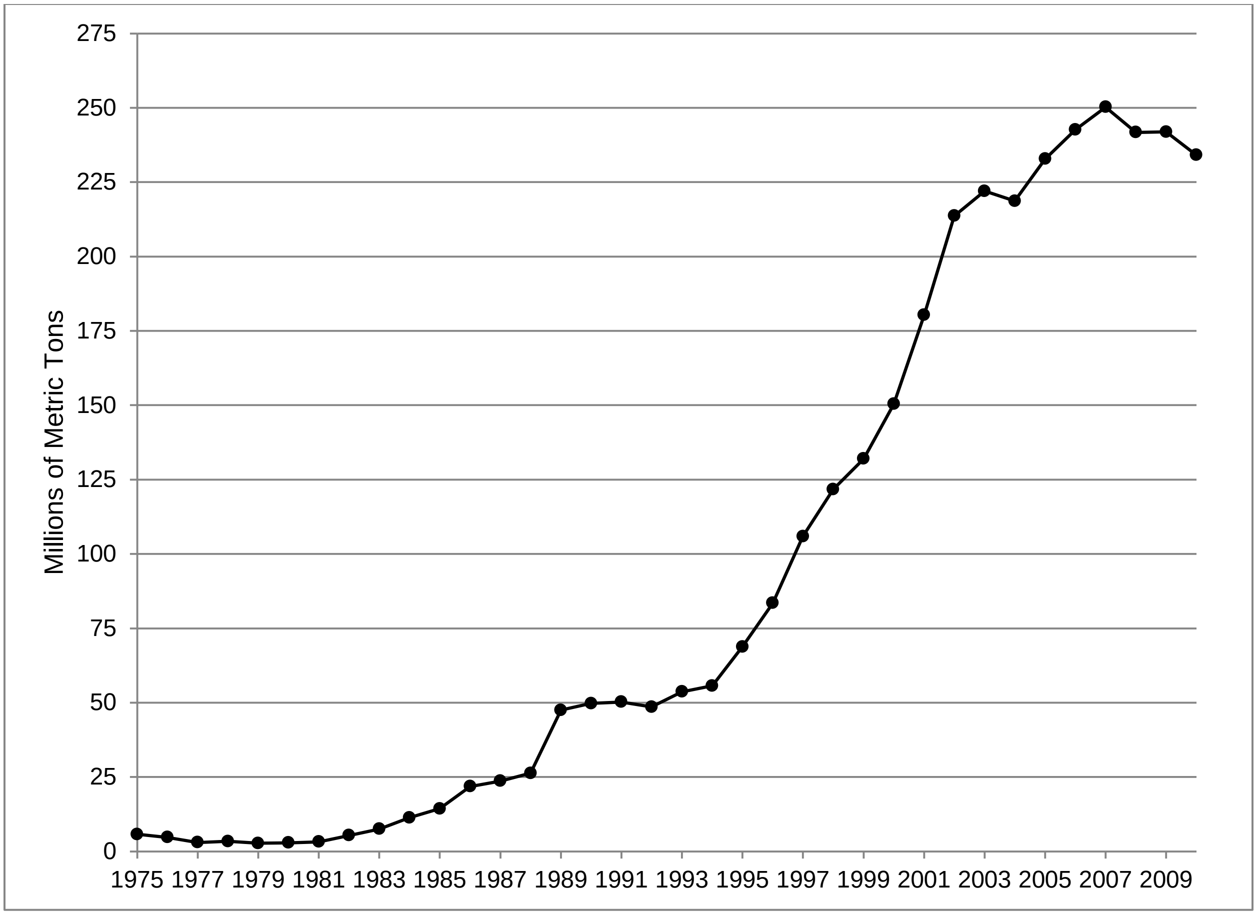

Figure B-1. Imports of edible salmon products into the U.S., 1975-2010 (source: NOAA National Marine Fisheries Service, Office of Science and Technology, Silver Spring, MD).

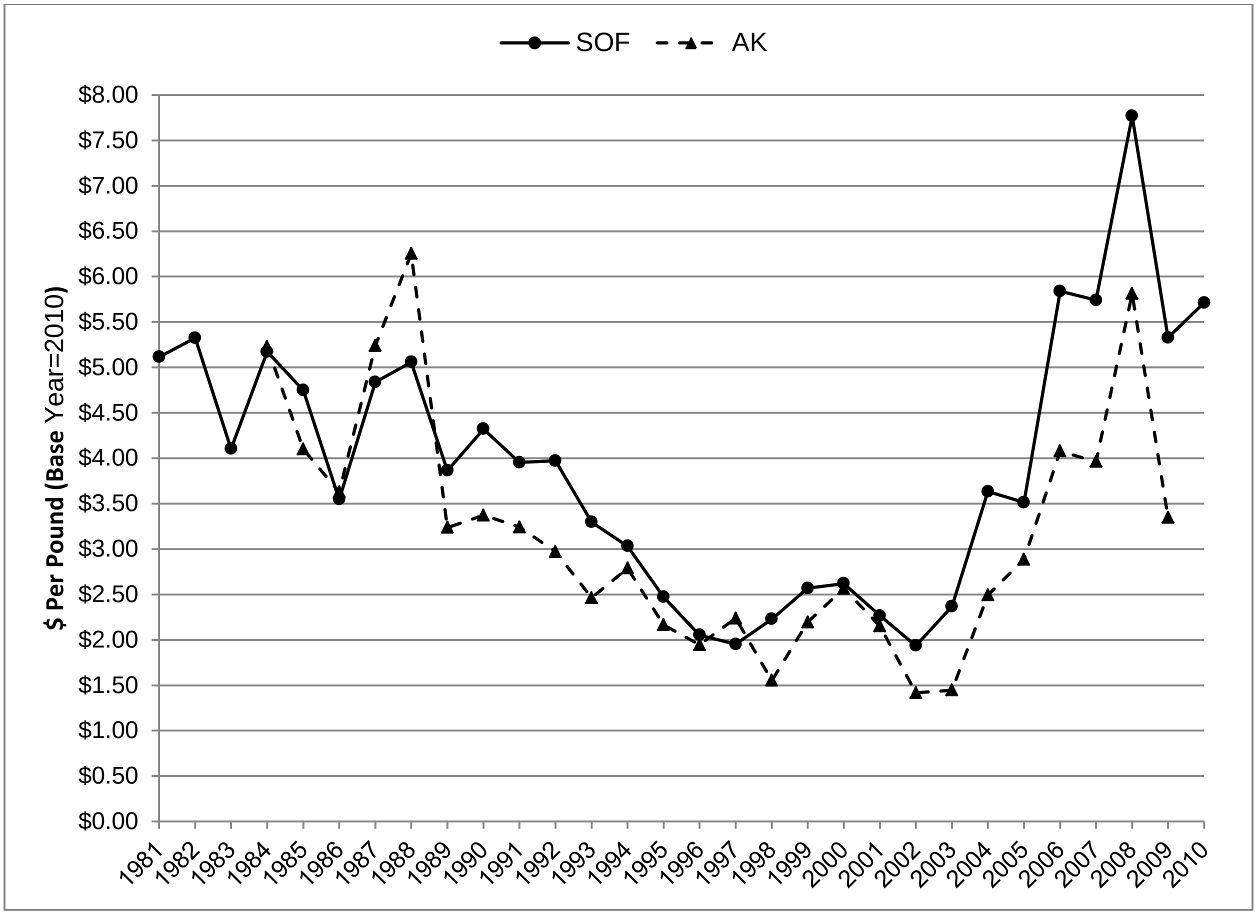

Figure B-2. Ex-vessel prices of troll-caught Chinook in California and Oregon south of Cape Falcon during 1981-2010 and in Southeast Alaska during1984-2009 (2012$) (sources: PFMC 1998, 2011b; ADFG 2009).[20]

The record high prices during 2006-10 coincided with years of record low landings on the west coast (Figure B-3), suggesting that the precipitous landings decline in those years was sufficiently large to have its own influence on prices. PRICE (the ex-vessel price of troll-caught Chinook south of Cape Falcon, Oregon) was calculated based on fishery data for 2004-05 – a period where prices reflect recent consumer preferences and more moderate fishery conditions than 2006-10.

[20] To help ensure comparability with prices of troll-caught Chinook south of Cape Falcon, Oregon, Alaska prices pertain to Chinook harvested in Southeast Alaska, where a large majority of the commercial Chinook harvest is caught with troll gear (85 percent in 2010, according to Skannes *et al.* 2011).

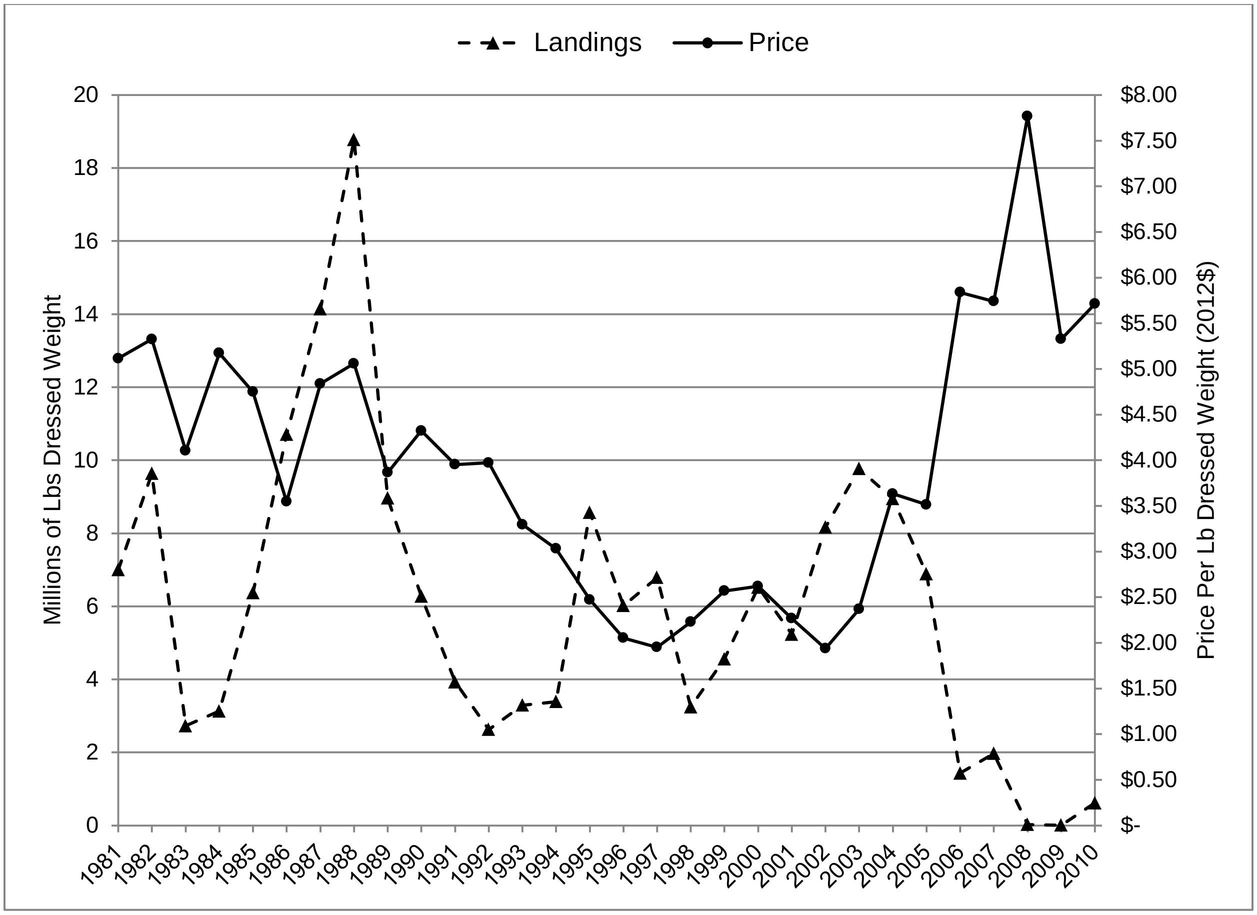

Figure B-3. Annual landings (pounds dressed weight) and ex-vessel price (2012$) of troll-caught Chinook south of Cape Falcon, Oregon, 1981-2010 (sources: PFMC 1990, 1991, 1998, 2001, 2011b).

B.2. Estimation of Discounted Present Value of Net Revenue

The NED analysis (Section IV) involved estimation of the discounted present value of net revenues; this requires that a discount factor be applied to net revenue in each year of the 50-year projection period. In order to estimate net revenue for each year t, average annual net revenue (all areas) projected for Alternative 1 (Table IV-1) was multiplied by a factor that reflects the interannual variation in Klamath Chinook harvest relative to mean harvest – as projected by the EDRRA model under the NAA. This factor is applicable to net revenues as well as harvest, due to the proportional relationship between harvest and net revenues. Specifically:

$$NETREV_t^{Alt1} = NETREV^{Alt1} \text{ x } KLAMCHNK_t^{NAA*} / KLAMCHNK_{mean(12\text{-}61)}^{NAA*} \quad [B2]$$

where

$NETREV^{Alt1}$ = average annual net revenue (all areas) under Alternative 1 ($17.1 million, according to Table IV-1), and

$KLAMCHNK_t^{NAA*} / KLAMCHNK_{mean(12\text{-}61)}^{NAA*}$ = the ratio of Klamath Chinook harvest in each year t to annual Klamath Chinook harvest averaged over the projection period t=2012,…,2061, as projected by the EDRRA model for the NAA.

Annual net revenue for each year t under Alternative 2 ($NETREV_t^{Alt2}$) was similarly calculated, as follows:

$$NETREV_t^{Alt2} = NETREV^{Alt2} \text{ x } KLAMCHNK_t^{DRA*} / KLAMCHNK_{mean(12\text{-}61)}^{DRA*} \qquad [B3]$$

where

$NETREV^{Alt2}$ = average annual net revenue (all areas) under Alternative 2 ($24.4 million, according to Table IV-2), and

$KLAMCHNK_t^{DRA*} / KLAMCHNK_{mean(12\text{-}61)}^{DRA*}$ = the ratio of Klamath Chinook harvest in each year t to annual Klamath Chinook harvest averaged over the projection period t=2012,…,2061, as projected by the EDRRA model for the DRA.

The discounted present value (DPV) of future increases in net revenue under Alternative 2 relative to Alternative 1 was estimated as follows:

$$DPV= \sum_{t=2012,\ldots,2061} [(NETREV_t^{Alt2} - NETREV_t^{Alt1})] (1+r)^{-t} \qquad [B4]$$

where

$NETREV_t^{Alt1}$ and $NETREV_t^{Alt2}$ = net revenue projection in year t for Alternatives 1 and 2 respectively, calculated on the basis of equations [B2] and [B3] above; and

r = discount rate.

B.3. Estimation of Percent of Years when DRA Harvest > NAA Harvest

The percent of years in which DRA harvest exceeds NAA harvest (PCTYRS) was estimated from EDRRA model outputs as follows:

$$PCTYRS=1/T \sum_{t=1,\ldots,T} \{(1/1000)\ COUNT_{t,j=1,\ldots,1000} [KLAMCHNK_{tj}^{DRA*}>KLAMCHNK_{t,j}^{NAA*}]\} \qquad [B5]$$

where

$KLAMCHNK_{t,j}^{NAA*}$ = troll harvest of Klamath Chinook projected by EDRRA model for year t and iteration j under the NAA;

$KLAMCHNK_{t,j}^{DRA*}$ = troll harvest of Klamath Chinook projected by EDRRA model for year t and iteration j under the DRA;

$\{(1/1000)\ COUNT_{t,,j=1,\ldots,1000} [\ ]\}$ = percent of iterations j=1,…,1000 when DRA harvest > NAA harvest, estimated separately for each year t. [ ] is shorthand for what appears in brackets in equation [B5]);

$1/T \sum_{t=1,\ldots,T} \{(1/1000)\ COUNT_{t,,j=1,\ldots,1000} [\ ]\}$ = mean of $\{(1/1000)\ COUNT_{t,,j=1,\ldots,1000} [\ ]\}$ over years t=1,…,T.

B.4. Estimation of Percent Difference in Frequency of Pre-Harvest Escapement ≤ 30,500

The percent difference between the NAA and DRA in the frequency of pre-harvest adult natural spawner escapements ≤ 30,500 (PCTDIFF) was estimated from EDRRA model outputs as follows:

$$PCTDIFF = 1/T \sum_{t=1,\ldots,T} \{[COUNT_{t,j=1,\ldots,1000}^{DRA*}(ESCAPE_{tj}^{DRA*} \leq 30{,}500) - COUNT_{t,j=1,\ldots,1000}^{NAA*}(ESCAPE_{tj}^{NAA*} \leq 30{,}500)] / COUNT_{t,j=1,\ldots,1000}^{NAA*}(ESCAPE_{tj}^{NAA*} < 30{,}500)\} \quad [B6]$$

where

$ESCAPE_{t\,j}^{NAA*}$ = pre-h arvest escapement of Klamath Chinook projected by the EDRRA model for year t=1,…,T and iteration j=1,…,1000 under the NAA;

$ESCAPE_{t\,j}^{DRA*}$ = pre-harvest escapement of Klamath Chinook projected by the EDRRA model for year t=1,…,T and iteration j=1,…,1000 under the DRA;

$COUNT_{t,j=1,\ldots,1000}^{NAA*}(ESCAPE_{t,j}^{NAA*} \leq 30{,}500)$ = number of iterations j in year t when $ESCAPE_{t\,j}^{NAA*} \leq 30{,}500$ under the NAA;

$COUNT_{t,j=1,\ldots,1000}^{DRA*}(ESCAPE_{t,j}^{DRA*} \leq 30{,}500)$ = number of iterations j in year t when $ESCAPE_{t\,j}^{DRA*} \leq 30{,}500$ under the DRA;

$[COUNT_{t,j=1,\ldots,1000}^{DRA*}(\,) - COUNT_{t,j=1,\ldots,1000}^{NAA*}(\,)]/COUNT_{t,j=1,\ldots,1000}^{NAA*}(\,)$ = percent difference between DRA and NAA in number of iterations when pre-harvest adult natural spawner escapement ≤ 30,500, estimated separately for each year t. ( ) is shorthand for what appears in parentheses in equation [B6];

$1/T \sum_{t=1,\ldots,T} \{[COUNT_{t,j=1,\ldots,1000}^{DRA*}(\,) - COUNT_{t,j=1,\ldots,1000}^{NAA*}(\,)]/COUNT_{t,j=1,\ldots,1000}^{NAA*}(\,)\}$ = mean of percent differences over years t=1.,…,T.

ATTACHMENT D – Letter to FERC from the Pacific Fishery Management Council (PFMC), dated 24 April 2006 regarding the Klamath Hydropower Project (sent separately).

This letter is a Secured File that cannot be electronically attached to this Master Document, but will be submitted for the record separately. It is incorporated herein by reference and may also be obtained directly from the Pacific Fishery Management Council (PFMC).

PACIFIC COAST FEDERATION of FISHERMEN'S ASSOCIATIONS

STEWARDS OF THE FISHERIES

Please Respond to:

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28 January 2016
Reply to Email: fish1ifr@aol.com

State Water Resources Control Board
Division of Water Rights
Water Quality Certification Program
P.O. Box 2000
Sacramento, CA 95812-2000

RE: PCFFA and IFR Scoping Comments on Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082).

SUPPLEMENTAL FILING

Dear Board Members and Staff:

These CEQA scoping comments are submitted on behalf of the **Pacific Coast Federation of Fishermen's Associations (PCFFA)** and the **Institute for Fisheries Resources (IFR)**. They are a Supplemental Re-Filing of our prior joint comments of 23 February 2009 on this same issue of Scoping of the prior 401 Certification Application by PacifiCorp. They are being re-filed in order to assure that they are in the Record of this new proceedings, and because frequent references are made to the Attachment 1-17 that were part of this prior filing in our contemporary filing

Again, thank you for the opportunity to comment on this important 401 Certification process. Please include these written comments and Attachments also in the public record for this new proceeding. And please call me if there are any questions about this submission, or if any part of it is not readable and printable.

Sincerely,
Glen H. Spain
Glen H. Spain, J.D.
NW Regional Director For PCFFA and IFR

Vivian Helliwell
Vivian Helliwell
PCFFA Watershed Conservation Director

PACIFIC COAST FEDERATION OF
FISHERMEN'S ASSOCIATIONS
and the
INSTITUTE FOR FISHERIES RESOURCES
Northwest Regional Office
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CA State Water Resources Control Board
Attn: Jennifer Watts
(jwatts@waterboards.ca.gov)
P.O Box 2000
Sacramento, CA 95812-2000

23 February 2009
Sent Via Email (PDF Format)
commentletters@waterboards.ca.gov

RE: Scoping Comments on CEQA Environmental Impact Report (EIR) for 401 Water Quality Certification for the Klamath Hydroelectric Project (FERC Project P-2082)

Dear Board Members and Staff:

These CEQA "scoping" comments are submitted on behalf of the Pacific Coast Federation of Fishermen's Associations (PCFFA), the Institute for Fisheries Resources (IFR).

We will discuss the "scoping" issues that should be considered in two categories below: (1) basic scoping issues (including baselines, geographic and temporal scope of your EIR analysis) that would generally be required or advisable under CEQA, and; (2) specific issues related to adverse water quality impacts and the relation of those impacts to losses of productivity in the Klamath River's once-abundant salmon fisheries and the related impacts of these declines on the economies and lives of coastal and in-river fishing-dependent communities.

A number of important documents are included as Attachments for the Administrative Record, as well as evidence that these adverse impacts are substantial and pervasive. These comments and Attachments are being submitted via email in PDF format for convenience of the Water Board Staff and for posting on the Board's web site devoted to this process.

These fisheries-specific comments are submitted to supplement, and in addition to, other written comments being submitted separately by other entities, and which we also endorse and incorporate herein by reference, including all written comments to be submitted separately by: the Karuk, Yurok and Hoopa Valley Tribes of California; by the Klamath Riverkeeper, and; by the Klamath Inter-Tribal Water Quality Working Group.

BASIC SCOPING ISSUES

(1) Geographic Scope of Cumulative Impacts Analysis: The "Project Area" for purposes of cumulative impacts analysis should be the entire area from Upper Klamath Lake's Link River Dam (containing the first structures within the Klamath Hydropower Project (KHP)), downstream to the estuary, *and also including* all impacts from salmon population and fisheries losses and declines that can be causally linked to the KHP and which occur within the coastal areas of the Klamath Management Zone ("KMZ") – an area extending from the shores of California and Oregon offshore out to 200 miles, and which extends north to at least Humbug Mountain, (OR) and south to at least Horse Mountain (near Shelter Cove), California.

Klamath-origin salmon, once they finally leave the Klamath River and enter the Pacific Ocean, are highly migratory. Thus adverse impacts at or below the KHP dams that affect out-migrating juvenile salmon (as for instance increasing their mortalities) also necessarily impacts ocean salmon fisheries and coastal fishing-dependent communities and economies far to the south and far to the north of the Klamath River estuary.

Cumulative impacts analysis (especially socioeconomic impacts) within this broader KMZ area is consistent with the "Project Area" designated by PacifiCorp in its License Application[1] and used as the FERC FEIS geographic scope for its cumulative impacts analysis (FERC FEIS, Sec. 3.2.1 (pp. 3-3—3-4)). In fact, the FERC FEIS itself notes:

> "For anadromous fish, we include the mainstem Klamath River and all habitat that was historically accessible upstream of the mouth of the river… We also consider appropriate management plans for salmon fisheries including those related to the Klamath Management Zone, which extends 200 miles offshore from Humbug Mountain, Oregon, to Horse Mountain (near Shelter Cove), California. We consider these plans because harvest (including commercial, tribal, and recreational) and escapement for Klamath stocks can affect the numbers of adult salmonids returning to the Klamath River Basin to

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[1] See PacifiCorp Final License Application, Socioeconomic Resources Final Technical Report (Feb. 2004), section 2.4.3 "Geographic Scope," particularly the following (page 2-7): "The preliminary study area for the socioeconomic analysis [of KHP impacts] includes Klamath, Jackson, and Curry counties in Oregon and Siskiyou, Humboldt, and Del Norte counties in California. These are the counties that contain the Project boundaries or whose economies, local services, and human resources are potentially affected by the incremental changes to the Project and PM&E measures." For PacifiCorp's own estimates of specific socioeconomic impacts of the Project on coastal salmon fishing dependent ports and communities within the KMZ, see PacifiCorp Final License Application, Socioeconomic Resources Final Technical Report (Feb. 2004), pp. 2-108 through 2-115 inclusive.

> spawn. We acknowledge that management measures for Klamath River fall Chinook salmon currently constrain fishing on other salmon stocks, from central Oregon to central California. As mentioned above, Klamath Hydroelectric Project structures and operation can affect adult spawning and subsequent downstream migration of juvenile salmonids which, in turn, serve as the basis for future harvests." (FERC FEIS pg. 3-4)

Using the same geographic area for the CEQA analysis as was used by FERC in its Final EIS (and indeed was used by PacifiCorp itself in its FERC Relicensing Application) allows a consistent and logical "apples to apples" comparison of impacts generally. Analyzing different areas in different ways would not.

(2) Temporal Scope of Analysis: The CEQA EIR should likewise analyze the cumulative and other impacts within the same time scale as the FERC FEIS, which is based on the proposed PacifiCorp license application itself, i.e., 30 to 50 years. (FERC FEIS Sec. 3.2.2 (pg. 3-4)).

(3) Proper Comparison Standard Should Be The "Natural Baseline Conditions" That Existed Prior To The KHP Dams: PacifiCorp must show that it can meet *all applicable water quality standards* with a new FERC license. Mere incremental improvements from an already highly degraded condition are <u>not</u> enough – either legally or biologically – for Clean Water Act certification and approval.

The Water Board is being asked to compare various options and alternatives/mitigation measures for bringing into compliance an *already highly degraded river system*. Some of the dams in the Klamath River (such as the CopCo 1 Dam) have been in place since 1917, with others built later but none later than 1962 with the completion of Iron Gate Dam. Adverse impacts on water quality in the Klamath River from Klamath dams have occurred for at least 90 years. The choice of baselines to compare to under CEQA is therefore critically important in obtaining meaningful information on whether water quality standards can be met under *any* future KHP configuration.

Unfortunately, the CEQA process is not well suited to analyzing additional impacts on an *already highly degraded system*. As presently configured and operated, the Klamath River cannot even *currently* meet state water quality standards with the KHP in place. It would therefore be legally inappropriate, as well as quite illogical, to use the current highly degraded system existing on the date of issuance of the NOP as the "baseline" against which to compare the various options for environmental mitigations.

The proper (and far more logical) "baseline" for EIR comparisons and for ascertaining the environmental impacts of the dams themselves, as well as changes (positive or negative) that may result from the various dam mitigation and removal options, is instead the comparison of these options to the "natural baseline conditions" that existed <u>before</u> the KHP dams were constructed -- and which would presumably exist without the dams in place today. Use of this more biologically meaningful baseline then gives us a straightforward comparison between the various alternative options and "dams out" or "Project out" environmental conditions meeting all water quality standards, which standards are themselves based on those natural conditions.

Such a comparison would give us a much clearer idea of just what environmental impacts the KHP dams actually created, positive or negative, when compared to a "no Project" or natural dams-out condition. This "no Project" baseline is also consistent with the comparisons used in the FERC Final EIS, which throughout uses a "dams in" vs. "dams out" comparison framework.

It should also be noted that if PacifiCorp's KHP ultimately cannot be certified under Sec. 401, then "dams out" is also the default condition since without that certification FERC cannot issue a license to operate and the dams will then have to be removed. Thus the "dams out" or "natural conditions" scenario is the only logical baseline against which to compare all potential mitigation measures.

Water quality standards in the Klamath Basin were in fact originally derived from these pre-Project "natural baseline conditions." Under pre-KHP natural conditions, all existing beneficial uses were preserved, and the full range of water quality parameters the natural aquatic species evolved within were protected. Various specific and numeric water quality standards derived for what this baseline looked like also create <u>specific</u> regulatory standard "baselines" of their own, for each parameter, which by law *must be met by the KHP if the Project as mitigated is to be certified*. The Clean Water Act Sec. 401 states clearly that "if the imposition of conditions cannot insure such compliance such agency [in this case FERC] shall not issue such license or permit."[2]

It should be noted that ascertaining the river's "natural baseline conditions" pre-KHP development, and then assessing adverse water quality impacts of the KHP against that pre-development baseline, is also precisely the methodology in use by the North Coast Regional Water Quality Control Board ("Regional Board") in its development of the Klamath Mainstem TMDLs, currently well underway. A public review draft of those Klamath Mainstem proposed TMDLs is scheduled for release sometime in April 2009. In testifying on November 3rd, 2008, Regional Board staff indicated that the Regional Board would be filing those draft documents on the administrative record for this proceeding.

This 401 Certification process should at least be consistent with the Regional Board's TMDL analytical methodologies so that this process can take advantage of the extensive prior Regional Board work already done, including its water quality models, and so that the standards used in this certification process will also be consistent with that later TMDL.

(4) J.C. Boyle and Keno Dam Impacts Directly and Indirectly Affect California Beneficial Uses As Well As Water Quality, and Therefore Must Also Be Considered and Their Impacts Analyzed: The Klamath Hydroelectric Project is operated under a <u>single</u> FERC license and as one operationally integrated whole, with each structure upriver influencing the total -- and cumulative -- water quality impacts of the Project as a whole well downstream into California and even out to the estuary. Thus water quality problems generated in the Oregon portion of the KHP <u>inevitably</u> wash downstream into California. The portions of the Project that

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2 Federal Water Pollution Control Act ("Clean Water Act"), Sec. 401(a)(2) [33 U.S.C. §1341(a)(2)].

are upstream in Oregon (J.C. Boyle and Keno Dams) are therefore not exempt from CEQA analysis because they generate "emissions or discharges that would have a significant effect on the environment in this state."[3]

The Notice of Preparation (NOP) dated Sept. 30, 2008 only says this about impacts on the Klamath River coming to California downstream from Oregon KHP structures:

> "Modification to the Oregon facilities will be addressed through the Oregon Department of Environmental Quality's 401 water quality certification. The EIR will address these contingencies as part of the cumulative impacts analysis." (NOP, pg. 10)
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> "The State Water Board has identified only two potential adverse impacts caused by discharges from the Oregon facilities: (1) impacts of J.C. Boyle peaking operations on California portions of the river, in the event of removal of the California dams that currently re-regulate flows; and (2) sediment release into California if J.C. Boyle Dam is removed."

The Board Staff are correct that at least these two Oregon-KHP impacts exist on the lower river into California, and must therefore also be considered as part of the KHP's cumulative impacts analysis under CEQA. In fact, prior to the construction of Iron Gate Dam rapid daily ramping rates at J.C. Boyle were extremely destructive to stream-edge fish spawning and rearing habitat in the reaches of the river below J.C. Boyle Dam.[4]

Remember, however, that both water and water quality problems flow downhill, in this case from Oregon to California *within* the KHP. There are also many other significant impacts from these Oregon KHP structures and operations that also impact California waters and therefore should also be considered under CEQA. Those additional J.C. Boyle and Keno Dam water quality impacts on California waters include *at least* the following:

(1) Both Oregon dams create slack, warm-water reservoirs that expose the Klamath River to sunlight for longer periods of time and with less shade over a much broader surface area, thus raising its overall ambient daily water temperature. This plume of warmed water washes far downstream before it is fully attenuated, if at all, by other colder inflows.

(2) J.C. Boyle and Keno both trap and hold natural sediments that would otherwise contribute to spawning and rearing gravel below them, thus impoverishing instream spawning and rearing habitat in what would otherwise have been prime spawning and rearing areas for resident rainbow and redband trout (and would have similar impacts on salmon and steelhead after fish passage is provided).

(3) Because J.C. Boyle and Keno (as all dams do) trap sediments, they serve to concentrate nutrients that are the food sources for the growth of various algae species that thrive in these warm-water reservoirs, including the highly toxic blue-green algae species

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[3] CA Public Resources Code §21080(b)(14).
[4] See Expert Report of Mike Rode, Attachment 1, at 9-10.

Microcystis aeruginosa. However, *M. aeruginosa* in turn produces the highly toxic but colorless and odorless liver toxin microcystin, which is highly soluble in water. Several recent algae monitoring studies in the reservoirs (see the comments of the Karuk Tribe of California) indicate that *Microcystis aeruginosa*, which is rare to non-existent in Upper Klamath Lake and Link River, first appears in dangerous concentrations within Keno Reservoir where ideal conditions (warm, still water with high nutrient concentrations) exist there almost certainly primarily due to the existence of Keno dam.

(4) Microcystin generated by *Microcystis aeruginosa* in Keno Reservoir, then in J.C. Boyle Reservoir, naturally washes downriver and into California waters where it has been shown to concentrate in human food chains. Likewise the algae mats that first develop and grow in Keno Reservoir (toxic and otherwise), also wash downriver where they can "seed" new areas downstream (such as Iron Gate Dam) with these algae species wherever similar conditions exist for their growth.

(5) The very existence of Keno Reservoir further increases already warm Klamath River water temperatures by flooding out and/or inundating a number of small cold-water tributaries and springs that would in the past have served as important cold-water refugia for salmon and steelhead during critical water summer months. Many salmonids depend on these types of cold-water refugia flowing into the Klamath River for their summer survival. Today, several of these cold-water streams and springs are inundated by the reservoirs and their refugial benefits are completely lost.

(6) Problems with high water temperatures at Keno and J.C. Boyle Reservoirs result, as a consequence, in lowered dissolved oxygen (DO) levels.[5] Additional sudden DO concentration dips can be caused by algae bloom die-offs. As these algae mats die off, their natural decay process also leads to elevated ammonia levels and various changes in pH from normal baseline conditions. These pervasive water quality problems all begin at Keno Dam and its warm-water reservoir, are continued downstream into J.C. Boyles Dam and reservoir, where they get more widespread and impactive, and then they all wash downstream into California, where they then exacerbate all the water quality problems of the river below, making it that much harder to meet TMDL and other California water quality standards.

All these adverse water quality impacts at J.C. Boyle and Keno Dams are widely known and just as widely documented. In fact, in his *Ultimate Findings of Fact and Conclusions of Law* in the Federal Adjudicatory Decision[6] of the Hon. Judge Parlen L. McKenna in the Administrative Appeal by PacifiCorp of the federal agency "prescriptions" under the Federal Power Act, on Sept. 27, 2006, Judge McKenna concluded:

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[5] The physical ability of water to absorb dissolved oxygen is more or less ***inversely*** proportional to its temperature at normal temperature ranges.

[6] *In the Matter of Klamath Hydroelectric Project (FERC Project No. P-2082)*, U.S. Dept. of Commerce Adjudication Docket No. 2006-NMFS-0001, Final Order and Decision Sept. 27, 2006. This Final Order will also be submitted for the record in this hearing in its entirety.

> "Ultimate Finding of Fact 6: USFWS/NMFS ISSUE 3: Project operations have and continue to adversely affect the resident trout fishery by, among other things: a) confining the resident trout between the Project dams and associated reservoir thereby impairing their utilization of the full range of life history strategies and spawning productivity; b) unscreened flow through Project turbines result in mortality of juvenile and adult trout migrating down stream; and the inability to effectively migrate adversely affects the genetic health and long term survival of the resident species.
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> "Ultimate Finding of Fact 7: USFWS/NMFS ISSUE 4: Entrainment at Project facilities have and continue to adversely affect the resident fishery resources.

The Judge was not limiting this findings to only those dams in California, but also included impacts on fisheries at J.C. Boyle and Keno Dams. Judge McKenna also formally found that:

> "Ultimate Finding of Fact 14: BLM ISSUE 16: Current Project operations, particularly sediment blockage at the J.C. Boyle Dam, the flow regime, and peaking operations, negatively affect the redband trout fishery. The proposed River Corridor Management Conditions would improve fishery resources.
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> "Ultimate Finding of Fact 15: BLM ISSUE 17: The BLM's proposed upramp rate will improve conditions for fish resources and other aquatic organisms by reducing adverse effects caused by the existing nine inch/hour upramp rate."

Judge McKenna also made numerous other secondary "Findings of Fact and Conclusions of Law" in this Adjudicatory Hearing, all based upon and specifically referencing the evidence submitted on the hearing record, to the effect that both J.C. Boyle and Keno Dams have considerable adverse impacts on both water quality and fish populations (all of which are "beneficial uses" under California's Porter-Cologne Water Quality Act) that would normally have impacts far downriver and well into the State of California.

These various Oregon-origin adverse impacts on California beneficial uses cannot be ignored, simply because they originate in Oregon. None of these impacts are exempt from CEQA analysis as noted above, especially as they are *significant* contributors to cumulative adverse Klamath River environmental impacts in California.

Additionally, if and when the CopCo dams and Iron Gate Dam either have fish passage installed as called for in the agency "prescriptions," or are ultimately removed, adverse peaking and other water quality impacts from J.C. Boyle will not be moderated by the CopCo and Iron Gate reservoirs, and will once again play an important negative role in the health of the Klamath River much farther downriver than they do today. Before the construction of Iron Gate Dam as a flow regulation dam, these J.C. Boyles daily fluctuating ramping rates killed large numbers of juvenile salmon, stranded many spawning adults and dewatered many salmon egg nests ("redds").[7] There were also documented cases, some resulting in litigation, of in-river fishermen

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[7] See Expert Testimony of Mike Rode, Attachment 1, Sec. 5.2.

being stranded on rocks and drowned by sudden upsurges of water levels due to high ramping rates at J.C. Boyle prior to the construction of Iron Gate Dam as a flow regulator.

Therefore as a matter of law, the California State Water Board's CEQA analysis must include a review of impacts on California of the entire Klamath Hydro Project, including Oregon dams and reservoir components of the KHP at J.C. Boyle and Keno Dams.[8]

The thorough analysis of the many J.C. Boyle and Keno Dam water quality impacts can easily be coordinated with Oregon's similar and parallel 401 Certification process, which is also proceeding in Oregon albeit on a slower time frame. The Klamath inter-state TMDLs are already coordinated this way through a bi-state Memorandum of Agreement (MOA), and this has proven quite effective.

(5) Inadequacy of Range of Alternatives – Two Additional Dam Removal Options Must Be Considered: Since there are clearly adverse impacts on California water quality and beneficial uses of water from the J.C. Boyle and Keno Dams which must be analyzed under CEQA, the potential futures of J.C. Boyle and Keno Dam should therefore also be included in the CEQA EIR range of dam removal alternatives. Failure to consider a total removal of the KHP unlawfully truncates consideration of the full range of possibilities available, and even likely, in this situation.

We cannot stress this point enough: both Oregon and California should be analyzing the same range of alternatives. *If California does not analyze removal of dams in Oregon, and Oregon does not analyze removal of dams in California, then who will analyze a complete removal option? If full KHP removal options are not analyzed, this unfairly (and unlawfully) biases the decision toward keeping some parts of the Project intact when indeed that option may not meet legal water quality standards.*

While the removal of J.C. Boyles and Keno Dams (both located in Oregon) are not technically within the power of the State of California to legally *require*, the actual and likely future impacts of these dams are certainly within the power of California to *analyze* – a very different issue. They are part of the same FERC license, and both California and Oregon are supposed to be coordinating their efforts in their parallel 401 certification analyses. *The two states should not be analyzing vastly different alternatives.* If they do so, comparison of the two state analyses in any meaningful way will be impossible.

In summary, not to include analysis of J.C. Boyle and Keno removal options would *wrongfully assume* that Oregon will itself certify these two dams as meeting its standards in its parallel process and that they would remain in place under a new license. This artificially and capriciously biases the final decisions on the fate of these dams toward J.C. Boyle retention – merely by the default of never actually considering their removal. The State Oregon, which does have jurisdiction over those two dams, could also *very well deny* 401 Certification to J.C. Boyle and to Keno, forcing them ultimately to be removed or significantly modified. Under

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[8] CA Public Resources Code §21080(b)(14).

CEQA, therefore, the State of California should therefore include this as a potential (even likely) option that much also be analyzed as to its environmental impacts.

Thus a *complete* set of removal options, including (a) the removal of J.C. Boyle alone in Oregon with removals of the California dams, and; (b) removal of both J.C. Boyle and Keno Dam in Oregon with the removals of the California dams (i.e. "Project-out conditions") should be fully analyzed *on both sides of the state border* as part of the bigger suite of likely KHP removal alternatives. Removal of both Oregon dams is at least a potential outcome of Oregon's own parallel water quality certification process, and therefore surely foreseeable. It is also necessary to have these options analyzed *by both states* in order to be sure that both states are considering the full range of potential options.

Again, the Klamath Hydroelectric Project is a single Project, under a single FERC license, for a very good reason – all the parts of the Klamath Hydroelectric Project are intended to work together. Neither state alone has jurisdiction over the whole KHP, but both acting together certainly do. Thus both states should analyze the same full-removal option regardless of state lines.

Nor is there any requirement of actual legal authority to remove a dam necessary in order to *analyze* that removal as a foreseeable or comparative alternative for purposes of environmental impacts analysis within a full range of foreseeable options. Indeed it is FERC – and not the states – that have the power to order dam removal of a FERC-licensed dam.

In summary, to take into account the foreseeable contingency decisions that Oregon might make regarding the KHP dams under its jurisdiction, there should thus be two additional options analyzed in the CEQA Alternatives, which are as follows:

> **Additional Option A:** Removal of Iron Gate, CopCo No. 1, CopCo No. 2 and J.C. Boyle: This would be a four-dam removal option that would leave Keno Dam (and Keno Reservoir) in place but with appropriate fish passage prescriptions and water quality mitigation measures, but take out the four hydropower-producing components of the KHP below Keno.
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> **Additional Option B:** Removal of Iron Gate, CopCo No. 1, CopCo No. 2, J.C. Boyle *and* Keno Dam: In other words, this would be the removal of all KHP structures in the mainstem Klamath River, resulting in a free-flowing river from Link River all the way downstream to the estuary.

(6) Special Problems at Keno Dam: Keno Dam creates it own special water quality problems, including being the first site within the KHP where the toxic blue-green algae species *Microcystis aeruginosa* has been observed in any significant quantity (see Attachment 2 (Kann)). Thus Keno dam's impacts should be assessed in such a way that they can be looked at separately as well as a part of Additional Option B impacts above.

There are a number of rather serious water quality and structural problems at Keno Dam that need to be addressed. Among other problems, Keno: (1) effectively blocks current fish passage, and has no adequate passage for salmonids or Pacific lamprey; (2) traps sediment that would otherwise wash downstream and replenish depleted spawning gravel beds; (3) creates a solar "heat sink" to raise water temperatures; (4) traps and concentrates nutrients washing from upriver; (5) encourages the growth of the toxic blue-green algae *Microcystis aeruginosa*, which in turn produces the highly toxic, bio-accumulative but colorless and odorless liver toxin microcystin, both of which naturally float downriver and into California, where the algae mats from Keno help seed *Microcystis aeruginosa* growth in the lower reservoirs in California, and where the microcystin toxin can be absorbed by fish and mussels and in various other ways adversely affect public health.

We do note that PacifiCorp has proposed as part of its License Application to FERC that the Keno Dam be omitted from any future FERC license. It may or may not ultimately be sold by PacifiCorp. However, this does not release PacifiCorp from responsibility for the Keno dam merely by omission, nor does it remove Keno Dam from FERC's on-going jurisdiction as part of the current FERC license.

Keno Dam is a non-power flow regulatory dam that has *always* been a part of the basic FERC license for this Project. Though Keno Reservoir storage capacity is limited, Keno Dam nevertheless lies in the heart of the Klamath Hydroelectric Project, and controls flows to the dams in the other parts of the Project below it. This allows PacifiCorp to better time its peaking power generation and to benefit from the peaking abilities primarily of J.C. Boyles. Keno Reservoir levels are kept high enough in the summer time to serve some 91 water diversion points in Keno Reservoir, but can be varied much more during non-irrigation season, or in emergencies.

FERC's Policy Statement on Decommissioning ("FERC Decommissioning Policy") issued December 14, 1994 (69 FERC ¶ 61,336) states:

> "In those instances where it has been determined that a project will no longer be licensed, <u>*because the licensee either decides not to seek a new license*</u>, rejects the license issued, or is denied a new license, the project must be decommissioned." (FERC Decommissioning Policy, pg. 3 (emphasis added))

and also:

> "The Commission is of the opinion that implicit in the section 6 surrender provision is the view that a licensee ought not to be able simply to walk away from a Commission-licensed project without any Commission consideration of the various public interests that might be implicated by that step. Rather, the Commission should be able to take appropriate steps that will satisfactorily protect the public interests involved." (*Ibid.*, pg. 37)

In other words, PacifiCorp cannot just walk away from the many water quality problems at Keno dam, which it benefited from for 90 years as part of the FERC license, leaving these problems to the States of Oregon and California or to public taxpayers. FERC retains jurisdiction over any dam which leaves a license by default, to make sure the public's interests are protected, including protecting public health, assuring water quality, requiring appropriate fish passage[9] and mitigation for other adverse impacts that arise in this instance. Another good reason for California to analyze the impacts on lower river water quality in California of Keno Dam is that, with FERC retaining jurisdiction over Keno dam, FERC could very well order mitigation and other remediation measures at Keno that would *directly* affect water quality downriver far into California.

Keno Dam would also be the only remaining flow regulation dam in the Klamath River should Iron Gate Dam be ultimately removed. However, Keno dam lies above J.C. Boyle, and therefore cannot mitigate for rapid ramping at J.C. Boyle, only for impacts from unpredictable irrigation withdrawals from the Link River's A-Canal intake for the Klamath Irrigation Project and for irrigation withdrawals from its approximately 91 other much smaller reservoir diversion systems and pumps. These are factors that should be assessed as well.

On March 24, 2006, the National Marine Fisheries Service (NMFS) formally recommended <u>full dam removal</u> to FERC as the biologically best option to revive the Klamath's failing salmon runs. In its own Federal Power Act 10(a) recommendations filing, NMFS stated:

> "<u>Recommendation</u>: The Licensee shall develop and implement a plan to remove the lower four Project dams (Iron Gate, Copco 2, Copco 1, and J.C. Boyle dams), restore the riverine corridor, and bring upstream and downstream fish passage facilities at Keno dam into compliance with NMFS guidelines and criteria within ten years of license issuance, expiration or surrender.

Under its justification, NMFS went on to, among many other things, add:

> "While NMFS is prescribing preliminary fishways under its authority in Federal Power Act Section 18, NMFS believes that within this relicensing process the best alternative to contribute to restoration of all fish species of concern in the Klamath watershed is the decommissioning and subsequent removal of the four lower Project dams (Iron Gate, Copco 1 & 2, and J.C. Boyle), combined with improvements in fish passage at Keno Dam. The dam removal alternative is a superior alternative from a fish passage, water quality, and habitat restoration standpoint…. Implementing this dam decommissioning and dam removal alternative would go a long way toward resolving decades of degradation where Klamath River salmon stocks are concerned."

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[9] Otherwise we might have the bizarre result that federal agencies could require, and FERC could order, volitional fish passage through the rest of the Project below Keno Dam up to Keno, but be unable to secure fish passage through Keno Dam because it has lost jurisdiction over it through the act of the Applicant to simply exclude it from a new license. Such a result would make federal and FERC authority to protect public resources, including to require fish passage, virtually meaningless whenever an applicant wants to simply omit a key component of a prior license.

Similar recommendations were also made by the U.S. Fish and Wildlife Service, which has jurisdiction over non-salmon terrestrial fish species in the upper Klamath River.

In summary, J.C. Boyle and Keno Dam removal alternatives must be included in the Board's CEQA analysis because: (1) they are parts of the same FERC license and PacifiCorp's 30 to 50 year license application; (2) they are an integral part of the entire KHP, affecting water quality all the way downstream well into California; (3) impacts at J.C. Boyle and/or Keno may determine whether or not California water quality standards can even be met at the point where the Klamath River enters the California border flowing south; (4) J.C. Boyle's and Keno's warm-water reservoirs both provide ideal breeding conditions for otherwise very rare *Microcystis aeruginosa* toxic blue-green algae, as well as many other algae species, that wash downstream where the adversely affect water quality as well as fisheries, and where they seed new algae blooms into regions and reservoirs far downriver and well into California; (5) FERC retains jurisdiction over Keno regardless of whether it remains in any new PacifiCorp license, and has the power to order mitigation and other remediation measures that would inevitably affect lower river water quality far down river and well into California.

CEQA requires that ***all portions*** of the same project be analyzed for their environmental impacts. In spite of the artificial divisions of a state line, the Klamath Hydroelectric Project is one single project, under one single FERC license, all parts of the Project are designed to work together and interact in various ways – and all parts affect the waters of the State of California. California case law also requires that a proposed project *must be analyzed as a whole*, not broken into separate parts to avoid CEQA analysis.[10]

(7) Copco 1 Removal Means Immediate Silting Up of the Much Smaller Copco 2 Dam Just Below: The Copco1 dam is just upriver from the much smaller Copco 2. Since Copco 1 was the first dam built in the system (circa 1916), it naturally has the most sediment trapped behind it in its large reservoir, and by blocking this sediment it has greatly reduced the sediment inflows to the much smaller CopCo 2 dam and reservoir built many years later. Thus removal of the Copco 1 dam in NOP Proposed Alternative 2 would almost immediately result in the complete silting up of the remaining lower CopCo 2 dam, which has almost no remaining reservoir capacity to store this sediment, quickly making it dysfunctional as a dam and forcing the CopCo 2 turbines to be shut off. As a completely silted-up dam it may also then become a serious safety hazard. Failure to acknowledge or address these Copco No. 2 siltation issues was one of the lacks of the FERC FEIS in its analysis of its "Retirement of Copco 1 and Iron Gate Developments" alternative.

Since without CopCo 1 Dam to catch sediment, the CopCo 2 Dam would silt up almost immediately (within weeks, even days) and then have to be retired or removed, its theoretical retention in the proposed NOP Alternative 2 would be more or less meaningless. Therefore we

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[10] See *Calif. Farm Bureau Federation v. California Wildlife Conservation Board* (App. 3 Dist. 2006, 49 Cal.Rptr.3d 169, 143 Cal.App.4th 173 ("Improper for an agency to divide a project into separate parts to avoid CEQA analysis"), and *San Joaquin Raptor Rescue Center vs. County of Merced* (App. 5 Dist. 2007), 57 Cal.Rptr.3d 663, 149 Cal.App.4th 654, as modified ("The entirety of a project must be described in an EIR, and not some smaller portion of it.").

strongly recommend that the NOP proposed Alternative 2 be rethought and discarded as impractical for these reasons, and that the CopCo Dams Nos. 1 & 2 be considered for removal *together* as part of every scenario.

(8) Ramping Rates Contemplated at J.C. Boyle in the Federal Mandatory Conditions Were Developed With the Presumption that Iron Gate Dam Would Remain in Place to Moderate Extreme Flow Changes: Another problem with the FERC analysis is that it does not take into account that, should Iron Gate Dam and Copco Dams Nos. 1 & 2 all be removed, the intense peaking flow changes at J.C. Boyle would rapidly raise and lower the flows (and thus the height) of the Klamath River far downstream into California. This is precisely what happened time and again before Iron Gate Dam was constructed, leading to massive losses of salmon and other fish species by periodically dewatering large areas of river edge habitat in which they typically lay their eggs, and by adult and juvenile strandings.[11]

(9) Implementing Tribal Water Quality Standards: The Water Board must consider and implement all Tribal Clean Water Act standards, including those from the Hoopa Valley, Yurok, and Karuk Tribes. The Hoopa Valley Tribe's standards have been approved by the US EPA, and so must be incorporated in the Water Board's standards by law. Under the Clean Water Act, the Hoopa Valley Tribe must be considered as equivalent to a "state" in this certification process. The Hoopa Valley Tribes water quality standards are available from the Hoopa Valley Tribe's web site at: www.hoopa-nsn.gov/departments/tepa/waterquality.htm.

(10) Consistency With Federal and State Fish Recovery Plans and State Law: Under CEQA, the Water Board must also make sure that any 401 Certification, and any water quality standards required of PacifiCorp, are consistent with various regional Klamath fishery restoration Plans. These Plans include the *Long-Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program* (January 1991 and various updates) created pursuant to the Klamath Fishery Restoration Act of 1986 (the "Klamath Act").[12] This law is still in effect and mandates various efforts to restore salmon fisheries and their habitat to the Klamath Basin, which the *Long-Range Plan* delineates in greater detail.

Coho salmon in the Klamath are also federally protected as "threatened with extinction" under the federal Endangered Species Act (ESA) (16 U.S.C. § 1531 *et seq*.), as part of what is called the "Southern Oregon/Northern California Coho (SONCC)" population unit. The National Marine Fisheries Service (NMFS) is in the final stages of preparing a SONCC salmon recovery plan for this population, though it has not yet been released as of this date. However, NMFS has prepared and formally released a prior Klamath coho recovery plan that is specific to threatened coho sub-populations in the Klamath mainstem river pursuant to separate requirements of the Magnuson-Stevens Reauthorization Act adopted in 2007, titled *Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan* (July 10, 2007).[13] The

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[11] See Expert Report of Mike Rode, Attachment 1, Sec. 5.5 (Power Peaking Operations) at pp. 9-10.

[12] The Klamath Act was signed into law as Public Law 99-552 (Oct. 27, 1986), codified at 16 U.S.C. §460ss-3 et seq. The Long Range Plan is available at: http://www.krisweb.com/biblio/gen_usfws_kierassoc_1991_lrp.pdf .

[13] Available at: http://swr.nmfs.noaa.gov/salmon/MSRA_RecoveryPlan_FINAL.pdf.

State Water Board's certification process should also be consistent with and take that formal federal Klamath coho recovery plan into account.

Coho salmon are not only federally protected under the federal ESA, but also listed by the State of California under the California Endangered Species Act (CESA) as of 2003. On February 4, 2004, the California Fish & Game Commission formally approved the *Recovery Strategy for California Coho Salmon* to guide future coho restoration efforts in the state, including coho recovery efforts on the Klamath River. There are nineteen (19) specific strategies in this document for the Klamath mainstem, including the following most relevant to this certification process:

> "KR-HU-04. Develop a plan, including a feasibility analysis, for coho salmon passage over and above Iron Gate and Copco dams to restore access to historic habitat.
>
> "KR-HU-10. Support efforts to improve quality of water entering the Klamath River mainstem from the upper Klamath River Basin.
>
> "KR-HU-11. Perform cost/benefit analysis of full or partial hydroelectric project removal for the purposes of improving water quality, coho salmon passage, and sediment transport.
>
> "KR-HU-13. Ensure that uplands in key cold-water tributaries are managed in a way that preserves their cold-water thermal regime.
>
> "KR-HU-19. Conduct studies in and around the Klamath River Hydroelectric Project to see if the project is contributing to habitat for the ceratomyxosis intermediate host.
>
> "HR-HU-20. Restore appropriate course sediment supply and transport near Iron Gate Dam. Means to achieve this could include full or partial removal of the Klamath River Project, or gravel introduction such as is done below other major dams (e.g., Trinity Dam)."

These specific measures should also be considered as priority mitigation measures necessary under CESA. There are also many more *Recovery Strategy for California Coho Salmon* general fish conservation and recovery measures that would apply to coho salmon in the Klamath below Iron Gate Dam that should also be considered in your analysis.

Finally, it should be noted that the Klamath Hydropower Project remains in continuous violation of fish protections in the California Fish and Game Code § 5937, which reads:

> "Sec. 5937. The owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam. During the minimum flow of water in any river or stream, permission may be granted by the department to the owner of any dam to allow sufficient

> water to pass through a culvert, waste gate, or over or around the dam, to keep in good condition any fish that may be planted or exist below the dam, when, in the judgment of the department, it is impracticable or detrimental to the owner to pass the water through the fishway."

Given the many negative water quality impacts from the Klamath Dams on downriver salmon fisheries, and the immense fish losses these impacts have caused to these valuable runs, including contributing to the largest adult fish kill ever recorded in the U.S., during the massive 2002 adult spawner fish kill, it could hardly be said that the salmon runs of the Klamath are in "good condition."

(11) Irrelevancy of Nutrient Inflows From Above the Project: There are clearly problems with elevated nutrient inflows, particularly phosphates, coming into the Klamath Hydropower Project area from Upper Klamath Lake -- both from anthropogenic as well as natural sources. How these sources divide up between anthropogenic and natural sources, however, *is not relevant* to this KHP certification process.

While PacifiCorp may not be responsible for, nor can it avoid, most of these nutrient inflows from Upper Klamath Lake which come from areas hydrologically above the Klamath Hydroelectric Project, nevertheless, PacifiCorp's KHP must still operate within the environmental conditions it finds itself in, *including* any naturally nutrient-enriched water sources.

PacifiCorp <u>is</u> responsible for, *and must mitigate for*, all conditions created by its KHP dams and their operations (and their associated slackened flow, warm-water reservoirs) where, *given already enriched nutrient loads from above the Project,* these nutrients biologically combine with the slack-flow, warm-water conditions artificially created within PacifiCorp's KHP reservoirs to concentrate and "cook" these nutrients under ideal warm-water conditions to contribute to deteriorating water quality and widespread algae blooms. It is these <u>many additional</u> water quality problems, all traceable to configuration and/or operations of the dams, that cause water quality not to meet California state water quality standards, and which greatly and adversely impact lower river salmon as well as in-Project resident fish and other aquatic wildlife. It is these additional impacts which must be analyzed.

And finally, if additional efforts must be made by PacifiCorp to make sure its proposed Project will meet state water quality standards within the KHP because of already degraded conditions in the river, they must nevertheless meet those standards in water discharges from their Project. It is the company asking for the state's permission to use the river, and not the river itself, which must bear the burden of any failures to meet these standards.

FISHERIES-RELATED KHP ADVERSE IMPACTS

(1) The KHP's Biologically Adverse Impacts on Salmon Fisheries: Today the Klamath Hydroelectric Project (KHP) has contributed substantially to an 88% reduction in salmon runs on the Klamath in many different ways. KHP adverse impacts include but are not limited to:

- Physically blocking salmonid access to habitat above Iron Gate Dam from between 300 (for chinook) and 600 (for steelhead) stream miles of once fully occupied habitat that historically supported runs of between 149,734 to 438,023 adult fish (Huntington, 2004) and today could potentially support at a conservative estimate 111,230 adult fish (Huntington, 2006) (see Attachments 9 and 10).

- KHP reservoirs inundate and dilute the benefits of some of the most important cold-water tributaries in the basin, historically offering vitally important thermal refugia for salmonids, including Jenny, Spencer, Shovel and Fall Creeks. Occupying these cold water refugia areas during hot summer months was an important strategy for salmonids to survive summer periods of very warm water temperatures. Several former important cold water streams (such as Jenny Creek) now flow *directly* into warm water reservoirs such as Iron Gate where their thermal refugia benefits quickly disappear. Warm-water reservoirs also are high water temperature thermal barriers (even with future fish passage) that will continue to block access to several of these once-important spawning and rearing tributaries. Several formerly important cold-water groundwater springs likewise now disappear into the reservoirs is several places, their cold-water benefits also lost (see Attachment 1, Mike Rode Sec. 5.1 (pg. 9)).

- The Copco 1 and Iron Gate reservoirs particularly slow down and spread out the water that would naturally flow quickly through the river without the dams, and this allows sunlight to heat it up to near-fatal temperatures for downstream cold-water salmon. Warmer waters favor the growth and predation by warm-water fish predators generally, increasing predation against cold-water salmon whose defenses are already weakened by these warmer waters. Also, adult salmon typically die when exposed to prolonged water temperatures of 20º Centigrade (68º Fahrenheit), but reservoir water temperatures typically exceed such temperatures for several weeks of each year. Elevated water temperatures also not only encourage algae blooms but also encourage warm-water parasites like *Ceratomyxa shasta* and *Parvicapsula minibicornis*, which are fatal to many juvenile salmon, resulting in the mortality equivalent of a major fish kill nearly every year even far below the dams. Currently these diseases result in high rates of juvenile salmonid mortality -- as high as 80% in some studies (see Attachments 1 (Rode), sec. 5.4.1 (pp. 12-14); Attachment 2 (Kann) on toxic algae studies; Attachments 15 and 16 on the prevalence of fish diseases in juvenile salmonids just below the dams; and the FERC FEIS pp. 3-304 through 3-312).[14]

- Warmed river waters caused by the KHP also stress both adults and juveniles salmon generally, making them much more susceptible to both predators and fish pathogens even far downriver from the dams. Water temperatures consistently above 20^{o} Centigrade –

[14] "The Klamath Hydroelectric Project has likely contributed to conditions that foster disease losses in the lower Klamath River by (1) increasing the density of spawning adult fall Chinook salmon downstream of Iron Gate Dam; (2) promoting the development of attached algae beds that provide favorable habitat for the polychaete alternate host for *C. shasta* and *P. minibicornis*; and (3) contributing to water quality conditions that increase the stress level of juvenile and adult migrants and increase their susceptibility to disease." (FERC FEIS, pg. 3.309)

68^{o} Fahrenheit are fatal to salmon. Juvenile salmon are even more stressed by warm water temperatures than adults. The U.S. Environmental Protection Agency recommends temperature limits for the protection of various life stages of chinook salmon, including that maximum seven-day floating average water temperatures not exceed 13^{o} C. for spawning times. The KHP has directly changed the hydrology, thermal mass and temperature profiles vs. time of the river below it so that "water temperatures in the mainstem river below Iron Gate Dam are cooler in the spring by up to 5^{o} C. and warmer in late summer and fall by up to 5^{o} C. than they would otherwise be, absent the reservoirs" (see Attachment 1 (Rode), Sec.5.4.1, pg. 13 and Figure 5.4.1-1 (pg. 23); see also FERC FEIS, pp. 2-208 to 2-216).

- Blockage of access by the KHP to the upper river has significantly changed the species composition of the river's salmonid runs greatly, as well as their seasonal migration timing. Formerly, spring chinook were the dominant stocks in the river, today it is fall chinook. Steelhead runs, also once abundant above the dams, have now be severely limited to below Iron Gate dam and have nearly disappeared. Coho are greatly reduced in number, and some stocks of salmon (such as pink salmon) that were once found in the Klamath are now presumed extinct (see Attachment 1 (Rode), Sec. 4.1.1, pp. 3-5; see also FERC FEIS pp. 2-208 to 2-212).

(2) Changed River Ecosystems: The synergistic combination of decades of poor water quality and altered river flows caused by the dams have dramatically changed the riverine ecosystems in many ways. These changes need to be examined carefully as part of the EIR analysis. Some (but not all) of these impacts are delineated in many places in the FERC FEIS in Section 3.0.

(3) Changed River Morphology: Numerous changes to the historical morphology of the river have been caused by the dams, including reductions of the number of "flood event" flows that typically disturbed the river gravel beds and stream edge riparian vegetation more frequently prior to construction of the dams. These changes have also resulted in impacts to lower river fisheries by reducing natural riparian scouring which allows more growth of permanent stream edge vegetation, which in turn reduces edge habitat necessary for juvenile salmonids during their early rearing periods. These impacts are discussed in detail in the FERC FEIS, particularly at pp. 3-27 through 3-57.

(4) Spawning Gravel Impoverishment Below the Dams: The dams also trap and hold back natural gravel-rich sediments, thereby impoverishing salmon spawning gravel beds for as much as 50 miles downriver of Iron Gate Dam.[15] This greatly limits the ability of both chinook and coho salmon (as well as steelhead) to spawn in the river as well as pushes them out of some of their best remaining habitat (see FERC FEIS, pp. 3-41 through 3-51 inclusive). This impact has doubtless contributed to salmon declines in the Klamath River over many decades.

[15] "[W]e conclude that a sediment deficit could easily exist to the confluence with the Scott River (RM 143)." FERC FEIS, pg. 3-49.

(5) Synergistic Causal Links Between Dams and Virulent Lower River Fish Pathogens: Poor water quality and altered river morphology produced by the Klamath Hydropower Project, particularly both in combination, also contribute to higher than normal incidence of various fish diseases such as *Ceratomyxa shasta* and *Parvicapsula minibicornis*. Both these virulent warm-water parasites are simply more active (and thus juvenile exposures more frequent and more likely to be fatal) in the warmer river waters that now occur every summer for longer periods than historically occurred. Juvenile fish are especially vulnerable to these virulent pathogens. When juvenile salmonids contract either of these virulent fish diseases it is frequently fatal, even more so when juvenile fish (as is all too common) contract both.

Among other synergistic casual factors, the dams first impoverish natural spawning gravel recruitment as well as reduce the number of natural high flow events in ways that prevent natural gravel from rolling rapidly downriver as normally would have occurred. Rapidly moving gravel naturally cleans itself (and large portions of the river bed) of algae, and thus reduces the growth and prevalence of the algal species that harbor (and are the major food sources) for the polychaete worm *Manayunkia speciosa* that is the alternative disease vector for *Ceratomyxa shasta*. In other words, less gravel with fewer cleansing flows results in far more algal growth, which harbors more polychaete worms which carry more *C. shasta* spores, which then leads to much greater *C. shasta* exposures of juvenile salmonids than would otherwise naturally have occurred. The *P. minibicornis* pathogen has a similar complex lifecycle.

Additionally, cumulative changes in the annual water thermograph have meant lower river water temperatures in the spring, which have delayed juvenile salmon growth in early springtime to the point where they out-migrate today *several weeks later than historically occurred*, when early springtime river temperatures are typically much warmer. Both growth and timing of out-migration as smolts is affected by ambient water temperatures:

> "The cumulative effect of delayed spawning in the fall with reduced fry growth rates in the spring is that rearing and outmigration are now generally occurring at a later date than would have occurred pre-KHP, thus subjecting these fish to even greater temperature and disease exposure (see Attachment 1 (Rode), pp. 13-14).

Likewise, the larger thermal mass of the reservoirs causes water to warm faster in late spring and to remain at higher temperatures for longer periods of time throughout the summer and fall. These earlier, warmer waters cause *Ceratomyxa shasta* spores to emerge earlier – causing more and longer overlap between juvenile fish remaining later and pathogens emerging earlier today than historically occurred. Thus more juvenile salmon are now in the river when *C. shasta* spores emerge and these spores are more contagious – resulting today in *far* greater juvenile mortalities than normally occurred from this fish pathogen prior to dam construction. Juvenile chinook are especially susceptible to *C. shasta*, and *once infected nearly all will die* before reaching adulthood. These disease impacts of the KHP are included in the FERC FEIS analysis, particularly at pp. 3-304 through 3-315).

Such a large portion of these juveniles runs are now infected annually that fish pathologists recently observed that:

> "Depending on the juvenile Klamath River salmon population size and smolt to adult return ratio, the effective number of adult salmon lost to *C. shasta* as juveniles could rival the 33,000+ adult salmon lost in the 2002 Klamath River Fish Die-off." (Attachment 15, Summary pg. 1).

The reference to the "2002 die-off" is to the largest adult fish kill ever recorded in the Klamath, said to be the worst in U.S. history, in which it was ultimately determined that more than 78,000 adult fish died before they could spawn as they tried to travel upriver. The loss of nearly this entire year-class of adult spawners devastated the west coast salmon fishery, resulting in far fewer eggs being laid and thus fewer juveniles outmigrating in 2003, and this eventually resulted in so few harvestable adults coming back in 2006 that the Secretary of Commerce declared a fishery disaster in 2006 and imposed widespread closures (see Attachments 12 and 13). Economic damages to the west coast salmon fishing industry from the 2006 were estimated at over $100 million, and Congress appropriated $60.4 million in disaster assistance to these affected fishing families and communities.

Adult fish kills make national headlines, but massive *juvenile* fish kills are silent and mostly hidden – but have economic impacts that may be just as devastating. The disease-caused equivalent of one of these types of major fish kills is apparently happening *nearly every year*, but instead of happening to the spawning adults it happens to the juvenile salmon populations whose wholesale demise is much harder to directly observe (see Attachment 1 (Rode), Sec. 7.0, pp. 15-17; Attachments 15 and 16 for fish pathogen surveys during 2004 and 2007). As seen above, there is a direct causal link between changes created in the river from the Klamath Hydroelectric Project and these nearly annual major fish kills.

Socio-Economic Impacts of Klamath Salmon Declines on Fishing-Dependent Coastal Communities

(1) Original Populations of Salmon on the Klamath: Before European development of the Klamath River, there were an estimated 660,000 to 1.1 million adult salmon returning to the Klamath River, with an average of about 880,000, predominately spring-run chinook, returning each year to spawn (see *Estimates of Pre-Development Klamath River Salmon Run Size*, Attachment 4). Salmonids were also historically widely distributed throughout the basin, with some species such as steelhead abundant well above Upper Klamath Lake (see Hamilton, et al., Attachment 3).[16]

Today's river water quality conditions are so degraded, and loss of habitat through dam blockage and other factors so devastating, that salmonid runs in the Klamath basin (including both wild and hatchery fish) are now only about 12% of what they once were, averaging only about 105,000 adult returns over the time frame of 1978-2007, but the majority of even these are

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[16] The term "salmonids" is a biological category which includes closely related members of the fish genus *Oncorhynchus* such as chinook (*O. tshawtscha*), and coho (*O. kisutch*) salmon, as well as closely related anadromous steelhead (*O. mykiss gairdneri*) and other species.

of hatchery origin (especially in the Trinity River).[17] This means that the wild fish runs still remaining (i.e., fish produced in the wild and not dependent on hatcheries for any portion of their lifecycle) are considerably *less* than 12% of their historic runs size (probably about 6%), though such estimates vary. ESA-listed coho salmon are down to less than 1-2% of their historic abundance in the basin, and were never as abundant as chinook, which is why they are now federally and state protected.

Prior to dam construction, the predominant salmon population above the current location of Iron Gate Dam were the spring chinook, which may have historically outnumbered fall-run chinook in total numbers throughout the basin.[18] Today the dominant population is fall chinook, with spring chinook (which depended upon habitat now mostly blocked by the dams) nearly extirpated in the river except for a few remnant populations spawning in the Salmon River and just below Iron Gate Dam. Since steelhead depended upon upper river habitat (now above the dams) more than other salmonids, steelhead too are greatly reduced in numbers in the Klamath Basin except in portions of the Trinity River, the Klamath's major tributary.

Two other species of salmonids known to exist in the river before the KHP dams blocked it were chum salmon (*O. keta*) and pink salmon (*O. gorbuscha*). However, today chum salmon are extremely rare in the Klamath (and thought to be functionally extinct) and pink salmon, once thought relatively abundant, are extinct.

Thus the very existence of the Klamath Hydropower Project dams has dramatically changed the anadromous species composition as well as run timing for salmonids in the lower river. This has adversely affected the ability of these species and sub-species to remain viable and to respond to changed environmental conditions.

(2) What Is the Value of a Restored Klamath River Salmon Fishery? The present net economic value of a restored pre-development sized Klamath Basin salmon fishery can also be estimated, depending on discount rate assumed. At an assumed discount rate of 3%, the net present economic value of this fishery would have been between $2.634 and $4.347 ***billion*** dollars, for a net present economic value to the regional economy of just over $3.49 billion dollars (see Attachment 4, Table 4). Other independent studies, using very different methodologies, have come to similarly large value numbers (see USGS Aaron Douglas study, Attachment 5).

Today, even with stringent fisheries management and at least 20 years of targeted habitat restoration efforts, the biological carrying capacity of the Klamath Basin is still so seriously eroded that from 1978-2002, the average fall chinook run size has been only 85,855 – just 9.7% of historic abundances. Subtracting hatchery-raised spawners from these totals gives only 60,723 natural fall chinook spawners returning, on average, during this time period – *just 6.9% of the historic run size* (see FERC FEIS, pg. 3-195 (Table 3-48)). And this is for the most *abundant* stock – the fall run chinook. This does not count other species, particularly coho

[17] See Attachment 1, Expert Report of Mike Rode, Figure 4.1.1-1 (pg. 21).
[18] See FERC FEIS pp. 2-208 to 2-212

salmon, that are so depressed they require ESA protection,[19] nor does it count spring-run chinook, once the dominant run throughout the upper basin, that have today been all but extirpated by the Klamath Hydroelectric Project dams.

Assuming (as a rough estimate) a proportional reduction from pre-development to current run sizes (even counting hatchery fish as partial mitigation) would create a proportional decrease in harvest and thus fishery values, with all other factors kept the same, then the value ***reduction*** of the present day Klamath fishery would be a 100.0% - 9.7% = 90.3 % reduction in harvest capacity today from historic capacity. *This means that the net loss of net economic value of the Klamath salmon fishery to the regional economy – in large part caused by the Klamath dams – would be calculated as a loss of value of $3.15 billion dollars.* This may be how much the Klamath dams have directly cost the regional fishing-based economy. This does not even begin to count secondary economic costs due to "weak stock management" that requires widespread ocean coastal fishing closures, such as experienced in 2006, that can hit ocean fishing ports far to the north and south of the Klamath over 700 miles of coastline.

While the impact of the Klamath Project dams is certainly not the only impact on these stocks or their habitat, it is almost certainly the single largest impact, as well as one of the few impacts we have some real control over, through FERC relicensing.

A major impact of the Klamath Dams is that when the losses of Klamath fall chinook are high, this can trigger "weak stock management" closures of ocean fisheries all up and down the coast. Under the federal Magnuson-Steven Act "Salmon Fishery Management Plan," the Klamath fall chinook are the key stock around which all other harvest opportunities are regulated in California, Oregon and Washington. Since both weak and strong stocks intermingle in the ocean, all ocean fisheries must be halted – even on otherwise abundant stocks from other river systems – whenever intermingling Klamath fall chinook drop below a certain level, or there would be normal harvest impacts that would bring them below the "minimum spawner floor" of 35,000 adults returning to spawn in the river.[20] This 35,000 minimum spawner floor is the minimum number of spawning adults absolutely necessary to perpetuate the species to the next generation. Fishery managers must diligently restrict total cumulative harvest impacts on the Klamath fall chinook to always make sure at least the 35,000 "minimum spawner floor" can be met each year.[21]

The situation also appears to be worsening. Poor in-river conditions and disease problems are so pervasive in the Klamath River that fishery managers are now hard pressed to maintain even the "spawner floor" of 35,000 returning adult fall chinook, *even with zero fishing impacts*. For

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[19] Coho in the Klamath Basin are estimated to be at between 1-2% of historic abundance, and are both federally and state listed under the Federal and California Endangered Species Acts.

[20] See FERC FEIS pp. 2-230 to 3-241for a more extensive discussion of the "weak stock management" problem and how it causes extensive coastal ocean fishing closures when Klamath fall chinook are in very low abundance.

[21] Since 2006 a minor amendment to the Pacific Fishery Management Council's *Salmon Fishery Management Plan* (Amendment 15) has been formally adopted to allow, in some years, a *de minimus* impact exception to the 35,000 minimum spawner floor to avoid massive closures such as occurred in 2006, but this exception is still very narrow and only applies to truly *de minimus* impacts that must be made up later. Otherwise ocean salmon fishery management remains the same as in 2006, i.e., it is largely still controlled by the abundance of Klamath fall chinook.

instance, the ocean commercial fishery in 2006 suffered through a nearly total closure to prevent as much impact as possible on Klamath fall chinook that might intermingle with otherwise abundant stocks. Economic losses to fishing-dependent economies in 2006 alone were estimated at more than $100 million. Congress ultimately appropriated $60.4 million in direct disaster assistance to these communities.

With improvements in water quality from dam removal, a large part of the value of the Klamath fishery could be restored, giving fish access once again to hundreds of miles of historic spawning and rearing habitat and improving juvenile survival throughout the system because of better water quality. As noted in the FERC FEIS itself:

> "Huntington (2006) estimates that there are 355.6 miles of existing stream habitat that is currently or was recently capable of supporting anadromous salmonids in tributaries to Upper Klamath Lake and another 70.4 miles that he considers recoverable within the next 30 to 50 years (table 3-67). Although much of this habitat has been degraded, substantial portions in the Wood and Williamson river systems are considered to be in good condition (Huntington et al., 2006), and habitat conditions are expected to improve over time, due to numerous ongoing restoration efforts in the upper basin (FWS, 2006c)." FERC FEIS pg. 3-284.

Huntington (2004) estimated that the historic returns of adult chinook salmon to areas upstream of Upper Klamath Lake were between 149,734 and 438,023 fish per year, and were most likely in the lower end of this range. (Attachment 9)

Huntington (2006) (see Attachment 10) later amended his estimate, after additional field research, to say that the upper basin habitat could support an additional run of 111,230 chinook salmon once fish passage is restored, acknowledging that this was a conservative estimate. Once problems with poor water quality, high water temperatures and conditions that encourage various fish parasites are also cured by dam removal, juvenile survival rates in the lower river would also improve, therefore allowing more fish to survive to adulthood and return as harvestable adults.

If water quality were improved by removal of the dams, and given access to additional habitat above the dams, it is therefore highly likely that an additional 100,000 adult fall chinook would come back to the river after only a few fish generations. Assuming only a 50% harvest rate on these adult returns, this means an additional 50,000 fish might be available for some form of harvest as a result of dam removal. Then turning to Attachment 6, Table 3 (from Meyer Resources, (1984)), with the numbers updated to 2009 dollars[22] for the annual economic benefits to the regional economy per 50,000 additional harvested adult fish, in market benefits ***only*** (to be conservative) this would mean an additional economic benefit to the regional economy of:

Low Value: $353,416 per 1,000 fish x 50 = $17,670,800 restored economic benefits

[22] Using the standard CPI adjustment of 2.03 to convert 1984 dollars to 2009 dollars. CPI adjustments can be easily calculated on the Internet at: http://data.bls.gov/cgi-bin/cpicalc.pl. See Attachment 4 for methodology.

This would likely be a low or conservative value of the additional economic personal impact benefits that would accrue to the fishing-based and regional economy from dam removal and subsequent water quality improvements (resulting in increased survival rates as well as larger populations) from dam removal.

It should be particularly noted that this conservative estimate of salmon harvest economic benefits which could be readily derived from Klamath dam removal *exceeds* the "annual net benefits" of *all* of the FEIS options except for the "no action" alternative, which is not a legal option. With an incremental annual increase of personal income impacts from restored fisheries conservatively estimated at $17,670,800, this is also more than enough to offset the FERC-estimated annual costs of the Four-Dam Removal Option of -$13,186,870 (see FERC FEIS, pg. 4-2 (Table 4-3)), *by more than $4.48 million/year*.

In other words, using FERC Staff's own FEIS cost estimates, it appears that the most economically beneficial course to follow for society as a whole is to remove all four of the KHP hydropower dams (Iron Gate, CopCo 1 & 2 and J.C. Boyles) in order to restore the lost but very valuable salmon and steelhead fisheries these dams originally destroyed.

It should be noted, however, that these restored Klamath fishery economic benefits could only be fully achieved under a full KHP "Four Dam Removal" option. Anything *less* than a full removal of the KHP dams would mean some dams (and reservoirs) still in place, and this would still mean: (1) some mortalities due to artificial fish passage as opposed to full volitional free passage in a restored river, since no artificially engineered fish passage system is perfect; (2) remaining large thermal barriers and other problems for salmon migration in the reservoirs behind the dams because reservoirs would still heat up, adding to salmonid stress, encouraging warm-water reservoir predators, and decreasing resistance to diseases; (3) remaining good growing conditions for toxic and other species of algae with all their associated water quality problems.

The above "restored fishery benefits" numbers are also conservative figures in that they excludes *all* non-market benefits. They also exclude other and potentially *much* greater economic benefits to commercial ocean salmon fishermen which would accrue simply by having more fish in the system and thus being able to meet the "spawner floor" of 35,000 minimum escapement requirements far more frequently – thus eliminating current severe restrictions such as we saw in 2005, and worse in 2006, on ocean commercial fishermen that are triggered by Klamath salmon populations declines, and thus allowing fishermen far more access to otherwise abundant intermingling oceans stocks from other basins, primarily from the California Central Valley hatcheries.

Fewer fishery restrictions of the sort that required a 90% ocean fishery closure in 2006 and a 60% ocean fishery closure in 2005 over more than 700 miles of Northern California and Oregon coastline has great economic value to the west coast salmon fleet. Had these additional Klamath fish been available during those years, there would have been no question about meeting the "spawner floor," and this would have saved the coastal commercial fishing industry from draconian closures that cost their coastal communities well over $100 million in economic losses and damages -- all caused by mandatory Klamath-driven closures because of very low in-river survival rates, in some large part because of KHP-induced adverse ecological changes in the river.

Some of the potential economic "restored fishery benefits" that may accrue to in-river sportsfishing businesses (particularly within Siskiyou County) from a restored upper basin salmon fishery after dam decommissioning have been delineated in the recent study, *Preliminary Economic Assessment of Dam Removal: The Klamath River* (January 31, 2006), by Sarah A. Kruze and Astrid Scholz (Kruze, S. A. and A. Scholz (2006)) (see Attachment 8), in which the authors have estimated additional fisheries economic benefits of up to $140 million annually from KHP four-dam decommissioning.

Additional ecological benefits of KHP four-dam removal might also include adding an addition of 10% or more to existing ESA-listed coho habitat, making them far more viable and resistant to extinction, and finally moving them toward future recovery. This benefit was acknowledged in a Ruling in the EPAct Hearings by Judge McKenna as Finding 7-16:

> "Over time, access to habitat above Iron Gate Dam would benefit the Coho salmon population by: a) extending the range and distribution of the species thereby increasing the Coho salmon's reproductive potential; b) increase genetic diversity in the Coho stocks; c) reduce the species vulnerability to the impacts of degradation; and d) increase the abundance of the Coho population.[23]

Reduced need for restrictive ESA-driven land use regulation also has great value (though exact amounts are hard to quantify) to local landowners in terms of fewer land and water use restrictions, etc., and the hope of coho recovery and eventual delisting.

In general, the FERC FEIS does not properly assess or evaluate the probable economic ***benefits*** of a restored fishery that would accompany the dam removal options, nor does it adequately assess the ***severe economic damages*** perpetually being suffered by coastal ocean fishing-dependent communities because of lack of Klamath fish – a lack caused in large part by the KHP dams. One way to measure those loses, and to ascertain the magnitude of these declines, is to look at the recent history of salmon landings to what were once the most productive salmon ports in the lower 48 states – the salmon ports within the Klamath Management Zone (KMZ). We have done so in Attachment 7. Landings averaged over the

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[23] Evidence in the record cited by the ALJ in that Ruling was: *Aug. 23, 2006 Transcript at 163:1-2; Aug. 25, 2006 Transcript at 107:5-20; NGO Ex. 27 at 3:11-4:7 (allowing access to additional habitat does not decrease the size of the population existing below Iron Gate Dam); Yurok-Hillemeir Direct Testimony-NMFS/FWS Issue 7 at 5:7-8 (access to project area is one of the quickest ways to increase population abundance), 6:4-22; CDFG-Pisano-Ex. 1 at 5, 11:18-12:23; NMFS/FWS-Issue 7-Simondet-Ex. 1 at 5:21-6:15; NMFS/FWS-Issue 7-Williams-Ex. 1 at 6:15-19, 7:15-9:22 (explaining that additional spatial structure reduces species vulnerability to changing environmental conditions); HVT-Franklin-Ex. 1 at 6:16-7:12 (explaining that diverse habitat leads to populations adapted to diverse life history forms and greater viability for the species); NGO ex. 4 at 11:15-28.* These documents are hereby incorporated into these comment by reference.

years (1976-1980) as compared landings in these same port areas averaged over 2001-2004[24] shows huge declines during this time frame, as follows:

SALMON FISHERY LOSSES BY PORT AREA OVER TIME
(Average of Years 1976-1980 as compared to Average of 2001-2004 landings)

Port Area		**Decline (%) of Fishery**
Eureka (CA)	=	**97% LOSS**
Crescent City (CA)	=	**87% LOSS**
Brookings (OR)	=	**82% LOSS**

These precipitous losses started with a few short (3-year) salmon generations shortly after the completion of Iron Gate Dam, the last dam in the KHP series of dams, in 1962. See also the FERC FEIS at pg. 3-235 (Table 3-55), and also the PacifiCorp *Final License Application (FLA), Socioeconomic Resource Final Technical Report*, pgs. 2-108 to 2-114 for landing loss figures to the same effect.

These absolute salmon landing losses have been *economically devastating* for these Northern California and Southern Oregon coastal port economies, translating into thousands of lost jobs, fishermen forced to relocate with their families in order to find work or to sell their boats and quit fishing, fragmented fishing-dependent communities and the fleeing of processors, ice plants, fuel depots and other allied infrastructure businesses from these communities over the last 30 years. *If even a small portion of these losses is directly or indirectly attributable to poor water quality problems, or disease problems exacerbated by the dams, then it is far more beneficial to society as a whole to remove the Klamath dams than to keep them, knowing their economic and social costs to these many coastal communities.*

And these losses above are to the commercial salmon fleet only. They do not include separate but also large economic losses to recreational fishing-dependent small businesses throughout the lower river, nor to Tribal communities for the loss of both a source of revenues as well as a basic subsistence fishery that supports those communities and their ancient, salmon-centered cultures. *The combined cumulative socioeconomic losses to all these fisheries and all these fishing-dependent communities greatly exceeds any potential future economic benefits from hydropower production at the dams.*

In recognition of this fact, the Pacific Fishery Management Council (PFMC), which manages all ocean salmon fisheries in federal waters under the Magnuson-Stevens Fishery Management and Conservation Act (16 U.S. C. §1801 et seq.), formally endorses Klamath Project "Four-Dam Removal" as its recommended option for restoring damaged Klamath fisheries, and so noted in a letter to FERC dated April 24, 2006:

[24] To create a representative baseline for landing number by port, fishery managers always average over several years to eliminate sometimes large annual variations.

> "The value of ocean fisheries is high when Klamath natural chinook are abundant, but can be much lower when Klamath fish constrain the catch of other healthy stocks. The Council estimates that between 1970 and 2004, the average annual personal income impacts of the recreational and commercial ocean salmon fishery in the area where Klamath fish are found amounted to $92 million. The constraints on the fishery in 2006 caused by the need to protect Klamath River natural fall chinook are expected to reduce the value of this fishery to less than $33 million. In contrast, the Klamath hydropower project produces 163 megawatts with an annual net economic value of $16.3 million. NMFS notes that the 'generating capacity provided through continued Project operations is nominal … relative to the watershed level of benefits to aquatic resources and regional and national priorities for restoring anadromous salmonids.'…
>
> "The Council believes the proposed relicensing of this project will have substantial adverse impacts on EFH [Essential Fish Habitat] in the Klamath River. The project causes harm to salmon habitat; to the health of fish stocks; to commercial, recreational, and tribal fisheries; and to fishing communities along the Oregon and California coasts and in the Klamath River basin. Consequently, the Council recommends that FERC order the immediate decommissioning and removal of the four lower Klamath River dam structures and full restoration of habitat affected by the dams and reservoirs. "

A copy of this PFMC letter has been filed in the FERC docket and is enclosed as Attachment 17.

(3) Market Impacts of Poor Klamath Salmon Quality: The Klamath River-origin salmon are known in the fishing industry to be of increasingly poor quality due to distinctive "green algae" taste created by the salmon's exposure to excessive algae in the river. There was oral testimony in the record to that effect. While hard to quantify, this does adversely affect coastal and other markets for salmon, and many processors now avoid purchasing salmon caught in the Klamath River.

There are also some recent studies, including one by the State Water Board itself, showing that Klamath River adult salmon are accumulating the potent blue-green algae liver toxin microcystin in their livers and flesh, making their use for human consumption increasingly problematical.[25]

TEMPERATURE AND OTHER WATER QUALITY PROBLEMS WILL BE EXACERBATED BY REGIONAL CLIMATE CHANGE

(1) Water Temperatures in the Klamath River Have Been Steadily Increasing Due To Global Climate Change. Recent studies show that Klamath River average water temperatures

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[25] See for instance, *Technical Memorandum: Microcystin Bioaccumulation in Klamath River Fish and Freshwater Mussel Tissue: Preliminary 2007 Results,* by Jacob Kann, Aquatic Ecosystem Sciences (April, 2008), and *Final Report to the U.S. Environmental Protection Agency on Cyanotoxin Accumulation in Fish and Freshwater Mussels of the Klamath River,* CA State Water Board publication (Nov. 2008) (available from the Internet at: www.waterrights.ca.gov/FERC/cequ_projects.html). Both of these documents are hereby incorporated into these comments by reference.

have been gradually, over the last several decades, increasing consistent with current projects of overall regional climate change. Bartholow (2005) found a high probability (95% confidence interval) of an 0.5º C./decade upward average summer water temperature trend and that the "season of high temperatures that are potentially stressful to salmonids has lengthened by 1 month over the period studied, and the average length of main-stem river with cool summer temperatures has declined by about 8.2 km/decade." (see Attachment 14). It is important to note that this adverse water temperature impact is above and *added* to anthropogenic temperature increases caused by the KHP. Since these higher water temperature impacts are apparently related to overall regional average temperature and climate changes of the sort projected to continue (and accelerate) for the foreseeable future over the next 30-50 years, these are foreseeable "global warming" impacts that must also be taken into account as cumulative and foreseeable future impacts under CEQA.

This makes a "Precautionary Approach" to keeping water temperatures in the river as low as possible mandatory. Reducing *all* anthropogenic heat sources – such as the warm water sinks of the reservoirs – is thus even *more* important, given these potential global warming problems which will add additional temperature stress to river ecosystems as well as salmonids in the Klamath Basin, than ever before.

(2) Foreseeable Future Impacts Also Adversely Affecting Water Quality: Foreseeable future impacts also include drought and reduced flows from Upper Klamath Basin, etc., as well as changes in climate.

The Upper Klamath Basin is naturally arid, with an average rainfall in downtown Klamath Falls, OR of only about 12 inches/year. Droughts are not only frequent, but apparently increasing in both number and severity. All water quality parameters must therefore be calculated so as to be achievable *even in the increasingly frequent drought and dry years.* Otherwise, major portions of the basin's aquatic resources – including its economically and culturally irreplaceable salmon runs – could "wink out" because of serious water quality problems occurring during any prolonged drought, and would then be extinct when conditions improved – which could be way too late. Again, a Precautionary Approach requires that water quality standards must be satisfied in poor rainfall years as well and wet years.

MITIGATION MEASURES

We do not believe that <u>any</u> conceivable combination of water quality mitigation measures will be effective in the KHP to bring water quality standards in compliance with the law – at least not short of *enormously* expensive reconstructions that would cause the Project to cost far more than it can ever generate in revenues or economic benefits. We therefore support <u>denial</u> of a 401 Certification for FERC relicensing, and support ultimate dam removal supervised by FERC – either through a negotiated Settlement or a FERC decommissioning order. We believe that the economics and the science are both now clear that these dams are no longer cost effective, that they will do far more environmental and economic harm, even if FERC relicensed, than can be offset or justified by any of their likely economic benefits, and that the best option for these dams is that they be decommissioned and their structures removed from the river, allowing PacifiCorp to invest its saved resources if more efficient renewable energy facilities elsewhere.

If the 401 Certification Application is denied, the question then becomes only what interim measures should be imposed between now and dam removal to try to mitigate as much as possible the harms these dams will still do prior to their removal.

(1) Potential Interim Mitigation Measures: Reduced ramping rates and peaking flows at J.C. Boyles and appropriate fish screens and other mitigation measure in accordance with the NMFS, FWS and BLM "Mandatory Prescriptions" and recommendations should be among the interim measures, as well as other measures in addition to those FWS and BLM Mandatory Prescriptions, imposed until such time as PacifiCorp formally submits a FERC license surrender application and begins the process of dam removal. These interim measures should be scaled up in accordance with how long a delay dam removal will take. They should also become conditions to the current FERC license by way of an amendment to that license, so that they continue in full force and effect through all future one-year license extensions.

In the event of dam removal, various mitigation measures to reduce sediment loads expected to be released by dam removal should also be imposed to minimize adverse (though temporary) impacts from these sediment releases, particularly on in-river fish. Simultaneous dam removal and sediment discharges should be preferred over sequential releases, as this minimizes total number and duration of fish exposure times to high levels of sediment. A single high level sediment surge that may impact a single year-class is much less destructive to lower river salmon runs than smaller (but still fatal) sediment surges poorly timed that impact multiple year-classes.

Trap and haul programs as proposed by PacifiCorp will not work in the Klamath – they would only move smolts from one toxic part of the river to another toxic part. Juveniles will die under such conditions wherever they are placed, plus artificial transportation itself creates intense stresses on juvenile salmon which greatly decreases their chances for survival.

There are some values to retaining Keno Dam – with, of course, installation of appropriate fish passage facilities for salmonids and other species – because of the flow regulation capacity of that dam. Mitigation measures at Keno Dam should involve upgrades to existing poorly functioning fish passage to adapt that structure to both salmonids and to lamprey. Various water quality mitigation measures should also be imposed as appropriate at Keno dam as a pre-requisite to any exclusion from the next FERC license or any transfer by PacifiCorp.

(2) Likely Failure of Permanent Mitigation Measures: While it is noted that physical blockage of fish passage by the dams is "not an impact on the California environment caused by a discharge," (NOP pg. 12), it is important to also note that: (1) even with fish passage installed in retained (but retrofitted) dams, there will still be some unavoidable dam-related mortalities at each passage bottleneck. This is particularly true for juveniles migrating downstream, which may also become physically entrained in fish screens or lost in the power turbines that would still be running with the dams in place under either a new FERC license, or until such time under a license surrender that the dams could be decommissioned and removed. These are impacts which must also be analyzed under CEQA, including those types of impacts at dams in Oregon which may adversely affect water quality at California's border.

No artificially engineered fish passage system can ever be as efficient in passing fish as a healthy and free-flowing river corridor. This is important to remember in any analysis of the environmental consequences of dams remaining in place.

PacifiCorp has failed to fully mitigate for the fisheries losses caused by the KHP in a variety of ways, including lack of support for hatchery programs at Iron Gate Dam, including abandoning mitigation measures for spring chinook. These failures are discussed in Mike Rode's Expert Report enclosed as Attachment 1.

<u>In Summary</u>: Dam removal is the only effective option to solve the many water quality problems that occur in the dam. Full "Four Dam Removal" should be analyzed in great detail. Although J.C. Boyles and Keno Dams are physically located in Oregon, nevertheless under CEQA the State of Oregon can and should analyze both their impacts on lower river water quality in California, as well the impacts (positive and negative) on water quality in Oregon expected from their removal.

*****

Thank you for the opportunity to comment on this process. Please include these written comments and Attachments in the public record for this proceeding.

Sincerely,

Glen H. Spain, J.D.
NW Regional Director
For PCFFA and IFR

PCFFA/IFR COMMENT LETTER ATTACHMENTS:

(1) Mike Rode *Expert Report* from *McConnell* case Exhibits.
(2) Jacob Kann *Expert Report* from *McConnell* case Exhibits.
(3) Hamilton et al. (April 2005), "Distribution of Anadromous Fishes in the Upper Klamath River Watershed Prior to Hydropower Dams – A Synthesis of the Historical Evidence," *Fisheries* 30(4), pp.10-20.
(4) *Estimates of Pre-Development Klamath River Salmon Run Size* (IFR Report)
(5) Aaron J. Douglas Klamath Fishery Values Report.
(6) *Fishery Values of the Klamath Basin*, Meyer Resources (1984).
(7) Klamath Management Zone Port Landing Losses since 1976-1980.
(8) *Preliminary Economic Assessment of Dam Removal*, Kruze and Scholz (Jan. 2006).
(9) Huntington, C.,W., 2004. *Preliminary Estimates of the Recent and Historic Potential for Anadromous Fish Production Above Iron Gate Dam*.
(10) Huntington, C.W., 2006. *Estimates of Anadromous fish runs above Iron Gate Dam.*
(11) Klamath Index Selections from PFMC Klamath Salmon Management Plan.
(12) Secretary of Commerce 2006 Fishery Failure Declaration.
(13) Governor Schwarzenegger Klamath Fishery Declaration of Emergency (2006).
(14) Barthelow, John M., (2005). "Recent Water Temperature Trends in the Lower Klamath River, California," *North American Journal 0f Fisheries Management* 25:152-162 (2005).
(15) *Health Monitoring of Juvenile Klamath River Chinook Salmon* (USFWS California-Nevada Fish Health Center, Nov. 2005).
(16) *Klamath River Juvenile Salmonid Health Monitoring, April-August 2007*, (USFWS California-Nevada Fish Health Center, Sept. 2008).
(17) Letter to FERC from the Pacific Fishery Management Council (PFMC) dated April 24, 2006.

ATTACHMENT 1

Mike Rode *Expert Report* from *McConnell* case Exhibits

Adverse Impacts of the PacifiCorp Klamath Hydroelectric Project

On

Anadromous Fishery Resources of the Klamath River

Expert Report

of

Michael Rode

Prepared for:

Lawyers for Clean Water, Inc.
San Francisco, California
July 25, 2008

1.0 Introduction

I was retained to represent the plaintiffs in McConnell vs. PacifiCorp, Inc. (U.S. District Court Northern District of California Case No.: CV 07-02382 WHA) as an expert witness. I was asked to evaluate the effects of the PacifiCorp Klamath Hydroelectric Project (KHP) (FERC: P-2082) Copco 1, Copco 2 and Iron Gate Dams, operations and facilities on the anadromous fish, habitat, and fisheries of the Lower Klamath River in California.

My opinions are based on my professional knowledge and experience, including 15 years of working on Klamath River Basin fishery issues as a professional biologist, and the review of data, reports and studies prepared by PacifiCorp and its consultants, federal and state agencies, Klamath River tribes, university researchers, independent consultants, the National Academy of Sciences and the Federal Energy Regulatory Commission (FERC) and consultation with other expert witnesses for the plaintiffs.

I have been deposed once, I believe in 2004, relative to the September 2002 Klamath River adult fish kill lawsuit, but have never provided direct court testimony.

I am being compensated for my work on this report and subsequent work at the rate of $175.00 per hour and $200.00 per hour for depositions and court appearances, plus travel and other expenses.

2.0 Professional Background

I have thirty years of experience as a fishery biologist and environmental scientist, the last twenty eight years, from 1978 through 2005, working for the California Department of Fish and Game (CDFG), headquartered in Mt. Shasta, California. I have been retired from state service for approximately 2½ years and this testimony is the first paid professional work I have done since then. On May 15, 2008, I was asked to testify as an expert witness before the U. S. House Natural Resources Committee, Subcommittee on Fisheries, Wildlife and Oceans on the role of the Klamath River in the 2008 collapse of west coast salmon fisheries. I was not paid to do this.

I have a Bachelor of Arts degree in Biology from the University of California, Santa Barbara (emphasis in ichthyology and fresh water and marine ecology) and two years graduate work in the Biological Conservation MS (fisheries emphasis) Program at California State University, Sacramento. During the last fifteen years of my employment with the CDFG, my job title was Klamath River Coordinator. In that capacity, I represented the CDFG on numerous committees, working groups and task forces on Klamath River threatened and endangered fish recovery, fish habitat restoration, stream flow studies, harvest management, flow management, dam relicensing and other efforts. I was an early participant in the Klamath Hydroelectric Project relicensing. I was a member of the following: Klamath River Basin Fisheries Task Force, KRBFTF Technical Work Group, Klamath Watershed Coordination Group, Southern Oregon-Northern California Coasts (SONCC) Threatened Coho Salmon Recovery Team, Pacific Fishery

Management Council Habitat Committee, CDFG Threatened Trout Committee, Klamath Technical Team (Hardy Phase II Flow Study) and many Coordinated Resource Management and Planning groups. I was the lead CDFG scientist for the review of the National Marine Fisheries Service Biological Opinions (BOs) on the Effects of the Bureau of Reclamation's Klamath Project on SONCC Coho Salmon and numerous other plans, environmental documents, studies and reports. Based on the above experience, I believe I have expertise in and am qualified to comment on the biology, status, habitat, threats, and recovery needs of Klamath River anadromous salmonids.

3.0 Summary

The Klamath River was one of the great salmon producers of the west coast, exceeded in production only by the Columbia and Sacramento River systems. Close to 1 million salmon and perhaps more than several million steelhead, representing multiple species, numerous runs and complex life history strategies, ascended the river each year, some traveling close to 400 mi from the ocean to reach their natal tributaries. There were literally adult salmon or steelhead in the river every month of the year. This diverse bounty sustained the native peoples of the Klamath River Basin for thousands of years and later non-native inhabitants of the basin. For many years the salmon, steelhead and other fish species supported viable ocean commercial and recreational, native tribal, and inriver sport fisheries.

Although some decline in the fishery had already been noted by the late 1800s, it intensified during the early decades of the 1900s and the decline reached a critical point during the 1970s, resulting in the U.S. Congress enacting Public Law 99-552, the "Klamath Act" in 1986, a 20-year-long Federal-State Cooperative Klamath River Basin Conservation Area Restoration Program for the rebuilding of the Klamath River's fish resources (KRBFTF 1991). However, in spite of the accomplishments of this program, the decline of Klamath River anadromous fisheries has continued, as evidenced by restrictive fishing regulations and complete closure of fisheries in recent years.

The reasons for the dramatic demise of these fisheries are varied and complex but a critically important factor in their decline has been the construction and operation of the lower-most 3 dams of the KHP: Copco 1, Copco 2 and Iron Gate (IGD). Figure 3-1 depicts the location of these dams on the Klamath River. Section 4 of this report describes the known historic status, trends, and present status of the more important anadromous fish species. Particular emphasis is given to the life histories of the various races and runs of Chinook salmon to point out that those fish that require a complex and extended fresh water life history phase are most vulnerable to aquatic environmental perturbations and have, therefore, declined the most. Table 4.1-1 lists the life-stage periodicities for the three most important anadromous salmonids (Chinook salmon, coho salmon and steelhead) for four reaches of the Klamath River. Figure 4.1.1-1 depicts total adult fall Chinook salmon run size for the period 1978-2007. Section 4.2 discusses the importance of the various fisheries and what the economic value of a healthy, pre-development salmon fishery would be in terms of 1996 dollars. Section 5.0 of the report puts the impacts of the KHP in perspective with other factors that have affected anadromous fishery resources in the Klamath River. Section 5.1 describes the loss of anadromous fish habitat and estimates the loss of Chinook salmon production from the upper basin by the construction of the Copco 1 and 2 Dams and IGD. Section 5.2 documents the adverse effects on anadromous salmonids from 45 yrs of power peaking operations of the Copco facilities. Section 5.3 discusses the failures of IGH to provide full mitigation for lost upstream anadromous fish production and the fact that the hatchery may be contributing to wild anadromous fishery impacts. Figure 5.3-1 depicts total adult fall Chinook salmon returns to IGH for the 1978-2007 period. Sections 5.4-5.4.3 discuss KHP effects on water quality, including temperature, dissolved oxygen (DO) and pH. Figure 5.4.1-1 describes the increase in fall and decrease in spring water temperatures below IGD caused by the KHP and their adverse affect on anadromous salmonids. Figure 5.4.2-1 depicts the decline in DO values that has resulted from KHP operations and IGD. Figures 5.4.3-1 and 2 describe KHP induced increases in pH below IGD. Section 6.0 describes the KHP influence on Lower Klamath River geomorphology and hydrology. Finally, section 7.0 relates how the KHP has altered habitat below IGD that favors proliferation of the secondary polychaete host for two myxozoan parasites that are causing high mortality in juvenile anadromous salmonids (see Figure 7.0-1).

4.0 Historic Fish Populations, Trends and Value

4.1 Anadromous Fish Species

There are thirteen native and two introduced anadromous fish species that occur in the Klamath River watershed (NAS 2004). Of the two introduced species, the brown trout (*Salmo trutta)* is rarely sea-run, though common in some tributaries and the American shad (*Alosa sapidissima*) is uncommon and only occurs in the lower reaches of the river. Of the thirteen native species, nine are tribal trust species (NAS 2004). The more important anadromous fish include Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*), green sturgeon (*Acipenser medirostris*), Pacific lamprey (*Lampetra tridentata*), coastal cutthroat trout (*O. clarki clarki*) and eulachon (*Thaleichthys pacificus*). Chum salmon (*O. keta*) is today considered rare and pink salmon (O. gorbuscha) is extinct (NAS 2004), thus these two species, which may have had tribal significance historically, no longer play an important role in Klamath River fisheries.

4.1.1 Chinook Salmon

The Klamath River Basin was once the third most productive salmon system in the lower forty-eight states (NMFS 2007). One estimate of historical (pre-development) annual salmon run size ranged from 660,000-1.1 million adults (880,000 annual average) (IFR 1998). The predominant salmon species, in terms of number, size and human utilization, was the Chinook salmon. Two main races of Chinook, each exhibiting varied and different life history strategies, existed in the Klamath: the fall-run and the spring-run. The life histories of Chinook salmon will be examined in more detail below than those of the other anadromous fishes because of their commercial, recreational, and tribal importance, the fact that more is known about them than other anadromous species and because their life history requirements clearly illustrate the deleterious impacts that aquatic environmental deterioration and modifications have had on the full assemblage of Klamath River anadromous fish species.

In the Klamath, fall-run Chinook are ocean maturing fish that typically spend less than one-year in fresh water, with some exceptions, and are referred to as having an ocean-type life history. Historically, the run started entering the lower river in July and peaked in August before declining in September (Snyder 1931). Due to this run-timing, Snyder (1931) referred to these fish as summer-run. Today the run occurs later. The run peaks at the mouth of the Klamath in early September and continues through late October, with spawning peaking in mid-October and generally finishing by mid-November (NAS 2004). Another run of fall Chinook, referred to as the late fall-run, enters tributaries of the Lower Klamath (e.g. Blue Creek) from November through December with some returning as late as February (Hardy et al. 2006).

The period of egg incubation and time to emergence for fall Chinook is temperature dependent and varies from year to year and for different locations. In the main stem alevins generally emerge from early February through early April. Fry disperse downstream in the tributaries and the mainstem, in response to competitive pressures for food and space, increasing temperatures and sometimes diminishing flows. They take up residence in shallow, slow moving, vegetated near-shore habitats to rear. At about 55 mm in length, they begin downstream movement to the estuary with peak outmigration occurring at the U.S. Fish and Wildlife Service (USFWS) Big Bar Screw Trap (RM 49.7) during June and July (Tom Shaw, USFWS, personal communication). The salmon that exhibit this most common type of life history are referred to as Type I Chinook salmon. The Type I life history strategy has adapted to minimize exposure time to the freshwater environment in the mid-reaches of the Klamath River in order to avoid predation, high water temperatures, and disease. Two other life history forms that may have been more prevalent historically, but are poorly represented today are: Type II Chinook which rear and over-summer in their natal tributaries and then outmigrate through the estuary in the fall as 0+ age fish after main stem temperatures have dropped to tolerable levels and Type III Chinook salmon that over-summer and –winter in tributaries and then outmigrate the following spring as 1+ age fish. The Type II and III strategies result in larger-sized outmigrants that have higher rates of survival and, thus, greater rates of return as adults. However, these life history forms require high quality fry and juvenile rearing habitat with sustained summer flows and ideal temperatures, conditions not as common in the Klamath Basin today.

Sexually immature spring Chinook adults (also called springers) enter the Klamath River from April through July and ascend cold-water tributaries where they hold over the summer before spawning in the fall with peak spawning occurring in October (NAS 2004). Immigration during the high flow season allows springers to access head water tributaries and spawn at higher elevations than can fall Chinook, which are limited in their upstream distribution by low flows and high water temperatures during the summer and fall (Moyle 2002). This type of spatial and temporal separation allows for maximum niche utilization in an aquatic ecosystem and contributes to genetic isolation between the two races of salmon.

Spring Chinook fry emerge from March through early June and rear in their natal headwater tributaries. Some move downstream in the fall, but most do not outmigrate to the estuary and then the ocean until the following spring (Hardy et al. 2006) and thus, are referred to as exhibiting a stream-type life history.

Table 4.1-1 shows the life-stage periodicities for Chinook salmon, coho salmon and steelhead for different reaches of the Klamath River from Iron Gate Dam to the estuary.

Fall Chinook numbers have declined drastically within the Klamath Basin during the past century. NAS (2004) using Snyder's (1931) estimates of inriver harvest at the mouth of the Klamath River for the 1916-1927 period, estimated that total ocean and inriver harvest averaged 120,000-250,000 fall Chinook/yr. If a 50% harvest rate is assumed for that period, total run sizes (harvest and escapement) averaged 240,000-500,000 adults/yr during the 1916-1927 period. This compares closely with the run sizes reported by Hardy et al. (2006) citing Rankel (1982) who estimated total annual catch and escapement of fall Chinook between 1915-1928 at between 300,000-400,000. In 1972, it was estimated that 148,500 Chinook entered the Klamath system (Coots 1973 cited in Hardy et al. 2006). Between 1978-2007, the estimated total adult fall Chinook run size (hatchery and natural fish) to the entire Klamath Basin has been highly variable and averaged 105,357 fish, ranging from a low of 26,698 in 1992 to a high of 222,768 in 1995 (Figure 4.1.1-1) (CDFG 2008). Natural fall Chinook on average made up 77% of the run; Trinity River Hatchery contributed 8.6% and IGH 14.4% of the run, respectively (CDFG 2008).

Historically, large numbers of both spring and fall Chinook salmon accessed tributaries above Upper Klamath Lake to spawn (Hamilton et al. 2005). The spring-run may have been the more abundant of the two Chinook races above Upper Klamath Lake and may have equaled the fall-run in numbers basin-wide (Hamilton, et al. 2005, NAS 2004). Today, spring-run have been extirpated from the Klamath system, save for one small residual population in the Salmon River and several small remnant natural populations and a hatchery supported run on the Trinity River (Hardy et al. 2006).

4.1.2 Coho Salmon

Coho salmon were historically widely distributed and abundant throughout the Klamath River and it's tributaries as far upstream as Spencer Creek (RM 227.6) (today, tributary to the upper reach of J.C. Boyle Reservoir) (Snyder 1931; FERC 2007; Hamilton et al. 2005). Although accurate estimates of historic numbers are not available, coho have been in serious decline for at least the last fifty years and today the natural population is severely reduced in number and distribution and dominated by hatchery produced coho salmon (CDFG 2002). Klamath River Basin coho are considered part of the Southern Oregon/Northern California Coast (SONCC) ESU and SONCC coho were listed as threatened in 1997 by the National Marine Fisheries Service (NMFS 2007). Commercial and recreational ocean fishing for coho as well as inriver recreational angling has been banned in California since 1994 (Boydstun et al. 2001, cited in NAS 2004). Hatchery fish appear to far outnumber natural coho. In 2000 and 2001 61% and 73%, respectively of the smolts sampled in the estuary were of hatchery origin (M. Wallace unpublished data 2002 cited in NAS 2004). The fact that coho spend 14 to 18 months of their 3 year life cycle in fresh water (NAS 2004) subjects coho fry and juveniles to a longer period and greater variety of potential environmental hazards than typical Type I fall Chinook experience and plays and is a major reason for their threatened status today.

4.1.3 Steelhead

Steelhead, the anadromous form of rainbow trout, are represented by 3 races in the Klamath Basin: spring/summer-run, fall-run and winter-run (Hardy et al 2006). Steelhead most likely had the widest historical distribution and were the greatest in number of any of the anadromous salmonids in the Klamath Basin (Snyder 1930; Fortune et al. 1966, Hamilton et al. 2005). Hamilton et al. (2005) observed that wherever Chinook salmon are found, steelhead will be found higher in that drainage and concluded that steelhead historically spawned in the headwaters of the Wood, Williamson, Sprague Sycan and other tributaries above Upper Klamath lake. Hardy et al., (2006) postulated that steelhead run sizes prior to 1900 were likely to have exceeded up to several million fish. However, estimates of steelhead runs had declined to 400,000 in 1960 (USFWS 1960, cited in Leidy and Leidy 1984, cited in Hardy et al. 2006), 250,000 in 1967 (Coots 1967, cited in Hardy et al. 2006), 241,000 in 1972 (Coots 1972, cited in Hardy et al. 2006) and 135,000 in1977 (Boydstun 1977, cited in Hardy et al. 2006). This downward trend has continued with estimates during the 1980's indicating that run sizes were approximately 10,000 summer/fall steelhead and 20,000 winter steelhead basin-wide, including returns to Iron Gate and Trinity River Hatcheries (Busby et al. 1994). At Iron Gate Hatchery, steelhead returns averaged only 166 fish per year for the 1991 through 1995 period versus 1935 fish per year for the 1963 through 1990 period (Hiser 1994, cited in Hardy et al. 2006). In 1996, only 11 steelhead returned to Iron Gate Hatchery. Even though such severe declines have led the National Marine Fisheries Service (NMFS) to conclude that, based on available information, Klamath Mountain Province ESU Steelhead populations are not sustainable and are subject to endangerment, they were not listed under the Endangered Species Act (ESA) (NMFS 1998, cited in Hardy et al. 2006). A unique run of steelhead called half-pounders are immature fish that migrate to the sea in spring and then re-enter the Klamath as part of the summer and fall steelhead runs and spend the winter in fresh water. They typically migrate back to salt water the following spring (Moyle 2002).

4.1.4 Green Sturgeon

Green Sturgeon of the Klamath River system constitute the largest spawning population of the species, which ranges from Mexico to the Bering Sea. The NMFS has identified two distinct population segments (DPS) of green sturgeon: (1) a northern coastal population segment including the Eel River and coastal drainages northward and (2) a southern coastal population segment including coastal drainages south of the Eel River, including the Sacramento River system (FERC 2007). The Klamath River probably accounts for 70-80% of all green sturgeon production with spawning taking place in the lower reaches of the Klamath and Trinity Rivers (NAS 2004). Green sturgeon juveniles rear in the lower reaches of the Klamath until age 1-3 years, then move to the estuary and eventually the ocean, where they spend 3-13 years traveling long distances along the coast (NAS 2004). Some evidence suggests that there has been a general population decline, but recent restrictions in commercial and recreational harvest may be reversing those trends. The fishery supports a constant year-to-year tribal harvest of several hundred fish (Moyle 2002).

4.1.5 Pacific Lamprey

Historically, Pacific lamprey were extremely numerous and widely distributed in the Klamath River system. There is some disagreement as to how far they may have migrated upstream in the Klamath River. Hamilton et al. (2005) note that lamprey show a distribution similar to steelhead and salmon and concluded that they migrated upstream as far as the vicinity of Spencer Creek (RM 227.6), a distance similar to that of coho salmon. The NAS (2004) thought it certain that lamprey entered the upper basin above Klamath Falls at least occasionally based on the genetics of resident lamprey. However, FERC (2007) cites a September 27, 2006 Administrative Law Judge Decision (McKenna Decision) "*that there is insufficient evidence in the record to determine whether Pacific lamprey historically were distributed above the present site of Iron Gate Dam*." But, the McKenna Decision further concluded that *"the record evidence shows that access to habitat would benefit that species of fish by providing it with additional spawning and rearing grounds."* Today, their numbers are low and declining (Moyle 2002).

4.1.6 Coastal Cutthroat Trout

Coastal cutthroat trout occur primarily in small streams tributary to the lower 22 mi of the Klamath River. They appear underappreciated and often overlooked because of their similarity to steelhead NAS 2004), and population status is poorly known (Hardy et al 2006). They do not appear to have been present in the Upper Klamath Basin, presumably because of their intolerance to warm water (Moyle 2002).

4.1.7 Eulachon

Eulachon, also known as candlefish, is a smelt that once supported an important tribal fishery (Moyle 2002). Historically, large numbers would migrate into the lower 8 mi of the Klamath River during March and April to spawn (NAS 2004). Since the mid-1970's their numbers have been too low to support a fishery in most years (NAS 2004).

4.2 Fisheries Importance and Value

Chinook salmon have been the mainstay of Klamath River fisheries historically as well as today. Chinook have provided for tribal subsistence and ceremonial needs since time immemorial and, during recent times, tribal commercial fishing during years of abundance. In addition, Chinook have supported extensive commercial and recreational ocean fisheries from approximately Monterey Bay, California to Cape Falcon, Oregon and inriver recreational fisheries both on the Klamath and Trinity Rivers. Coho salmon contributed to these same fisheries as well until 1997, when commercial and recreational take of Klamath coho was forbidden by regulation because of their depleted status. This fishery remains closed today.

Using the 660,000 – 1.1 million historic salmon population estimate, and a 50% harvest rate, the Klamath should be able to produce a total annual income stream of market-based salmon related economic benefits (excluding non-market values) totaling between $82,900,878 to $137,432,650/yr. in 1996 dollars, thus supporting between 4,145 to 6,870 family wage jobs (IFR 1998). If non-market benefits are included the economic benefits could be as high as $374.86 million /year (IFR 1998). The net asset value (assuming a term of 100-years) of a historic pre-development Klamath salmon fishery (run size of 1.1 million salmon), at a fifty per cent harvest rate, calculated at a three per cent discount rate, has been conservatively estimated to be 4.5 billion dollars in 1996 dollars. If non-market benefits are included, the calculated net asset value of the fishery could then potentially be as high as $11.85 billion dollars (IFR 1998).

Steelhead have supported a very popular recreational fishery throughout the Klamath and Trinity Rivers and their major tributaries, but today this fishery is strictly regulated by specific water closures, season, gear type, and bag limit (wild steelhead may not be possessed) to protect wild salmon and steelhead stocks (CDFG 2007).

5.0 Impacts of The Klamath Hydropower Project

The reasons attributed to the decline of Klamath River anadromous fish runs have been varied and many. KRBFTF (1991), NAS (2004), Hardy et al. (2006) and others have described an extensive list of factors, some permanent and others transitory, that have affected anadromous fish species over the years in the Lower Klamath River. These include, but are not limited to: placer, gravel, and suction mining; timber harvest; salmon over-harvest; global warming; road building and maintenance; agricultural practices; water diversions for mining, power and agriculture; dams; water management and introduction of exotic fish species. Some of these factors, such as placer mining and fish over-harvest, no longer play an important role and fish populations would be expected to recover from these impacts. Others, such as global warming, may form a new baseline of environmental conditions that will have to be considered in species recovery. However, a review of the literature and personal knowledge of factors related to the decline of anadromous fisheries in the Klamath River lead me to conclude that construction and operation of the KHP lower-most 3 dams have been the major contributor to anadromous fish declines. The reasons are: (1) the impacts of the dams to loss of habitat and anadromous fish production in the upper basin were sudden, large, and long-lasting (90 yrs); (2) peaking operations chronically killed massive numbers of fish and aquatic insects and destroyed aquatic habitat for 45 yrs; (3) Iron Gate Hatchery (IGH), rather than mitigating for lost upstream production, has failed to meet mitigation goals and is instead interfering with anadromous fish recovery; (4) The 3 dams have chronically adversely affected water quality and stream channel morphology and contributed to salmonid disease epidemics.

5.1 Loss of Habitat and Fish Production Above Iron Gate Dam

Upstream passage of anadromous fish on the mainstem Klamath River may have been impacted with the start of construction of Copco 1 Dam in 1911 (RM 198.6)(FERC 2007), but was permanently blocked for the first time in 1917 with the completion of the Copco 1 facility (Hardy et al 2006). Copco 2 Dam (RM 198.3) was completed in 1925 and Iron Gate Dam (IGD) (RM 190.1) in 1962, but IGD, which is the current limit of upstream passage, may have effectively blocked fish migration as early as 1960 (FERC 2007). None of these dams incorporated fish passage facilities.

Prior to construction of the 3 dams, anadromous fish (spring and fall Chinook salmon, coho salmon, steelhead and Pacific lamprey) had access to approximately 600 mi of holding, spawning, incubation and rearing stream habitat above the site of IGD (Hamilton et al. 2005, Huntington 2004). Huntington (2004) estimated that historically this habitat may have been capable of supporting a Chinook salmon run-size of between 149,734 - 438,023 fish, but believed the actual figure was toward the lower end of the estimate. After additional field reconnaissance, Huntington (2006) conservatively estimated that upper basin habitat could support a run of 111, 230 Chinook salmon. Because steelhead generally spawn higher in tributaries and have greater thermal tolerance, it could be expected that the upper basin could support significantly greater number of steelhead than Chinook. Huntington, et al. (2006) have estimated that today the quantity of existing habitat potentially available, but presently inaccessible, in the upper Klamath Basin is 304 mi for ocean-type (Type-1) fall Chinook salmon, 370 mi for stream-type Chinook salmon and 500 mi for fall/winter steelhead.

In addition to the loss of anadromous salmonid spawning and rearing habitat within and above the KHP, the KHP has also blocked anadromous fish access to some of the most significant thermal refugia in the Klamath River. For example, the lower 3 dams block access to inriver springs below J.C. Boyle Dam that provide 225-250 CFS of clear, cold water that, historically, provided thermal refugia for anadromous salmonid adults and juveniles moving up and down stream between the upper and lower basins. Likewise, a number of cold water tributaries, including Spencer, Shovel, Fall and Jenny Creeks, played a major role as cold water thermal refugia but are now inaccessible. In river systems such as the Klamath, where attainment of optimal temperatures for salmonids is difficult, thermal refugia play a critical role (U.S. EPA 2003).

5.2 Power Peaking Operations

Another significant adverse impact created by the dams was that Copco 1 and 2 operated as power peaking operations for approximately 45 yrs. (1918-1962). No minimum flows were required during this period, and during the course of a week flows would vary from 3,200 CFS to 200 CFS while in a 20 minute period water level might drop or rise several feet (Jones and Stokes 1976, Taft and Shapovalov 1935 cited in KRBFTF 1991).

Hazards were created for fishermen and fish due to the extreme and unnatural short-term fluctuations. Complaints were many and eventually lawsuits were filed (KRBFTF 1991).

In several studies, adult and juvenile salmon and numerous insects were observed being stranded along the shore and then the sudden rise in flows would wash-out recently constructed redds (fish nests) (Snyder 1934, Taft and Shapovalov 1935 cited in KRBFTF 1991). The phenomenal biological impact of power peaking was quantified by California Department of Fish and Game (CDFG) biologists who calculated that during the period June 1948-May 1949, the Klamath River below Copco Dam experienced a loss of 1,862,132 salmonid fingerlings, yearlings and adults (primarily steelhead) as a result of the power plant's fluctuating releases (Wales and Coots 1950 cited in KRBFTF 1991). Multiplying this effect by the 45 years it took to solve the problem (a very conservative loss of 84 million salmonids) and the fact that the effect was felt, on a diminishing scale, probably to the estuary especially during summer low flow periods, indicates the magnitude of the tremendous loss to the fishery. Iron Gate Dam, located about 7 mi below the Copco 2 Power House, was constructed to reregulate Klamath River flow, as well as generate power (KRBFTF 1991).

5.3 Iron Gate Hatchery Does Not Fully Mitigate For Project-induced Losses of Fish Productivity

Iron Gate Hatchery (IGH) was constructed in 1962 as a requirement of the 1956 FERC license to mitigate for loss of Chinook and coho salmon and steelhead spawning habitat in the Klamath River and its tributaries between IGD and Copco 2 Dam (FERC 2007). There were no requirements in the FERC license to mitigate for loss of habitat above the Copco facilities. In addition, mitigation was not required for the loss of spring-run Chinook and lamprey production above IGD. The result, for these reasons alone, is that IGH has not fully mitigated for loss of Chinook and coho Salmon, steelhead and lamprey production caused by the KHP. Furthermore, the Klamath Tribes, which have treaty-guaranteed fishing rights, and other Upper Klamath Basin residents have not been able to participate in these fisheries at traditional locations for more than 90 yrs. This last issue has never been satisfactorily addressed.

Broodstock for the IGH fall Chinook program has been attained exclusively from Klamath River stock, however, attempts to establish a spring Chinook run from native stock, as described below, were unsuccessful (KRBFT 1991). Insufficient numbers of native coho salmon returned to IGH after IGD was built to establish a viable coho salmon brood stock, necessitating importation of coho eggs from other hatcheries, including Trinity River Hatchery, Cascade Hatchery in Oregon, and Mt. Shasta Hatchery (perhaps Noyo River strain coho)(CH2MHill 1985 cited in KRBFTF 1991). Steelhead native broodstock were supplemented with eggs imported from Trinity River Hatchery and Cowlitz River steelhead from Washington (KRBFTF 1991).

Current production goals at IGH are 4.92 million subyearling fall Chinook salmon, 1.08 million yearling fall Chinook, 75,000 yearling coho salmon and 200,000 yearling steelhead (Hampton, 2005). For most of the operational history of IGH, subyearling fall

Chinook were released over a several day period by the second week of June, water temperatures permitting. The goal was to rear fish to the largest size possible and then release them to the river before the onset of stressful or lethal temperatures. However, on a number of occasions significant mortalities of released fish occurred when river water temperatures unexpectedly reached lethal levels (KRBFTF 1991). The Chinook subyearling release strategy was changed at the recommendation of the Joint Hatchery Review Committee (CDFG & NMFS 2001) so that fall Chinook smolts were released semi-volitionally in four groups, one group/week, starting in May. This was initiated to increase hatchery Chinook survival and to decrease competition with wild (natural) Chinook. Fall Chinook yearlings are typically released in November, Coho yearlings in March and Steelhead March-May.

Chinook smolt production has ranged from 454,546 fish in 1965 to 12,727,288 in 1985 and has been below production goals 30% of years, above 21% of years, and approximately equal to production goals 49% of years. Coho salmon production has ranged from 0 to 200,000 smolts per year and has met production goals about 70% of the time. Steelhead yearling production has varied widely from a low of 10,702 in 1997 to a high of 642,857 in 1970. Steelhead production has declined steadily since 1970 and the production goal has not been met since 1991 (FERC 2007).

Prior to 1969, spring Chinook salmon were not differentiated from fall-run Chinook. From 1969-1979, springers were counted, with the numbers ranging from 0-181 fish per season with the largest number, 181, returning in 1972. The springer program, such as it was, was discontinued due to small returns of adults and limited hatchery space for continuing the program (CDFG 2008).

Fall Chinook salmon adult (excluding grilse) returns to IGH from 1963-2007 have averaged 11,652 fish per year and ranged from 365 fish in 1965 to 71,154 fish in 2000 (CDFG 2008). The returns have fluctuated greatly, being significantly below average (except 1976) from 1972-1984, above average from 1985-1989, again significantly below average from 1990-1992, and above average from 1993-1998. Record returns occurred in 2000-2001. Since then returns have generally been near average or a little above. (CDFG 2008). Figure 5.3-1 shows adult fall Chinook salmon returns to IGH for the 1978-2007 period during which the average return was 15,176 adults.

Coho salmon returns have averaged 859 adults for the 1963-2007 period, but have fluctuated widely from zero returns in 1964/65 to 3546 in 1996/97. Years of relatively robust returns are often followed by years of only a few hundred fish (CDFG 2008). The 2001/02-2005/06 returns were all above average, perhaps being influenced by the 1997 ban on commercial and sport take of threatened SONCC coho salmon. However, the 2006/07 and 2007/08 runs were only 263 and 625 adults, respectively (CDFG 2008).

Steelhead have exhibited widely fluctuating returns, but during the 1970s and 1980s adult returns to IGH were typically no lower than 1500 fish and as high as 4,000; the largest return of 4,411 fish occurred in 1977/78. During the 1990s, however, steelhead returns experienced a precipitous decline with only 12 fish returning in 1995/96. The runs recovered somewhat from 2000-2005, but only 161 and 325 steelhead returned in years 2006/07 and 2007/08, respectively (CDFG 2008). One major concern is that a significant portion of IGH-produced steelhead may be residualizing in the mainstem at a greater frequency than wild stocks and not expressing an ocean life history. Chesney (2003) examined the otoliths of 19 IGH origin steelhead returning to the hatchery and determined that 8 steelhead (50%) (3otoliths were inconclusive) had not gone to the ocean.

To summarize, fishing opportunities for anadromous fish species have been non-existent in the Upper Klamath Basin for more than 90 yrs. Iron Gate Hatchery, which was required to mitigate for this loss, has failed to meet its production goals for Chinook and coho salmon 30% of years and has a steelhead program that presently may be totally non-functional. Runs of Chinook, coho and steelhead to IGH in most years have been far below that which would have returned to the Upper Klamath Basin in the pre-dam era. Assuming a harvest of 50% and the average Chinook salmon return to IGH of 11, 652 adults, the total number of adults that could have potentially passed IGD to the upper basin would have averaged 23,304, about 21% of the number of fish estimated conservatively by Huntington (2006) to have reached the upper basin, on average, prior to development.

Survival of IGH Chinook, coho and steelhead production may be severely limited by poor Klamath River water quality, high temperatures and disease (see below). Coho salmon and steelhead broodstock genetics may have been compromised by the introduction of out-of-basin stocks that are poorly adapted to Klamath River environmental conditions. Instead, IGH production may be negatively impacting wild Klamath River fish populations through competition, hybridization and disease transmission (described below).

5.4 Water Quality is Severely Impaired

The entire length of the Klamath River from the Oregon state line to the Pacific Ocean is listed as impaired under the California 303(d) list for nutrients, organic enrichment, DO and temperatures that do not meet either numerical or narrative water quality objectives (SWRCB 2002). Furthermore, Klamath River waters within the KHP do not meet North Coast Regional Water Quality Control Board (NCRWQCB) (2001) objectives for pH, ammonia toxicity, taste and odor, floating material, settleable material, and chemical constituents. The NCRWQCB (2001) has found that the beneficial uses that are impaired by poor water quality include: rare, threatened or endangered species; cold freshwater habitat; migration of aquatic organisms; spawning, reproduction and/or early development; sport and commercial fishing; Native American culture; contact and non-contact recreation; wildlife habitat; navigation; municipal and domestic supply; and agricultural and industrial service supply.

5.4.1 Water Temperature

The Klamath River is considered temperature impaired by the State of California, North Coast Regional Water Quality Control Board (SWRCB 2002). High water temperature can be a major stressor that makes fish more susceptible to other stresses such as disease, or it can cause direct mortality in fish. In conjunction with low dissolved oxygen (DO), high water temperature has been implicated as a major contributing factor in juvenile and adult fish kills in the Klamath River (CDFG 2004, NRC 2004, USFWS 2003, FERC 2007).

The KHP detrimentally alters water temperatures in the Klamath River, thus significantly impacting anadromous fish resources (PacifiCorp 2004). Due to the thermal mass of Copco and Iron Gate Reservoirs, water temperatures in the mainstem river below Iron Gate Dam are cooler in spring by up to 5º C and warmer in late summer and fall by up to 5º C then they would otherwise be, absent the reservoirs (Figure 5.4.1-1) (PacifiCorp 2005, PacifiCorp 2004). These seasonal water temperature shifts would be expected to vary in timing and magnitude from year to year due to variations in river flow and weather.

The U.S. Environmental Protection Agency (EPA) recommends temperature limits for the protection of various life history stages of Chinook salmon. For Chinook spawning, EPA recommends that the maximum seven day floating average (7DADM) not exceed 13º C (U.S. EPA 2003), which is shown as a reference line in Figure 5.4.1-1. Fall Chinook in the Klamath main stem between IGD and Seiad begin spawning about mid-October with the peak occurring in late October-early November (Magnusen et al. 2001). As Figure 5.4.1-1 indicates, most present day spawning occurs at temperatures above 13º C. Eggs laid under such sub-optimal conditions are likely to have higher pre-hatch mortalities, a greater rate of developmental abnormalities and result in lower alevin weight (McCullough 1999). If the mainstem were free-flowing, without the presence of the KHP, water temperatures would decrease to 13º C by the first week of September, three weeks earlier than occurs presently with the KHP in place (Figure 5.4.1-1). As was discussed earlier, Klamath River fall Chinook salmon run-timing today is delayed by about three weeks over that which occurred pre-KHP and subsequently spawning has also been shifted back by three weeks, most likely as a behavioral response to avoid sub-optimally high water temperatures. The delay in run-timing reduces the separation of the main Klamath River fall Chinook run from that of the Trinity River run, potentially leading to denser concentrations of salmon in the Lower Klamath River. Such a condition was an important factor in the unprecedented 2002 Klamath River fish kill (CDFG 2004, USFWS 2003).

The lower limit temperature threshold for salmonid growth is 4º C (U.S. EPA 2003, McCullough 1999). Flows from IGD stay below this threshold from early February through mid-March, while modeled flows with out the KHP in place are mostly above the threshold from early February through March and are significantly warmer throughout the month of April (figure 5.4.1-1). The February-April period is critical for fall Chinook fry rearing in the main stem Klamath River (Hardy et al. 2006). The consequence of the shift to lower temperatures induced by the KHP dams is that fry will grow more slowly than they would have in a free flowing river. Larger smolts generally take less time to emigrate to the estuary than do smaller ones, thus minimizing exposure to mortality factors such as predation, disease and lethal water temperatures. The larger a smolt is at ocean entry the greater the rate of survival to maturity and spawning (Nicholas and Hankin 1988). The cumulative effect of delayed spawning in the fall with reduced fry growth rates in the spring is that rearing and outmigration are now generally occurring at a later date than would have occurred pre-KHP, thus subjecting these fish to even greater temperature and disease exposure.

5.4.2 Dissolved Oxygen

KHP operations result in reduced DO concentrations in the mainstem Klamath River below IGD, often below the State of California's numerical objectives (minimum of 7.0 mg/L above IGD and 8.0 mg/L below IGD and 50% or more of the monthly means in a calendar year must be above 10 mg/L from the state line to the Pacific Ocean) (FERC 2007). Measurements taken in August, 2004 showed depressed DO concentrations from IGD downstream to the confluence of the Scott River with average daily minimum DO values below 6.0mg/L (Kier Associates 2006).

Figure 5.4.2-1 compares DO concentrations below IGD for existing (Project) and modeled no project scenarios for a low flow water year. DO concentrations are significantly higher without the KHP than with during most of the year but especially during the fall Chinook adult migration and spawning season. Current DO levels below IGD are below State of California standards from early May to early November, often below 5-6 mg/L, thus deleteriously affecting fall Chinook salmon fry rearing, smolt outmigration and adult spawning life history phases. Other anadromous species present in the mainstem Klamath during this period, such as coho and steelhead, are also harmed. In contrast, the with out KHP DO concentrations are above 8.0 mg/L, often significantly so, during the entire year, save for a short period in late June/early July. Modeling results by PacifiCorp show similar results for other water year types, but with more variability (FERC 2007).

5.4.3 pH

Healthy waters typically have a pH of 6.0-8.0 and studies have shown that values exceeding 8.5 are stressful and those at 9.6 or above are lethal to salmonids (Wilkie and Wood 1995). In the Lower Klamath River, the stressful effects of high pH are amplified by the presence of typically high water temperatures and low DO from spring to early fall.

The NCRWQCB (2001) Basin Plan prescribes a standard for the Klamath River of pH not to exceed 8.5. Never-the-less, under present KHP operations this standard is exceeded on a daily basis during summer months along large reaches of the Klamath River with the maximum concentrations occurring from IGD to Seiad Valley (Figures 5.4.3-1 and 5.4.3-2) (Kier Associates 2006). The variability in pH values between years and sites is due to year-to-year differences in weather patterns, flows and other factors.

The persistent exceedance of the 8.5 pH standard is an indication of excessive nutrient loading and subsequently results in chronic fish health problems.

The KHP contributes to high downstream pH levels in two ways: (1) by releasing reservoir-generated high pH water at IGD that directly affects the downstream environment and fish and (2) by altering channel substrate and hydrology below IGD in ways that increase downstream growth of algae, periphyton and rooted macrophytes. Respiration of these organisms increases the CO_2 content of water which causes high pH levels during the day followed by low levels at night (diel swings).

6.0 Fluvial Geomorphology and Hydrology

Reservoirs often cause geomorphic and hydrologic changes that contribute to downstream luxuriant growth of periphyton (benthic algae, attached algae) and aquatic macrophytes (Biggs 2000); Iron Gate and Copco Reservoirs are no exception.

By interrupting sediment transport, Iron Gate and Copco reservoirs deprive downstream reaches of gravel, resulting in an armored streambed composed of larger substrates (e.g. cobble and boulders) that require higher flows for mobilization than smaller substrates such as gravel and sand (PacifiCorp 2004, FERC 2007). Cobble and boulder provide stable substrates that allow periphyton to reach high biomass (Biggs 2000, Anderson and Carpenter 1998). This paucity of gravel has also severely reduced available quality spawning habitat below Iron Gate Dam (FERC 2007).

In addition, flow regulation by reservoirs results in a smoothed hydrograph (reduced magnitude and frequency of peak flows), reducing scour of periphyton and macrophytes and allows biomass to reach higher levels than would occur naturally (Biggs 2000). Upper Klamath Lake is the primary water storage reservoir for the Klamath River, but Iron Gate and Copco Reservoirs do exert some hydrologic effect by allowing capture of small and medium storm flows from tributaries between Keno and Iron Gate Dams (i.e. Spencer Creek, Shovel Creek, Fall Creek, Jenny Creek).

High biomass of periphyton and aquatic macrophytes in rivers can result in degradation of water quality conditions (Tetra Tech 2006, Anderson and Carpenter 1998). Photosynthesis and respiration by periphyton and aquatic macrophytes in the Klamath River below Iron Gate Dam causes large diurnal swings in dissolved oxygen and pH, causing stress to juvenile salmonids. Additionally, one of the species that thrives in the reach below Iron Gate Dam is *Cladophora*, filamentous green algae that is one of the major habitats for the polychaete worm that is the alternate host of *Ceratomyxa shasta*, a major parasite of Klamath River salmonids (Stocking 2006) (See Fish Disease section for more detail).

7.0 Fish Diseases

A critical factor limiting recovery of anadromous fish populations in the Klamath River is the presence of several disease pathogens that annually cause severe mortality in juvenile

Chinook and coho salmon. The two most prevalent and significant pathogens are the myxozoan parasites *Ceratomyxa shasta* and *Parvicapsula minibicomis*, with the disease (Ceratomyxosis) caused by *C. shasta* considered the most important disease affecting juvenile salmon in the Lower Klamath Basin (Nichols et al. 2003). Bartholomew and Courter (2007) (cited in FERC 2007) reported that Coho may have less resistance to *C. shasta* than Chinook salmon and steelhead appear to have strong resistance to the parasite. Stone et al. (2008) confirmed the strong resistance of steelhead to *C. shasta* but found that coho and Chinook appear to have similar susceptibility to the parasite. . A number of studies have shown high *C. shasta* infection rates in mainstem Klamath River outmigrating fall Chinook smolts (Foote et al. 2002; Nichols et al. 2003). In a 2004 study of juvenile Chinook outmigrants, Nichols and Foote (2005) estimated that 45% of the outmigrant population were infected with *C. shasta* and 94% with *P. minibicomis* and that the majority of the dual myxozoan infected fish (98% of *C. shasta* infected fish) would not survive. Furthermore, Nichols and Foote (2005) concluded that:

> *"Depending on the juvenile Klamath River salmon population size and smolt to adult return ratio, the effective number of adult salmon lost to C. Shasta as juveniles could rival the 33,000+ adult salmon lost to the 2002 Klamath River Fish Die-off."*

The pathogenic infections and resultant juvenile anadromous salmonid mortalities are presently an annual occurrence, though the magnitude of the fish losses are sometimes difficult to determine because the small size of the fish causes them to quickly disappear and fish kills often occur in relatively inaccessible areas of the river. A July 21, 2008 USFWS preliminary report estimated that *C. shasta* had been detected in 46% and *P. minibicomis* in 63% of Chinook salmon sampled by June 1, 2008 (Accessed online at: http://www.fws.gov/arcata/fisheries/projectUpdates/FishHealthMonitoring/Klamath%20Juvenile%20Salmonid%20Health%20Update%2007-09-2008.pdf.

Resistance to infection may be reduced by higher water temperatures (Scheif et al. 2001), but Foott et al. (2004) concluded that the degree of parasite exposure may be more important than water temperature. In a 2003 experiment, Stocking et al. (2006) exposed fall Chinook salmon to *C. shasta* in both the upper and lower Klamath River. The experimental Chinook in the upper river did not become infected while those in the lower river suffered a 50% mortality rate. Stocking et al. (2006) concluded that the dramatic difference in mortality between the upper and lower Klamath groups could not be explained by differences in water temperature and are probably differences in infectious dose. Thus far, the presence of *C. shasta* and *P. minibicomis* infections have only been detected in the mainstem Klamath River and have not been found in the tributaries, including the Trinity River (Stocking 2006; Stocking et al. 2006).

The life cycles of both *C. shasta* and *P. minibicomis* utilize a salmonid host and an alternate host polychaete worm, *Manaynukia speciosa* (Figure 7.0-1). The life cycle of *C. shasta* is described in detail by Bartholomew et al.(1997). *C. shasta* myxospores develop in the salmonid and are then released into the water, where they infect the polychaete worm. They then develop in the polychaete before being released as actinospores which then infect salmonids.

The high incidence of *C. shasta* infections of *M. speciosa* below IGD appear to explain the high spore infectious rates of concurrent studies and the observations of *C. shasta* induced mortality in Klamath River fall Chinook salmon (Stocking and Bartholomew 2007). Recent surveys have found that the preferred habitats of *M. speciosa* are fine benthic organic matter occurring in low velocity areas and beds of *Cladophora spp* (a macro-algae) adhering to harder substrate such as boulders and cobbles and containing diatoms and fine organic material (Stocking and Bartholomew 2007). The highest densities of *M. speciosa* are always found associated with *Cladophora spp*. (Stocking and Bartholomew 2004)

A plausible explanation for the high incidence of *C. shasta* in the Klamath River is that *M. speciosa* populations have increased as a result of an increase in available polychaete habitat (Stocking and Bartholomew 2004). The KHP has altered the hydrodynamics, channel morphology and the nutrient dynamics of the Klamath River below IGD, which has increased habitat for polychaetes, thus increasing their numbers and the infection rates of the *M. speciosa* population. In addition, the KHP has increased water temperatures and pH and reduced DO levels, especially in the reach of river below IGD, thus stressing salmonids and making them more susceptible to myxozoan infections and potential death. All of these dynamics are further aggravated by the fact that IGD and the close proximity of IGH cause large spawning aggregations of fall Chinook to assemble in the river within a limited area that possesses some of the best polychaete habitat in the river. When these large numbers of salmon die in a rather confined space, myxospores are spread in profusion into a large and receptive *M. speciosa* population which then spreads its actinospores to the next generation of fall Chinook the following spring. This becomes a never-ending circular problem unless polychaete habitat is severely disrupted by a major storm event or some other, as yet untested, action.

8.0 Conclusions

The Klamath River anadromous fishery has gone from being one of the west coast's premier fisheries to being on the brink of collapse.

Anadromous fish numbers were severely depleted when the KHP Copco 1 Dam was constructed in 1917, blocking fish access to the Upper Klamath Basin. In spite of this and the fact that power peaking at the Copco facilities killed many millions of fish over a 45 yr period, anadromous salmonid runs persisted, albeit in much smaller numbers, because several cold-water refugia and some spawning and rearing habitat remained below the Copco 2 Power House. With the completion of Iron Gate Dam in 1962, the last remaining significant summer thermal refugia in the upper reaches of the lower river was eliminated. The KHP blocked about 600 mi of habitat above IGD that is estimated to have been able to produce a minimum of 111,230 adult Chinook salmon and many steelhead and coho . The effect of IGD was felt by the mid-1970s as the salmon runs declined to new lows.

Iron Gate Hatchery, constructed to mitigate for lost production above IGD, did not plan to and has not mitigated for spring Chinook or lamprey, has failed to adequately mitigate for steelhead and has not fully mitigated for fall Chinook or coho salmon. Instead it has, at times, grossly over-produced Chinook salmon smolts and yearling steelhead leading to high levels of competition with natural salmonid stocks. At other times (30%) IGH has under-produced Chinook and coho and has failed to sustain a viable steelhead production program.

For 46 yrs IGD has impacted the water quality of the Lower Klamath River in many ways, but most notably by altering the temperature regime, depressing DO and increasing pH, all to the detriment of anadromous salmonids. Geomorphic and hydrological changes induced by IGD have created habitat conditions in the Lower Klamath River favorable for growth of dense beds of algae that support unusually large populations of polychaete worms that act as a secondary host for two myxozoan parasites that infect and kill large numbers of anadromous salmonids. This combination of poor water quality, geomorphic and hydrological changes, and the presence of unnaturally large congregations of spawning Chinook salmon below IGD have worked in concert to create disease mortality in juvenile anadromous salmonids of epidemic proportions.

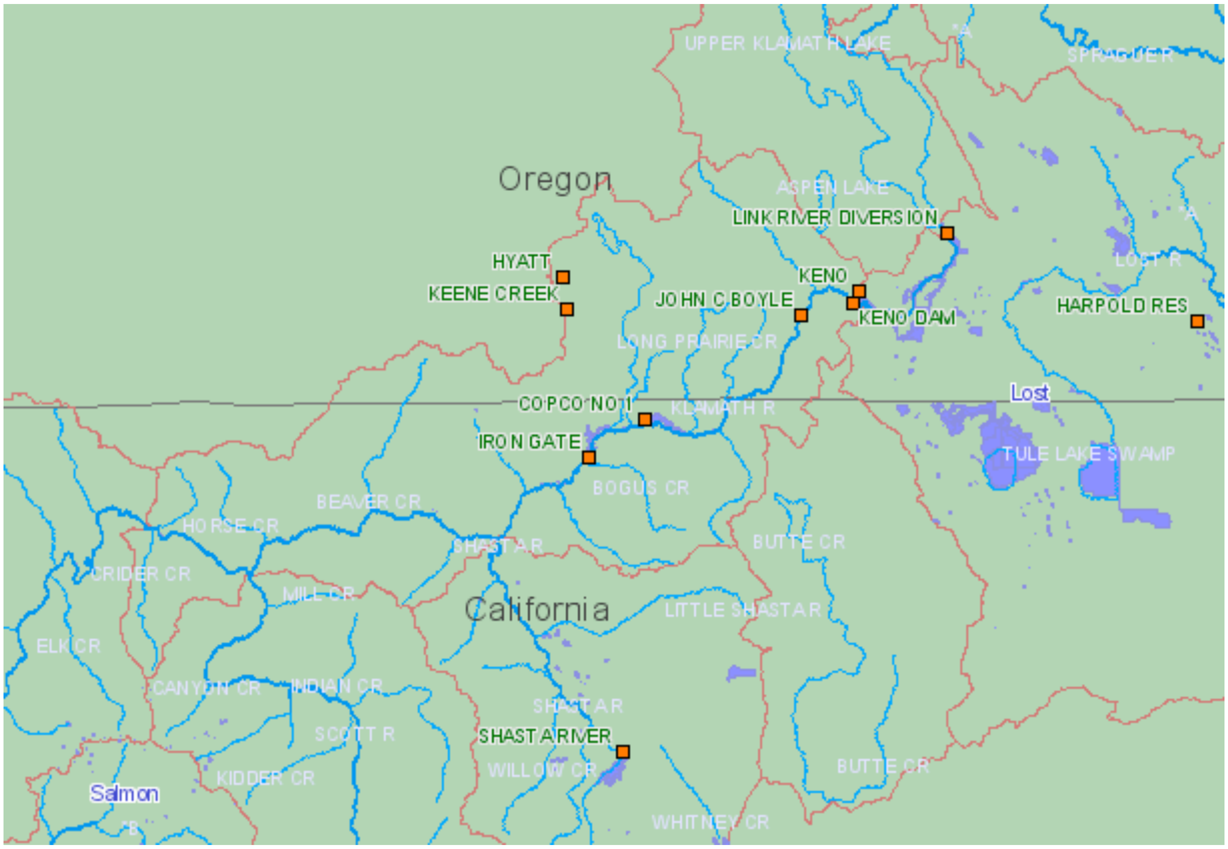
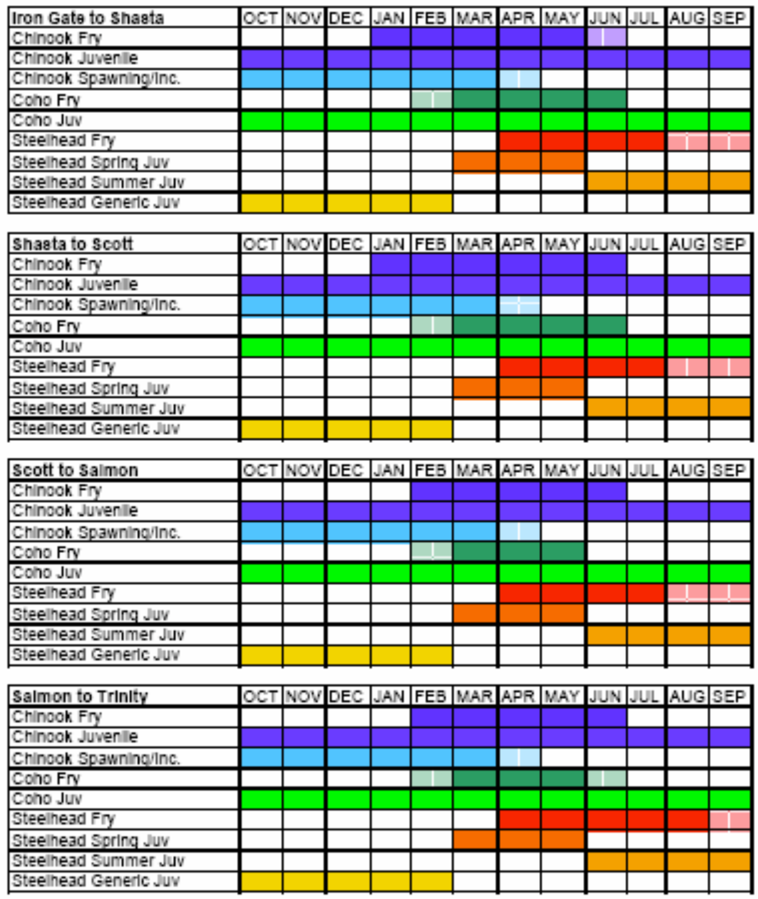


Figure 3-1. Location of the Klamath Hydroelectric Project, including Copco and Iron Gate Dams and Reservoirs (note: Copco 2 Dam is 0.3 mi downstream from Copco 1 Dam). Source: http://klamath.humboldt.edu/php-bin/index.php

Table 4.1-1. Species and life stage periodicities for four reaches of the main stem Klamath River between Iron Gate Dam and the estuary (hatching indicates occasional usage for that month). Source: Hardy et al. 2006 by permission.



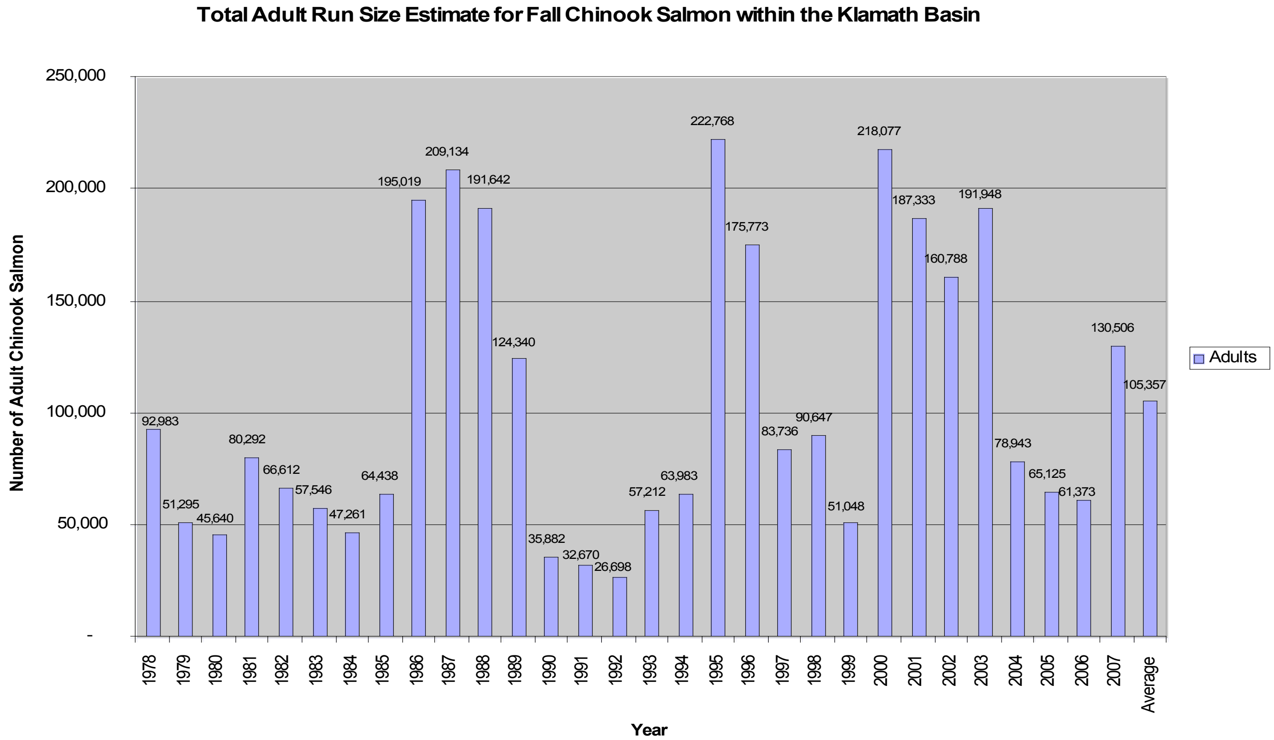


Figure 4.1.1-1. Total adult fall Chinook salmon run size (harvest and escapement) (natural and hatchery fish) for the Klamath Basin, 1978-2007. Source: CDFG unpublished data by permission.

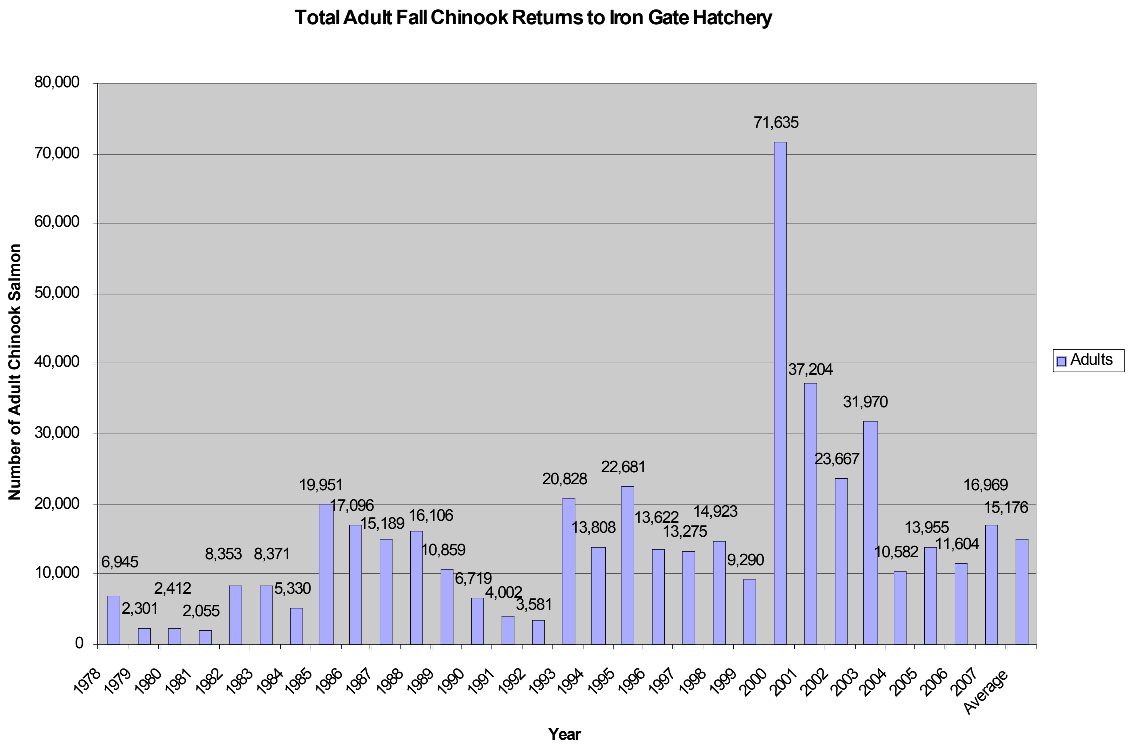


Figure 5.3-1. Total adult fall Chinook salmon returns to Iron Gate Hatchery, 1978-2007. Source: CDFG unpublished data.by permission.

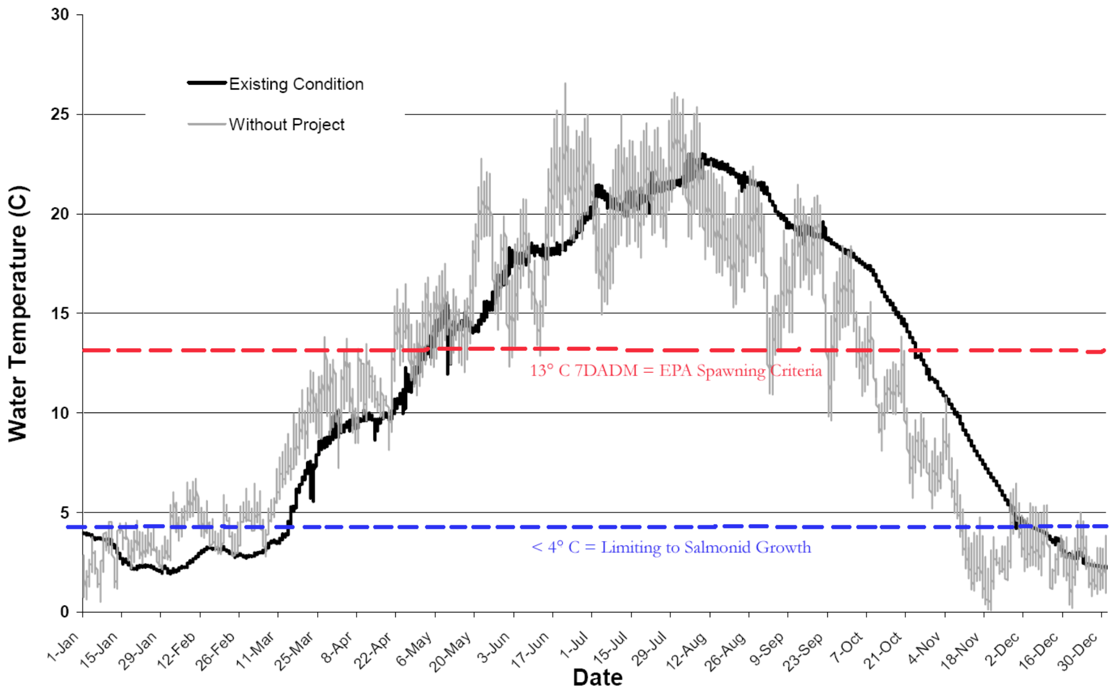


Figure 5.4.1-1. PacifiCorp water quality monitoring output showing water temperatures at Iron Gate Dam for the year 2000, comparing existing conditions (with project) and without project scenarios (PacifiCorp 2005)..References for salmonid spawning and the lower limit for salmonid growth are from U.S. EPA (2003). Accessed online at: http://www.klamathwaterquality.com/ig_temps%20copy.jpg

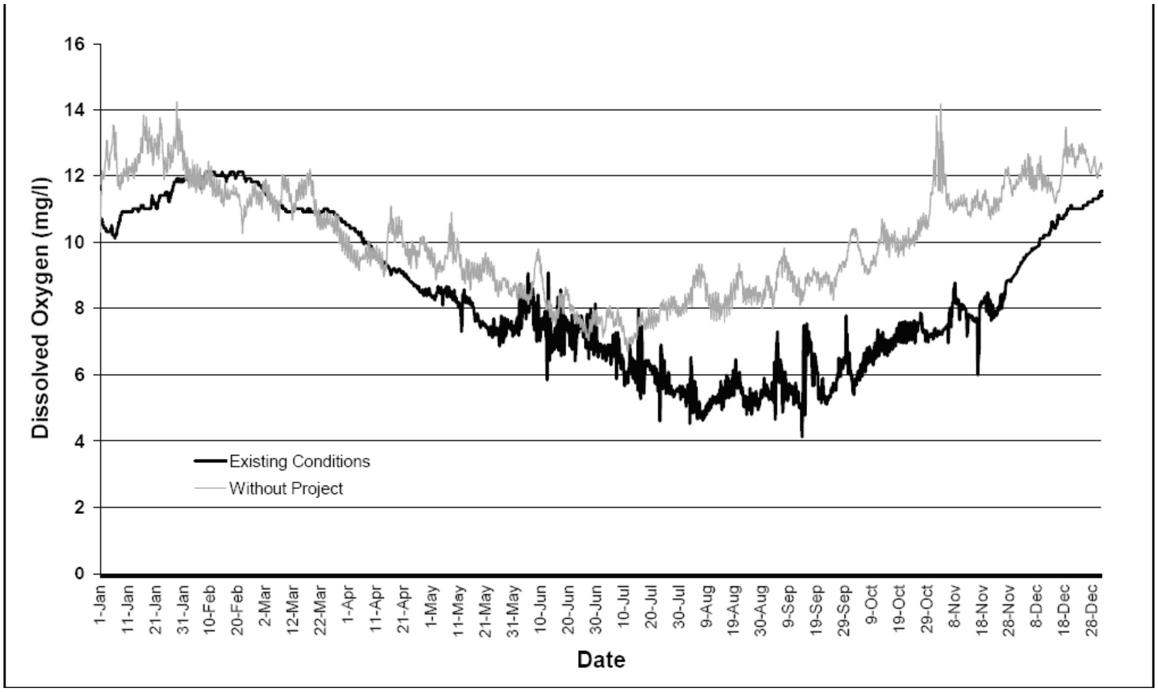


Figure 5.4.2-1. Simulated hourly DO levels below Iron Gate Dam based on 2002 (a dry year) existing conditions (with Project) compared to conditions without Project (Source: PacifiCorp 2005). Accessed online at: http://www.klamathwaterquality.com/ig_temps%20copy.jpg

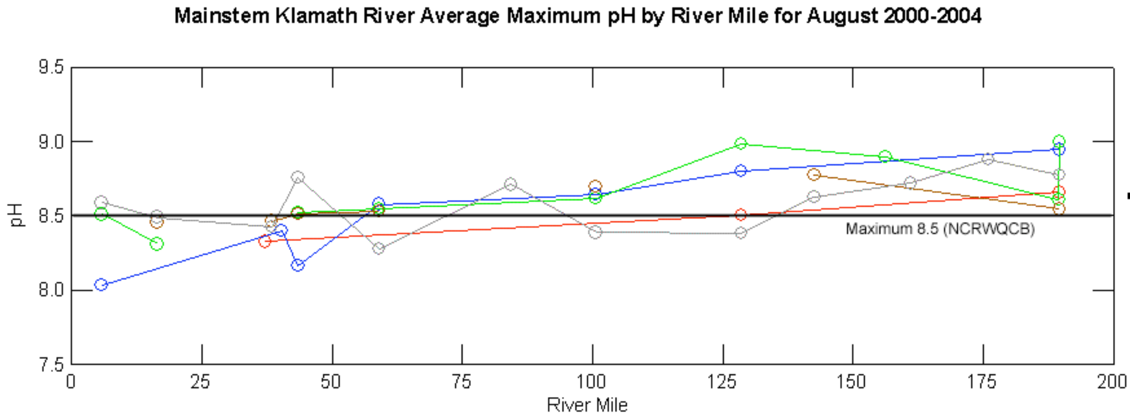


Figure 5.4.3-1. Average maximum pH of the Klamath River by river mile showing patterns for the years 2000-2004. The horizontal line shown on the graph is the NCRWQCB (2001) standard for pH. Data are from the USFWS, Karuk Tribe, Yurok Tribe and USGS. Source: Kier Associates (2006).

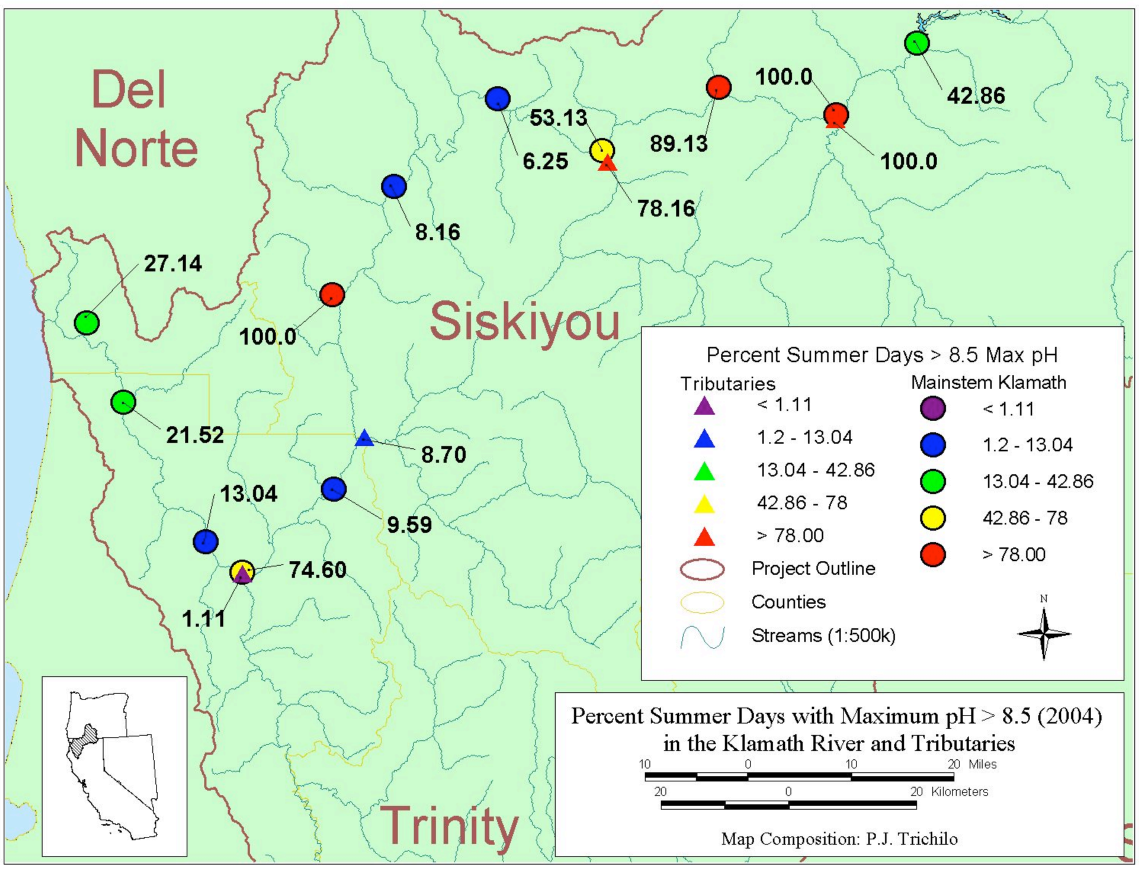


Figure 5.4.3-2. Map showing the percent of summer days in 2004 where maximum pH exceeded 8.5. Data are from Yurok Tribe, Karuk Tribe, and U.S. Fish and Wildlife Service. Figure adapted from Kier Associates (2006).

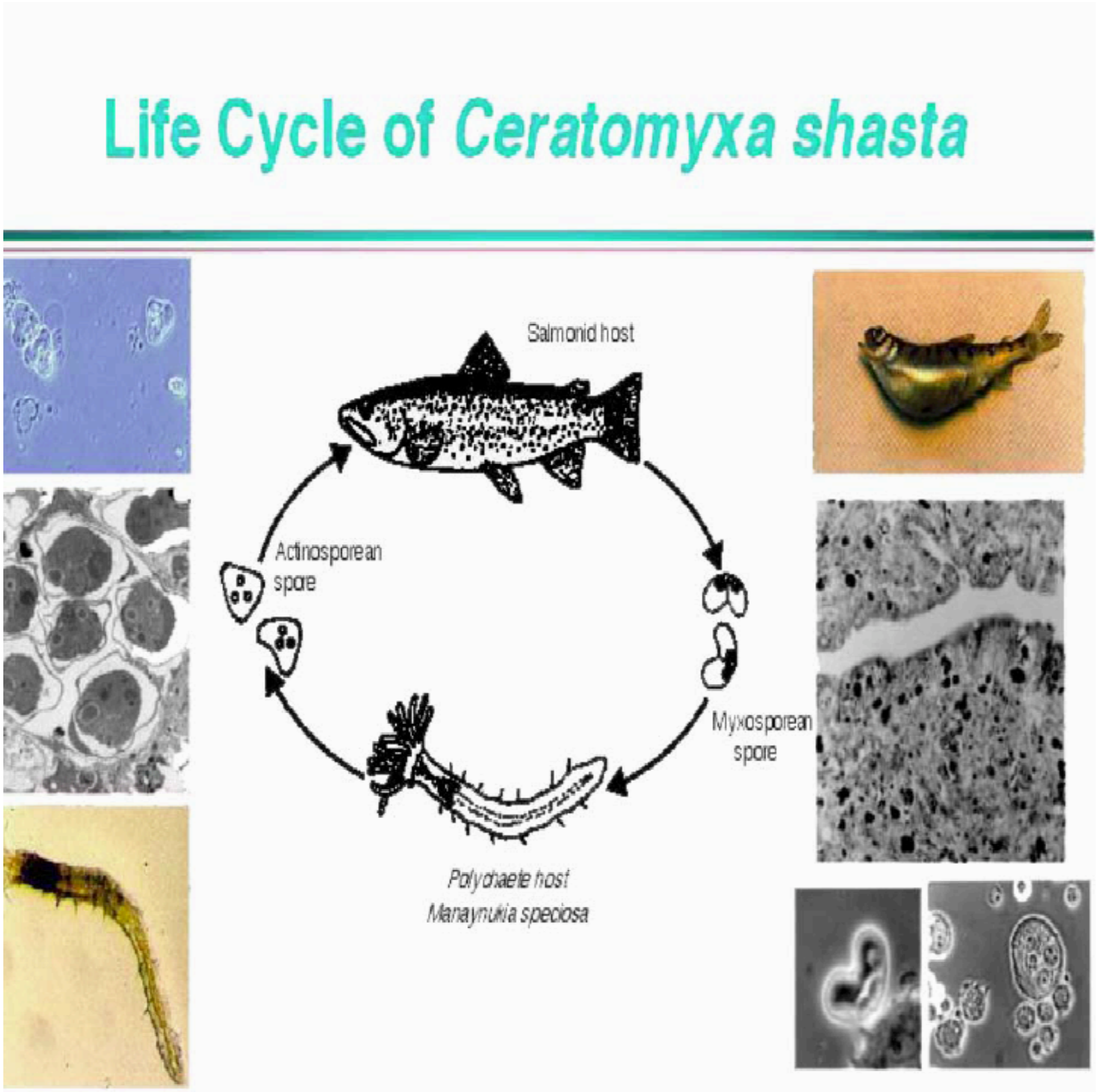


Figure 7.0-1. Life Cycle of *Ceratomyxa shasta* involves two hosts: (1) salmonids and (2) a polychaete worm, *Manayunkia speciosa* as a secondary host. *P. minibicomis* has a similar life cycle. Source: Bartholomew et al. 1997.

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This is to assert that this report was prepared by the individual named below.

Michael Rode

July 25, 2008

Michael Rode

Date

ATTACHMENT 2

Jacob Kann *Expert Report* from *McConnell* case Exhibits

EXPERT REPORT
OF
JACOB KANN, Ph.D.

In the Matter of MCCONNELL et *al*.
v.
PACIFICORP, INC

Prepared for:

Lawyers for Clean Water

Prepared by:

Aquatic Ecosystem Sciences, LLC
295 East Main St., Suite 7
Ashland, OR 97520

Jacob Kann, Ph.D.
President

July 25, 2008

Introduction

I was retained by Lawyers for Clean Water to evaluate effects of PacifiCorp's Klamath Hydroelectric Project on water quality, toxic algae, and fisheries in the Klamath River system of Northern California. I am the President of Aquatic Ecosystem Sciences, LLC in Ashland, Oregon. I have over twenty years of experience researching the biological, physical, and chemical aspects of aquatic ecosystems. I hold a B.A. degree in Ecology from Rutgers University, an M.S. degree in Fishery Resources from the University of Idaho, and a Ph.D. in Aquatic Ecology from the University of North Carolina, Chapel Hill. I have been involved in specific research activities related to water quality and aquatic ecology of the Klamath River system, as well as on other water bodies in the Northwestern United States. I have presented and provided these results at a variety of professional meetings, and in both research reports and peer reviewed literature. I have over 20 years of specific expertise relating to the ecology of blue-green or cyanobacterial algal blooms, including having performed numerous studies on blooms of toxigenic cyanobacteria (a.k.a harmful algal blooms or HABs) in lakes and reservoirs in California, Oregon, Washington, and Idaho.

My qualifications, along with a list of my publications, are contained in my curriculum vitae, which is attached as Appendix A. In addition, in my role as a research scientist I have been recognized as a regional expert in HAB's, serving as an advisor to the State of Oregon's DHS Environmental Toxicology Program on toxic algal monitoring and public health threshold guidelines, as well as provided expertise on HABs to the U.S. Environmental Protection Agency, the California State Water Resources Control Board, numerous municipalities, and Native American Tribes of the Klamath River system.

Based on my above outlined expertise and my intimate knowledge of water quality and algal dynamics in the Klamath River system, I am highly qualified to comment on matters pertaining to algal bloom (including HABs) and other water quality dynamics related to the presence and operation of the Copco and Iron Gate Dams and Reservoirs located on the Klamath River in California. Below I provide a synopsis of relevant data and studies that demonstrate causal links between conditions created by PacifiCorp Dams (including Copco and Iron Gate Reservoirs) and water quality, as well as the occurrence and growth of the toxigenic blue-green alga *Microcystis aeruginosa* and associated trends in the cyanotoxin microcystin (a potent liver toxin) above, within, and below the reach occupied by PacifiCorp's Copco and Iron Gate Reservoirs.

General Background and Water Quality Impacts

Copco and Iron Gate Reservoirs located on the mainstem of the Klamath River are severely degraded and represent clear cases of highly eutrophic to hypereutrophic (meaning excessive production) reservoir systems that are responsible for poor water quality problems (e.g., high ammonia and pH, and low dissolved oxygen) typical of excessive growth of algae. In addition, these reservoirs foster the growth of extensive toxigenic blooms of the blue-green alga *Microcystis aeruginosa* (MSAE) and associated high concentrations of the liver toxin (hepatotoxin) microcystin such that cell and toxin concentrations exported downstream to the Klamath River are substantially higher than those upstream from the reservoir complex.

Although substantial nutrients required for algal growth are imported to the reservoir complex from upstream, the damming and subsequent formation of Copco and Iron Gate Reservoirs (without which PacifiCorp could not operate the dams for power generation) alters the free-flowing Klamath River environment from one of flowing, turbulent conditions to that of a relatively calm, thermally stratified, and warm body of water. As demonstrated below, in the presence of adequate nutrients, this change from a riverine to a lake environment provides ideal growing conditions for toxigenic MSAE. In addition, the stratified reservoir condition as evidenced by thermal profiles (e.g., see Kann and Asarian 2007; PacifiCorp 2004; FERC 2007) along with high algal production during the summer season causes releases of water with high pH and low dissolved oxygen (DO) that impair water quality requirements for salmonids downstream of the dam (FERC 2007). Both the existing North Coast Regional Water Quality Control Board (2001) DO (>8 mg / L) and pH objectives for salmonids (not greater than 8.5 and not less than 7.0) for the Klamath River downstream of Iron Gate are exceeded on a regular basis (Hoopa TEPA 2008).

Moreover, primarily due to the thermal mass of Iron Gate and Copco reservoirs, the KHP significantly alters water temperatures in the Klamath River (FERC 2007; PacifiCorp 2004; PacifiCorp 2005) in ways that are detrimental to runs of anadromous fish in the Klamath River. For example, as PacifiCorp notes, water temperatures in the mainstem Klamath below Iron Gate Dam are cooler in spring, and warmer in late summer and fall, than would occur in the absence of the Copco and Iron Gate dams (PacifiCorp 2004, PacifiCorp 2005c, Deas 2004). Such warm temperatures in the fall negatively impacts fall Chinook spawning success and egg survival, and results in a several week delay in run-timing, and cool spring temperatures slows salmonid growth by keeping water temperature below the optimum growth temperatures for juvenile salmonids (see Rode, M. Expert Report July 2008 for additional detail). The resulting smaller-sized Chinook salmon juveniles migrate downstream more slowly than would larger individuals (PFMC 1994) and are less likely to survive to maturity and spawn (Nicholas and Hankin 1988). This increased transit time exposes them to prolonged stress, increasing their likelihood of becoming infected with parasites.

As noted by FERC in its final environmental impact statement regarding the relicensing of the Klamath Hydroelectric Project, removal of Iron Gate and Copco Reservoirs would result in improved temperature, dissolved oxygen, pH, and ammonia (FERC 2007).

Although the effects of the PacifiCorp dams on water temperature, dissolved oxygen, and pH and subsequent effect on salmonid success and survival are one component of dam effects on diminished fisheries and impaired riverine ecology, Copco and Iron Gate reservoirs also provide ideal habitat for growth of toxigenic MSAE and have been shown to export bloom material and toxins to downstream areas of the Klamath River. Following is a description of the aforementioned toxigenic bloom dynamics in the Klamath River system.

Synopsis of Data and Studies Relating to Enhanced Production of Toxic Algal Blooms and Associated Toxin in Copco and Iron Gate Reservoirs and in the Klamath River Downstream from the Reservoirs.

Background

Cyanobacteria, also known as blue-green algae, are a diverse group of single-celled aquatic organisms found in surface waters worldwide. Lakes, reservoirs, ponds, and slow-moving rivers are especially suitable for cyanobacteria, and given the right conditions, e.g., calm water, light, and adequate concentrations and ratios of nitrogen and phosphorus, these organisms can reproduce at a high rate, forming vast blooms in the water (e.g. Reynolds 1984). The resulting high cyanobacterial algal concentrations are not only aesthetically unpleasing, but often produce toxins that have been implicated in human health problems ranging from skin irritation and gastrointestinal upset, to death from liver or respiratory failure (Carmichael 1995, Chorus and Bartram 1999, Chorus 2001, and numerous authors summarized in Hudnell 2007). Copco and Iron Gate Reservoirs have been shown to provide ideal habitat for large blooms of one such cyanobacterial species (*Microcystis aeruginosa*) that produces the potent hepatotoxin microcystin (Kann 2006; Kann and Corum 2006; 2007).

Public Health Thresholds

These hepatotoxins (liver toxins) are powerful cyclical peptides which disrupt the structure of liver cells, causing cell destruction, liver hemorrhage, liver necrosis, and death (Carmichael 1994; and see Carmichael, W.W. Expert Report, July 2008 for additional information). In addition to hepatotoxicity, long-term laboratory animal studies indicate that microcystins can act as liver tumor promoters and teratogens (Kuiper-Goodman et al. 1999). Microcystin poisoning has been implicated in the largest number of cyanobacteria-associated animal deaths worldwide, and enough work has been done, both with rodents and pigs, on microcystin effects at various levels of exposure, that the World Health Organization has issued a provisional guideline of 1 μg/L for microcystin concentration in drinking water as well as developed Tolerable Daily Intake values for use with recreational exposure (WHO 1998). With actual microcystin concentration data frequently unavailable, public health alert level guidelines based on cell counts have been established for MSAE (as well as other cyanobacteria) blooms in drinking and recreational waters (Yoo et al. 1995, Chorus and Bartram 1999, Stone and Bress; SWRCB 2007). Public health advisories have been posted for Copco and Iron Gate Reservoirs and for the Klamath River below Iron Gate (e.g., Jacoby and Kann 2007).

In addition to WHO public health guideline values (as published in documents for the WHO and EPA: e.g., Falconer el al. 1999 and Chorus and Cavalieri 2000), cell density and toxin concentration that are MSAE specific have been recommended by the California State Water Resources Control Board (SWRCB 2007) and by the state of Oregon (Stone and Bress (2007). These levels are 40,000 cells/ml of MSAE and 8 μg/L of microcystin and are also consistent with recent Australian analysis of health risk threshold values (NHMRC 2005). The WHO (Falconer et al. 1999) also lists cyanobacterial scums in swimming areas as having a high probability of adverse health effects (i.e., the potential to cause acute poisoning) and recommends immediate action to prevent contact with scums. Graham et al. (2008) confirms the appropriateness of surface sampling of scums to determine maximum toxin concentration in recreational areas.

Fish Health Effects

Although mammalian health effects of toxins from the blue-green algae MSAE are better studied (WHO, 1998), fish health effects have also been recently researched (Zambrano and Canelo 1995, Wiegland and Pflugmacher 2005), including effects on salmonids (Tencalla et al. 1994, Bury et al. 1996; Fischer et al. 2000, Best et al. 2003). These effects are discussed here because there is evidence that hepatotoxins created by MSAE are a threat to fish health independently, and may also act synergistically with other water quality problems (i.e. pH, D.O., temperature and ammonia) in causing cumulative stress or in contributing to immunosuppression and subsequent outbreaks of fish disease epidemics.

Microcystin toxins accumulate in the liver where they disrupt many different liver enzymes and ultimately cause the liver to break down (Fischer et al., 2000). Fish species that directly graze algae may be the most susceptible to microcystin poisoning, but other fish may ingest whole MSAE cells or breakdown products from the water column (Wiegland and Pflugmacher 2005). In laboratory experiments, rainbow trout were found to excrete microcystin toxins in bile fluids when exposed to them orally. The toxins caused increased drinking in this species and increased water in the gut, which was a sign of osmoregulatory imbalance and could promote diffusion of toxins into the blood (Best et al., 2003).

Tencalla et al. (1994) noted that large scale fish kills around the world have resulted from microcystin poisoning. They postulated that a 60 g rainbow trout would only have to ingest 0.1-0.4 g of algae (wet weight) or 0.2-0.6% of its body weight to experience massive liver damage.

The most definitive effect of microcystin on fish concerns Atlantic salmon reared in net pens in coastal waters of British Columbia and Washington State, USA. As yet unidentified microcystin-producing organisms produce a progressive degeneration of the liver in salmon smolts placed into open-water net pens (Anderson et al., 1993). The disease, referred to as Net Pen Liver Disease (NPLD), has resulted in significant economic losses for the mariculture industry.

Bury et al. (1996) studied brown trout exposed to sublethal levels of microcystin toxins and found greatly altered blood cortisol levels indicating acute stress and reduced immunosuppression. This is a concern in the mainstem Klamath River because of the recognized fish health problems (Foott et al. 2003; Nichols and Foott 2005), and the potential for additional diminishment of resistance to disease caused by microcystin exposure of juvenile salmonids. As summarized in Fetcho (2006), detection of microcystin toxin in steelhead livers collected from the Weitchpec area indicated that these fish were exposed to microcystin in the lower-Klamath River environment (also see below for recent accumulation studies documenting microcystin in Iron Gate hatchery yearling Chinook).

Longitudinal Patterns of MSAE and Microcystin in the Klamath River

In earlier work I provided a summary of four datasets that included information about the distribution and abundance of MSAE in the Klamath River basin (Kann 2006). These included Upper Klamath Lake data from the Klamath Tribes during 1990-1997, PacifiCorp Klamath River data from below (UKL) to below Iron Gate dam during 2002-2004, Karuk Tribe/State Water Resource Control Board (SRWCB) data for stations above, within, and below the Copco and Iron Gate Reservoirs during 2005, and Yurok Tribe/U.S. Fish and Wildlife Service (USFWS) data from below Iron Gate dam to the Klamath River estuary during 2005.

These data showed that while MSAE was found in Upper Klamath Lake (UKL) and Agency Lake, it was only rarely detected in the outlet of UKL (which is the beginning of the Klamath River and located upstream from Copco and Iron Gate Reservoirs). PacifiCorp's own data showed that MSAE was only detected twice (August 21, 2003 and September 10, 2002) in the Klamath River directly above Copco (river mile 206.42), but was then common in Iron Gate and Copco Reservoirs and below. Karuk Tribe/SWRCB data for 2005 showed that MSAE was never detected at the station above Copco Reservoir, but was common in Iron Gate and Copco Reservoirs and in the Klamath River at the outlet of Iron Gate Dam. Yurok/USFWS data from 2005 showed that MSAE and microcystin toxin were found in the Klamath River from Iron Gate Dam to the Klamath estuary.

The results described above from multiple datasets summarized by Kann (2006) indicate that Iron Gate and Copco Reservoirs were directly responsible for the high levels of MSAE and microcystin toxin detected in the Klamath River below Iron Gate Dam. This conclusion is consistent with literature showing that MSAE and other buoyant cyanobacteria do not dominate in conditions of turbulent mixing (e.g., Huisman et al. 2004) such as that known to occur in the Klamath River above Copco and Iron Gate Reservoirs..

Conversely, because MSAE dominates at low turbulent diffusivity (calm-stable conditions) when their flotation velocity exceeds the rate of turbulent mixing, the stable and stratified conditions created by Copco and Iron Gate Reservoirs provide ideal conditions for MSAE and other buoyant cyanobacteria. For example, Kann and Asarian (2005) show that KHP dams result in hydraulic retention times in the reservoirs ranging from ~10 days in the spring to greater than 50 days during the period of MSAE dominance, and depth profiles of temperature and dissolved oxygen indicate highly stratified water column conditions (e.g., Kann and Asarian 2007). By contrast, the river environment (absent the KHP reservoirs) in this reach would by well mixed (no stratification) and hydraulic retention would be on the order of 1 day.

Analysis of Additional Algal Groups and Depths

Further analysis of the 2005 Karuk/SWRCB data also clearly showed that Iron Gate and Copco Reservoirs hosted large blooms of blue-green algae, including toxigenic (*Microcystis aeruginosa*) and nitrogen-fixing (*Aphanizomenon flos-aquae*, *Anabaena*[1] *sp.*, and *Gloeotrichia*

[1] *Anabaena* can also be toxigenic, producing the potent neurotoxin anatoxin-a; this toxin was detected in Iron Gate Reservoir on 9-3-2005 by the California Department of Health Services (CDHS).

echinulata) species (Kann and Asarian 2007). These blue-green algae were most concentrated in reservoir sites at upper water column depths, and though concentrations generally declined with increasing depth, they were present throughout the water column and were at times the most abundant taxonomic group even at depths of up to 10 meters.

Similar to previous studies, the longitudinal trend in chlorophyll *a*, and both total biovolume and percent biovolume of the Cyanophyta (group including blue-green algae) increased substantially through the reservoirs and below at KRBI (Kann and Asarian 2007), and for the June-September period median and upper quartile biovolume values were 20x to >100x higher in Copco and Iron Gate Reservoirs than they were in the Klamath River above Copco Reservoir, and were 3-7 times higher at KRBI, below Iron Gate Dam (Kann and Asarian 2007). The trend in Cyanophyta percent composition was more pronounced through the reservoir complex than absolute biomass, with upper quartile levels in Copco and Iron Gate increasing from <5% above Copco to >80% in Copco and Iron Gate Reservoirs, and >30% at KRBI. These trends in the upper distribution indicate that periodic high values of both biovolume and percent biovolume of Cyanophyta occurred in the reservoir complex and below relative to stations directly upstream. In contrast to the reservoirs, the Klamath River station upstream from the reservoir (KRAC) was dominated by non-toxigenic diatoms for the majority of the season; while downstream below Copco Reservoir at KRAI and below Iron Gate Dam (KRBI) the Cyanophyta increased in importance on a seasonal basis, at times accounting for >50% of the composition.

Analysis of Recent Data

MSAE and microcystin data collected in 2006 and 2007 continued to show a similar trend of increasing MSAE cell density and microcystin toxin concentration in and below Copco and Iron Gate reservoirs relative to the Klamath River above the reservoirs (Kann and Corum 2007; Kann 2007). All three years (2005-2007) demonstrated widespread and high abundance of toxigenic MSAE blooms in Copco and Iron Gate reservoirs from July-October, with MSAE cell density and toxin concentrations exceeding public health thresholds by 10 to over 1000 times during these months (i.e., a 40 pound child accidentally ingesting 100 milliliters of reservoir water would have exceeded the WHO tolerable daily intake level by 10 to over 1600 times during dense bloom periods).

Although toxin production per unit cell density was highly variable both within a month and between months, the probability of exceeding critical microcystin toxin values generally increased as MSAE cell density increased (Kann and Corum 2006, Kann and Corum 2007; Kann 2007). On several occasions (particularly in 2005 and 2007) when MSAE cell counts remained elevated, corresponding microcystin concentrations tended to be lower than would have been predicted based on July-August cell density-microcystin relationships (Kann 2007). The trend of lower microcystin production was apparent during the mid-September and early-October 2007 sample periods when MSAE levels at KRBI that were more than double the SWRCB/OEHHA (2007) Harmful Algal Bloom Public Health Level were associated with microcystin values that did not exceed 1 µg/L (Kann 2007). Such changes in microcystin over the course of a season can be due to environmental factors (e.g., nutrients *cf.* Gobler et al 2007), genetic shifts in MSAE strain composition, or possible change in the microcystin congener produced that would then not be detected using standard ELISA technology. Nonetheless, the overall relationships between cell density and toxin concentration showed good correspondence between MSAE cell density and public health guideline values based on microcystins (e.g., SWRCB/OEHHA 2007; NHMRC 2005; Stone and Bress 2007). Such relationships are important to demonstrate because public health advisories in the Klamath River system are often based on cell counts in the absence of laboratory toxin measurements.

In numerous documents PacifiCorp has indicated that the cause of the toxic MSAE blooms is not due to conditions created by the Copco and Iron Gate dams but rather to the presence of such blooms upstream in UKL (e.g., PacifiCorp 2007; Application for Water Quality Certification). For example PacifiCorp states in their Application for Water Quality Certification (PacifiCorp 2007) that:

> "Cyanobacteria capable of producing toxins harmful to humans and other animals are present in UKL, the Klamath River, and a variety of other lakes in California, Oregon, and throughout the country. Their presence is a natural consequence of the environmental conditions that exist in UKL. Currently, they appear to be present at times in Copco and Iron Gate reservoirs in sufficient abundance to cause a potential health risk to humans, domestic animals, or wildlife."

However, as noted in Kann (2006) an analysis of stations near the outlet of UKL shows that there were very few instances when MSAE density exceeded 1 colony/mL, and over the 8-year period there was only 1 incidence in 77 sample collections (1.3%) during July-October when these stations exceeded 1 colony/mL. Moreover, also as noted by Kann (2006) several lines of evidence point to the role of the Copco and Iron Gate Reservoirs in providing ideal habitat conditions for MSAE. First, although MSAE clearly exists in UKL and Agency Lakes and is known to form periodic blooms in both systems[2], when data are filtered by excluding Agency Lake (which is located well north or upstream of the UKL outlet) and by evaluating only what is leaving UKL and entering the Klamath River system, occurrences were rare and density very low over an 8-year period (generally< 1 colony/mL); especially in contrast to MSAE values commonly exceeding 10,000 colonies/mL in Copco and Iron Gate Reservoirs.

Second, similar to the Karuk/SWRCB 2005 data set and the Klamath Tribes UKL data set, the PacifiCorp data set described above (in Kann 2006) showed low incidence and magnitude of MSAE leaving UKL and in the Klamath River above Copco Reservoir, yet high incidence and magnitude was observed in Copco and Irongate Reservoirs.

Third, MSAE was not detected at KRAC (above Copco reservoir) during the Karuk/SWRCB 2005 data collection effort, even when reservoir stations showed substantial concentrations of both toxin and MSAE cell density. In contrast to the Klamath River upstream, 87.5% and 89.7% of the samples were positive for MSAE in Copco and Iron Gate, respectively.
Fourthly, as indicated by cell count and toxin values at KRBI below the Iron Gate Dam and in the Yurok/USFWS data that were higher than those measured in the Klamath River upstream

[2] Although the blue-green algal species *Aphanizomenon flos-aquae* and not MSAE is the predominant bloom-former in UKL.

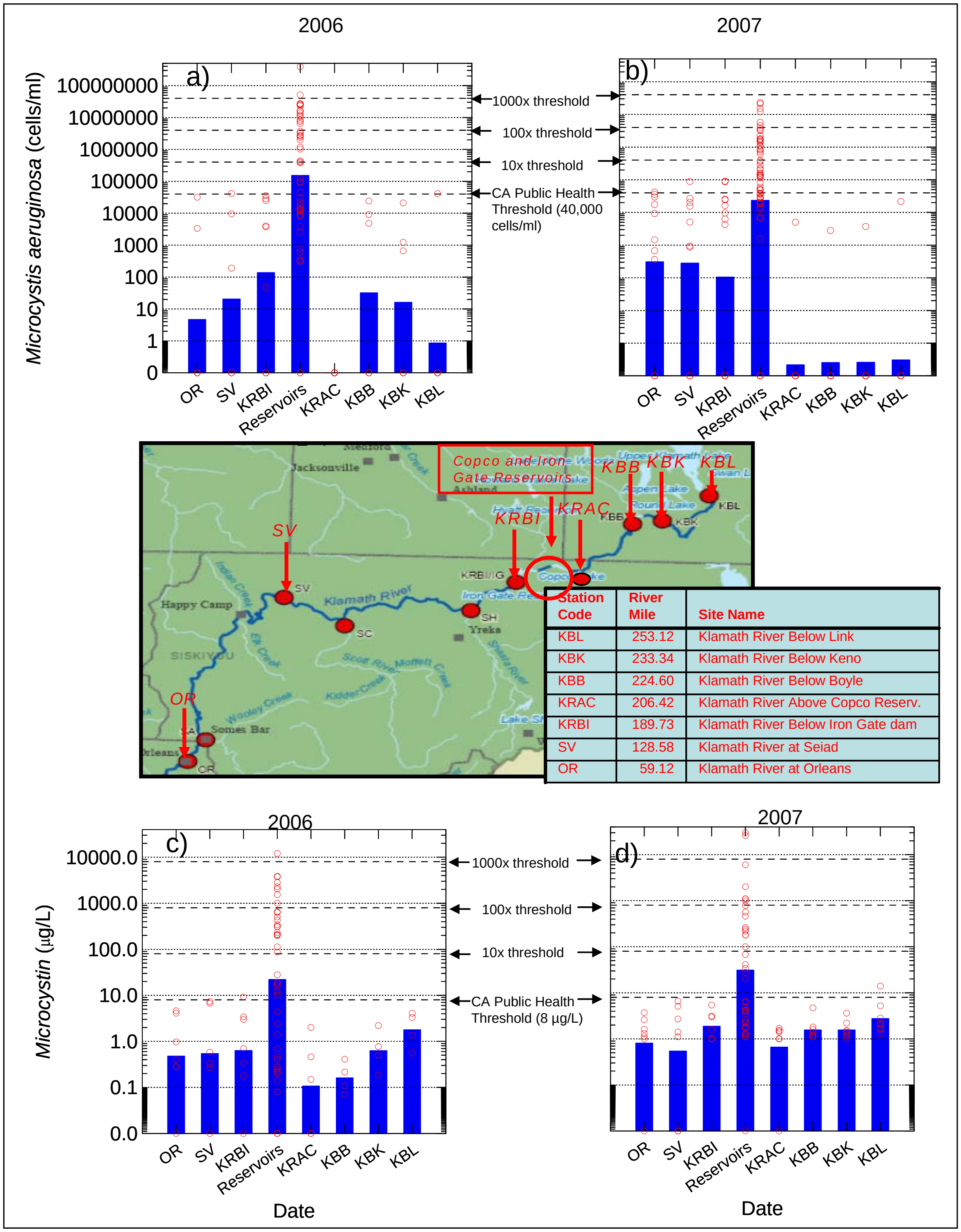
from the reservoirs, export from the reservoirs of both cells and toxin to downstream environments had clearly occurred.

Continued data collection in 2006 and 2007 confirms the dramatic increase in MSAE cell density and microcystin within and below Copco and Iron Gate relative to concentration leaving UKL. For example, when U.S. Bureau of Reclamation MSAE cell density and microcystin data collected at three stations above the Copco and Iron Gate Reservoirs (below Link River; KBL, below Keno Reservoir; KBK, and below JC Boyle Reservoir; KBB) in 2006 and 2007 are plotted with data contained in Kann and Corum (2006) and Kann (2007) the trend clearly shows that MSAE and microcystin toxin, although present in the outflow from UKL, decreased in the Klamath River between UKL (KBL) and above Copco Reservoir (KRAC), and then increased substantially within (Reservoirs) and below Copco and Iron Gate Reservoirs (KRBI, SV, and OR) relative to KRAC above Copco (Figure 1).

Although the inter-annual pattern varies as does the station pattern for KBB and KBK; values always decrease by the time the river reaches KRAC, and an evaluation over all years comparing above (KRAC) and below (KRBI) the reservoir complex clearly shows an elevated probability of both MSAE cell density and microcystin toxin concentration below the reservoirs relative to above the reservoirs (Figure 2).

This is further illustrated in aerial photographs where a dramatic contrast between inflowing Klamath River water and the vast blooms of MSAE is noted during a September 24th, 2007 fly-over (Figure 3a,b). During this same bloom MSAE cells are shown being actively transported downstream from Iron Gate Dam (Figure 3c).

Although, as noted above, the ratio of microcystin to MSAE cell density had declined during this period and thus associated toxin values were low relative to MSAE cell count (Kann 2007), during other periods of downstream transport toxin values can be elevated (e.g., see Figure 2 above where a microcystin value exceeding the 8 ug/L public health advisory level was observed). As shown below, microcystin transported downstream to the Klamath River can bioaccumulate in downstream organisms.



Station Code	River Mile	Site Name
KBL	253.12	Klamath River Below Link
KBK	233.34	Klamath River Below Keno
KBB	224.60	Klamath River Below Boyle
KRAC	206.42	Klamath River Above Copco Reserv.
KRBI	189.73	Klamath River Below Iron Gate dam
SV	128.58	Klamath River at Seiad
OR	59.12	Klamath River at Orleans

Figure 1. Longitudinal pattern in MSAE cell density (a,b) and microcystin concentration (c,d) in 2006 and 2007; KBL, KBK, and KBB data provided by USBR; data for other stations contained in Kann and Corum (2007) and Kann (2007). X-axis station orientation is upstream- right; downstream- left (following map). The blue bar indicates the station mean and red circles are individual data points (MSAE at KRAC in 2006 includes multiple zeros but appears as one value)

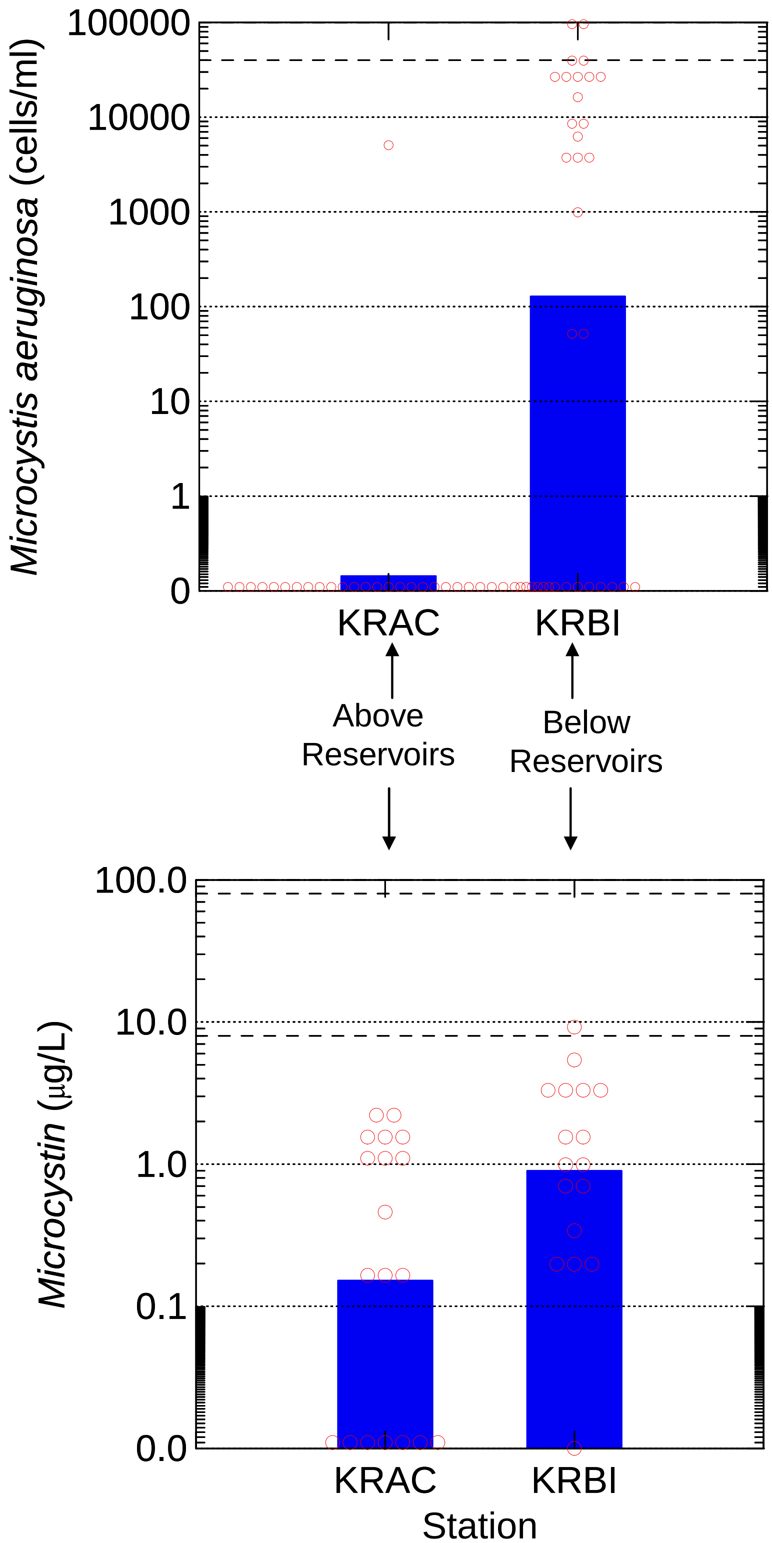


Figure 2. Comparison of 2005-2007 MSAE cell density (a) and 206-2007 microcystin concentration (b) in the Klamath River above Copco (KRAC) and in the Klamath River below Iron Gate Dam (KRBI). The blue bar indicates the station mean and red circles are individual data points grouped by intervals.

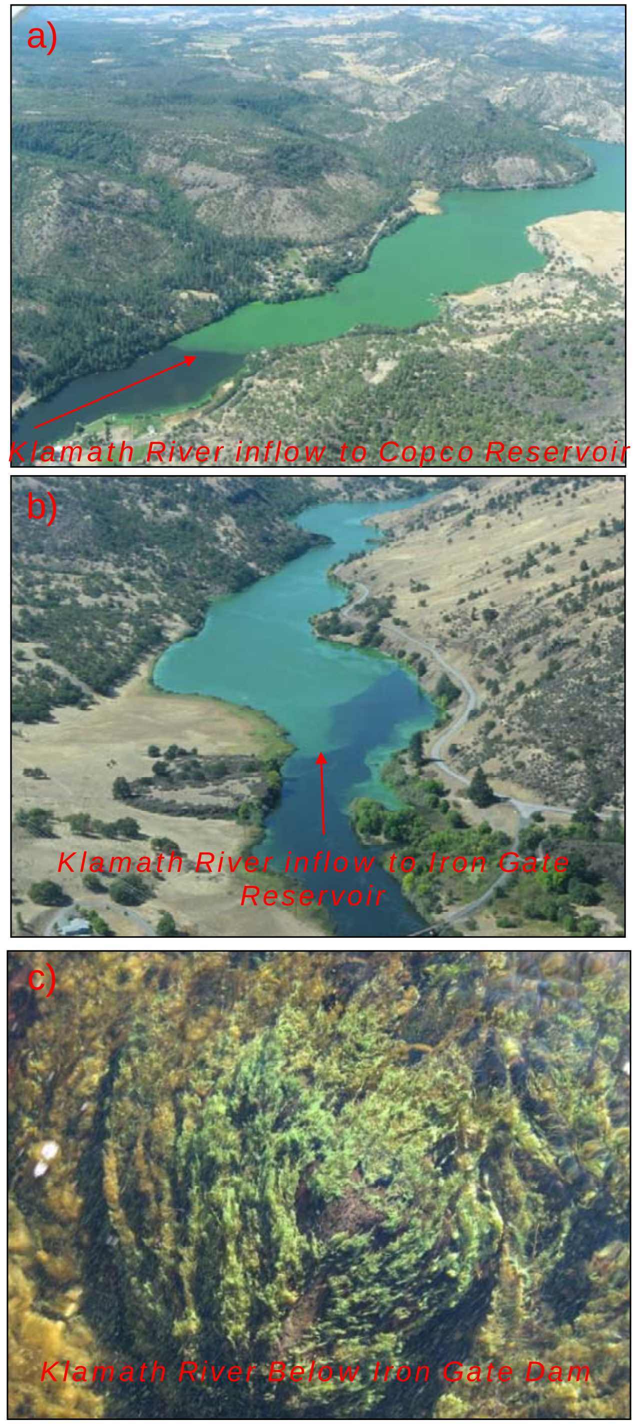


Figure 3. Areal photographs contrasting the Klamath River inflow (red arrows) to massive blooms of MSAE in Copco Reservoir (a), and Iron Gate Reservoir (b), and photo of MSAE colonies transported in the water column and collecting on other periphytic algae at KRBI below Iron Gate Dam (c), September, 24, 2007.

Thus, contrary to PacifiCorp's assertion that the presence of toxigenic MSAE is a natural consequence of the environmental conditions that exist in UKL, these data are consistent with literature showing that MSAE and other buoyant cyanobacteria do not dominate in conditions of turbulent mixing such as that known to occur in the Klamath River above Copco and Iron Gate Reservoirs. Conditions supporting MSAE growth are more likely to occur in lakes and reservoirs as velocity and turbulence are reduced, and numerous studies show MSAE to be favored in lake and reservoir environments that tend to be warmer and less turbulent than riverine ones (Reynolds 1984).

Moreover, as stated earlier, although adequate nutrients are necessary for MSAE blooms to proliferate, such concentrations alone are not sufficient to cause the types of blooms observed in Copco and Iron Gate reservoirs, otherwise the Klamath River above the reservoirs which receives the same nutrient load as the reservoirs, would also show prolific MSAE growths.

Bioaccumulation in Fish Tissue and Freshwater Mussels

As stated above, detection of microcystin toxin in steelhead livers collected from the Weitchpec area indicated that these fish were exposed to microcystin in the Lower Klamath River environment (Fetcho 2006). More recent sampling and analysis performed by the California Department of Fish and Game also shows that tissue concentration results for various microcystin congeners showed some level of bioaccumulation in the majority (85%) of samples tested in July and September of 2007 (see summary in Kann 2008). Evaluation of bioaccumulation in yellow perch fillets and freshwater mussels with respect to public health guidelines indicates that all guideline levels as defined by Ibelings and Chorus (2007) were exceeded to varying degrees in tested Klamath River organisms, including several observations of values exceeding acute thresholds.

Although risk assessment determinations such as those in Ibelings and Chorus (2007) are based largely on the microcystin-LR congener, as reviewed in Sivonen and Jones (1999), most of the known congeners are highly toxic within a comparatively narrow range. Nonetheless even when only the microcystin–LR congener is evaluated using an analysis proved by the California Office of Environmental Health Hazard Assessment (OEHHA 2008) it is clear that for several of the mussels in July that only a single 8oz meal of freshwater mussels for a child would exceed the maximum number of 8oz meals/month advocated by OEHHA (sometimes by many times, and the concentration in one of the mussels would also exceed the single meal/month limit for an adult). Moreover, the approach taken by OEHHA of calculating the number of 8 oz meals allowed per month is similar to the approach followed in Kann (2008) and is equivalent to the Seasonal TDI as defined by Ibelings and Chorus (2007). In other words, the concentration at which a single meal per month is exceeded is equivalent to the Seasonal TDI concentration as computed from Ibelings and Chorus (2007) and utilized by Kann (2008).

It should be noted that using only microcystin-LR underestimates total toxicity and public health risk because other congeners (particularly microcystin-LA) were also prevalent in many of the Klamath River samples (Kann 2008). Microcystin accumulation in livers of Iron Gate Hatchery yearling Chinook also indicates (as noted above) that the hepatotoxins created by MSAE may, through other sub-lethal effects, contribute to overall decline in fish health in the Klamath River system.

Finally, the bioaccumulation of microcystin in organisms many miles downstream from Iron Gate Dam (e.g., freshwater mussels at Big Bar are ~140 miles below the dam) illustrates the importance of the increased microcystin levels (relative to upstream) leaving the reservoir complex.

Summary

My evaluation of data related to both water quality and to toxic cyanobacterial blooms of *Microcystis aeruginosa* and associated microcystin toxin indicate that Copco and Iron Gate Dams and Reservoirs directly and negatively impact the Klamath River system with respect to human use and fishery needs. Reviewed data clearly indicate that Iron Gate and Copco Dams negatively impact downstream temperature, dissolved oxygen, pH, and ammonia conditions, and as FERC (2007) concluded these downstream conditions would be improved in the absence of the dams.

In addition, based on evaluation of numerous algal and toxin data sets from a variety of Federal, State, and Native American agencies, as well as PacifiCorp, the change from a riverine to the reservoir environments created by Copco and Iron Gate Dams clearly provides ideal growing conditions for toxigenic MSAE (that would not otherwise occur in the river reach currently occupied by the reservoirs) and subsequent transport to the Klamath River downstream. Moreover, observed levels of MSAE and microcystin toxin frequently exceed public health thresholds by 10-1000 times, and bioaccumulation of toxin in freshwater organisms indicates that consumption of such organisms would exceed established public health advisory values. Thus, clear causal links between PacifiCorp's Copco and Iron Gate projects and contribution to poor water quality and input of toxins are demonstrated.

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Wiegland, C. and S. Pflugmacher. 2005. Ecotoxicological effects of selected cyanobacterial secondary metabolites, a short review. Toxicology and Pharmacology, Vol. 203, p 201-218.

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Zambrano, F. and E. Canelo. 1995. Effects of Microcystin-LR on Partial Reactions of the NA+-K+ Pump of the Gill of Carp (Cyprinus carpio). Toxicon, Vol. 34, No. 4, pp 451-458.

APPENDIX I

CURRICULUM VITAE

JACOB KANN

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Ashland, OR 97520
(541) 482-1575 (voice)
(541) 552-1024 (fax)
Email: jacobkann@aol.com

EDUCATION

B.A., ECOLOGY	1983	**Rutgers University**, Rutgers College Department of Biological Sciences, New Brunswick, New Jersey 08901
M.S., FISHERIES RESOURCES	1987	**University of Idaho**. Department of Fish and Wildlife Resources Moscow, Idaho 83843.
Ph.D., AQUATIC ECOLOGY	1998	**University of North Carolina Curriculum in Ecology** Chapel Hill, North Carolina 27599.

AREAS of SPECIALIZATION

- Ecological research pertaining to limnological, fisheries, wetland, and watershed dynamics.
- Ecology and dynamics of toxic algal blooms.
- Integration of water quality and hydrologic factors with fisheries ecology and management.
- Lake and reservoir restoration and management
- Trophic dynamics
- Ecosystem restoration projects
- Limnological investigations with special emphasis on water quality, nutrient dynamics, and eutrophication
- Statistical analysis and modeling.

CURRENT POSITION

CONSULTING AQUATIC ECOLOGIST 295 E. Main St, Ste 7, Ashland, Oregon, 97520.
AQUATIC ECOSYSTEM SCIENCES LLC. Principal in firm conducting research and providing expertise in aquatic ecology, fisheries, and water quality. Length in position: 11 years (1997 to present)
Environmental Sciences Graduate Program Faculty, Oregon State University, Corvallis, Oregon, 97331.

Recent and Current Clients:
- City of Ashland, OR – Water quality and toxic algae assessment of city water supply reservoir (Reeder Reservoir)
- R2 Resource Consultants/BIA – Upper Klamath Lake Water Quality Analyses
- City of Portland Parks and Recreation – Assessment and Management of Laurelhurst Pond for *Microcystis*

- Karuk Tribe – Nutrient Loading/Toxic Cyanobacteria in Klamath River Reservoirs
- Yurok Tribe – Nutrient and Algal Dynamics in the Klamath River System
- Kier Associates/Karuk tribe – Nutrient Budget for Copco and Irongate Reservoirs
- City of Lakeside Oregon and Tenmile Lakes Basin Partnership – Toxic Algal Blooms in Tenmile Lakes, OR
- Klamath Tribes Natural Resources – Nutrient Loading and Water Quality Research in Streams and Lakes of the Klamath Basin; limnological analysis of Upper Klamath lake data.
- Willamette NF/Eugene Water Board/ PGE – Toxic Cyanobacteria Workshop
- Oregon Human Services – Review Toxic Algal Monitoring and Threshold Guidelines
- Josephine County Parks Dept. – Toxic algal blooms in Lake Selmac
- US Forest Service Umpqua NF – Assessment of Diamond Lake, Oregon Toxic Algal Blooms
- US Environmental Protection Agency – Klamath and Lost River TMDL Planning
- Kier Associates/Klamath Basin Tribal Water Quality Work Group- Klamath River, CA water quality assessment.
- Oregon Dept. of Environmental Quality/JC Headwaters – Diamond Lake TMDL analysis and modeling.
- Betts, Patterson and Mines/City of Lakewood – Limnological Data Assessment, Steilacoom Lake, Washington
- Klamath Basin Rangeland Trust – Water Quality and Fisheries Monitoring in the Wood River Valley Oregon.
- Oregon Department of Fish and Wildlife – Assessment of Diamond Lake Restoration Options
- US Fish and Wildlife Service/Graham Matthews and Associates – Water Quality in Stream Restoration Projects Tributary to Klamath Lake.
- Jim Root Crooked Creek Ranch – Aquatic Habitat Restoration and Monitoring.
- Native American Rights Fund (NARF) – TMDL and Oregon SB1010 Non Point Pollution Research and Modeling in the Klamath Basin.
- US Bureau of Reclamation/JC Headwaters – Upper Klamath Lake Paleolimnological Study and Reservoir Water Quality Modeling Review.
- US Geological Survey Biological Resources Division – Fish Kill Water Quality Study on Upper Klamath Lake.
- The Nature Conservancy – Monitoring and Inventory at the Sycan Marsh Preserve – Klamath Basin.

OTHER COMMITTEE and PROJECT INVOLVEMENT

- Scientific Review Committee for State of Oregon DEQ TMDL on Upper Klamath Lake.
- Technical Advisory Committees for State of Oregon DEQ TMDL and Oregon Dept. of Ag. 1010 Non-point Agricultural Pollution Program
- Technical Advisor for State of Oregon Health Division on toxic algal blooms in Oregon Lakes.
- Wood River Wetland and Channel Restoration Team.
- Williamson River and Wetland Restoration Technical Committee.
- Endangered Lost River and Shortnose Sucker Recovery Team.
- Colleague (peer) reviewer for U.S. Geological Survey Portland Water Resources Division technical reports.
- Klamath River Basin Fisheries Task Force Upper Basin Amendment Technical Team.

ACADEMIC ACTIVITIES

- Environmental Sciences Graduate Program Faculty, Oregon State University.
- Oregon State University Graduate Committee for M.S. Thesis: Nutrient export from irrigated cattle pasture in the Wood River Valley, Oregon.
- Humboldt State University graduate committee of Margaret Forbes, M.S. Thesis: Horizontal Zonation of periphyton in Hanks Marsh, Upper Klamath Lake, Oregon. , 1997.
- Lecturer in the Environmental Sciences Program at the Oregon Institute of Technology and Southern Oregon University.
- Lecturer for a graduate level course in Aquatic Ecology at the University of North Carolina, Chapel Hill.
- Organized and taught laboratory classes in biological and physical/chemical Limnology (aquatic ecology) the University of Idaho.
- Lecturer for a general biology laboratory classes at the University of North Carolina, Chapel Hill.
- Presented aquatic workshops for Dakubetede Environmental Education Program, Headwaters Environmental Center, Orion Society Forgotten Language Tour, and Oregon Trout's Salmon Watch Program.

- Affiliate Faculty Dakubetede Environmental Education Program/Antioch and Prescott College

PROFESSIONAL AFFILIATIONS

- *North American Lake Management Society*.
- *Oregon Lakes Association – Board of Directors 1998-2001*
- *American Fisheries Society.*
- *Pacific Fishery Biologists*
- *Ecological Society of America – Aquatic Ecology Section*

AWARDS

- Awarded the U.S. Fish and Wildlife Service ***Distinguished Service Award*** from the Seattle National Fisheries Research Center in 1988.
- One of three lead biologists awarded the 1996 ***Conservation Achievement Award*** from the Western Division of the American Fisheries Society for research and recovery efforts on the endangered Lost River and shortnose suckers and their habitats.

POSITIONS PREVIOSLY HELD

AQUATIC ECOLOGIST Klamath Tribe Natural Resources, P.O. Box 436, Chiloquin, Oregon, 97624.
Responsible for coordinating and performing research on phytoplankton bloom dynamics and eutrophication trends in lakes and tributaries; including fisheries, watershed, wetland, and tributary linkages/ecology and restoration. Also responsible for wetland, water quality and endangered fish species management. Supervised 1-6 employees. February 1988 to November 1997. (Doctoral research was completed during this tenure).

FISHERY BIOLOGIST U.S. Fish and Wildlife Service, National Fishery Research Center, Seattle, WA 98115.
Performed and coordinated limnological and fisheries research for an inter-agency endangered fish recovery program on Upper Klamath Lake and its watershed. Responsible for monitoring development of massive algal blooms and associated limnological conditions as they relate to fish distribution and habitat. April 1987 to February 1988.

RESEARCH ASSOCIATE Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho 83843.
Responsible for procurement of continued funding and research leader for ongoing studies on blue-green algal toxicity. Initiated funding, designed, and conducted research on the use of *in situ* substrate to study periphyton growth as an early indicator of increasing eutrophication rates in Lake Pend Oreille, Idaho. May 1986 to April 1987.

RESEARCH/TEACHING ASSISTANT Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho 83843.
Designed and conducted research on blue-green algal toxicity in lakes of northern Idaho. Supervised five employees in limnology laboratory. Assisted in Payette Lake eutrophication-sewer study, Twin Lakes eutrophication study, Bear Lake Marsh nutrient processing study. Taught and organized laboratory classes in biological and physical-chemical limnology. January 1984 to May 1986.

REFERREED ARTICLES

Eilers , J.M., D. Loomis, A. St. Amand, A. Vogel, L. Jackson, **J. Kann**, B. Eilers, H. Truemper, J. Cornett, & R. Sweets. 2007. Biological effects of repeated fish introductions in a formerly fishless lake: Diamond Lake, Oregon, USA. ***Fundamental and Applied Limnology. 169:265-277***

Jacoby, J.M., and **J. Kann. 2007.** The occurrence and response to toxic cyanobacteria in the Pacific Northwest, North America. ***Lake Reserv. Manage. 23:123-143***

Jones, M., J. Eilers, and **J. Kann.** 2007. Water quality effects of blue-green algal blooms in Diamond Lake, Oregon.

Pages 102-110 in M. Furniss, C. Clifton, and K. Ronnenberg, eds: Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference, San Diego, CA. PNW-GTR_689, Portland, OR. http://www.fs.fed.us/pnw/publications/gtr689/volume1.pdf

Kann, J. and E. B. Welch. 2005. Wind control on water quality in shallow, hypereutrophic Upper Klamath Lake, Oregon. ***Lake Reserv. Manage. 21(2):149-158***

Eilers J. , J. **Kann**, J. Cornett, K. Moser, A. St. Amand. 2004. Paleolimnological evidence of change in a shallow, hypereutrophic lake: Upper Klamath Lake, Oregon. ***Hydrobiologia 520: 7-18.***

Terwilliger, M.R., D.F. Markle , and J. **Kann**,. 2003. Associations between water quality an daily growth of juvenile shortnose and Lost River suckers in Upper Klamath Lake, Oregon. ***Trans. Am. Fish.Soc****. 132:691-708*

Kann, J., and V. H. Smith. 1999. Chlorophyll as a predictor of elevated pH in a hypereutrophic lake: estimating the probability of exceeding critical values for fish success using parametric and nonparametric models. ***Can. J. Fish Aquat. Sci*** 56: 2262-2270

Barbiero, R. P., and **J. Kann**. 1994. The importance of benthic recruitment to the population of *Aphanizomenon flos-aquae* and internal loading in a shallow lake. ***J. Plankton Res***. 16(11): 1581-1588.

Kann, J. and C. M. Falter. 1989. Periphyton as indicators of enrichment in Lake Pend Oreille, Idaho. ***Lake Reserv. Manage***. 5(2): 39-48.

Kann, J. and C. M. Falter. 1987. Development of toxic blue-green algal blooms in Black Lake, Kootenai County, Idaho. ***Lake Reserv. Manage***. 3:99-108.

REPORTS

Kann, J. and J. Eilers. 2008. Reeder Reservoir (Ashland Oregon) Water Quality and Sediment Assessment, 2007. Technical Memorandum to City of Ashland, Oregon, 45pp.

Kann, J. 2008. Microcystin Bioaccumulation in Klamath River Fish and Freshwater Mussel Tissue: Preliminary 2007 Results. Technical Memorandum Prepared for the Karuk Tribe Department of Natural Resources. April 2008.

Kann, J., and E. Asarian. 2007. Nutrient Budgets and Phytoplankton Trends in Iron Gate and Copco Reservoirs, California, May 2005 – May 2006. Final Technical Report to the State Water Resources Control Board, Sacramento, California. 81pp + appendices.

Kann, J. , and S. Corum 2007. Summary of 2006 Toxic Microcystis aeruginosa Trends in Copco and Iron Gate Reservoirs on the Klamath River, CA. Technical Memorandum Prepared for the Karuk Tribe Department of Natural Resources. June 2007.

Kann, J. and E. Asarian. 2006. Longitudinal analysis of Klamath River phytoplankton data, 2001-2004. Final Technical Report to the Yurok Tribe Environmental Program, Klamath, California.

Kann, J. and J. Eilers. 2006. Evaluation of management options for controlling toxic cyanobacteria in Laurelhurst pond, Portland, Oregon. Technical Memorandum to Portland Parks and Recreation, Portland Oregon. 13pp.

Asarian, E. and **J. Kann**. 2006. Klamath River Nitrogen Loading and Retention Dynamics, 1996-2004. Kier Associates Final Technical Report to the Yurok Tribe Environmental Program, Klamath, California. 56pp + appendices.

Kann, J. , and S. Corum 2006. Summary of 2005 Toxic Microcystis aeruginosa Trends in Copco and Iron Gate Reservoirs on the Klamath River, CA. Technical Memorandum Prepared for the Karuk Tribe Department of Natural Resources. March 2006.

Kann, J. 2006. Microcystis aeruginosa Occurrence in the Klamath River System of Southern Oregon and Northern California. Technical Memorandum Prepared for the Yurok Tribe Environmental and Fisheries Programs. February 2006.

Kann, J., and E. Asarian. 2005. 2002 Nutrient and Hydrologic Loading to Iron Gate and Copco Reservoirs, California. Kier Associates Final Technical Report to the Karuk Tribe Department of Natural Resources, Orleans CA, 95556. 61pp + appendices.

Kann, J., 2005. Review of Diamond Lake Toxic Algal Monitoring Program, 2001-2004. Summary report prepared for USFS Umpqua National Forest, 2900 NW Stewart Parkway, Roseburg, OR 97470.

Kann, J., 2005. Lake Selmac Toxic Algal Sampling. Summary report prepared for Josephine County Parks Department, 125 Ringuettte St., Grants Pass, Oregon, 97527.

Kann, J., C. Pryor, and G. Matthews. 2004. Water Quality Baseline Surveys In the Wood River Valley, Oregon. Vol. 5 *In:* Klamath Basin Rangeland Trust 2003 Pilot Project Monitoring Report. Klamath Basin Rangeland Trust, P.O. Box 4310, Medford, Oregon 97501.

Kann, J., and G. Reedy. 2004. Fish and Habitat Surveys In the Wood River Valley, Oregon. Vol. 6 *In:* Klamath Basin Rangeland Trust 2003 Pilot Project Monitoring Report. Klamath Basin Rangeland Trust, P.O. Box 4310, Medford, Oregon 97501.

Kann, J., C. Pryor, and G. Matthews. 2003. Water Quality Monitoring In the Wood River Valley, Oregon. *In:* Klamath Basin Rangeland Trust 2002 Pilot Project Monitoring Report. Klamath Basin Rangeland Trust, P.O. Box 4310, Medford, Oregon 97501.

Kann, J., G. Reedy, and J. Kiernan. 2003. Biological Monitoring In the Wood River Valley, Oregon. *In:* Klamath Basin Rangeland Trust 2002 Pilot Project Monitoring Report. Klamath Basin Rangeland Trust, P.O. Box 4310, Medford, Oregon 97501.

Eilers J., K. Vaché and **J. Kann. 2002.** Tenmile Lake Nutrient Study: Phase II Report. Report Submitted to Tenmile Lakes Basin Partnership – Supported by Oregon Department of Environmental Quality and City of Lakeside, Oregon**.**

Eilers J. and J. **Kann**. 2002. Diamond lake Database and Toxic Bloom Analysis, 2001. Final Report Submitted to U.S Forest Service, Umpqua National Forest, Roseburg, OR.

Eilers J. , J. **Kann**, J. Cornett, K. Moser, A. St. Amand, C. Gubala. 2004. Recent Paleolimnology of Upper Klamath Lake, Oregon. Final Report Submitted to U.S. Bureau of Reclamation, Klamath Falls Project Office, Klamath Falls, OR, 97603 Contract 9-FG-20-17730.

Kann, J., D. Perkins, and G.G. Scoppettone. 2000. The role of poor water quality and fish kills in the decline of endangered Lost River and shortnose suckers in Upper Klamath Lake. U.S. Geological Survey, Biological Resources Division Final Report Submitted to U.S. Bureau of Reclamation, Klamath Falls Project Office, Klamath Falls, OR, 97603 -- Contract 4-AA-29-12160. (in revision: ***Environmental Biology of Fishes***)

Kann, J. 1999. 1998 Monitoring Program for toxic *Microcystis* blooms in Tenmile Lakes, Oregon. Prepared for City of Lakeside, Lakeside, OR

Kann, J., and W. W. Walker. 1999. Nutrient and Hydrologic Loading to Upper Klamath Lake, Oregon, 1991-1998. Klamath Tribes Natural Resources Department-U.S. Bureau of reclamation Cooperative Studies. U.S. Bureau of Reclamation Klamath Falls Project Office, Klamath Falls, OR 97603. 106p.

Kann, J., and D. Gilroy. 1998. Ten Mile Lakes toxic *Microcystis* bloom, September-November 1997. Oregon Health Division Technical Report. Environmental Services and Consultation Center for Environment and Health Systems, OHD, 800 NE Oregon St., Ste. 608, Portland, OR 97232.

Kann, J. 1997. Ecology and water quality dynamics of a shallow hypereutrophic lake dominated by cyanobacteria (blue-

green algae). Chapter 1: *Chlorophyll as a predictor of elevated pH in a hypereutrophic lake: estimating the probability of exceeding critical values for fish success using parametric and nonparametric models*. Chapter 2: *Effects of nutrients, consumers, and physical factors on phytoplankton succession and dominance in a shallow hypereutrophic lake*. Ph.D. Dissertation, University of North Carolina, Chapel Hill, 1997.

Kann, J. 1997. Effect of Lake Level Management on Water Quality and Native Fish Species in Upper Klamath Lake, Oregon. Draft Klamath Tribes Research Report. 19 pp.

Campbell, S. G., W. J. Ehinger, and J. **Kann**. 1993. Wood River Hydrology and Water Quality Study. In: C. Campbell (ed.). *Environmental Research in the Klamath Basin, Oregon - 1992 Annual Report.* Bureau of Reclamation Technical Report R-93-16. pp. 9-92.

Kann, J. 1993. Limnological Trends in Agency Lake, Oregon - 1992. In: C. Campbell (ed.). *Environmental Research in the Klamath Basin, Oregon - 1992 Annual Report.* Bureau of Reclamation Technical Report R-93-16. pp. 91-134.

Kann, J. 1993. Agency Lake Limnology, 1990-91. In: C. Campbell (ed.). *Environmental Research in the Klamath Basin, Oregon - 1991 Annual Report.* Bureau of Reclamation Technical Report R-93-13. pp. 103-110.

Coleman, M., J. **Kann**, and G. Scoppettone. 1988. Life History and Ecological Investigations of Catostomids from the Upper Klamath Basin Oregon. U.S. Fish and Wildlife Service Annual Report. National Fisheries Research Center, Seattle WA. 113pp.

Kann, J. and C. M. Falter. 1985. Blue-green algae toxicity in Black Lake, Kootenai County, Idaho. Idaho Water Resources Research Institute. Research Technical Completion Report G903-02. NTIS PB86 157385/AS.

PRESENTED PAPERS

Kann, J**.** , and S. Corum 2006. Toxic *Microcystis aeruginosa* and microcystin trends in Copco and Iron Gate Reservoirs on the Klamath River, CA. Pacific Northwest Regional Meeting of North American Lake Management Society, Portland, Oregon. September, 2006.

Jacoby, J, and **J. Kann**. 2005. The Occurrence and Management of Toxic Cyanobacteria in the Pacific Northwest, North America. North American Lake Management Society Annual Meeting, Madison Wisconsin. November 2005.

Ciotti, D., and **J. Kann**. 2005. Water quality of runoff from flood irrigated pasture in the Klamath Basin, Oregon. Oregon American Fisheries Society Annual Meeting, Corvallis, Oregon. February, 2005.

Kann, J. 2004. Toxic algal blooms in Lake Selmac, Oregon. Oregon Lakes Association Annual Meeting, Bend, Oregon. September, 2004.

Kann, J. 2004. External loading and sources of phosphorus and nitrogen in Upper Klamath Lake. Upper Klamath Basin Science Workshop, Klamath Falls, Oregon. February 3-6, 2004.

Kann, J. 2004. Internal loading and sources of phosphorus and nitrogen in Upper Klamath Lake. Upper Klamath Basin Science Workshop, Klamath Falls, Oregon. February 3-6, 2004.

Kann, J. 2003. Toxic algal screening program for Tenmile Lakes, Oregon. Paper presented at 2003 Oregon Lakes Association Annual Meeting, October 10, 2003. Lakeside, Oregon. (Invited)

Eilers J. , K. Vache, **J. Kann**, J. Cornett, K. Moser, and A. St. Amand. 2003. Tenmile Lake Phase II Nutrient Study. Paper presented at 2003 Oregon Lakes Association Annual Meeting, October 10, 2003. Lakeside, Oregon.

Terwilliger, M. R., P. A. Murtaugh, **J. Kann**, and D. F. Markle. 2001. Modeling associations between water quality and daily growth of juvenile Lost River and shortnose suckers in Upper Klamath Lake, Oregon. Paper presented at 2003 Oregon American Fisheries Society Annual Meeting, Eugene, Oregon (Feb 26-28, 2003).

Kann, J. 2002. Updated AFS talk: The role of blue-green algal blooms, climate, and lake level in fish kill and water quality dynamics in Upper Klamath Lake. Paper presented at 2002 International Conference American Institute of Hydrology: Hydrologic Extremes: Challenges for Science and Management. October 13-17 2002. Portland, Oregon. (Invited)

Kann, J. 2002. The role of blue-green algal blooms, climate, and lake level in fish kill and water quality dynamics in Upper Klamath Lake. Paper presented at Oregon Chapter American Fisheries Society Meeting, Sun river, Oregon, February 27-March 1 2002. Bend, Oregon. (Invited)

Kann, J. and M. Jones. 2001. Toxic *Anabaena* bloom in Diamond Lake, 2001. Paper presented to the Oregon Lakes Association Annual Meeting, Portland Oregon. September 2001.

Terwilliger, M. R., P. A. Murtaugh, **J. Kann**, and D. F. Markle. 2001. Associations between water quality and daily growth of juvenile shortnose suckers (*Chasmistes brevirostris*) and Lost River suckers (*Deltistes luxatus*) in Upper Klamath Lake, Oregon. Paper presented at 2001 Joint Annual Meeting of ASIH and AES in State College, Pennsylvania (July 5-10, 2001).

Eilers J., **J. Kann**, J. Cornett, K. Moser, A. St. Amand, C. Gubala. 2001. Recent Paleolimnology of Upper Klamath Lake, Oregon. Paper presented at Klamath Basin Fish and Water Management Symposium, Arcata, CA, May 2001.

Eilers, J, **J. Kann**, and C. Gubala. 2000. Recent history of Upper Klamath Lake as viewed from the mud. Paper presented at Oregon Lakes Association Annual Meeting, Oregon Institute of Technology, Klamath Falls, OR October 6-7, 2000.

Kann, J. 2000. The role of blue-green algal dynamics, water quality, and mixing in recurrent fish kills in a shallow lake. Paper presented at WALPA 13th Annual Conference on Lakes, Reservoirs and Watersheds. SeaTac, WA. April 13-15, 2000. (update of below paper)

Kann, J. 1999. The role of wind-driven mixing in determining water quality dynamics in a shallow, hypereutrophic lake. Paper presented at *North American Lake Management Society 19th International Symposium on Lake and Reservoir Management*, Reno, NV. December, 2000.

Kann, J. 1999. Limnological trends associated with fish kills in Upper Klamath Lake, Oregon. *The 3rd Klamath Basin Watershed Restoration and Research Conference.* Oregon Institute of Technology, Klamath Falls, Oregon. March 9-11, 1999

Kann, J. 1998. Toxic Algae in Oregon Lakes: Tenmile Lakes Case Study. *Oregon Lakes Association: Problems and Opportunities in Southern Oregon Lakes.* Diamond Lake, Oregon. October 23-24, 1998

Perkins, D. L., **J. Kann**, and G. Scoppettone. 1998. The role of poor water quality and repeated fish kills in the decline of endangered Lost River and shortnose suckers in Upper Klamath Lake. Presented by J. Kann at *Pacific Fishery Biologists 60th Meeting*, Kelseyville, CA. October 15-17, 1998.

Kann, J. 1998. Invited Speaker for the *Oregon State University Hydrology Seminar Series: Multi-Objective Water Resources Planning in Crisis- Case Study of the Klamath River Watershed.* Corvallis, Oregon, April 29th, 1998

Kann, J. 1995. Effect of lake level management on water quality and native fish species in Upper Klamath Lake, Oregon. Paper presented at the *First Klamath Basin Ecosystem Research and Restoration Coordination Meeting*, Oregon Institute of Technology. May 15, 1995. An updated version was also presented at the *27th Annual Meeting of the Desert Fishes Council*, Reno, Nevada, November 16-19, 1995.

Kann, J. 1995. Effect of lake level management and watershed dysfunction on water quality and native fishes in Upper Klamath Lake, Oregon. Paper presented at the *American Institute of Hydrology Symposium: Stresses Placed on Water resources and Aquatic Biota by Managing Natural Resources*. Ashland, Oregon October 16-17, 1995. (Invited)

Kann, J. 1994. Watershed dysfunction, lake ecology, and incorporation of non-fish aquatic constituents into watershed studies. *Technical Workshop provided for the Watershed Management Council Fifth Biennial Conference: Watersheds >94 - Respect, Rethink, Restore.* Ashland, Oregon. November 16-18, 1994. (Invited)

Kann, J. 1994. Phytoplankton/nutrient dynamics and internal loading in a shallow hypereutrophic lake dominated by the blue-green alga *Aphanizomenon flos-aquae.* Paper presented at *North American Lake Management Society 14th International Symposium on Lake and Reservoir Management*, Orlando, FL. October 31-November 5, 1994.

Beaver, J, R., and **J. Kann**. 1994. Zooplankton dynamics relative to water quality in Upper Klamath Lake, Oregon (1987-1993). Poster presented at *North American Lake Management Society 14th International Symposium on Lake and Reservoir Management, Orlando*, FL. October 31-November 5, 1994.

Beaver, J, R., and **J. Kann**. 1994. Relationship between *Daphnia* and *Aphanizomenon* in Upper Klamath Lake, Oregon. Poster presented at *American Society of Limnology and Oceanography 1994 Meeting*, Miami, FL. June 12-16, 1994.

Kann, J. 1994. Watershed initiatives and sustainability in the Klamath Basin Ecosystem. Paper presented to *The Presidents Council on Sustainable Development, Western Regional Team on Natural Resources Management and Protection*. South Shore Lake Tahoe, NV. October 4-6, 1994. (Invited)

Kann, J. 1994. Watershed dysfunction, the ecology of Upper Klamath Lake, and downstream linkages. Paper presented to the *Governors Watershed Enhancement Board: "Who Will Catch the Rain?" Conference*. Ashland, OR. January 27-28, 1994. (Invited)

1993. Member of a scientific panel on blue-green algal ecology and management. *North American Lake Management Society 13th International Symposium on Lake and Reservoir Management, Seattle WA.* November 30-December 4, 1993. (Invited)

Kann, J. 1993. Water quality and habitat enhancement*. Presented at Governors Watershed Enhancement Board Workshop: Watershed Improvement – Let's Get To It!* Oregon Institute of Technology. June 16, 1993. (Invited)

Kann, J. 1992. The current condition of the Klamath watershed: what is the extent of the alteration of hydrology, habitat and fish and wildlife populations? What can be done to restore the river and its tributaries? Paper presented at the above Session at the *Klamath Watershed Forum: A Conference on the Future of the Klamath River*. Pacific Rivers Council. Oregon Institute of Technology. May 16, 1992. (Invited)

Kann, J. and V.H. Smith. 1991. Chlorophyll as a predictor of elevated pH in a hypereutrophic lake: estimating the probability of exceeding critical values for fish success. Paper presented at *North American Lake Management Society 11th International Symposium on Lake and Reservoir Management*, Denver, CO November 10-13, 1991.

Kann, J. 1989. Cultural eutrophication trends and effects on native fishes of Upper Klamath Lake, Oregon. Paper presented *at Pacific Northwest Regional Workshop on Lake and Reservoir Management,* September 15-16, 1989. Seattle, WA.

Kann, J. and C. M. Falter. 1989. Periphyton as indicators of enrichment in Lake Pend Oreille, Idaho. Paper presented at *North American Lake Management Society 8th International Symposium on Lake and Reservoir Management*, St Louis, MO. November 16-18, 1988.

Kann, J. 1988. Upper Klamath Lake, Oregon: hypereutrophy and endangered species. Paper presented at *North American Lake Management Society 8th International Symposium on Lake and Reservoir Management*, St Louis, MO. November 16-18, 1988.

Kann, J. and C. M. Falter. 1986. Controlling factors of a toxic blue-green algae bloom in Black Lake, northern Idaho. Paper presented at the *Idaho American Fisheries Society Annual Chapter Meeting*, Boise, Idaho. March 1986.

PROFESSIONAL COURSES

- Introduction to Geographic Information Systems for Water Resources Applications. American Water Resources Association, Reno, NV. November, 1992
- Mathematical Modeling of Lakes and Reservoirs. Duke University short course, November 7-11, 1988.
- Physical Habitat Simulation Modeling - IFG 310. USFWS Instream Flow Group, Ft. Collins, CO. November 1989.

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*Certified PADI SCUBA diver.

ATTACHMENT 3

Hamilton et al. (April 2005), "Distribution of Anadromous Fishes in the Upper Klamath River Watershed Prior to Hydropower Dams – A Synthesis of the Historical Evidence," *Fisheries* 30(4), pp.10-20

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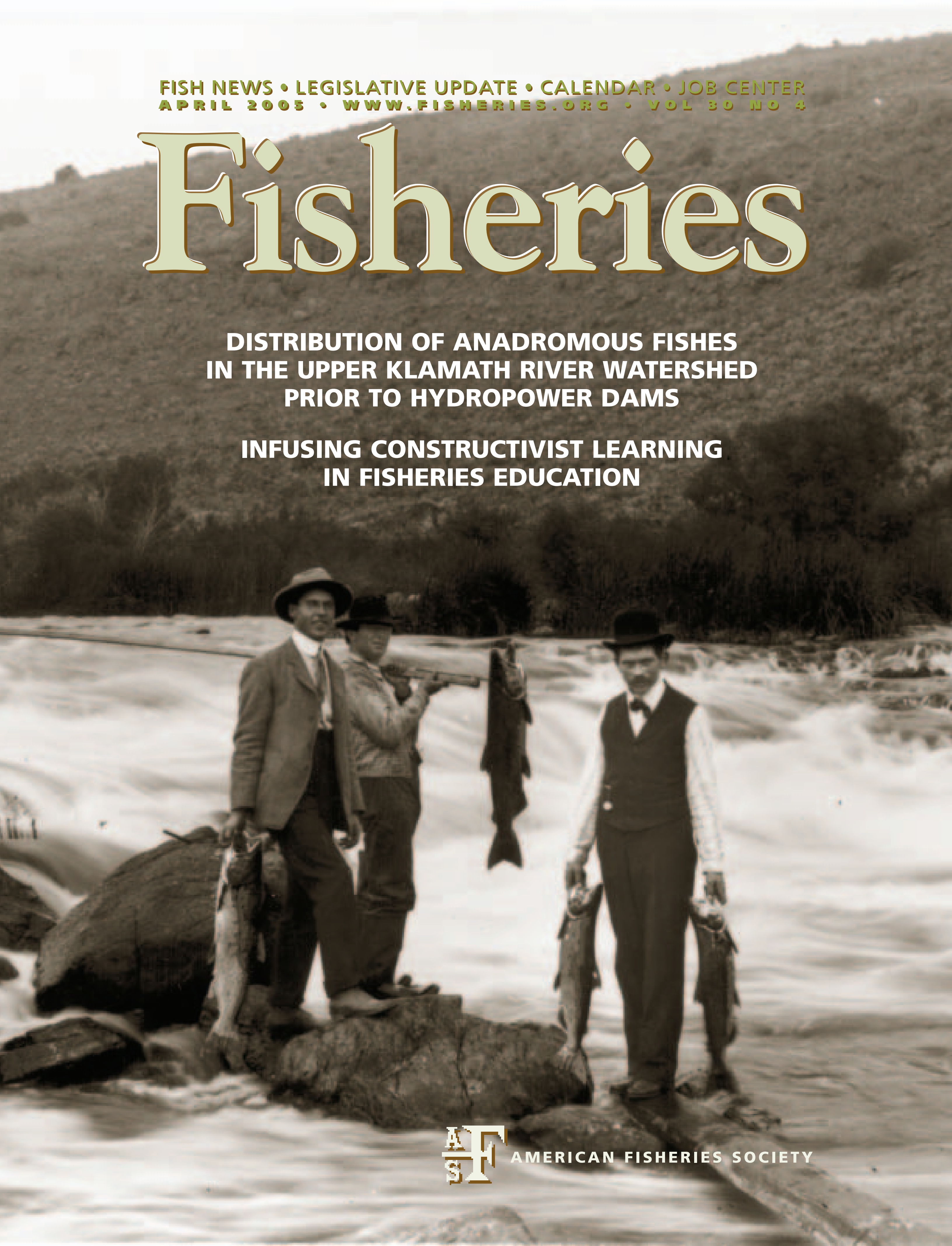
Fisheries

DISTRIBUTION OF ANADROMOUS FISHES IN THE UPPER KLAMATH RIVER WATERSHED PRIOR TO HYDROPOWER DAMS

INFUSING CONSTRUCTIVIST LEARNING IN FISHERIES EDUCATION



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feature

Distribution of Anadromous Fishes in the Upper Klamath River Watershed Prior to Hydropower Dams—A Synthesis of the Historical Evidence

ABSTRACT

Knowledge of the historical distribution of anadromous fish is important to guide management decisions regarding the Klamath River including ongoing restoration and regional recovery of coho salmon (*Oncorhynchus kisutch*). Using various sources, we determined the historical distribution of anadromous fish above Iron Gate Dam. Evidence for the largest, most utilized species, Chinook salmon (*Oncorhynchus tshawytscha*), was available from multiple sources and clearly showed that this species historically migrated upstream into tributaries of Upper Klamath Lake. Available information indicates that the distribution of steelhead (*Oncorhynchus mykiss*) extended to the Klamath Upper Basin as well. Coho salmon and anadromous lamprey (*Lampetra tridentata*) likely were distributed upstream at least to the vicinity of Spencer Creek. A population of anadromous sockeye salmon (*Oncorhynchus nerka*) may have occurred historically above Iron Gate Dam. Green sturgeon (*Acipenser medirostris*), chum salmon (*Oncorhynchus keta*), pink salmon (*Oncorhynchus gorbuscha*), coastal cutthroat trout (*Oncorhynchus clarki clarki*), and eulachon (*Thaleichthys pacificus*) were restricted to the Klamath River well below Iron Gate Dam. This synthesis of available sources regarding the historical extent of these species' upstream distribution provides key information necessary to guide management and habitat restoration efforts.

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Introduction

Gatschet's statement is that salmon ascend the Klamath river twice a year, in June and again in autumn. This is in agreement with my information, that the run comes in the middlefinger month [sic], May–June, and that the large fish run in the fall…They ascend all the rivers leading from Klamath lake (save the Wood river, according to Ball), going as far up the Sprague river as Yainax, but are stopped by the falls below the outlet to Klamath marsh.

—Spier (1930)

Parties coming in from Keno state that the run of salmon in the Klamath River this year is the heaviest it has [sic] ever known. There are millions of the fish below the falls near Keno, and it is said that a man with a gaff could easily land a hundred of the salmon in an hour, in fact they could be caught as fast as a man could pull them in…There is a natural rock dam across the river below Keno, which it [sic] is almost impossible for the fish to get over. In their effort to do so thousands of fine salmon are so bruised and spotted by the rocks that they become worthless. There is no spawning ground until they reach the Upper Lake as the river at this point is very swift and rocky.

—Front page article titled:
"Millions of Salmon—Cannot Reach Lake on Account Rocks (sic) in River at Keno"
Klamath Falls Evening Herald (24 September 1908)

The Klamath River watershed once produced large runs of Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) and also supported significant runs of other anadromous fish, including coho salmon (*Oncorhynchus kisutch*), green sturgeon (*Acipenser medirostris*), eulachon (*Thaleichthys pacificus*), coastal cutthroat trout (*Oncorhynchus clarki clarki*), and Pacific lamprey (*Lampetra tridentata*). One estimate (Radtke, pers. comm. cited in Gresh et al. 2000) put the historical range of salmon abundance for the Klamath-Trinity River system at 650,000–1 million fish. These runs contributed to substantial commercial, recreational, subsistence, and Tribal harvests (Snyder 1931; Lane and Lane Associates 1981; USDI 1985; USFWS 1991; Gresh et al. 2000). In particular, the Upper Klamath River above Iron Gate Dam once supported the spawning and rearing of large populations of anadromous salmon and steelhead (Lane and Lane Associates 1981; FERC 1990).

The first impassable barrier to anadromous fish on the mainstem Klamath River was Copco 1 Dam, completed in 1918 (followed by Copco 2 Dam in 1925 and Iron Gate Dam in 1962; Figure 1). Prior to dam construction, anadromous fish runs accessed spawning, incubation, and rearing habitat in about 970 km (600 miles) of river and stream channel above the site of Iron Gate Dam. This dam, at river kilometer 307 (river mile 190; Photo 1), is the current limit of upstream passage. The Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program (USFWS 1991) identified the lack of passage beyond Iron Gate Dam as a significant impact to the Klamath River anadromous fishery. At present, significant un-utilized anadromous fish habitat exists upstream of Iron Gate Dam (Fortune et al. 1966; Chapman 1981; NRC 2003; Huntington 2004). The Klamath Hydroelectric Project operating license expires in 2006 and the relicensing process is currently under way.

Need for Information on the Upstream Extent of Anadromous Fish Distribution

Knowledge of the presence and the historical extent of the upstream distribution for anadromous species on the Klamath River is important for restoration planning and future management decision-making. Public Law 99-552, the Klamath River Basin Fishery Resources Restoration Act (Klamath Act), was adopted by Congress on 27 October 1986, for the purpose of authorizing a 20-year federal-state cooperative Klamath River Basin Conservation Area Restoration Program for the rebuilding of the river's fishery resources to optimal levels. Among other charges, the Klamath Act directs the Secretary of Interior to improve and restore Klamath River habitats and promote access to blocked habitats, to rehabilitate problem watersheds, to reduce negative impacts on fish and fish habitats, and to improve upstream and downstream migration by removing obstacles and providing facilities for avoiding obstacles.

In addition to the Klamath Act, the Department of the Interior and the Department of Commerce are authorized to protect and restore anadromous fish and their habitats under several authorities including the Federal Power Act (through the requirement of mandatory fishway prescription under Section 18 of the act). Other authorities include the Endangered Species Act; federal Tribal Trust responsibilities; Pacific Coast Salmon Plan; Magnuson-Stevens Fishery Conservation and Management Act (which incorporates delineation of "essential fish habitat"); Sikes Act, Title II; the Fish and Wildlife Coordination Act; the Wild and Scenic Rivers Act; the National Historic Preservation Act; Federal Lands Protection and Management Act; Northwest Forest Plan; and various policies and initiatives of the U.S. Bureau of Land Management, U.S. Forest Service, the National Park Service, NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS). The states of Oregon and California also have significant regulatory authorities and responsibilities related to hydropower relicensing and the recovery of listed species.

These authorities provide a basis for restoration of native anadromous fish to their historical habitats. However, there have been persistent questions regarding whether anadromous fish occurred historically above Iron Gate Dam. Thus, prior to implementing anadromous fish restoration and the design of potential fishways that would be species specific, it is important to evaluate the evidence regarding which native anadromous species were present historically above Iron Gate Dam and determine the extent of their upstream distribution.

Methods

We summarize existing information regarding both the recorded historical (tens to thousands of years) presence and, more specifically, the upstream extent of the distribution of native anadromous fish in the Klamath River, based upon photos, historical documents, logical reasoning, and other available information. A distinction was made between presence and the extent of upstream distribution because, for some species, there was clear evidence for presence in general terms, but only vague information on their farthest upstream distribution. When reliable information on the extent of upstream distribution was available, it was important to include this level of certainty for consideration during relicensing and anadromous fish restoration. The presence of species above one dam, but not another, has implications for relicensing.

DAVID WHITE, NOAA FISHERIES

Photo 1. Iron Gate Dam has no fish passage facilities.

In this article, references to the Klamath Upper Basin include the Klamath River watershed upstream from and including the section of the Klamath River known as Link River. (Link River Dam, as shown in Figure 1, is on this short reach of the mainstem Klamath River immediately below Upper Klamath Lake).

Photos

We reviewed historical photo collections of the Klamath County Museum and Klamath Historical Society for documentation of anadromous fish above Iron Gate Dam. We assumed that captions on photos correctly identified the taxa, locations, and dates. The photos used here were taken in the vicinity of Klamath Falls and adjacent Link River.

Documents and Reports

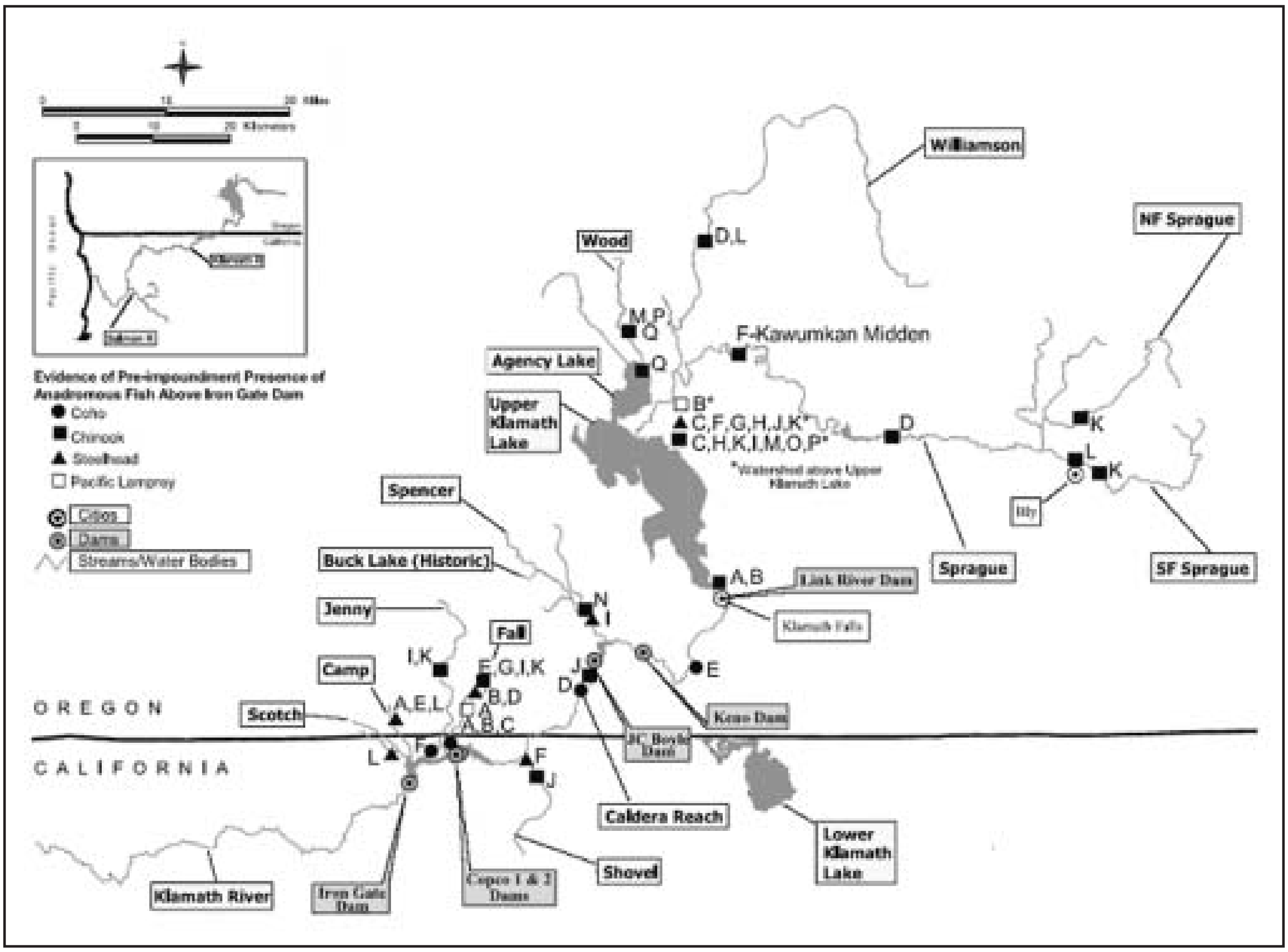
We reviewed published and unpublished fisheries, archeological, and ethnographic reports on the distribution and presence of anadromous fish in the Klamath River watershed. For a given reference we generally cited only the farthest upstream occurrence of a species in the Klamath River and/or its tributaries. When documents identified fish as only salmon, we assumed they were Chinook salmon. While ethnographic (Gatschet 1890; Spier 1930; Kroeber and Barrett 1960) and archaeological (Cressman et al. 1956) sources are cited, other reports from these disciplines may well contain additional documentation not specifically referenced in this paper. Fortune et al. (1966) referenced numerous articles from Klamath Falls newspapers regarding historical accounts of salmon above the current location of Iron Gate Dam. Of these, we have included only one (Klamath Falls Evening Herald 1908).

Personal Communications

We did not reference personal communications that included questionable identifications of species unless the communication included other supporting facts that would corroborate the identification of that species. For example, we discounted the identification of chum salmon (*Oncorhynchus keta*), coho salmon, and steelhead trout in the vicinity of Agency Lake and the Wood River, but included the reference to Chinook salmon because other information communicated on the size of these fish supported that identification.

Personal communications cited in Lane and Lane Associates (1981) regarding the presence of salmon in the Williamson and Sprague rivers were very numerous and we recommend that interested parties refer to this citation. We did not reference these personal communications individually here. When personal communications cited therein provided key information on presence or farthest upstream distribution of a species not cited elsewhere, we referenced Lane and Lane Associates (1981).

Figure 1. Extent of upstream distribution for anadromous fish in the Klamath River and tributaries based upon references in Table 1 (locations for citations are approximate).



Logical Reasoning

For Pacific lamprey and coho salmon we combined existing evidence with logical reasoning for a determination of the extent of upstream distribution of these species in the Klamath River watershed. This reasoning was partly based on the occurrence of the same species east of the Cascade Range in the Columbia River Basin. While we believe this reasoning is valid, we acknowledge that it does not have the same level of certainty as photographs, documents, reports, or personal communications for a specific determination of the limit of upstream distribution.

Results and Discussion

Table 1 summarizes sources of evidence for the historical distribution of Chinook salmon, steelhead, coho salmon, and Pacific lamprey above Iron Gate Dam on the Klamath River. Figure 1 is the corresponding map showing the locations cited for each species.

Evidence for the largest, most utilized species, Chinook salmon, was available from the greatest variety of sources and provided the highest level of certainty. Less information was available for the other three species. Nevertheless, there was substantial information and reasoning to determine that steelhead historically migrated to the Klamath Upper Basin and that the distribution of coho salmon and Pacific lamprey extended above Iron Gate Dam. More detailed information on our evaluation of sources and the presence and farthest upstream distribution is discussed below.

Chinook Salmon

Presence—Information cited here that provides evidence for the presence of Chinook salmon above the current site of Iron Gate Dam includes 2 historical photographs, 14 documents or reports, and 1 personal communication. Numerous other personal communications, testimony, and newspaper articles documenting the presence of Chinook salmon are referenced in Fortune et al. (1966) and Lane and Lane Associates (1981). We found one report that stated there was not enough information to conclude that Chinook salmon accessed tributaries of Upper Klamath Lake.

Chinook salmon spawned in Jenny Creek (Coots 1962; Fortune et al. 1966) and Fall Creek (Wales and Coots 1954; Coots 1957; Coots 1962; Fortune et al. 1966) prior to the construction of Iron Gate Dam. An interview with long-term resident of the area, W. G. Hoover, provided information on large concentrations of fall-run king salmon in Shovel Creek and on spawning that might have occurred near Shovel Creek in the mainstem Klamath River (Coots 1965). Hoover also noted that the river near the "Frame Ranch" was a favorite salmon spearing site and a potential spawning area (Coots 1965). Hoover was undoubtedly referring

Table 1. Documentation for pre-impoundment presence and extent of upstream distribution for anadromous fish in the Klamath River above Iron Gate Dam.

Source	Species			
	Chinook (■)	Steelhead (▲)	Coho (●)	Pacific Lamprey (❑)
Photos of historical presence above Iron Gate Dam	(A) Klamath County Historical Society Photo, Photo 2 (1860) (B) Klamath County Historical Society, Photo 3 (1891)			
Documents/reports/ other evidence	(C) *Gatschet (1890)* (D) *Spier (1930)* (E) *Wales and Coots (1954)* (F) *Cressman (1956)* (G) Coots (1957) (H) *Kroeber and Barrett (1960)* (I) Coots (1962) (J) Coots (1965) (K) Fortune et al. (1966) (L) Lane and Lane Associates (1981) (M) *Nehlsen et al. (1991)* (N) BLM et al. (1995) (O) *Thurow et al. (1997)* (P) *Moyle (2002)*	(A) Wright (1954) (B) Coots (1957) (C) *Kroeber and Barrett (1960)* (D) Coots (1962) (E) King et al. (1977) (F) Fortune et al. (1966) (G) Lane and Lane Associates (1981) (H) *Nehlsen et al. (1991)* (I) BLM et al. (1995) (J) *Thurow et al. (1997)* (K) *Moyle (2002)*	(A) Coots (1957) (B) Coots (1962) (C) CDWR (1964) (D) NMFS (1997) (E) IMST (2003)	(A) Coots (1957) (B) *Kroeber and Barrett (1960)*
Personal communications	(Q) Scarber (2004)	(L) Maria (2003)	(F) Bulfinch (2002)	
Logical reasoning			X	X

Italics = published literature. Reference identification letters correspond to symbols (■, ▲, ●, and ❑) showing approximate locations cited for each species (Figure 1).

to the "Frain Ranch" reach of the Klamath River, which is immediately upstream of the Caldera reach (Figure 1). BLM et al. (1995) referred to accounts of fall-run salmon in Spencer Creek and contained a photo taken prior to 1917 showing a Chinook salmon caught at the confluence of Spencer Creek and the Klamath River.

Two historical photographs document the presence of Chinook salmon at Link River. The Klamath County Historical Society provided these photos, dated 1860 and 1891, showing fishermen with their catch of salmon at Link River (Photos 2 and 3; Photo 2 is dated 1860 but may have been taken later in the nineteenth century; Judith Hassen, Klamath County Museum, pers. comm.). Fortune et al. (1966) reported that C. E. Bond, professor of fisheries at Oregon State University, examined a historical photo of salmonids from the Klamath Upper Basin and positively identified at least one fish as a Chinook salmon. We believe this photo may have been Photo 3 because it was available to the author and is the best known photo from the Klamath Upper Basin with a "salmon fishing" caption. The other three fish shown in this photo are clearly salmonids and likely were Chinook salmon as well.

In a footnote, Snyder (1931) referred to interviews he conducted with fishermen and long-time residents of the Klamath Lake region to learn of the past salmon runs. He reported that "testimony was conflicting and the lack of ability on the part of those offering information to distinguish between even trout and salmon was so evident, that no satisfactory opinion could be formed as to whether king salmon ever entered Williamson River and the smaller tributaries of the lake. However, this may be, large numbers of salmon annually passed the point where Copco Dam is now located." No information is provided in Snyder (1931) regarding the number of interviews or the effort made to interview fishermen and long-time residents.

In contrast, we found numerous historical accounts and fisheries reports referring to the presence of salmon in the tributaries to Upper Klamath Lake, in particular, the Williamson and Sprague rivers. Cressman et al. (1956) reported archeological evidence of salmon bones from the Kawumkan midden on the Sprague River (Figure 1), leading him to conclude that salmon passed the falls at the south end of Upper Klamath Lake. Lane and Lane Associates (1981) provided multiple accounts of the presence of anadromous salmonids and fishing in Sprague and Williamson rivers. This report was done under contract for the Bureau of Indian Affairs in the 1980s. Interviews were included in Lane and Lane Associates (1981) to ensure that a record of anadromous fish presence and the fishery on the Tribal reservation in the Klamath Upper Basin was maintained. In excerpts from 50 interviews, conducted in the 1940s, members of the Klamath Tribe and older non-Indian settlers in the region provided accounts of numerous salmon fishing locations on the Sprague River, the Williamson River, Upper Klamath Lake, and Spencer Creek. These accounts made a distinction between salmon and trout. In many instances the interviews in the document provided details on the weights of fish that indicated they could only be Chinook salmon.

One of the earliest references in Lane and Lane Associates (1981) is to the explorer Fremont's visit to the outlet of Upper Klamath Lake in May of 1846 and his observation of great numbers of salmon coming up the river to the lake. Most likely these would have been spring-run Chinook. Kroeber and Barrett (1960) stated that salmon ran up the Klamath into the Klamath lakes and their tributaries. Gatschet (1890) and Thurow et al. (1997) included the Klamath Upper Basin as within the range of Chinook salmon at the time of European settlement. Nehlsen et al. (1991) and Moyle (2002) referred to historical occurrences of fall, spring, and summer races of Chinook salmon in the Sprague, Williamson, and Wood rivers in the Klamath Upper Basin. Their accounts are similar to those of Fortune et al. (1966) and Lane and Lane Associates (1981) for the Sprague and Williamson rivers. For the Wood River, Nehlsen et al. (1991) and Moyle (2002) both state that Chinook salmon historically used this drainage. While one reference states that salmon did not go up the Wood River (cited in Spier 1930), an account of Chinook salmon harvest (Robert Scarber, former Klamath Agency Reservation resident, pers. comm., 2004) provides specific information that Chinook salmon occurred adjacent to and in the Wood River watershed. The Wood River has and continues to have suitable water quality and physical habitat to support anadromous salmonids. Without the presence of fish passage barriers, salmon undoubtedly inhabited this watershed.

Both spring and fall runs were reported above Upper Klamath Lake by Spier (1930) and Coots (1962). Fortune et al. (1966) provided reports and personal interviews that indicated the Sprague River was the most important salmon spawning stream, on the basis of testimony he received. According to four people interviewed by Fortune et al. (1966), salmon entered the Williamson River in autumn, possibly as early as August. One person interviewed provided the observation that, after salmon passed Link River, it took them five or six days to make their way through Klamath Lake before they reached the Williamson.

It is possible that fall-run Chinook reached Upper Klamath Lake and beyond in only wetter years. The lower Klamath River fall run (below Iron Gate Dam) is generally from August to October/November when flows and depths are often lowest for the year (Myers et al. 1998). Successful fish passage through the high gradient Caldera reach for large-bodied, fall-run Chinook may have been problematic during certain years. This low water passage difficulty was noted a short distance upstream at Keno in the Klamath Falls Evening Herald (1908). Spring-run Chinook salmon, on the other hand, have a bi-modal run distribution that spreads from April to August. The smaller sized, spring-run Chinook (their average weight was 5 kg or 11 lbs. according to Snyder 1931) encountered higher spring flows and would have been able to pass the Caldera reach. However, salmon runs to the Klamath Upper Basin undoubtedly had a fall-run component as evidenced by the size of salmon harvested (up to 27 kg or 60 pounds) and the timing of spawning noted in Lane and Lane Associates (1981).

Extent of Upstream Distribution—The extent of upstream distribution we found for Chinook salmon is shown in Figure 1. Chinook salmon utilized habitat in the Sprague River in the vicinity of Bly, Oregon, and further upstream. Fortune et al. (1966) reported that Chinook salmon spawned in the mainstem Sprague River; upstream on the South Fork of the Sprague above Bly to the headwaters; and on the North Fork of the Sprague as well (Figure 1). Lane and Lane Associates (1981) provided several independent testimonies that put the farthest upstream distribution of salmon for the Sprague River in the vicinity of Bly, Oregon. It should be noted that testimonies from Tribal members in Lane and Lane Associates (1981) were oriented toward harvest of adult salmon, which was restricted to within the reservation boundary, also located near Bly. Their report contained little information on the extent of anadromous salmonids in the Sprague River upstream of the reservation boundary. For the Williamson River, both Spier (1930) and Lane and Lane Associates (1981) listed the farthest upstream distribution of salmon as being the falls below the outlet to Klamath Marsh (Figure 1).

We note that accounts of Chinook harvest in general are based upon fisheries that took place in locations convenient for harvest, primarily in mainstem channels, and that the true farthest upstream distribution was probably above the sites where these fisheries took place.

Steelhead

Presence—Information cited here that provides evidence for the presence of steelhead above the current site of Iron Gate Dam includes 11 documents or reports and 1 personal communication. Other personal communications regarding steelhead above Iron Gate Dam are referenced in Lane and Lane Associates (1981). One report stated there was not enough information to conclude that steelhead accessed the Klamath Upper Basin.

BLM et al. (1995) includes a photo captioned "Fishing for steelhead on Spencer Creek…around 1900" from the photo collection of the Anderson Family, descendents of Hiram Spencer, an early settler in the Spencer Creek area. Fortune et al. (1966) cited a brochure from Southern Pacific Railroad, published in 1911, that referred specifically to the harvest of steelhead at the mouth of Shovel Creek (Figure 1).

KLAMATH COUNTY HISTORICAL SOCIETY

Photo 2. Link River salmon "fishing" around 1860. Site of present Klamath Falls.

KLAMATH COUNTY HISTORICAL SOCIETY

Photo 3. Gentlemen display their catch while salmon fishing on the rapids of Link River, 1891.

Extent of Upstream Distribution—The extent of upstream distribution we found for steelhead is shown in Figure 1. California Department of Fish and Game (CDFG) files include records of steelhead spawning in Camp Creek up to 1.6 km (one mile) upstream from the California state line, in at least one Camp Creek tributary approximately 0.8 km (0.5 mile) downstream from the California state line, and in nearby Scotch Creek (Dennis Maria, CDFG, pers. comm.). Wright (1954) and King et al. (1977) also reported that steelhead spawned in Camp Creek prior to the construction of Iron Gate Dam.

Coots (1957, 1962) discussed steelhead in Fall Creek. According to Puckett et al. (1966), steelhead were present as far upstream as Link River, but their presence above Upper Klamath Lake could not be documented. However, Kroeber and Barrett (1960), Nehlsen et al. (1991), Lane and Lane Associates (1981), Thurow et al. (1997), and Moyle (2002) all refer to steelhead accessing the Klamath Upper Basin. Fortune et al. (1966) states that due to the difficulty in differentiating steelhead from large rainbow trout (or redband trout, *Oncorhynchus mykiss irideus*), accurate information on the history of steelhead migrations in the Klamath Upper Basin was impossible to obtain. However, Fortune et al. (1966) also stated that there was enough agreement from interviews conducted to derive some general information. Included in this general information were accounts of steelhead in the Wood, Sprague, and Williamson rivers.

Generally, in watersheds where both Chinook salmon and steelhead are present, the range of steelhead is the same if not greater. The reports above, the overlapping distribution for the two species in most watersheds, and the fact that Chinook salmon were present in the Klamath Upper Basin are substantial evidence that steelhead were also present in tributaries to Upper Klamath Lake.

Coho Salmon

Presence—Information cited here that provides evidence for the presence of coho salmon above the current site of Iron Gate Dam includes five documents or reports and one personal communication. Snyder (1931) stated that "[s]ilver salmon are said to migrate to the headwaters of the Klamath to spawn. Nothing definite was learned about them from this inquiry because most people are unable to distinguish them." At the time, he said there was little interest in coho because Chinook salmon were so much larger and more abundant. Fortune et al. (1966) did not discuss coho salmon. However, Coots (1957, 1962) and the California Department of Water Resources (1964) reported that coho salmon spawned in Fall Creek, which now flows into Iron Gate Reservoir. Prior to construction of Iron Gate Dam, the confluence of Jenny Creek with the main stem Klamath River was well known by fishing guides as one of the best places in the upper river to fish for coho (Table 1 and Figure 1; Kent Bulfinch, Klamath River Basin Task Force representative, pers. comm.).

In 1911, 881 female coho were captured at the Klamathon Racks egg-taking facility about 8 km downstream from the current Iron Gate Dam site (CDFG 2002). Coho salmon are generally tributary spawners, and the only sizable tributary between the Klamathon Racks area and Iron Gate Dam is Bogus Creek. It is unlikely that all these spawning fish would have been destined for Bogus Creek and probable that a significant portion of the return was destined for tributaries above the current site of Iron Gate Dam. NOAA Fisheries estimated that within the Klamath River Basin, the construction of Iron Gate Dam blocked access to approximately 48 km (30 miles) of mainstem habitat, about 8% of the historical coho salmon habitat in the entire Klamath River Basin (NMFS 1997).

Extent of Upstream Distribution—The NOAA Fisheries estimate of the loss of approximately 48 km (30 miles) of mainstem coho salmon habitat above Iron Gate Dam would put the species' upper distribution in the vicinity of the J. C. Boyle powerhouse (Table 1 and Figure 1; NMFS 1997). Another report put the historical occurrence of coho salmon in the Klamath River as far upstream as the mouth of Lower Klamath Lake (IMST 2003). However, the report by Moyle (2002) stating that coho salmon once ascended the Klamath River and its tributaries at least as far upstream as Klamath Falls, Oregon, is an error resulting from the author's imprecise use of zoogeographic boundaries (Peter Moyle, University of California Davis, pers. comm.). To the best of his knowledge, there are no records of coho in the Klamath Upper Basin.

Given this information about the distribution of coho salmon in the mainstem Klamath River, the fact that coho are generally tributary spawners, our knowledge of their rearing and spawning habitat, and the characteristics of various Klamath River tributaries, we conclude that coho salmon would have used Spencer Creek, a medium-sized, low-gradient tributary, with suitable spawning habitat. Side channel and beaver pond areas in Spencer Creek would also have provided rearing habitat for this species. Thus, we reason that the farthest upstream distribution of coho salmon likely extended at least to this vicinity.

Anadromous Pacific Lamprey

Presence—We found two documents, but no personal communications, that provided evidence for the presence of Pacific lamprey above the current site of Iron Gate Dam. Coots (1957) reported that *Lampetra tridentata* entered Fall Creek, which now flows into Iron Gate Reservoir. Literature references to Pacific lamprey in the Klamath Upper Basin prior to the construction of downstream dams (Gilbert 1898; Evermann and Meek 1897) may have applied to a resident, non-anadromous taxon of uncertain systematic status (Stewart Reid, USFWS, pers. comm. 2004). Gilbert (1898) reported a "young" specimen that measured 26 cm in length. Lampreys of this size correspond with the larger lamprey taxon still encountered in Upper Klamath Lake, but are considerably smaller than anadromous adults in the Klamath River (Kan 1975; Lorion et al. 2000). The current lamprey taxon in Upper Klamath Lake was recognized as a distinct subspecies of *L. tridentata* by Kan (1975) in his unpublished dissertation, and as "non-anadromous" *L. tridentata* in Lorion et al. (2000) due to the lack of a formal systematic revision of the Klamath lampreys. Mitochondrial DNA analysis has shown no evidence of contemporary anadromous Pacific lamprey populations in the Klamath Upper Basin or Spencer Creek (Lorion et al. 2000; Margaret Docker, Great Lakes Institute for Environmental Research, pers. comm. 2004).

This taxonomic confusion would have made it difficult to distinguish anadromous Pacific lamprey from resident taxa. However, anadromous Pacific lamprey currently occur throughout the mainstem and principal tributaries of the lower Klamath River and fish fauna are generally considered to be similar throughout the mainstem Klamath River upstream to Spencer Creek. Historically, there were no physical barriers that would have prevented anadromous lampreys from migrating above Iron Gate Dam (Stewart Reid, USFWS, pers. comm.).

Extent of Upstream Distribution—Kroeber and Barrett (1960) reported that Pacific lamprey ascended to the Klamath Lakes, based on the accounts of Native Americans (Table 1, Figure 1). While the difficulty in distinguishing anadromous Pacific lamprey from Klamath Upper Basin resident lamprey taxa brings this account into question, we note that the historical distribution of Pacific lamprey in the Columbia and Snake rivers was coincident wherever salmon occurred (Simpson and Wallace 1978). Wydoski and Whitney (2003) stated that Pacific lampreys occur long distances inland in the Columbia and Yakima river systems. Pacific lamprey still migrate well upstream to at least the Snake River (Christopher Claire, Idaho Department of Fish and Game, pers. comm.) and Idaho's Clearwater River drainage (Cochnauer and Claire 2002). Current limits to the distribution of Pacific lampreys in the Columbia River system are at Chief Joseph Dam on the mainstem Columbia and Hells Canyon Dam on the Snake River (Close et al. 1995). Both of these dams are well over 800 km (500 miles) upstream from the ocean and Pacific lamprey distribution may have extended further upstream prior to the construction of these dams, which have no fish passage facilities. On the Willamette River, Pacific lamprey were historically able to pass upstream at Willamette Falls with winter steelhead and Chinook salmon (USDI 2003).

The extent of Pacific lamprey migrations in other coastal rivers, their general congruence with anadromous salmonid distributions, the historical absence of lamprey passage barriers in the mainstem Klamath River, and the homogeneity of the lower Klamath River fish fauna throughout the mainstem Klamath upstream to Spencer Creek suggest that, historically, anadromous Pacific lamprey would likely have migrated up the Klamath River past where Iron Gate Dam now exists and that their upstream distribution extended to at least Spencer Creek.

Other Anadromous Species

Sockeye Salmon— There is some evidence that a run of sockeye salmon may have occurred in the Klamath River above the current location of Iron Gate Dam. The southernmost distribution of sockeye (*Oncorhynchus nerka*) in North America is recorded as the Klamath River (Jordan and Evermann 1896; Scott and Crossman 1973). Cobb (1930) reported that 20 sockeye were taken in the Klamath River in the autumn of 1915. Sockeye salmon require a lake for rearing. The only potential lake rearing habitat in the Klamath River system accessible to anadromous fish would have been Upper Klamath Lake, Lower Klamath Lake, or Buck Lake (in the upper reaches of Spencer Creek before being drained, Figure 1). Lower Klamath Lake was probably too shallow to provide suitable rearing habitat for sockeye salmon, but some authors (Fry 1973; Behnke 1987) believe that a small run of sockeye may have occurred to Upper Klamath Lake, until eliminated by dams. However, Snyder (1931) reported that no evidence substantiated the statement of Jordan and Evermann (1896) that sockeye salmon occur in the Klamath River, and Moyle (2002) stated that individual anadromous sockeye found in streams south of the Columbia system are probably non-spawning strays or kokanee (the landlocked form of sockeye) that went out to sea. At any rate, if anadromous sockeye were present historically, they have been extirpated.

It is notable that kokanee salmon currently are observed in Upper Klamath Lake (Logan and Markle 1993), especially in springs on the west side of the lake (Bill Tinniswood, ODFW, pers. comm.). These are believed to be fish that have drifted downstream from the Four Mile Lake population, introduced in the 1950s or before (Bill Tinniswood, ODFW, pers. comm.; Roger Smith, ODFW, pers. comm.).

Green Sturgeon—To the best of our knowledge there is no evidence for the distribution of native sturgeon above the current location of Iron Gate Dam. Chuck Tracy (ODFW, pers. comm.) stated that the upstream limit of distribution appears to be Ishi-Pishi Falls (near the confluence of the Klamath River and the Salmon River) on the Klamath River. Moyle (2002) mentioned a green sturgeon spawning site in the Klamath River approximately

208 km (129 miles) below Iron Gate Dam. Sturgeon are known to spawn in the Salmon River, a tributary to the lower Klamath River, which flows into the Klamath River about 201 km (124 miles) below Iron Gate Dam. Kroeber and Barrett (1960) put the upstream-most distribution of sturgeon in the same vicinity. While some green sturgeon may presently migrate beyond the confluence of the Salmon and Klamath rivers, they are the exception rather than the rule (Tom Shaw, USFWS, pers. comm.).

Gilbert (1898) reported that green sturgeon were not observed in Upper Klamath Lake. The current small population of sturgeon in Upper Klamath Lake is derived from white sturgeon (*Acipenser transmontanus*) introduced in 1956 (ODFW 1997).

Eulachon—To the best of our knowledge there is no evidence of the distribution of eulachon above the current location of Iron Gate Dam. Eulachon are usually restricted to spawning in lower river reaches (Scott and Crossman 1973). Accounts of Yurok Tribal elders indicate that eulachon utilized the lower Klamath River for spawning at least as far upstream as 40 km (river mile 25; Larson and Belchik 1998). Historically abundant, they may now be extirpated in the Klamath River (Larson and Belchik 1998).

Cutthroat Trout—Typically, coastal cutthroat do not occur more than about 160 km (100 miles) from the coast (Behnke 1992). There are no accounts of cutthroat in the Klamath Upper Basin. Considering the multiple life history strategies cutthroat exhibit, had they been present above Iron Gate Dam historically, there would likely be resident populations in the upper basin or other tributaries above the dam.

Chum Salmon—To the best of our knowledge there is no evidence for the distribution of chum salmon, above the current location of Iron Gate Dam. The distribution of chum salmon is generally limited to lower river reaches (Scott and Crossman 1973). Small runs of this species still maintain themselves in the lower Klamath River (Moyle 2002).

In some historical accounts there are references to dog salmon in the Upper Klamath River Basin. Dog salmon is a common reference used for chum salmon in the Pacific Northwest and Alaska. However, the common name dog salmon was also applied to Chinook salmon in the Klamath River in early accounts (Snyder 1931; Lane and Lane Associates 1981). Hence, there may have been confusion as to the upstream distribution of chum salmon in the Klamath River.

Pink Salmon—To the best of our knowledge there is no evidence for the distribution of pink salmon (*Onchorynchus gorbuscha*) above the current location of Iron Gate Dam. The distribution of pink salmon is generally limited to lower river reaches (Scott and Crossman 1973). Small numbers of pink salmon have been reported in the lower Klamath River (Moyle 2002).

Conclusions

We found numerous sources of information regarding the occurrence of Chinook salmon, steelhead, coho salmon, and Pacific lamprey above the current location of Iron Gate Dam on the Klamath River. We are not aware of any credible reports that these species did not migrate beyond this point. For Chinook salmon and steelhead, we found one report for each species stating there was not enough information to say definitively they migrated into the Klamath Upper Basin. In contrast, we found several lines of evidence that clearly showed that Chinook salmon historically migrated to the Klamath Upper Basin. A determination of the upstream extent of distribution for steelhead, coho salmon, and Pacific lamprey was more difficult. However, available documentation indicates that steelhead accessed habitat in the tributaries of Upper Klamath Lake as well. Pacific lamprey probably accessed habitat upstream at least to Spencer Creek and possibly beyond, as did coho salmon. There is limited evidence that a small run of sockeye salmon may have accessed habitat in Upper Klamath Lake or Buck Lake. Green sturgeon distribution extended upstream to the vicinity of the Salmon River in the mid-Klamath River portion of the watershed. Chum salmon, pink salmon, eulachon, and cutthroat trout were limited to the lower Klamath River, well below the current location of Iron Gate Dam. This documentation resolves a great deal of the uncertainty regarding which species were present above Iron Gate Dam and the extent of their upstream distribution, both key to realizing fisheries restoration opportunities.

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ATTACHMENT 4

Estimates of Pre-Development Klamath River Salmon Run Size

(IFR Report – Updated to Feb. 2009)

Estimates of Pre-Development Klamath River Salmon Run Size

Historically, salmon were an important food source and cultural symbol for the Indian tribes of California. "It's been a part of the culture, the religion and the diet for thousands of years," said Mike Orcutt, director of the fisheries department for the Hoopa Valley Tribe along the Trinity River. "The salmon runs were dependable and dried salmon provided food for the winter."[1] However, virtually no reliable data exists concerning the magnitude of historic Native American harvest levels on the Klamath and Trinity Rivers.

The California Department of Fish and Game (CDFG) first set the Klamath Basin fall run chinook spawning escapement goal at 115,000 in 1978. This rebuilding goal is based on Klamath Basin escapement estimates for the early 1960s and includes 97,500 natural and 17,500 hatchery spawners.[2] The PFMC later adopted this goal, which however has never been met.[3] By 1983, the goal was modified downward to include a "rebuilding schedule" whose first step, to be in place for four years, was a goal of 68,900 spawners, with the 115,000 goal to be in place by 1995.[4] Soon into the rebuilding plan it became obvious, however, that even though these goals were only a small fraction of the original run size that they still could not be met within the present seriously degraded state of inland habitat. Therefore, in 1986 and long before any of these goals could be met, a whole new methodology was introduced by which the fishery itself was to be managed. Nevertheless these remain the "official" rebuilding goals for salmon in the basin.

Coho runs from the North coast numbered about 150,000 annually in the 1940's decade, while steelhead runs were estimated to be about 300,000.[5] Since no other information is available on coho and steelhead, a factor of 50 percent harvest rate is used in our calculations as an estimate of what would be potentially available. Thus the estimate is that the Klamath River could have supported harvests of up to 75,000 coho and 150,000 steelhead at that time.

For purposes of analysis some assumptions needed to be made about species/run composition of the chinook salmon harvested, since their economic value varies by species/run. Species of harvested chinook are thus assumed to be in the same proportion as in the Sacramento system (i.e. 5% late fall, 10% winter, 37% spring and 48% fall).

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1. "California's Chinook Salmon: Upstream Battle to Restore the Resource," Water Education Foundation, Western Water, November/December 1992.
2. Boydstun, L.B., "Draft Evaluation of Klamath River Fall Chinook Escapement Options," Memorandum, September 8, 1988, California Fish and Game.
3. *An Assessment of the Current Carrying Capacity of the Klamath River Basin for Adult Fall Chinook Salmon, Hubbell and Boydstun, CDFG, Sept. 1985.*
4. *Ibid., see also Final Framework Amendment for Managing the Ocean Salmon Fisheries..., PFMC, October 1984, p. 3-20.*
5. "An Environmental Tragedy: Report on California Salmon and Steelhead Trout," State of California, California Department of Fish and Game, March 15, 1971.

There are no generally accepted estimates of pre-development salmon run sizes for California rivers except for the Fisher estimates of Central Valley stocks.[6] For the Columbia River study, the Northwest Power Planning Council made its estimates based on review of habitat and on historical catch records. However, using the number of square miles in a basin as a factor and interpolating production numbers from similar basins where data is more complete, it is possible to arrive at workable estimates of pre-development runs of up to 4 million fish in the Sacramento/San Joaquin system and 1.1 million in the Klamath system (Table 1). These are the figures assumed for purposes of our analysis.

Table 1
Comparison Between Three River Systems: Columbia River, Sacramento/San Joaquin System, and Klamath River, in Terms of Total Square Area, Salmon Habitat Miles, Best Estimate of Historical Harvests, and Present Escapement

	Total Salmon Habitat Land Area in Basin	**Pre-Development Habitat Stream Miles**	**Historic Record Harvests (No. of Fish)**	**Estimated Pre-Development Runs**	**Escapement Goal**
Columbia River System	163,000 sq. miles to 260,000 sq. miles /1	14,666 miles of stream /1	3 to 3.6 /4, record canning pack 630,000 cases, about 40 million pounds	10–16 million fish	varies for stocks in the Columbia
Sacramento/ San Joaquin System	38,340 sq. miles /2	6,000 miles of stream /3	12 million pounds /5, average 5 million pounds from 1873–1910	1.95 million /6 to 4.0 million fish /7	122,000–180,000 /9 (mostly hatchery)
Klamath River System	9,691 sq. miles	no estimates	no estimates	0.66 to 1.1 million fish /8	97,500 natural, 17,500 hatchery /10

Notes: 1. Prior to development, over 163,000 square miles of salmon and steelhead habitat existed in the Columbia River. (Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin. Appendix D of the 1987 Columbia River Basin Fish and Wildlife Program. Northwest Power Planning Council. Portland, Oregon. Page 87.) The Columbia River drains a watershed that is 260,000 square miles. (Bonneville Power Administration. "The World's Biggest Fish Story: The Columbia River's Salmon." Backgrounder. July 1987. Page 4.)

2. John Snyder. California Department of Water Resources.
Sacramento = 26,548 square miles
San Joaquin = 11,792 square miles
Delta = 4,154 square miles
Personal communication, January 1996.

3. The California Department Fish and Wildlife feels this estimate made in 1928 is too high. ("An Environmental Tragedy." Report on California Salmon and Steelhead Trout. Assembly Concurrent Resolution #64/1970 Session. March 1971. California Department of Fish and Game.)

4. High years:
1892 = 3.3
1895 = 3.3
1898 = 3.3
1911 = 3.1

6. *Fisher, Frank W., "Past and Present Status of Central Valley Chinook Salmon," Conservation Biology, Vol. 8, No. 3, September 1994.*

1918 = 3.6
1919 = 3.1
1923 = 3.2
1924 = 3.1
1926 = 3.0

Radtke, Hans D. and Shannon W. Davis. “Lower Columbia River/Young’s Bay Terminal Fisheries Expansion Project.” Salmon For All. January 1996.

5. In 1882, the California commercial salmon catch reached its historic peak of 12 million pounds. (E.R.G. Pacific, Inc. “The Economic Issues Associated with the Commercial Salmon Fisheries and Limited Entry in California.” A Report to the California Commercial Fishing Review Board. October 1986. Page 1.)

6. Fisher, Frank. “Past and Present Status of Central Valley Chinook Salmon.” Conservation Biology. Volume 8, No. 3. September 1994.

7. This estimate is based on the Columbia River Basin land area ratio to Sacramento/San Joaquin land area. This may be a high estimate, especially when compared to Frank Fisher’s estimate of 1.95 million fish from the Columbia River.

8. Based on the land area ratios, the Klamath area could have had a pre-development run size of about 0.65 to 1 million fish.

9. Includes natural and hatchery fish. (“Review of 1994 Ocean Salmon Fisheries.” Pacific Fishery Management Council. Portland, Oregon. 1994. Page 8.)

10. Although natural production from the Klamath system includes both spring and fall runs, only the dominant fall run is managed by the PFMC. (“Review of 1994 Ocean Salmon Fisheries.” Pacific Fishery Management Council. Portland, Oregon. 1994. Page 11.) The escapement goal has been changed to 33%–34% in 1987 with a floor of 35,000. “Natural” as defined by the California Dept. of Fish and Game is not, however, the same as “wild.” “Natural” as CDFG uses it may include any hatchery-origin fish so long as it is found outside the hatchery (see discussion in the body of this report).

Surprisingly, there has been little effort to determine the actual population size of the remaining wild salmon runs still left in the Klamath. Thus it is very difficult to determine whether in fact these populations are still declining or by how much. In fact, the current data collection and stock classification system used by the California Department of Fish and Game (CDFG) actually obscures this data. CDFG now classifies <u>*all*</u> fish found in hatcheries as “hatchery fish” *regardless of origin*. What is worse, all fish that are found <u>*outside*</u> of hatcheries <u>*during any given sample period*</u> are classified de facto as “natural fish,” *again regardless of genetic origin*. It is obvious that some wild fish may stray into hatcheries, but more important is the fact that the vast majority of hatchery fish *never make it back to their hatchery of origin*, and thus would (if found anywhere just short of the hatchery) be classified by CDFG as “natural fish.”

This practice blurs and obscures important genetic differences between hatchery stock (often imported) and the remnant wild stocks, leads to genetic dilution of the hard-won survival traits of the overall wild fish population, and almost completely masks actual wild stock declines. Since these “natural” fish are often confused in the literature with truly indigeneous “wild” stocks, this practice can also easily lead to gross over-estimates of native fish populations. This in turn allows grossly inflated estimates of the success of agency stock reseeding practices and rosy estimates of the total fish present in the system.

However, “natural” fish are not “wild” fish as geneticists define them. Only a comparison between pre-development genetically indigenous *wild* fish and current genetically indigenous *wild* fish populations gives a meaningful estimate or a true “before and after picture” of the extent of indigenous wild salmon stock declines.

It is clear, though, that the majority of the returning Klamath Basin salmon are now hatchery reared fish, rather than wild fish. However, hatchery fish—unlike their wild counterparts—require the continual input of human dollars and energy to generate them, and are thus more costly to society than their wild counterparts. Hatchery production costs must first be subtracted to get their net economic value. These costs also vary from year to year depending upon widely fluctuating survival rates. In years of good ocean conditions when survival rates are relatively high, hatchery program costs can be amortized over a larger number of returning adults. However, in years of very poor ocean conditions (or when other habitat factors seriously affect smolt survival) the costs of hatchery production must then be amortized over a much smaller number of harvestable fish.

Hatcheries are used most often to compensate for habitat that for all practical purposes can never be restored (as above an impassable dam) as a way to continue to produce at least some fish for sport and commercial harvest. This type of "mitigation hatchery" serves an important economic function. Without mitigation hatcheries there would be nothing coming from many river systems because their native runs have long since been destroyed. However, the belief that hatcheries can adequately and forever substitute for salmon genetically adapted for millions of years for survival in the wild may be a false dream. Precipitous declines of wild salmon runs throughout the region is fundamentally *a biological and social problem* caused by widespread habitat destruction and the way we misuse our own technology.

While hatcheries play (and should continue to play) an important role in maintaining commercially harvestable populations in many areas, hatchery programs should be managed to *supplement and maintain* wild runs, not to *replace* them. Protection and restoration of wild runs puts a limit on land use activities which destroy watersheds, and thus imposes a limit on corporate greed. All too often the mere existence of a hatchery simply becomes a politically expedient excuse to avoid protecting wild fish habitat at all.[7]

Also, hatcheries cost money to run. Even productive hatcheries are now finding it harder to find funding in an era of severely declining state and federal budgets. Hatchery programs can suffer from genetic problems, disease, stress on juvenile fish from overcrowding, behavioral problems with hatchery-reared fish failing to adapt to wild conditions, and many other problems. Overproduction in some years may lead to precipitous declines in both hatchery and wild returns in other years. Also, hatchery programs which are run without careful attention to genetic impacts or competition effects on wild salmon populations can potentially be devastating to the genetic integrity of wild runs.[8]

Artificial hatchery production rarely duplicates the high survival rates and genetic adaptability of wild fish. Neither can hatcheries adequately substitute for the loss of natural spawning and rearing habitat.[9]

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[7]. *This report does not attempt to quantify the job base currently being maintained by the existing hatchery production programs in the Klamath. Unfortunately, the data available to us will not allow us to make that assessment unless a great deal more information about the costs of each of these hatchery programs on a per smolt and per returning adult basis is obtained.*

[8]. *For the most recent criticism of hatchery production programs see the National Research Council report "Upstream: Salmon and Society in the Pacific Northwest," National Academy Press (1996), which concluded among other things that: "Despite some successes, hatchery programs have been partly or entirely responsible for detrimental effects on some wild runs of salmon." For a good summary of all the scientific literature on hatchery and supplementation programs generally and the many problems they face, refer to U.S. Dept. of Energy, Bonneville Power Administration Technical Report 1990 (September, 1990), "Analysis of Salmon and Steelhead Supplementation," (Document DEO/BP-92663-1).*

[9]. *Destroying in-stream salmon habitat destroys both hatchery and wild fish alike. Once released into the wild, hatchery fish use the very same feeding and sheltering habitat as do wild fish. Destroying stream habitat for*

Nor can hatchery production really get fishery management out of the "weak stock management" and ESA downward spirals it has gotten itself into, since these problems are based on wild fish which still continue to decline. Finally—as a matter of political realism—shrinking agency budgets will mean many hatchery programs are likely to be closed simply for lack of funds.

These and many other factors make ultimate reliance by the fishing industry on hatchery programs unstable in the long term. *Ultimately, the only way to "hedge bets" biologically and economically so as to assure a future west coast salmon fishery is to maintain and restore (to as great an extent as possible) the wild salmon runs which are uniquely adapted to long term survival.*

Hatcheries must still be used where necessary to mitigate for permanent loss of habitat and in order to maintain a commercial fishery in the interim, but within an overall policy of genetic conservation *coupled with an aggressive program of habitat protection and restoration*.

How Much is a Restored Klamath Salmon Fishery Worth?

Because most jobs in the fishing industry are seasonal rather than full-time, published employment figures of commercial and recreational fishing may be misleading. Therefore, full-time equivalent employment numbers must be calculated by dividing the estimated total personal income generated by fishing activity by a representative annual personal income average. In the Pacific Northwest in 2009, a $40,000 per year wage or salary is a fair representation of a full-time equivalent job when considering all jobs that are generated by an activity, from crewmen to waitresses to lawyers.

Each fish harvested produces a net economic benefit to society as it travels through the chain of commerce from the boat to the consumer's table. The combined sums of all those benefits is the 'net personal income impact' of that one fish.[10] These values have been quantified for the Klamath Basin in previous studies. For instance, in a recent study entitled "Fishery Values of the Klamath Basin—A Report to CH2M Hill," by Meyer Resources, Inc., May 1984, printed in "Klamath River Basin Fisheries Resource Plan," U.S. Department of the Interior, February 1985, an estimate was made of the potential annual benefits associated with a catch of 1,000 adult Klamath salmonids to be $173,910 in 1984 dollars, which is equivalent to $353,416 including all direct, indirect and induced market-based economic benefits when expressed in 2009 dollars (see Table 3).

However, Meyer's study made no effort to assess historic run sizes. Using the numbers developed in this report by Radtke is appropriate as the best available estimate of the biological potential of the Klamath Basin for salmon production. We therefore combine Meyer's figures with the estimated pre-development run sizes derived in Table 2 to give us a number for the "net economic benefit" which is missing from the salmon-based economy due to recent declines and losses.

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wild fish will also decrease survival rates of hatchery fish—a double whammy which threatens to collapse both wild and artificial runs simultaneously. Allowing the destruction of the wild stocks which have genetically adapted to a particular river system for millions of years also extinguishes the very best gene pool from which to replenish that river's hatcheries.

10. *In other words, the sum of all the direct, indirect and induced economic activity generated by that product as it makes its way through the chain of commerce.*

Assuming the pre-development escapement estimates developed above of between 657,500 to 1,090,000 million adult equivalents to be accurate, and assuming only a 50% harvest rate, this would indicate under Meyer's methodologies that the Klamath should be able to produce a total annual income stream of between $116,185,510/year and $192,611,720/year in *market-based* salmon related economic benefits alone (i.e., excluding any of Meyer's non-market values), when expressed in 2009 dollars.

From this we can easily calculate that a total job base (at $40,000/job, which is at or near regional median income) of *between 2,905 to 4,815 family wage jobs could potentially be supported by fishing in the Klamath or generated by salmon fishing on stocks originating from this basin. This is the potential economic productivity of the Klamath as a salmon producer in today's economy. It is also a measure of the potential number of jobs which are at risk if salmon declines in the basin continue.*

This figure also excludes *all* economic benefits allocated by Meyer (Table 3) to the category of "non-market benefits" and so may be greatly understating the true social value of this fishery. Once added back in these non-market economic benefits would bring the total annual personal income impacts to much higher numbers. Hence the above estimates, based entirely on market benefits, should be considered conservative.

Table 2
Annual Potential Harvests Which Could Be Derived from Historic Salmon and Steelhead Run Sizes in the Klamath Basin.[11]

Species	Estimated Pre-Development Run Size - Range /1			Harvest (at 50% of Run Size) - Range			Average Weight per Fish (pounds)	Total Fish Weight (pounds) - Range		
Late Fall Chinook	22,500	-	45,000	11,250	-	22,500	15.0	168,750	-	337,500
Winter Chinook	45,000	-	90,000	22,500	-	45,000	15.0	337,500	-	675,000
Spring Chinook	160,000	-	320,000	80,000	-	160,000	15.0	1,200,000	-	2,400,000
Fall Chinook	205,000	-	410,000	102,500	-	205,000	15.0	1,537,500	-	3,075,000
Coho	75,000	-	75,000	37,500	-	37,500	9.0	337,500	-	337,500
Steelhead	150,000	-	150,000	75,000	-	75,000	8.5	637,500	-	637,500
Total	657,500	-	1,090,000	328,750	-	545,000		4,218,750	-	7,462,500

[11] Notes: Based on square mile comparisons between Columbia River and estimates of historic species comparison of the Sacramento River for chinook. Coho and steelhead estimates are based on northern California harvest rates.

Table 3
Potential Annual Benefits Associated with a Catch of 1,000 Adult Klamath Salmonids (from Meyer) in 1984 Dollars.

Benefiting Group	Business Benefits in Dollars	Non-Market Benefits in Dollars (based on restorative activity)	Subsistence, Cultural, Religious, & Social Benefits
Commercial Fishermen			Supports way of life Provides 7,000 to 7,500 lbs of food
• Chinook	22,090		
• Coho	14,040		
Sport Fishermen			Provides 7,000 to 7,500 lbs of food
• Chinook/coho	28,730	128,080	
• Steelhead		172,370	
Indian Peoples			Maintains cultural and religious well-being Provides 7,000 to 7,500 lbs of food
• Chinook	22,090		
• Coho	14,040		
Coastal Communities			Provides 7,000 to 7,500 lbs of food Supports basic community way of life
• Commercial chinook	10,030		
• Commercial coho	6,380		
• Sport fish	56,510		

MARKET BENEFITS = $173,910 (expressed in 1984 dollars [12])

Note: One problem with using that figure today was that it was originally in 1984 dollars. In order to convert that into 2009 dollars one must use an escalation factor derived from the increases in the Consumer Price Index (CPI) since that time. This factor turns out to be 2.03.[13] Thus in 2009 dollars 1,000 adult harvested Klamath salmon could generate as much as **$353,416** in total net economic benefits and personal income impacts in accordance with Meyer's figures.

Making this adjustment to 2009 dollars we have the following per 1,000 fish values:

MARKET BENEFITS = $353,416 (expressed in 2009 dollars)

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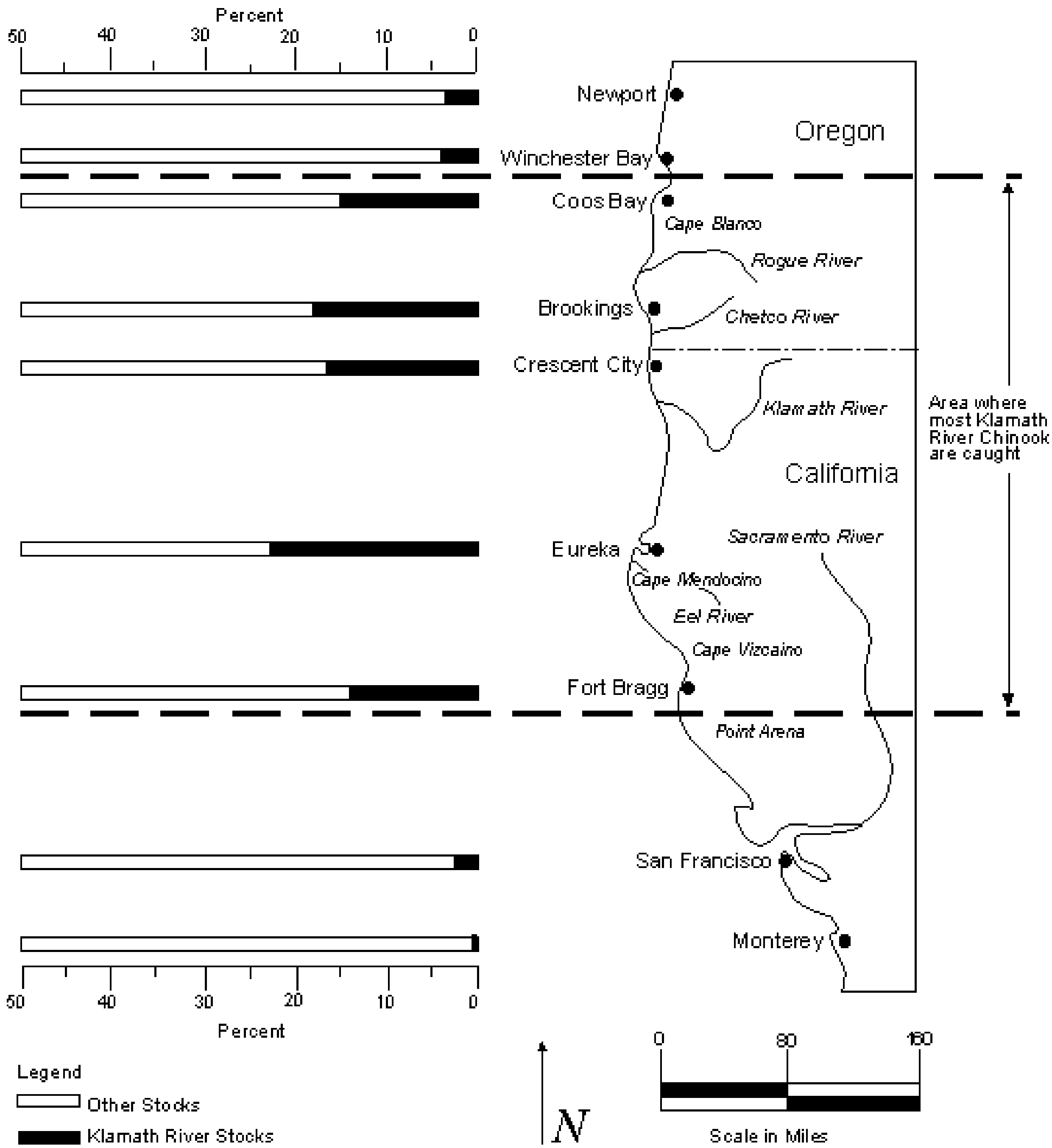
[12] *The Meyer report relied heavily on recreational and aesthetic non-market benefits to estimate total economic values of restoration. However, these values are inherently less certain and more speculative than purely market values. The decision was therefore made in this report to use commercial value as our sole indicator of economic value because it is the most easily quantifiable using well established methodologies.*

[13] *The escalation factor "P" is derived as follows: P = CPI09 ÷ CPI84 = 211.14/103.90 = 2.03. The Consumer Price Index (CPI) set by the Bureau of Labor for 1982-1984 = 100. For more information on the CPI and a CPI calculator see the U.S. Bureau of Labor Statistics site at: http://www.bls.gov/CPI. CPI adjustments can also be easily calculated on the Internet at: http://data.bls.gov/cgi-bin/cpicalc.pl.*

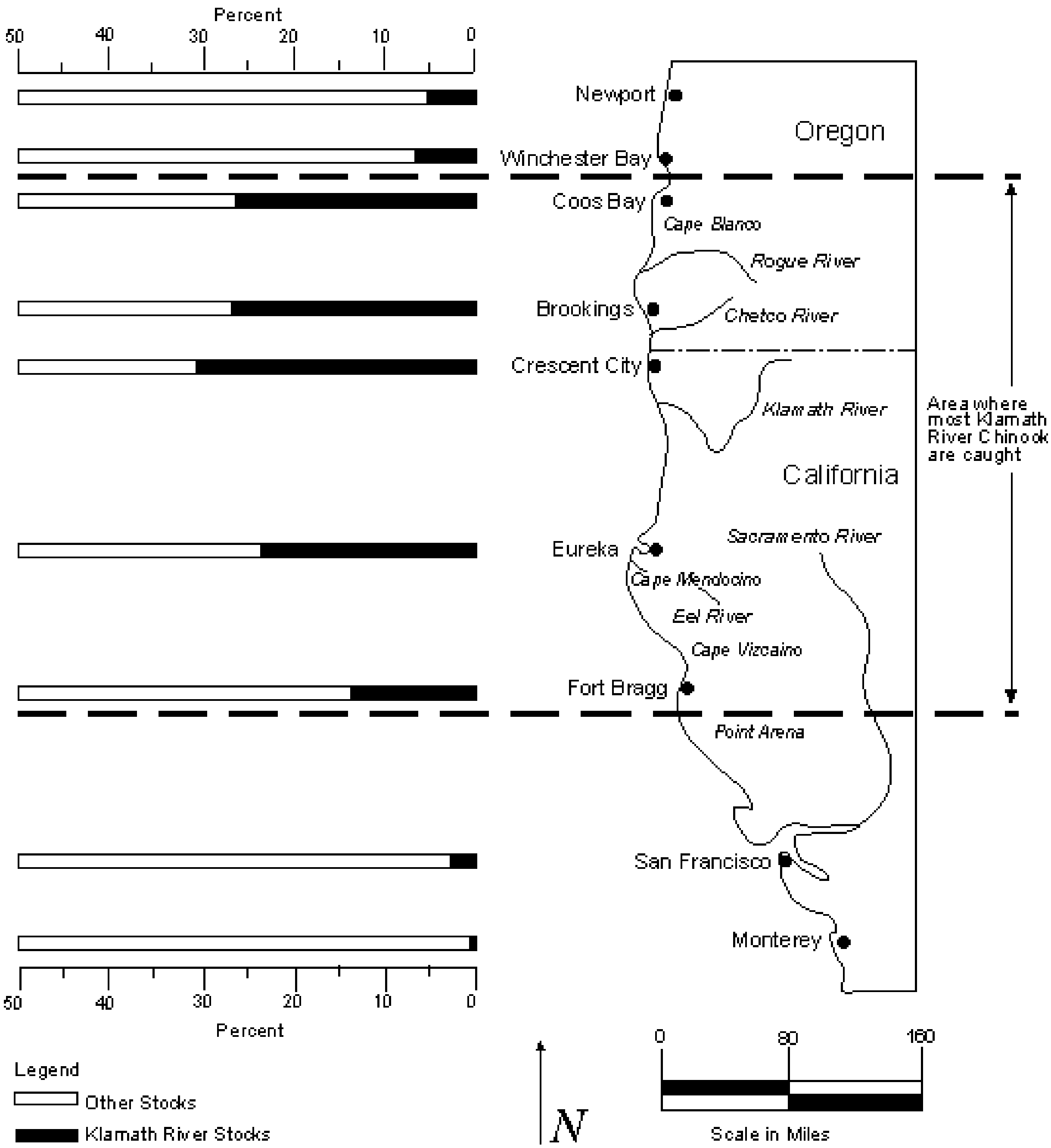
Figure 1

Distribution of Recoveries of Coded Wire Tagged Klamath Fall Chinook in the 1979–1983 Ocean Fisheries



Source: US Dept. of Interior (1985), maps prepared by CH2M Hill

Figure 2
Contribution of Coded Wire Tagged Klamath Fall Chinook by Port in the 1979–1982 Ocean Fisheries



Source: US Dept. of Interior (1985), maps prepared by CH2M Hill

ATTACHMENT 5

Aaron J. Douglas Klamath Fishery Values Report

FINAL PRE-PUBLICATION COPY 12-03

Making Unbiased TCM Benefits Estimates with Klamath River Basin TCM and Contingent Use Data

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ABSTRACT

Several northern California coastal rivers provide important regional social and economic benefits. California's lower Klamath River provides recreationists with an ensemble of activities including swimming, wading, canoeing, whitewater rafting, and angling. In the early 1900's, the Klamath was widely regarded as one of the nation's finest salmonid fishing streams. In this paper we estimate the nonmarket recreational benefits provided by the lower Klamath River with the travel cost method (TCM), and compare the benefits with the costs of restoring the fishery. Klamath River anadromous fish runs have declined in size and viability during most of the post-World War II period, but the decline accelerated sharply during the 1980's and 1990's. Throughout this period, low river water quality has been a major causal factor underlying the decreases in fish stocks. The benefit-cost estimates of the current analysis provide baseline TCM estimates of $2.026531 billion ($7.327008 billion) per annum. Restoration benefits for the Klamath River (of the Klamath-Trinity system) are estimated by combining the baseline TCM estimates with survey based contingent use (CU) data. The combination of these two data types facilitate a comparison of the benefits and costs of improving the water quality of the Klamath River and the freshwater harvests of the Klamath-Trinity system.

1. Introduction

We use the travel cost method (TCM) and survey data to estimate the nonmarket recreation benefits provided by California's lower Klamath River. We also present a new "alternative" TCM consumer surplus model. We argue that conventional TCM techniques overestimate aggregate trip expenditures and regional employment effects. On the other hand, conventional TCM consumer surplus (CS) estimates have a negative bias. This particular set of issues comes to the forefront in the Klamath and Trinity River (Douglas and Taylor, 1999) TCM benefits estimates because aggregate recreation trip expenditures for these rivers are quite large and have a notable economic impact.

The TCM data were gathered from a survey distributed to users of the lower Klamath River and its major tributaries in the winter and spring of 1997-98. A similar Trinity River recreational survey was distributed in this region in 1993-94. Hence, survey respondents were informed that water based recreation trips to the "Lower Klamath River Basin" are trips to "the Klamath River below Iron Gate, all tributaries of the mainstem Klamath River and any streams that flow into Klamath River tributaries--except for the Trinity River".

The headwaters of the Klamath River are in southern Oregon above Klamath Lake (see Figure 1). The Iron Gate and Copco Dams divide the Klamath River into lower and upper reaches; only the lower reach has anadromous fish (Quinn and Quinn, 1983). The Klamath River Development Project (project) has major adverse water quality impacts on both the upper and lower basin (Klamath River Basin Fisheries Task Force, 1991; listed hereafter as "Task Force, 1991").

2. Klamath River Basin Water Management Issues

The Klamath River Development Project

Oregon and California passed legislation ceding lands to the project in 1902; construction began in 1905. The project delivers water designated by U.S. Bureau of Reclamation contracts to 240,000 acres of project land (U.S. Bureau of Reclamation, 2000). The dams, tunnels, canals, and pumping stations of the project are designed so that project waters can be reused several times. The mean per acre net use for project water is 2.0 acre-feet; in 1999 roughly 199,000 acres were irrigated with 400,000 acre-feet of water. The value of the irrigated crops produced on project lands in 1999 was $104 million ($112.3 million in 2002 dollars) (U.S. Bureau of Reclamation, 2000).

The project drains land in the lower Klamath and Tule Lake regions, diverts and stores irrigation water supplies, and prevents flooding on the drained lands (U.S. Bureau of Reclamation, 2000). The Lost River provides substantial quantities of project water although the Klamath is the major source of project irrigation water. Contaminant loading from runoff in the upper basin has adverse aquatic habitat impacts on the lower basin (Task Force, 1991). Klamath River Basin substrate formations contain large amounts of phosphorous and the underground movement of the agricultural return flows does not lower phosphorus levels in the water (Campbell, 2001).

Water Resource Management Issues

The mainstem of the Lower Klamath River is about 190 river miles in length (Quinn and Quinn, 1983). The major tributaries of the Klamath--the Trinity, Shasta, Scott, and Salmon Rivers--are northern California Rivers (see Figure 1). Before the development of the Klamath River Basin project, the mean annual flow (maf) of the Klamath River at Weitchpec was about 1.4 million acre-feet. The maf of the Klamath River at Weitchpec is now about 1.6 million acre-feet (U.S. Bureau of Reclamation, 2000). However, before the completion of the Trinity River project in 1964, the maf of the Trinity River at Weitchpec was 1.2 million acre-feet. It is now about 340,000 acre-feet per annum. Trinity River water diversions have sharply lowered Klamath River flows below Weitchpec and produced major adverse impacts on Klamath-Trinity system fish stocks (Task Force, 1991; Bartholow, 2001).

The Klamath River Basin Act (P. L. 99-552) of 1986 notes that "floods, the construction and operation of dams, diversions and hydroelectric projects, past mining, timber harvest practices, and road-building have all contributed to sedimentation, reduced flows, and degraded water quality which have significantly reduced the anadromous fish habitat in the Klamath River system". The act authorizes funding for a 20-year Federal-State cooperative Klamath River Basin Area Restoration Program to rebuild Klamath River Basin fish stocks.

The Water Resource

Figure 1 gives one only a hint of the diversity of the water resources of the lower Klamath River Basin. There are 44.1 river miles in the Salmon, 30.1 miles in the North Fork of the Salmon, 63.6 miles in the Scott, and 43.6 miles in the Shasta River. Dozens of small creeks and streams flow into the Shasta, Scott, Salmon and mainstem of the Klamath River. Hence, there are more than 400 water miles in the lower Klamath River Basin. There are no impoundments on the mainstem of the lower Klamath River.

The recreational activities provided by the lower Klamath River and its tributaries include swimming, wading, canoeing, whitewater rafting, angling, and shoreline activities (Quinn and Quinn, 1983). A fish hatchery at Iron Gate annually releases millions of chinook (king), coho (silver) salmon, and steelhead (trout) fingerlings into the Klamath River (Quinn and Quinn, 1983). The hatchery output has helped sustain regional tribal, marine, and sportfishing harvests. However, declines in Klamath-Trinity system stocks are a major concern (Task Force, 1991).

The river provided habitat for several endemic species including American eel, green sturgeon, white sturgeon, American shad, coast cutthroat trout, steelhead trout, chinook (king) salmon, and coho (silver) salmon (Quinn and Quinn, 1983). Species native to the estuarine area near Requa include surf smelt, starry flounder, and redtail surf perch (Quinn and Quinn, 1983). The freshwater anadromous sport fish harvests below Weitchpec in the 1950's rose to more than 100,000 fish per annum. The Klamath River Basin survey notes that in the mid-1980's, the average annual harvest on the mainstem was in the 8,000-12,000 fish per annum range although large harvests rose as high as 18,000 fish. The survey assumes that the mean current fresh and marine sport harvests for the lower Klamath Basin are 25,000 fish per annum and that sustained sport harvests of 38,000 (50% increase) and 50,000 (100% increase) are feasible (Task Force, 1991).

3. The Klamath River Survey

The Center for the Resolution of Environmental Disputes (CRED), a northern California based not-for-profit organization, distributed marine and freshwater printed surveys in the winter-spring of 1997-98. CRED supplemented the survey data base with responses to a streamlined phone version of the survey. The phone survey omitted contingent use (CU) queries but included contingent valuation method (CVM) willingness-to-pay (WTP) questions. The phone survey was administered "cold"; respondents did not see printed versions of the survey questions before being contacted by phone calls. The entire survey was also administered over the phone to mail survey non-respondents.

The marine survey preamble designated "a region around the mouth of the Klamath River Basin as being the area in which augmented Klamath-Trinity River fish stocks would have the greatest positive impact on the marine sport fishing harvest". The region stretches from Fort Bragg to Gold Beach just north of the California-Oregon border.

Response Rates

There were only 382 responses to the initial mail-out of 1010 surveys. However, an additional 234 surveys were obtained from a follow-up phone survey administered to non-respondents. Finally, there were 200 responses to the streamlined version of the phone survey in the data base. Thus, 816 completed surveys were returned to CRED, and 809 responses were used in the economic analyses. After address unknowns and mail-outs to non-user households are excluded, there were only 749 potential responses in the initial mail-out. Thus, the response rate (*R.R.*) for the initial mail-out was *R.R.* = (382)/749 = 51.01%; for the phone survey, *R.R.* = (200)/204) = 98.03%; and for the 234 follow-up phone responses *R.R.* = 100%. For the composite data base, *R.R.* = (809)/(953) = 84.8898%.

Participation Rates

CRED randomly called 200 households in Nevada, California, Oregon, and Washington (e.g., 800 households in the western U.S.) and asked if they had been to the Klamath River in the last 3 years. The participation rate is the positive response rate percentage divided by 3. The participation rate(s) are 0.5% for Nevada, 1% for California, 9% for Oregon, and 0% for Washington.

There were 676,000 Nevada households, 11,446,000 California households, and 1,286,000 Oregon households in 1998 (U.S. Bureau of the Census, 2000). Hence, 233,580 households made recreation trips to the lower Klamath River in 1998 including: (1) 3,380 Nevada households, (2) 114,460 California households, and

(3) 115,740 Oregon households (we estimated the number of households with 1998 data and used 1997 dollars to estimate benefits).

4. The TCM data

Foregone Wages

The mean income of the respondents was $64,880.24 (668 cases) in 1997 (1997 dollars). The conventional estimate of mean per trip foregone income is the product of the average trip time and the hourly family wage rate. The mean hourly income is the mean family income divided by the number of hours in 365 days (8,760 hours). The mean hourly family income was $7.4064. For TCM studies the estimation of aggregate foregone wage (FW) is problematic. A graduate textbook notes that: "Another difficulty with the travel cost approach is the unobservable value of time involved for site visits. The greater the travel distance, the less attractive a site becomes, not only because of direct monetary expense but also because of time spent driving, and so on." "Appropriate valuation of user costs necessarily involves determination of leisure time foregone; otherwise, user costs do not adequately reflect true marginal benefits" (p. 292; Just *et al.*, 1982).

We use a household wage rate in this paper. Contractual rigidities that prevent an individual from adjusting his hours worked in response to economic factors do not prevent a family from making large shifts in hours worked through entrance into and exit from the labor force by household members.

Transient Visitors

"Transients" provided cost data for trips but did not usually make recreation trips to the lower Klamath River Basin and reported zero trips for the last 12-months. All survey "transient" respondents made at least one recreation trip since 1990. The trips variable we use for the Klamath River data survey analyses is the number of usual trips if it is available, and if it is unavailable, trips for the last 12-months. We imputed a small number of trips for transients, thereby adjusting the original estimate of 7.5520 trips per annum upward to 10.0646 trips (697 cases).

There were 571 non-transient respondents and 128 transients; 56% of the transients made a visit less than 36-months prior to receiving the survey. The maximum number of imputed trips for the transients was 5 (imputed to 8 transients) and the minimum number was zero (imputed to 44 transients). Thus, 6.3% of the 697 cases were "zeros" (e.g., cases with positive costs and zero trips) (Creel and Loomis, 1990).

The probability of imputing a non-zero value to a transient was a monotonically increasing function of the year last visited. The probability of a non-zero value was 0.88888 for those who visited in 1997 and 0.11111 for 1990 visitors. If a transient lived within 50 miles of the site, she was imputed 5 trips. If she lived more than 400 miles from the site, she was imputed 1 trip. Respondents who usually made trips to the site and lived within 50-miles of the site made about 50 trips per annum (sample mean).

The mean (maximum) one-way distance of a trip to the usual site was 268.1628 miles (3,000 miles), and the average (maximum) cost of a trip was $469.131 ($6480). Although no transit time data are available, time on-site data are available for all three sub-samples and we used these data to estimate the value of aggregate foregone wage (FW). We used 6,000 hours on-site--about 8 months and one week--as the cutoff point for outliers for total time on-site. We estimate labor's share of national income to be 78.877% of national income by averaging data from Table 700 of the 1997 *U.S. Statistical Abstract* (U.S. Bureau of the Census, 1998) for 1992-96 and assume that 25% of proprietary income is a return to capital. Hence foregone hourly wages are $5.84195. Because we deduct property income from foregone income, we did not attempt to weed out retiree income. Thus, the use of the conventional methodology indicates that the mean time on-site was 2045.5001 hours, and mean annual FW was $11,949.7015 (547 cases). However, the conventional methodology produces a sharp upward bias in the estimate of aggregate FW.

5. A New Approach to Making TCM Consumer Surplus Estimates

The Definition of Consumer Surplus; the TCM and Consumer Surplus

The consumer surplus (CS) is a generic measure of the benefits provided by a market good or service. The TCM estimates the CS for recreation trips. The CS is the triangular area bounded from above by the demand curve, from below by the horizontal line linking the vertical price axis to the equilibrium price, and by the price axis (see Figure 2). Let p (p_e) be (the equilibrium) price, q be the number of items purchased per unit time, and $f(p)$ be the demand curve. If $U > p_e$ is the choke price shuts off demand, the CS is the definite integral

$$CS = \int_{p_e}^{U} f(p)dp . \qquad (1)$$

Let *y* be the trips in the last-12-months, *d* be roundtrip travel distance in miles, *e* be trip expenses, *tc* = (*c***d*) be "travel cost" in dollars, and let the regression model be

$$y = K + b_1(tc) + b_2(e) \; ; \quad K > 0,\ b_1 < 0,\ b_2 < 0 . \qquad (2)$$

The variable of integration is the "active" price variable, and the other price variable is an "auxiliary variable". To evaluate the definite integral, the product of the estimated coefficients of the auxiliary variables and the respective sample means are added to *K* to form a grand constant $G = K + \sum(b_i)(\overline{x}_i)$. Because *tc* is the active price for most TCM studies, Douglas and Taylor (1999) multiply $(CS)_e$ by *r*, $r = tc_m/e_m$, $0 < r < 1$ to convert $(CS)_e$ into a number comparable to $(CS)_{tc}$. We also use this procedure, and for the Klamath River data C.F. = *r* = (\$166.261/\$469.131) = 0.354401939 (the Trinity C.F. = 0.3086566).

If the choke price is infinite we could use the largest sample value of *tc* as the upper limit of integration because everyone who makes a trip receives at CS of at least a dollar (Douglas and Taylor, 1999). However, because the largest value varies sharply across data sets, Douglas and Taylor (1999) suggest setting the upper limit of integration so that it is 55%-75% of the maximum sample value.

A Source of Upward Bias

Let $E_s(tc)$ be the mean travel cost for the sample, $E_s(y)$ be the mean number of trips per household for the sample, $E_s[(tc)(y)]$ be the sample mean value of annual household trip expenditures, *TE* be aggregate expenditures for the sample, and N be the number of households making trips. An unbiased estimate of total expenses is

$$TE_u = N\{E_s[(tc)(y)]\} . \quad (3)$$

However, economists estimate TE as $(TE)_b = \{(N)[E_s(tc)E_s(y)]\}$. If COV(tc, y) is the covariance of *tc* and *y*, the conventional estimate of TE is biased;

$$TE_b = TE_u - COV(tc, y) = N\,E_s[(tc)(y)] - COV(tc,y) . \quad (4)$$

Because COV (tc, y) < 0, the conventional estimate of TE has an upward bias. Moreover, the conventional estimate of the CS underestimates benefits. We estimate p_e, the cost of a trip, as $p_e < E_s(tc)$;

$$p_e = \frac{E_s[(tc)(y)]}{E_s(y)} . \quad (5)$$

The use of this formula increases the estimated value of the TCM CS. If the demand curve is fixed and the supply curve shifts to the right because the social cost of producing the good decreases in a competitive market, the same number of items can be purchased with smaller aggregate expenditure and the social cost of supplying the good decreases (see Figure 3). The CS "triangular area" will increase (see Figure 3). Because the TCM CS is a simulation of a competitive market CS, the decrease in expenditures for trips should generate a correlative increase in the TCM CS. Note that we can and do make unbiased estimates of aggregate foregone wages by estimating the sample mean for the product of time on-site, household wages, and trips.

6. Klamath River Regression Models

The Household Regression Models

We provide regression results for household level and aggregated household data because household level TCM models often produce mediocre fits (Mitchell and Carson, 1989; Hof and King, 1992). We experimented with little success with linear and log-log ordinary least squares (OLS) models as well as Poisson, negative binomial, and Box-Cox maximum likelihood household data models. The Klamath River inverse price model does have high t-values (see Table 1). All of the regressions were run in Limdep™ (Version 7 for DOS; see Greene, 1995). The small finite choke price of the semi-log model precludes using the model to make CS estimates.

We recalculated the Trinity River *CS* with new limits of integration for a

Table 1. Household data OLS TCM regression models for the Klamath and Trinity Rivers. Usual trips is the dependent variable; t-values, p-values (two-sided test), and adjusted R^2 are listed in parentheses.

Klamath Model type	Intercept	Coefficient for TC	Coefficient for E	R^2 and F-statistic
Semi-log (665 cases)	76.500 (t = 13.261) (p = 0.00000)	- 14.710 (t = - 12.116) (p = 0.00000)	--------	0.18128 (0.18005) F = 146.80
Inverse price (649 cases)	0.55749 (t = 0.38917) (p= 0.69716)	19.926 (t = 6.7746) (p = 0.00000)	537.91 (t = 9.873) (p = 0.00000)	0.20019 (0.19772) F = 80.85
Trinity	--------	--------	--------	--------
Inverse price (617 cases)	1.9984 (t = 2.833) (p = 0.00461)	9.6996 (t = 11.566) (p = 0.00000)	60.686 (t = 10.305) (p = 0.00000)	0.38800 (0.38600) F = 194.63

new inverse price model so that the Klamath and Trinity River CS estimates are comparable. Thus, we use the same $0.31 per mile *tc* for both data sets (Douglas and Taylor, 1999). A dollar is added to the expenses variable and $0.155 is added to *tc* for both data sets to avoid dividing by zero. The lower limits of integration are determined by equation (5) for both data sets.

The grand constant *G* can be estimated in two ways with an inverse price model. Namely, the coefficient of the passive price variable can be multiplied by the inverse of the mean value of the price or by the mean value of the inverse. If the latter procedure is used to estimate *G*, the model passes through the means of the variables. The former method typically produces estimates of aggregate trips and the CS that have a downward bias. The original Trinity River CS value is the average of a large unbiased CS estimate and a biased estimate equal to roughly 50% of the unbiased value (Douglas and Taylor, 1999). We use the unbiased estimates.

The Aggregated Data Models

One set of aggregated data was generated by 33 groups sequestered by $100 intervals. Thus, the first point is the mean number of trips, the mean expenses, the mean travel cost, mean one-way distance, and mean income for those respondents whose (mean) trip expense *e* was between $0 and $100. The last data point for the aggregated models was generated by the mean values for respondents whose mean expenses are greater than $4,000. The intervals used for this type of aggregation are called "bins". For this data set, only 33 bins had both trips and expenses data.

The distance counterparts to the aggregate expenses models have 36 data points. For this data set, there are (potentially as many as) 40 data points formed by estimating mean values for (usual) trips, expenses, travel cost, one-way distance, and income for bins formed by 15 mile increments. The final bin was composed of data from households whose one-way travel distance was greater than 600 miles. However, only 36 bins had both trips and distance data for the relevant interval (see Tables 2 and 3).

Table 2. Two weighted Klamath River OLS TCM regression models. The data points are 33 cases formed by estimating the mean values for trips, expenses, travel cost, and income for groups defined by $100 increments in expenses.

Model type	Intercept	Coefficient for TC	Coefficient for E	R^2 and F-statistic
Log-log model	4.1225 (t = 11.555) (p = 0.00000)	--------	- 0.61522 (t = - 7.540) (p = 0.00000)	0.64714 (0.63576) F = 56.85
Inverse price	0.27134 (t = 0.333) p = 0.74167	--------	362.73 (t = 17.235) (p = 0.00000)	0.90550 (0.90245) F = 297.04

Table 3. Coefficients for two weighted Klamath River OLS TCM regression models. The data are the mean values for trips, expenses, travel cost, and income for 36 groups defined by 15 mile distance increments.

Model type	Intercept	Coefficient for TC	Coefficient for E	R^2 and F-statistic
Log-log	5.1089 (t = 9.896) (p = 0.00000)	- 0.84447 (t = - 7.650) (p = 0.00000)	--------	0.63253 (0.62172) F = 58.53
Inverse price	0.11753 (t = 0.119) (p = 0.90635)	333.73 (t = 22.100) (p = 0.00000)	--------	0.93492 (0.93300) F = 488.41

7. Aggregate Expenditures, Foregone Wages, and Data Alignment

Recall that the product of the sample means for trips and expenses produces a biased estimates of mean household trip expenditures. Unbiased estimates of household and aggregate trip expenditures can be obtained as the sample mean value of the product of expenses and trips. If the mean sample size of the groups visiting the river is greater than the size of the average household, the CS and aggregate expenditures must be adjusted downward.

On the other hand, a correlative inverse upward adjustment must be made to FW. The sample mean size of the Klamath River trip groups is 4.16496 people and the mean size of respondent households is 2.88344. Thus, aggregate expenditures and the CS must be adjusted by multiplying the household values by (2.88344)/(4.16496) = 0.69230917. The FW must be adjusted by (4.16496)/(2.88344) = 1.4444614. The correlative values for the Trinity River are 3.331524 (household size) and 3.986322 (group size), and the adjustment factors are 0.83573881 and 1.1965461 (see Table 4).

We made an inflation rate adjustment of 1.11073 for the Klamath and 1.24498 for the Trinity River and a population growth adjustment of 1.129168 for the Trinity. We used population growth data for California, Nevada, and Oregon to estimate the Klamath River user household population for 2002 (246,041). Our recent inflation data came from the U.S. Department of Labor's online consumer price index (CPI) inflation calculator (http://www.bls.gov.cpi). Recent population data are also online (Family Education Network; http://www.infoplease.com) (both sites accesed in November,

Table 4. Conventional and unbiased estimates of annual household trip expenditures and FW in 1993 (Trinity) and 1997 (Klamath) dollars; conventional and unbiased aggregate expenditures and FW in 2002 dollars and population base for both rivers; and the present value of the 2002 Klamath-Trinity unbiased expenditure estimates (discount rate of 7.5%; cases are in parentheses).

Klamath River	Expenditures	Foregone Wages
Conventional household	$4,721.6382	$11,949.702
Unbiased household	$1,969.8817 (676)	$2,560.8692 (560)
Conventional aggregate	$893,316,485	$4,717,127,450
Unbiased aggregate	$372,696,095	$1,010,899,423
	-----------	-----------
Trinity River		
Conventional household	$3,312.3886	$5,742.3965
Unbiased household	$1,353.3667 (634)	$2,238.0771 (1172)
Conventional aggregate	$2,769,233,443	$8,714,047,949
Unbiased aggregate	$1,131,445,861	$2,636,090,854
	-----------	-----------
Unbiased Klam.-Trin. P.V.	$20,055,226,080	-----------

2003). Population and price data data are also available in the *U.S. Statistical Abstract* (U.S. Bureau of the Census, 2000) series. We assume that the growth in households is proportional to the growth in overall population.

We use the number of respondents per bin as weights for weighted regressions for the aggregated data sets. Weighting is widely used in situations similar to ours in which the precision of the dependent variable increases with the number of cases. The weighted mean of trips is equal to the mean of the trips variable in the original data set.

We also apply a linear transform to the observations of the independent variables so that they have mean(s) equal to their original counterparts. For the linear and inverse price models the transform did not affect any model statistics--including R^2, t-values, and F-statistics--but there was a slight effect on the statistics of the log-log models. The back-transform is an "ad hoc" procedure for the log-log models. We use the expenses-to-travel cost C.F. to estimate the lower limit of integration for *tc*. Aggregate CS estimates based on the assumption that each trip is made by a household must be adjusted downward by the ratio (2.88344)/(4.16496) = 0.69230917. The lower limit of integration for the household CS expenses (tc) estimates for the Klamath is \$195.72379 (\$69.364883) and for the Trinity it is \$226.27010 (\$69.839750) (see equation (5)).

8. Contingent Use (CU) Data and Benefits Estimates

In the ensuing benefit versus cost analysis we use \$2.0265312 billion per annum (1997 dollars; see Tables 5 and 6) as the baseline benefit estimate for the restoration of the Klamath River and its major tributaries (except for the Trinity River). The counterpart value for the Trinity River is \$7.1298250 billion per annum in 1997 dollars.

The Klamath River survey queried respondents about the increments in trips generated by certain amenity improvements including: (1) a 45% increase in water quality, (2) a 50% increase in angling harvests, and (3) a 100% increase in angling harvests. These queries provided our contingent use (CU) data Note that the maximum feasible improvement in chlorophyll loading in the

Table 5. Annual per household CS estimates for Klamath and Trinity River TCM models household data models in 1997 dollars, and Klamath River aggregated data TCM model CS estimates in 1997 dollars.

Klamath Models	Raw Benefits	Expenses C.F.	Log C.F.	Final Version
Exp. CS values				
Table 1. Inv. Exp	$9,241.8248	0.354401939	-------	$3,275.3206
Table 2. log-log	$2,681.3058	0.354401939	2.17880109	$2,070.4274
Table 2. Inv. Exp	$2,128.5013	0.354401939	-------	$754.3450
TC CS values				
Table 1. Inv. tc	$7,188.8191	-------	-------	$7,188.8191
Table 3. log-log	$1,148.5356	-------	2.79436340	$3,209.4265
Table 3. Inv. tc	$1,084.9498	-------	-------	$1,084.9498
Trinity Model				
Table 1. Inv. Exp	$15,306.6411	0.308656555	-------	$4,724.4951
Table 1. Inv. tc	$7,594.6240	-------	-------	$7,594.6240

Table 6. Aggregate annual CS, FW, and total benefits estimates for recreation trips to the lower Klamath and Trinity Rivers in 1997 dollars and population levels. System benefits are the sum of values in rows 3 and 6.

Klamath River	Consumer surplus	Foregone wages	Total
Table 1. Inv. Exp.	$529,650,705	$864,030,335	$1,393,681,040
Table 1. Inv. tc	$1,162,500,888	$864,030,335	$2,026,531,223
Trinity River	-----------	-----------	-----------
Table 1. Inv. Exp.	$3,011,274,739	$2,289,202,039	$5,300,476,778
Table 1. Inv. tc	$4,840,622,949	$2,289,202,039	$7,129,824,988
Klamath-Trinity	CS	FW	Total
Grand sums	$6,003,123,837	$3,153,232,374	$9,156,356,211

waters of the lower Klamath River Basin is 45% (Campbell, 2001). Chlorophyll produces algae blooms which create malodorous waters, painful skin rashes on contact, and fish kills.

CU data can be validated by on-site counts estimating the change in visits induced by an amenity improvement (Duffield *et al*., 1992). CU non-responses were estimated at either 30% (small number of non-respondents) or 25% of the value for respondents. To convert increments in trips to increments in benefits, the percentage increment in trips was multiplied by the baseline value of $2.0265 billion per annum. We have information about the qualitative importance of the various restoration activities, but no quantitative data about the impact of the various activities. Therefore, we simply sum the costs for four major restoration activities and compare them with the sum of the present values (see Table 7) of the CU-TCM benefits estimates for a 45% water quality improvement and a 100% sport fish harvest enhancement.

9. Habitat Restoration Costs

We estimated the present values in 1997 dollars for the costs of: (1) the purchase of project farmland; (2) the purchase of environmentally sensitive forested land; (3) increasing Trinity River instream flows; and (4) the removal of some Klamath River dams. We used 1992 and 1997 data in Table 1103 of the *U.S. Statistical Abstract* for 2000 to estimate the cost of acquiring the 240,000 acres project farmland. In 1997, there were 17.4 million acres of Oregon farmland with a value of $16.316 billion. Hence the mean value of an acre was $16,316 million/17.4 million acres = $937.70 per acre. We multiplied

Table 7. Klamath River CU-TCM values in 1997 dollars. Annual values are 10.0646 for trips and $2.0265 billion for the CS plus FW.

Amenity Improvement	Increment in trips	90% Confidence limits	CU-TCM benefit increment in millions
45% increase in water quality	1.3449929 (13.3636%)	±0.3336213 (±24.8047%)	$270,817,529
50% increase in angling harvest	1.5176829 (15.0794%)	±0.3190164 (±21.01902%)	$305,589,074
100% increase in angling harvest	2.2468121 (22.32391%)	±0.5200510 (±23.1462%)	$452,400,978
45% increase in water quality plus 100% increase in harvest	3.591805 (35.6875%)	--------	$723,218,506

$937.70 by 240,000 to derive the value of project farmland.

We estimated the annual cost of increasing the Trinity River maf from 340,000 to 840,000 acre-feet per annum--$42.897 million in 1993 dollars--by adjusting the published value for inflation to $47.622 million in 1997 dollars and then discounting at 7.5% (Douglas and Taylor 1998).

We imputed the same CS per kilowatt hour (KWH) for the Klamath River PacifiCorp complex as that provided by the Trinity River Bureau of Reclamation complex. The CS is the price differential per KWH between electric power from all sources and Trinity River hydropower times the number of KWH. The 1997 annual output of Copco #1 and #2, J. C. Boyle, and Iron Gate Dams was 916.676 million KWH (Prendergast, 2001). We adjusted the estimated value of $20.625 million for inflation and discounted the annual value by 7.5%.

There are nearly 10,000 acres of forested lands within 200 feet of the river channels of the lower mainstem Klamath and the Scott, Shasta, and Salmon Rivers. Because there are numerous creeks that empty into the mainstem Klamath we estimated the cost of acquiring a 20,000 acre buffer strip around the rivers and streams of the lower basin. There are 622,760 acres located on slopes of more than 20% (rise over run) within 2 miles of the Scott, Shasta, Salmon and the lower mainstem Klamath (Giles, 2001). We used $1200 (buffer strips) and $800 (steep slopes) per acre as acquisition costs (Frey, 2001; see Table 8).

The present value (7.5%; 1997 dollars) of the costs for 3 minor habitat restoration activities are: (1) $50,000,000 for channel management (U.S. Bureau of Reclamation, 1997), (2) $25,000,000 for wetland and farmland re-vegetation and restoration, and (3) $25,000,000 for the removal of project infrastructure and dam alterations (Bartholow, 2001; Campbell, 2001; Flug, 2001; Henriksen, 2001).

The Trinity River CS plus FW estimates for putting more water down the Trinity should be included in our analysis. The Trinity River annual TCM baseline benefits estimate listed in Table 6 is $7.12982499 billion. The annual CU-Trinity increment is 33.9639447% of total benefits, hence the annual Trinity River CU-TCM incremental value is $2.4215698 billion. The annual

Table 8. Present values for benefits and costs of major water quality improvement and aquatic habitat restoration activities in 1997 dollars.

Major activity	Cost	Klamath River TCM-CU benefit P.V.
Acquire Project farmland	$225,048,276	$9.64291342 billion
Acquire forest land	$522,208,000	$9.64291342 billion
Trinity River water	$634,965,398	$9.64291342 billion
PacifiCorp hydropower	$324,067,176	$9.64291342 billion
Total habitat restoration cost	$1.7062889 billion	$9.64291342 billion

Klamath-Trinity system CU-TCM increment is $3.1447883 billion; the present value of the Klamath-Trinity CU-TCM increment is $41.93051095 billion (7.5% discount rate; 1997 dollars).

We include an estimate of the cost of a 24-month fishing moratorium. This ban would be similar to those of the 1992-95 period which--with limited exceptions--closed commercial marine salmonid harvesting from the Oregon-California border to Point Arena. The ban would include freshwater harvests. Annual ceremonial tribal harvests would be limited to 200-300 freshwater fish, and hatcheries would be operated in a mode designed to increase self-reproducing stocks of fish. If the fishery responded quickly to the habitat restoration measures, no ban would be imposed.

Karuk, Yurok, Hoopa Valley, and Klamath tribal members and commercial fishermen would be compensated (see Table 9). The target is $12,500 for every tribal member--hence a family composed of four tribal members would receive $50,000--and $16,665 for every commercial fisherman. We estimated payment costs for 15,000 tribal members including 13,617 members in the four principal tribes and 1,139 members of 5 smaller tribes (Risling, 2002). However, we did not verify the willingness-to-accept a 2-year fishing moratorium in exchange for our payment proposals with any tribal or commercial fishing organizations. There are 19,817 fishing related jobs in California, and we estimated payment costs for 20,000 workers in 1997 dollars (U.S. Bureau of Labor Statistics, 2001a, 2001b; see Table 9).

10. Statistical Reliability

The statistical reliability of TCM CS estimates has rarely been discussed in the literature. Let $\overline{x}$ be the sample mean value of x, S_x be the standard deviation, and $(S.E.)_x$ be the standard error of x. Formulas for $(S.E.)_x$, and $(C.L.)_x$ are

$$(S.E.)_x = \frac{S_x}{\sqrt{N-1}}; \qquad (C.L.)_x = \bar{x} \pm [(S.E.)_x]\, t_{(\alpha/2)}. \qquad (6)$$

Bootstrap C.L.'s of CS can be constructed with a computer by generating hundreds of virtual replicates of the original data set by drawing samples with replacement (Efron and Tibshirani, 1993). We computed bootstrap C.L.'s for our original CS estimates for the Klamath and Trinity Rivers. However, Limdep™ (ver. 7 for DOS) provides estimates of the standard deviation of the

Table 9. Costs of major, minor habitat restoration activities, and leasing of regional fishing rights versus the benefits from Trinity River enhanced flow and Klamath River fishery and quality restoration activities (1997 dollars).

Cost or benefit estimate	Present values for Costs	Trinity River Benefits P.V.	Trinity plus Klamath River Benefits P.V.
Minor restoration costs	$100,000,000	-------	------
Major restoration costs	$1.7062889 billion	-------	------
Leasing of Fishing Rights	$520,800,000 million	-------	------
Present value of benefits and all costs	$2.3270889 billion	$32.2875982 billion	$41.9305100 billion

unbiased estimates of the foregone wages and expenditures and we use the output in conjunction with the C.L. estimates for the CU-increments to make bottom-of-range estimates for the unbiased estimates of FW. The lower edge C.L. (90%) for the CU trips increments are 27.205579% (Klamath) and 29.714035% (Trinity). For the Klamath, the bottom-of-range C.L. (90%) estimate of aggregate annual foregone wages (FW) is $190,198,408 and the present value is $2.535978768 in 1997 dollars. The bottom-of-range present value for the CU linked FW increment for the Trinity is the $8.107475616 billion (1997 dollars, 1998 population), and for the Klamath-Trinity system it is $10.64345438 billion in 1997 dollars (see Table 10).

Unfortunately, we had no bootstrap C.L.'s for the CS for our revised CS estimates. However, our perusal of the bootstrap programming results indicate that: (1) the higher the R^2 (multiple correlation coefficient) the tighter the C.L.'s, and (2) the bottom edge of the C.L.'s span a range of about 25%-75% of the mean. If we use a lower C.L. that is 33% of the value of the point estimate of the CS for the Klamath-Trinity system, the C.L. for the CS has a present value of about $7 billion.

We used Limdep™ standard deviation estimates for trip expenditures to estimate a bottom-of-range C.L. (90%) for the CU expenditure increment generated by the restoration of Klamath-Trinity system water quality and fish stocks. The present value of the lower C.L. value is $4,929,243,541 in 2002 dollars for a 2002 population base (see Table 10).

10. Policy Implications and Concluding Remarks

The nonmarket benefits point estimates of restoring the Klamath River anadromous fish runs and improving water quality are much greater than the estimated costs of these amenity enhancements. Moreever, the policy implications of the controversial large CVM existence benefits estimates of river restoration by other economists (Loomis *et al.*, 1990; Welsh *et al.*, 1995; Douglas and Taylor, 1999) are supported by the present study. User CVM benefits are comparable to marginal TCM benefits as measured by survey CU data. Existence benefits are roughly comparable to CS TCM baseline benefits estimates. The Klamath-Trinity system annual baseline CS TCM estimate of $6.0031238 billion (1997 dollars and population) is large even by <u>national</u>

Table 10. Lower 90% C.L.'s for the Klamath-Trinity CU increment in trips expenditures (2002 dollars and population) and benefits (FW) in (1997 dollars, 1998 population) at 7.5% discount rate, and total restoration cost in billions of 1997 dollars (cost in billions of 2002 dollars in parentheses).

1997 (2002) Habitat Restoration Cost	2002 P.V. of CU Expenditure increment	1997 P.V. of CU Benefits Increment
$1.7062889 ($1.8952203)	$4.929243541	$10.64345438
----------	----------	----------
Habitat plus leasing		
$2.3270889 ($2.584759283)	$4.929243541	$10.64345438

survey existence benefits standards.

The Trinity River draws a large number of recreation trips from the large San Francisco-Oakland Bay Area. The Klamath draws a notable visitor contingent from the smaller Portland metropolitan area. Hence, rivers that draw visits from moderate sized urban areas but have attractive amenities can generate large TCM non-market benefits estimates.

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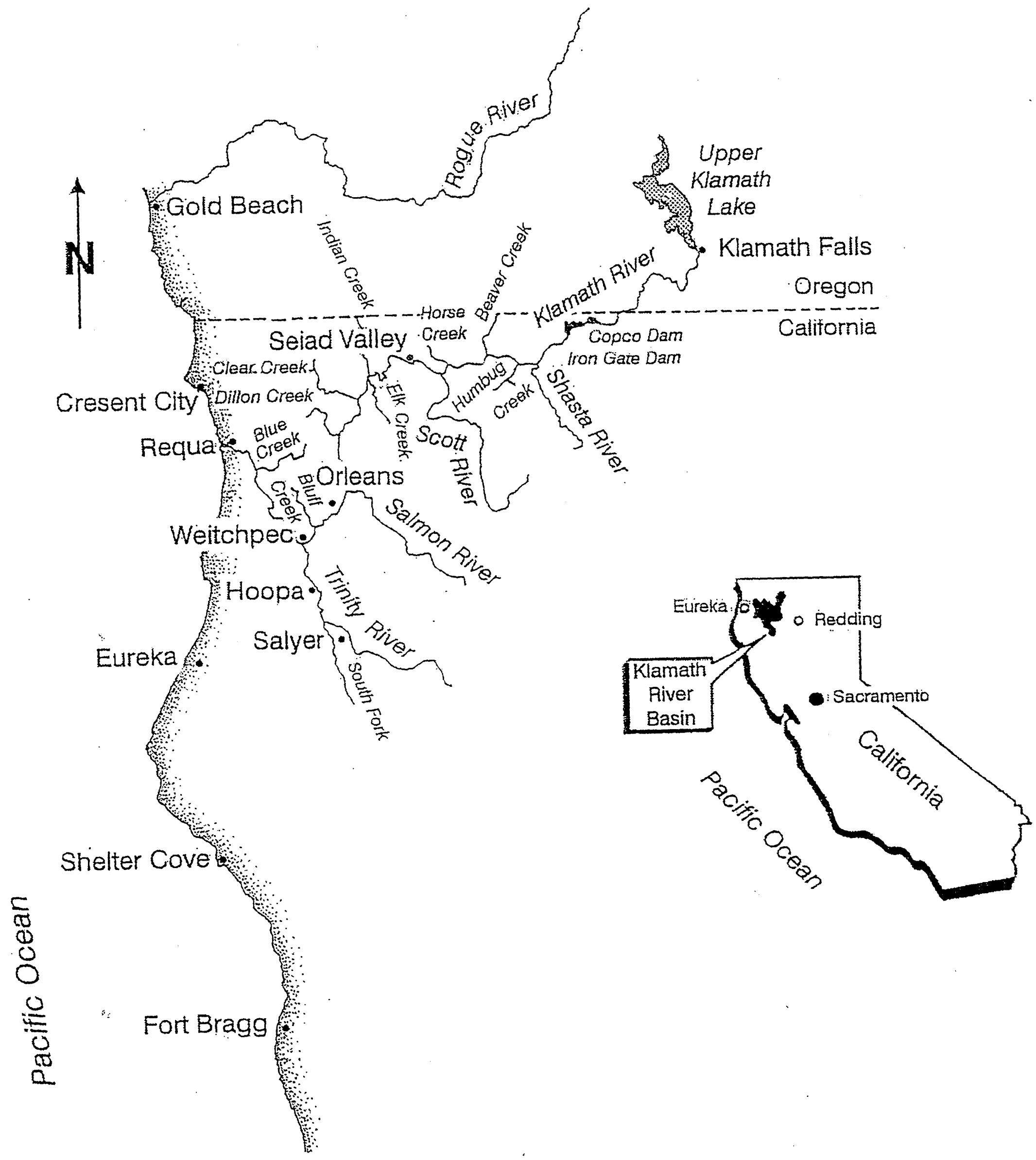

Figure 1. Map of Lower Klamath River Basin, the coastal zone, and major tributaries of the Klamath River.

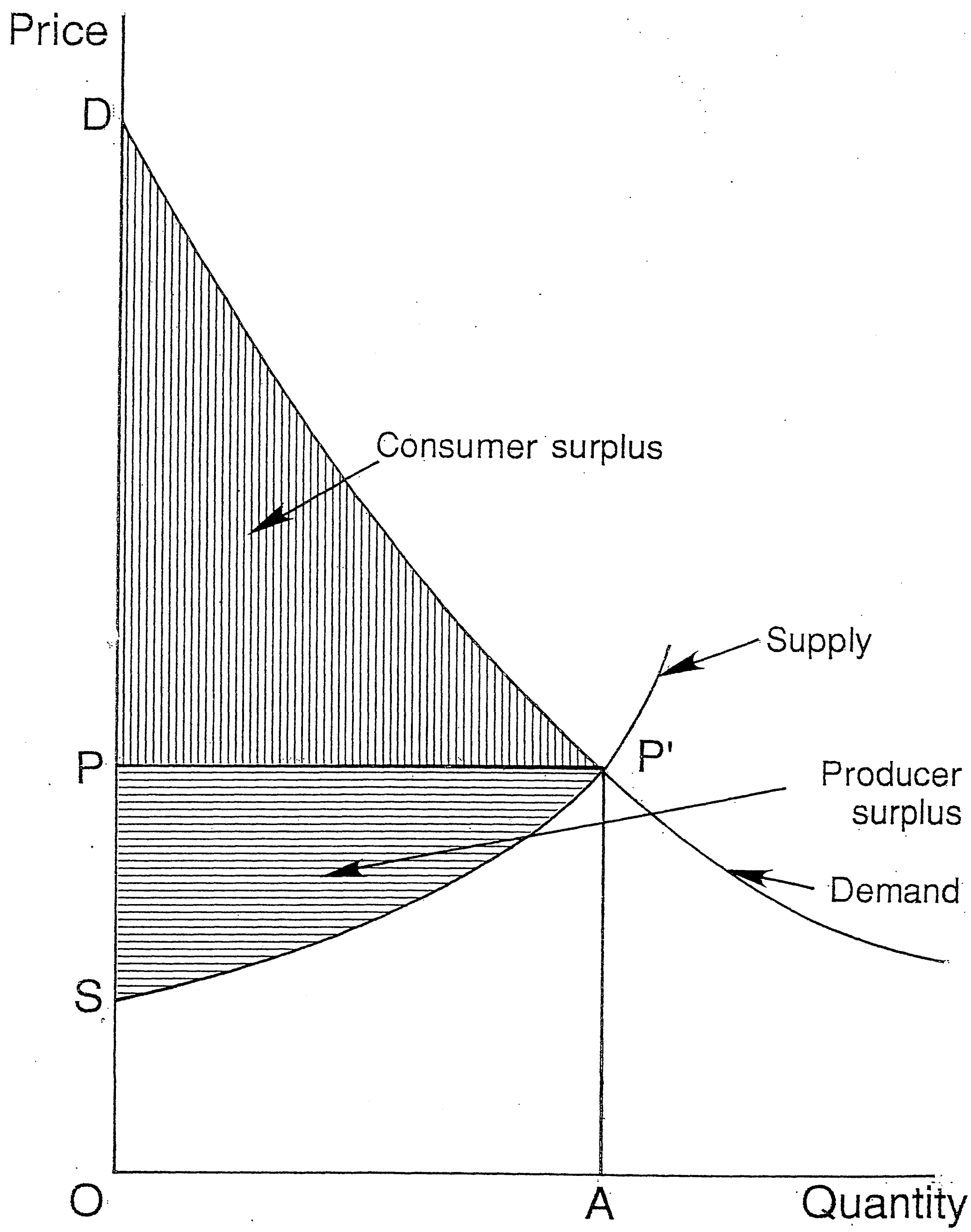

Figure 2. Diagrammatic representation of the consumer surplus and producer surplus components of the social benefits provided by a natural resource using market supply and demand curves.

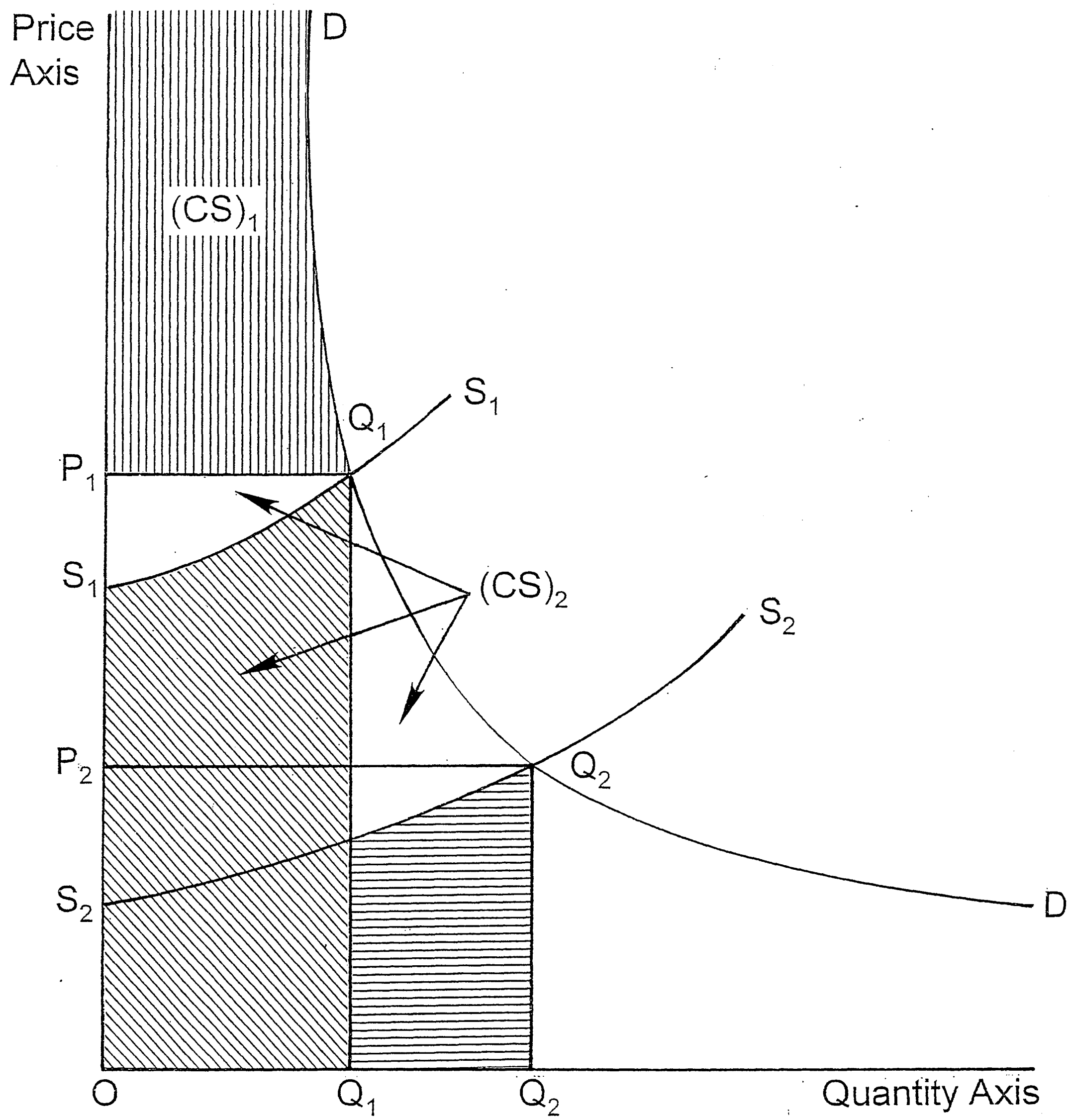

Figure 3. The supply curve shifts from S_1S_1 to S_2 S_2 but the demand curve DD remains fixed; the initial equilibrium price and quantity are $P_1$and Q_1. The area under DD above the horizontal line P_1Q_1 is the consumer surplus $(CS)_1$. The shift in supply increases CS to $(CS)_2$, the sum of CS_1 plus the 3 areas designated by arrows. The initial social cost is the area under S_1S_1 bounded by the line Q_1Q_1; the increase in supply shifts social cost to the area under S_2S_2 bounded by the vertical line Q_2Q_2. Thus, the social cost of output Q_1 decreases and the CS generated by producing Q_1 sharply increases.

ATTACHMENT 6

Fishery Values of the Klamath Basin, Meyer Resources (1984)

Fishery Values of the Klamath Basin

A Report to CH2M Hill

By Meyer Resources, Inc.

May, 1984

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I Summary of Benefits

The fish of the Klamath basin produce multiple benefits. They stand at the center of the Indian's culture and the fisherman's way of life. They provide food for both, for the coastal resident, and for the visitor. They produce significant business revenue in an economy where such opportunities are limited. They provide recreation to sportsmen of all ages. Their mere existence gives pleasure to many. Some of these values are presented in dollar terms in this report. Others are social or cultural and require more descriptive treatment. These benefits are arrayed in Table I in summary form.

Table I

Potential Annual Benefits Associated With a Catch of 1 '000 Adult Klamath Salmonoids

Benefitting Group	Business Benefits $	Non-Market Benefits in Dollars $	Subsistence, Cultural, Religious & Social Benefits
Commercial Fishermen			-Supports way of life.
- Chinook	22,090		-provides 7000 to 7500
- Coho	14,040		lbs. of food.
Sport Fishermen			-provides 7000 to 7500
- Chinook/Coho	28,730	128,080[1]	lbs. of food.
- Steelhead		172,370[1]	
Indian Peoples			-Maintains cultural
- Chinook	22,090		and religious well-being.
- Coho	14,040		-provides 7000 to 7500 lbs. of food.
Coastal Communities			-provides 7000 to 7500
- Commercial chinook	10,030		lbs. of food.
- Commercial coho	6,380		-Supports basic community way of
- Sport fish	56,510		life.

[1] Based on restorative activity.

This table must be read carefully. Each Klamath river salmon has the capability of supporting culture, religion and lifestyle, of providing subsistence, of generating business benefits and of providing recreational enjoyment. Table I provides an indication of the range of potential benefits--but measurement techniques vary, as does comprehensiveness of coverage, and benefits cannot be compared between columns. Further, in this summary analysis based on existing data, results are not accurate enough to definitively compare all business benefits listed in Column (1). We are confident that the relative values for chinook and coho are comparative, for either non-Indians or Indians participating in ocean commercial fishing. Business benefits associated with sport fishing, however, are based, in part, on inference and assumption, and while we feel they provide a reasonable order of magnitude basis to evaluate restorative plans on the Klamath, specific comparison of sport and commercial values would require more work. Finally, community benefit analysis measures additional income generated, and may or may not accurately reflect net value. Consequently, impact on community income should be analyzed separately from net business value by species. With respect to additivity of numbers, community business benefits are in addition to respective species net business values. Subsistence values are additive with cultural, religious, lifestyle and sport fishing values. Non-dollar sport fishing values are in addition to net business benefits of sport fishing, save where the sportsman is also a benefitting businessman. In sum, Table I, displays an array of potential benefits, that can be associated with restoration of Klamath stocks--benefits which, when considered relative to anticipated restorative costs, may prove benefit/cost effective over a wide range of project applications.

II Past and Present Economic Circumstances of Fisheries of the Klamath Basin

Fishing Klamath river stocks for sustenance, commercial and recreational purposes has been long established. Indian peoples have used fish as a main staple of their existence since earliest times. Fish were important to the Indian diet[1], and were usually available in sufficient numbers to feed the tribes[2]. Primary target species were salmon and steelhead, with sturgeon and eels providing less frequent sustenance, and whales occasionally washing ashore to provide large food supplies[3]. Salmon was generally taken for own use, including that of kin.

> "...salmon was a food staple for the tribes, served as a significant focus for religious ceremonies, and provided opportunities for status, enterprise and, to a lesser extent, wealth". [4]

---

1 W.J. Wallace, "Hupa, Chilula and Whilkut", Handbook of North American Indians, op. cit., pg. 164.

2 Ibid., pg. 165.

3 Ibid., pg. 165.

4 U.S. Department of Interior, Environmental Impact Statement on the Management of River Flows to Mitigate the Loss of the Anadromous Fishing of the Trinity River, California. Vol.I., November, 1980, p. C4-13.

The first cannery on the Klamath was established at Requa in 1888[5]. Others followed, with the peak of salmon canning taking place in 1912-1915. Stocks subsequently declined.

There is no single integrated set of catch statistics that permit a comprehensive assessment of the magnitude of present adult fish returns generated from the Klamath River basin. For fall chinook, statistics on river escapement, sport catch and Indian net catch are available from the Pacific Fishery Management Council (hereafter, PFMC). However, no statistical report on related ocean catch by commercial troll and sport fisheries is available. For other Klamath species, noteably coho and spring chinook, programs have been undertaken by the California Department of Fish and Game that may eventually provide catch data, but no such statistical information is available at this time. In the present survey document, the following reporting procedure will therefore be utilized with respect to catch.

i) Utilizing in-river data from PFMC, a ratio of ocean catch to in-river run size of 2:1[6], and an estimate for ocean sport catch of 7.5 percent of total ocean catch[7], annual estimates of the likely catch of Klamath fall chinook for all fishing sectors will be developed.

ii) Utilizing PFMC data, total catches of chinook and coho from Fort Bragg, Ca. to Coos Bay, Ore., the primary areas where Klamath salmon are delivered, will be reported.

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5 J.N. Cobb, Pacific Salmon Fisheries. U.S. Department of Commerce; Bureau of Commercial Fisheries; Document No. 1092, 1930.

6 L.B. Boydstun, California Department of Fish and Game, personal communication, May 2, 1984.

7 Ibid.

iii) Utilizing data, primarily from Humboldt and Del Norte Counties, the overall economic condition along the north coast of California and the south coast of Oregon will be characterized.

1. Estimated Magnitude of Klamath Fall Chinook Runs

Utilizing data from PFMC[8], and the ocean catch rates outlined in (i) above, estimates of the recent historic magnitude of harvests of Klamath fall chinook are provided in Table II.

Table II

Estimated Harvest of Klamath Fall Chinook

Year	Spawning Escapement	In-River Catch		Ocean Catch		Total Run
		Sport	Indian	Commercial	Sport	
	'000 fish					
1978	71.5	1.7	18.2	169.1	13.7	274.2
1979	33.4	2.1	13.7	91.0	7.4	147.6
1980	28.0	2.1	12.0	77.9	6.3	126.3
1981	38.3	6.0	33.0	143.0	11.6	231.9
1982[a]	40.5	7.7	14.5	116.0	9.4	188.1
1983[a]	45.7	4.3	7.9	107.1	8.7	173.7
Average	42.9	4.0	16.6	117.4	9.5	190.3

a - Preliminary

* Foreign interception of Klamath river salmon is estimated at negligible levels.

8 Pacific Fishery Management Council, A Review of the 1983 Ocean Salmon Fisheries and Status of Stocks and Management Goals for the 1984 Salmon Season off the Coasts of California, Oregon and Washington, March, 1984, p. II-8.

Readers are reminded that the ocean catch portion of this table is estimated and does not represent actual data. In fact, in years such as the present, where run sizes may be severely constrained, ratios of ocean catch to river escapement may vary considerably from the assumed longer term average. Further, Klamath natural chinook stocks have been depressed for several years, and escapement goals are not currently being met. Nevertheless, Table I likely provides a general indication of the average magnitude of fall chinook runs over recent time. As noted Klamath runs of coho and spring chinook are much smaller, and no data from which to estimate their magnitude is presently available.

2. Ocean Catches - Fort Bragg to Coos Bay

Salmon from the Klamath system are primarily caught in the ocean between Fort Bragg and Coos Bay. It may therefore be useful to determine recent levels of overall landings of chinook and coho into those two ports, into Eureka, Crescent City and Brookings. In Table III, total catch for these two species, for the 5 ports identified,are presented.

Table III

Coastwide Ocean Catch of Chinook and Coho

- Fort Bragg to Coos Bay -

Year	Commercial Catch Chinook	Commercial Catch Coho	Sport Catch Chinook	Sport Catch Coho	Total Catch Chinook	Total Catch Coho
	'000 fish					
1976	419	1392	40	261	459	1652
1977	567	216	61	102	628	318
1978	461	581	20	171	481	752
1979	631	518	25	112	656	630
1980	444	179	18	190	462	369
1981	403	292	24	75	427	367
1982	523	331	46	95	569	426
1983	152	182	29	105	181	290
Average	450	462	33	139	483	600

Due largely to el niño effects, 1983 was a disastrous year for salmon fishermen in northern California and southern Oregon. Prior to el niño, chinook landings to this area seemed to be holding at approximate 1970's levels. Landings of coho were more variable, but seem to have declined markedly since 1976. This is particularly true for landings into northern California ports. Further, the size of adult coho returning to fisheries seems reduced since 1975[9].

Finally, commercial salmon catches off Oregon and Washington have declined in recent years, crab catches are in a natural low cycle, albacore are down, and the west coast groundfish fleet is presently experiencing difficulties in matching capacity with markets[10].

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9 Meyer Resources, Inc., *A Report Concerning Multi-Species Limited Entry in Selected Coastal Fisheries of Washington, Oregon and California*. A Report to the National Marine Fisheries Service, March, 1983.

10 *Ibid*.

The net result has been increased commercial interest in northern California salmon stocks, both by California fishermen fishing multiple gears, and by out-of-state fishermen, primarily from Oregon. It follows that the Klamath Stock will likely come under increased pressure, and generate enhanced values in the years ahead. While the California limited entry plan for trollers will act to control pressure in the long run, it is our conclusion, in examining all these factors, that salmon stocks in this central coast area, including those of the Klamath system, will come under increasing pressure in the years immediately ahead. El niño has lent urgency to the situation, and it may be that restorative action is now more acutely required than before the precipitous decline in catch experienced in 1983.

3. General Economic Conditions in the Klamath Basin

Fisheries within the Klamath basin primarily impact people living in Humboldt and Del Norte counties, together with upriver residents of Siskiyou, Trinity and Shasta counties. As noted, ocean catches also affect residents of south coastal Oregon. In general, the economy of the area encompassed by the basin is not bouyant. Traditionally, lumber dominated economic activity, with fisheries and limited agriculture providing a continuing source of revenue and food. Mining has provided a periodic revenue source, while tourism provides substantial revenue over summer months.

Lumber production, and associated processing activity has been cut back in recent years--in part due to soft markets, but more importantly for the future, due to progressive reduction in allowable cut of old growth timber, as sustained yield calculations have been refined, and non-harvest forest considerations have gained in importance. Even tourism, a summer economic mainstay in Humboldt and Del Norte counties, may be realizing limits due to congestion on Highway 101. The result for the area, is that unemployment has become characteristically high. While annual rates vary, unemployment in Humboldt County has remained over 10 percent for the past decade[11], while Del Norte County unemployment ranged between 9.8 percent and 22.8 percent, 1978 through 1982[12,13]. Trinity County is in a similar situation, with a 1981 unemployment rate of 17.5 percent, 3rd highest among the 58 California counties[14]. Siskiyou County ranked 6th out of 58 California counties in unemployment during 1981, with a rate of 16.4 percent[15]. The situation in south coastal Oregon appears similar.

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11 Humboldt County Planning Department, Humboldt County Draft General Plan Revision Program, Policy Background Study on Population, March, 1983, p. 2-16.

12 Del Norte County, Overall Economic Development Program,1980, p. 28.

13 Employment Development Department, Labor Market Newsletter-- Del Norte County, 1982-1983, State of California, p. 4.

14 Employment Development Department, Labor Market Newsletter-- Trinity County, 1982-1983, State of California, p. 8.

15 Employment Development Department, Labor Market Newsletter-- Siskiyou County, 1982-1983, State of California, p. 8.

While the residents of Humboldt, Del Norte, Trinity and Siskiyou counties as a whole are experiencing difficult economic conditions, the situation for the people of the Hupa and Yuroks is much worse. Resource opportunities are similar to those established for the counties in general. On the Hoopa reservation, by 1981, all five lumber mills that had operated there were closed, and a current unemployment rate of 81 percent exists on the reservation[16]. Conversation with Yuroks suggests a similar level of unemployment likely exists in the downriver Extension[17]. Data from the Hoopa Valley Study[18] suggests that this rate of unemployment is increased from 50 percent in the fall/ winter of 1979, and 62 percent in the fall/winter of 1980.

> "The Hoopa Valley Indian Reservation is currently experiencing an extreme economic depression. In years past the Reservation population has been significantly dependent upon the logging and timber production industry for non-professional employment opportunities. However, in recent years, overproduction, increased automation, environmental impact priorities, and the rising prime interest rate (with consequent decreases in construction) have crippled the timber industry. The lumber mills on the Reservation that once employed many Indian people have been shut-down. The available employment opportunities in the field of tree harvesting(logging) has been reduced by approximately 85%. "[19]

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16 Hoopa Tribal Council, Draft Economic Development Plan, Hoopa, June, 1983.

17 J. Webster, a Yurok, at Klamath, June 22, 1983.

18 Hoopa Tribal Council, *op. cit.*

19 *Ibid*.

Under these conditions, opportunities for marginal improvement in the economy of the Klamath basin seem limited. The forest industry will continue to play an important role in north coast economics. However, it is unlikely to grow substantially. Tourism will continue, but again, major increases in Hwy 101 usership cannot be confidently predicted. Consequently, we must turn elsewhere if growth is to redress continuing levels of unsatisfactory income and employment. Undoubtedly, some level of growth in institutional infrastructure (such as that connected with Humboldt State University) can be expected. Further, periodic beneficial opportunities may come from extractive industry. In essence, however, the north coast area will need to carefully conserve every resource, job and dollar it can obtain if it is to ensure a viable economic future. It cannot afford to leave productive resource opportunities undeveloped nor to trade them off against each other--if overall levels of employment and well- being are to improve.

In sum, the economy of the Klamath Basin can be characterized as relatively narrow, beset by levels of income and unemployment that range between relatively inadequate and alarming, and offering few opportunities for economic recovery. In such a setting, it is understandable that interests would seek to gain special concessions from each other--and competition between counties, between Indian and non-Indian, between forestry, fishing, and mining, and so on is clearly evident. However, each of these groups, to some degree, seems disadvantaged. Consequently, resource decisions which simply rearrange existing opportunity between local groups offer little or no benefit to the region as a whole. Conversely, restoration of Klamath fisheries, offering as it does an opportunity to increase overall regional resource capability, may be of high value, and perhaps can be achieved without significant damage to present important activity. It is from this perspective that the present analysis of the value of restoring the Klamath basin fisheries will be conducted.

III Business Related Benefits from Klamath Fish Stocks

1) Dollar Revenue from Commercial Fishing

In this section, contemporary values per returning adult salmon will be established at ex-vessel, wholesale and community income levels.

a) Ex-Vessel Values

Estimated gross values per adult, for Klamath chinook and coho caught on the California north coast, are presented in Table IV. These data are considered to be most appropriate for Klamath stocks.

Table IV

Commercial Ex-Vessel Values per Dressed Troll Caught Salmon--California North Coast

Year	Chinook	Coho
	----------------$/lb.----------------	
1979	2.53	2.19
1980	2.27	1.36
1981	2.45	1.94
1982[a]	2.55	1.36
1983[a]	2.09	1.25
Average	2.38	1.62

Source: Pacific Fishery Management Council, *op. cit*., p. IV-9.

In real terms, prices for coastal salmon peaked in the late 1970's[20], and have been at lower levels for the past 4 years. Over longer periods of time, ex-vessel real prices have shown steady improvement, however[21]. Considering both short and long term data, it seems reasonable to utilize the five year average price as a basis for contemporary stock evaluation on the Klamath. On that basis, estimated average ex-vessel values for Klamath chinook and coho are presented in Table V. Average fish sizes are overall, and do not distinguish between chinook large, mediums and smalls[22].

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20 Pacific Fishery Management Counsil, *op. cit*.

21 U.S. Bureau of Commercial Fisheries, *Fisheries Statistics of the U.S.*.

22 Sizes based on L.B. Boydstun, *op. cit.*

Table V

Commercial Ex-Vessel Values per Dressed Toll Caught Salmon--Klamath Estimates

Species	Average Size Dressed lbs.	Price $/lb.	Value per Salmon $
Chinook	7.5	2.38	17.85
Coho	7.0	1.62	11.34

Economic analysis requires that impacts, whether beneficial or costly, be expressed in net value terms. In the commercial fishery, net values are calculated by subtracting catching costs from revenues received for catch. Where fishermen and their vessels do not have alternative opportunities for employment, increments of catching effort will incur only limited variable costs such as fuel and ice over a significant range of increased catch[23]. Along the California north coast, where relatively high unemployment is characteristic, where fishermen earn somewhat less than the average household[24], and

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[23] For a conceptual discussion of this issue, see, Water Resources Council, Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning (Level C); Final Rule, Federal Register, December 14, 1979, pp. 72892-72976. For a recent non-technical discussion, see, Meyer Resources, Inc. Economic Evaluation of River Projects. Vol. I, a Report for the California Resources Agency, December, 1982, pp. 14-17.

[24] Oregon State University, Socio-Economics of the Idaho, Washington, Oregon and California Coho and Chinook Salmon Industry, Vol. A. A Report to the Pacific Fishery Management Council, Corvallis, September, 1978, p. 23.

where a limited entry plan exists to retard new entry, such limited cost treatment seems warranted. Only limited empirical data is available to determine appropriate incremental costs. In the early 1960's, Fry[25] considering California fisheries, and Crutchfield[26] considering Washington fisheries, concluded that restorative increments of salmon could be taken at costs amounting to 10 percent of ex-vessel value. Later, in 1968, Richards[27] reached a similar conclusion for Columbia river fisheries. In 1980, in British Columbia, where species and fishing methods are similar, Barclay and Morley determined that the existing British Columbia fleet would be able to catch double existing levels of salmon without any change in capital cost, and with variable cost increments that begin at 1 percent of ex-vessel salmon price, and increased to 15 percent for a full doubling of catch[28]. Reviewing these data, we find no reason to depart from earlier conclusions, and will reduce ex-vessel values by 10 percent to obtain present net value estimates for the Klamath. This is done in Table VI.

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25 D.H. Fry, "Potential Profits in the California Salmon Fishery", California Fish and Game, October, 1962, pp. 256-267.

26 J.A. Crutchfield, K.B. Krol and L.A. Phinney, An Economic Evaluation of Washington State Department of Fisheries' Controlled Natural-Rearing Program for Coho Salmon. U.S. Fish and Wildlife Service Contract #14-17-007-246, 1965.

27 J.A. Richard, An Economic Evaluation of Columbia River Anadromous Fish Programs. Ph.D. dissertation, Oregon State University, Corvallis, 1968.

28 J.C. Barclay and R.W. Morley, Estimation of Commercial Fishery Benefits and Costs Data (1976-1978), Department of Fisheries and Oceans, Vancouver, August, 1980, pp. 3-4.

Table VI

Net Value Estimates for Klamath River Salmon Sold by Fishermen

Species	Net Value per Salmon $
Chinook	16.06
Coho	10.21

Again, it should be recalled that these values re based on broader ocean price averages.

b) Processing Values

Additional value is derived from fisheries via processing activities. Little consistent data is available for development of processing estimates however. Generalized data on price markup for salmon are provided in a British Columbia analysis[29], by Penn[30], Oregon State University[31] and Petry[32].

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29 Department of Fisheries and Ocean, Fisheries Statistics of British Columbia, 1978.

30 E. Penn, Cost Analysis of Fish Price Margins, 1972-1977, at Different Production and Distributor Levels. National Marine Fisheries Service, Washington, D.C., Appendix Tables A-31 and A-34.

31 Oregon State University, op. cit., Vol. B., p. 67.

32 G.H. Petry, Pacific Northwest Salmon and Steelhead Fishery Report--The Economic Status of the Oregon and Washington Non-Indian Salmon Gillnet and Troll Fishery, 2 Vols., Washington State University, Pullman, 1979.

The Oregon State University data develops an ex-vessel to processing markup of 65 percent, specific to Humboldt County salmon. It will be used here. Results are reported in Table VII.

Table VII

Recommended Markup to Processing

--Klamath River Salmon--

Species	Ex-Vessel Price $/fish	Markup %	Estimated Processing Price $/fish	Processing Increment $/fish
Chinook	17.85	65	29.45	11.60
Coho	11.34	65	18.71	7.37

These data may prove conservative. Other estimates in the same OSU document suggest processing markups of 136 percent for Tillamook County, Oregon [33], and between 84 percent and 113 percent for Puget Sound[34]. Petry's data suggest markups in the 111 percent to 116 percent range for Oregon and Washington processing respectively[35].

Finally, accrued gross value of processing must be reduced by associated cost to obtain net value. This step is empirically more difficult. At a conceptual level, it is possible over time that processors would divest themselves of all idle capital equipment.

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33 Oregon State University, op. cit., p. 94.

34 Ibid. pp. 112, 114.

35 G.H. Petry, op. cit. Vol. II, p. 46.

Yet, idle equipment has been a common sight over the years at fish processing locations, and is today. The answer to this anomaly may lie not in long term capital immobility, but in the diverse level of catch, measured on a year to year basis. Because of fluctuating catch, the processor must ensure adequate processing capability for the good year--knowing that some of that capacity will lie idle in less than good years. Consequently, and considering the currently depressed level of coastal fisheries, it seems reasonable that processors would be able to handle a significant measure of restored fishery production while encountering only variable costs[36]. National data from Penn[37] suggest that variable costs may range between 46 percent and 50 percent of the processing value increment, exclusive of fish purchases. A similar judgement is reached by Barclay and Morley[38], who estimate variable costs, excluding fish purchases, at 45 percent of processing value increment. For this analysis, we will use the midpoint of the U.S. national data estimate, and reduce value added by processing by 48 percent to obtain the net value increment. Results are presented in Table VIII.

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36 This perception was confirmed in a 1982 conversation with W. Jensen, West Coast Fisheries Developed Foundation.

37 E. Penn, *op. cit*.

38 J.C. Barclay and R.W. Morley, *op. cit*.

Table VIII

Net Value Through Processing Levels

Estimates for Klamath Stocks

Species	Net Ex-Vessel Value	Net Processing Value	Total Net Value
	----------------	$/fish	----------------
Chinook	16.06	6.03	22.09
Coho	10.21	3.83	14.04

c) Induced Economic Benefits

Revenues received into a community or area are generally recognized to have positive effects beyond those associated with initial cash impacts. These secondary effects are often referred to as "multiplier" effects--and are derived as receivers of income spend a portion of it locally, creating jobs and income for others. The accumulated impacts of such initial expenditures are generally displayed in input/output tables[39], which calculate final effects for any given initial change in revenue. Where both ex-vessel and processing values are developed (as they are here) the analyst must be aware of the fact that input/output data characteristically reports primary and processing sectors separately, and that multipliers for one will likely include economic activity in the other. A netting out procedure will consequently also be required to avoid double counting. Multipliers can measure cumulative affects on output, income or employment,

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39 For a general discussion, see, W.H. Miernyk, The Elements of Input Output Analysis. New York, Random House, 1965.

and may be expressed in gross or net terms. For this analysis, a net income multiplier is considered most appropriate. There appear to be three candidate income multipliers available with respect to Klamath stocks. These are arrayed in Table IX.

Table IX

Subject	Source	Multiplier
- California forestry and fishery products	- Department of Water Resources, Bulletin 210, March, 1980.	2.15
- California forestry and fishery products	- U.S. Forest Service, IMPLAN, September, 1983.	2.35
- California salmon trollers	- D.M. King & K.L. Schellhammer, The CIF Model, Sea Grant Working Paper #. P-T-S.	- small 2.23 trollers - large 1.81 trollers

These data are closely consistent, with King and Schellhammer's Type II multipliers giving the closest attention to salmon fishing. Consequently, a multiplier of 2 is suggested for the present analysis, with a recommendation that 2.23 be used for exclusively small trollers and 1.81 for exclusively large trollers.

As noted, it is necessary to subtract net processing markups out of multiplier calculations based on fishing activity to avoid double counting. Applying the K-S multiplier to the results of Table VI, and netting out the processing increment of net value identified in Table VIII, estimates of beneficial impact upon communities associated with Klamath salmon stocks is presented in Table X.

Table X

Estimated Beneficial Impact Upon Communities from Klamath Stocks

Species	Net Ex-Vessel Value	Net Processing Value	Net Community Value
	--------$/fish--------		
Chinook	16.06	6.03	10.03
Coho	10.21	3.83	6.38

To the extent that fishermen's variable costs benefit local residents, this value will slightly understate total community impact. Multiplier values are conceptually separate from the net economic benefits calculated at ex-vessel and processing steps and should be so treated in analysis.

2. Dollar Revenue from Sport Fishing

Sport fishing also provides significant commercial revenue for resort and motel operators, restaurants, guides, boat and gear renters, tackle shops, and so on. Estimates of such expenditures have been compiled in a number of studies. EDAW utilize information from the American Automobile Association to estimate daily expenditures by visitors to California of $30 per person day in 1979 dollars[40]. Grobey, et al. developed 1979 expenditure estimates of approximately

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40 EDAW Inc., Smith River Draft Management Plan. A Report to the California Department of Fish and Game, October, 1979, p. 73.

$14 per person day for visitors to Redwood National Park[41]. Recently, the U.S. Fish and Wildlife Service has published its 1980 National Survey of Hunting and Fishing for California[42]. This study estimates that, in 1980, California sport fishermen spent $32 per day on sport fishing, $13 in travel and $19 on equipment[43].

The American Automobile Association estimate and that of the U.S. Fish and Wildlife Service closely correspond, and as the latter is developed specifically for sport fishing, and utilizes latest available data, it will be employed here. Updating to 1983 via the U.S. Department of Labor's Consumer Price Index, daily expenditures associated with sport fishing for Klamath stock are estimated at $38.31.

Establishing dollar expenditures per day for salmon stocks does not establish values per fish. Traditionally this is obtained by the following formula:

$$(1)\quad V_f = V_d / C_d$$

where: V_f = the value of a fish.

V_d = the value of a fishing day.

C_d = catch per day in number of fish.

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41 J.H. Grobey, T.K. Ruprecht, F.I. Jewett, G.L. Hoopes, & L.M. Kirkham, Redwood National Park Tourism Study: Economic Impacts of Alternative Park Development Plans. Humboldt State University, Arcata, April, 1979.

42 U.S. Fish and Wildlife Service, 1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation--California, 1980.

43 *Ibid*. p. 1.

Estimates of angler days per fish for the north coast area vary. In 1977, Kesner estimated an angler day/fish ratio of 2.3 for inland Klamath sport fisheries, and 1.0 for ocean fisheries[44]. In the same year, Humboldt County reported a ratio of 2.5 for steelhead, 89.5 for coho and 22.3 for chinook[45]. These data were not considered representative, and the low ratio of 2.5 was recommended. In 1978, Smith recommended an angler day to catch ratio of 1.3 for ocean sport, 3.0 for rivers and 2.4 for steelhead for north coast streams[46]. Finally, in 1980, Meyer recommended an angler day to catch ratio of 1.25 for ocean catch, 3 for instream chinook and 2.3 for steelhead from the Trinity[47]. In considering these varying data, an all-fisheries ratio of angler days to catch of 2.5 is considered within a reasonable range, and will be utilized in the present analysis. Using this ratio, gross expenditures associated with capture of one sport salmon are estimated to approximate $95.78.

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44 W.D. Kesner, An Economic Evaluation of the Salmon and Steelhead Fisheries Attributable to Klamath National Forest. USDA Forest Service, Klamath National Forest, May, 1977, p. 7.

45 Humboldt County, Economic Loss to Humboldt County due to Potter Valley Diversion of Eel River Waters. Department of Public Works, Eureka, July, 1977, p. 8.

46 D. Smith, The Economic Value of Anadromous Fisheries for Six Rivers National Forest. USDA Forest Service, February, 1978, pp. 11-12.

47 P.A. Meyer, A Review of Socio-Economic Aspect of the December, 1979 Draft Consultant Report Entitled "Proposed Trinity River Basin Fish an Wildlife Plan". Center for Natural Areas, Sacramento, April, 1980, p. 38.

As noted earlier, not all revenue generated by sport fish related expenditure can be considered as net profit, for costs will be incurred in providing any given levels of service. Frederiksen, Kamine and Associates estimated such costs at 70 percent of revenue during their Trinity River analysis[48]. With a relatively high level of unemployment on the north coast, and the supplemental nature of fish stock associated with the Klamath River restoration plan, this estimate is considered high. It will be used here, as the only one presently available, however. Net business revenue associated with Klamath sport related expenditures is therefore calculated to be $28.73 per fish.

Finally, each dollar spent on sport fishing will have a multiplier effect on the community at large. Available empirical measures vary widely. California Department of Water Resource's Bulletin 210 estimates an income multiplier of 2.55 for "amusement and recreation services", while the U.S. Forest Service (IMPLAN) estimates a multiplier of 3.14 for the same service grouping. Grobey et al[49], on the other hand, in their study of Redwood National Park, cite dissipation of multiplier effects associated with tourism via significant importing of consumer goods to the north coast region, and recommend a multiplier value below unity. In considering this range of potential data, no firm conclusion can be drawn. It is our consequent recommendation

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48 Frederiksen, Kamine and Associates, Proposed Trinity River Basin Fish and Wildlife Management Programs, Appendix A--Socio- Economic Analysis. October, 1980, p. 138.

49 J.H. Grobey, T.K. Ruprecht, F.I. Jewett, G.L. Hoopes, & L.M. Kirkham, op. cit.

that the impact of sport fishing expenditures on north coast communities be treated similarly to commercial fishery expenditures, via use of a multiplier of 2.0, until better empirical data becomes available. On this basis, and utilizing a direct income coefficient of .59 for "amusement and recreation services" from DWR Bulletin 210, each Klamath sport salmon may develop $56.51 of additional community income[50]. Again, it should be remembered that this value should be treated separately from the $28.73 per fish net value associated with direct expenditures by sportsmen.

Calculation of sport based values in this section also depend on an assumed direct relationship between stock size and sport effort. Such a relationship may not hold for large stock changes,but likely provides a reasonable approximation for marginal changes in stock levels.

IV Non-Business Sport Fishery Values--Expressed in Dollar Terms

The value of sport fishing to participants often exceeds what they actually pay. This is due to a number of factors. Prices may not be structured to capture every last cent each participant would be willing to pay to fish, and do not adequately indicate the compensation participants would consider fair if fishing opportunity was pre-empted; fishermen may live close to the fishing site, so that travel costs are minimal; expenditures don't capture the value of time

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[50] $95.78 x .59.

expended in going fishing, and so on. Economists have developed methods to capture these broader concepts of fishing value, and have made recommendations specific to West Coast sport salmon fishing[51]. Available data was summarized in an 1982 NMFS report[52], and is presented in day value terms in Table XI.

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51 These concepts of consumer's surplus are also appropriate for commercial and Indian fisheries. However, economists have not pressed forward to develop actual values in these latter areas.

52 P.A. Meyer, Net Economic Values for Salmon and Steelhead from the Columbia River System. op. cit. pp. 17 & 20.

Table XI

Empirical Estimates of Recreational Day Values

Author	Recreational Product	Year Base Data Collected	Value in 1980 Dollars $
Estimates for Fisheries Enhancement			
Brown/Singh/Castle	Oregon salmon and steelhead fishing	1962	39.02
Gordon	Idaho salmon	1968	19.81
	Idaho steelhead	1968	37.14
Brown/Charbonneau/ Hay	Ocean Fishing	1975	35.20
	River Fishing	1975	81.60
Brown/Sorhus/Gibbs	Pacific Northwest salmon & steelhead	1977	63.94
Cruthfield/Schelle	Washington ocean salmon	1978	24.01
Estimates for Fisheries Protection Or Restoration			
Matthews/Brown	Washington salmon & steelhead	1967	121.00
Crutchfield/Schelle	Washington ocean fishing	1977	107.00

Data Sources

W.G. Brown, A. Singh and E.M. Castle, An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery. Oregon Agricultural Experiment Station Technical Bulletin 78, Corvallis, Oregon, 1964; D. Gordon, An Economic Analysis of Idaho Sport Fisheries. Idaho Cooperative Fishery Unit, University of Idaho, 1973; G.M. Brown, J.J. Charboneau and M.J. Hay, Estimating Values of Wildlife: Analysis of the 1975 Hunting and Fishing Survey. Draft Working Paper No. 7, U.S. Fish and Wildlife Service, Washington, D.C., 1978; W.G. Brown, C. Sorhus, and K.C. Gibbs, Estimated Expenditures by Sport Anglers and Net Economic Values of Salmon and Steelhead for Specified Fisheries in the Pacific Northwest. Oregon State U., 1980; J.A. Crutchfield and K. Schelle, An Economic Analysis Of Washington Ocean Recreational Salmon Fishing with Particular Emphasis on the Role Played by the Charter Vessel Industry. U. of Washington, 1978; S.B. Mathews and G.S. Brown, Economic Evaluation of the 1967 Sport Salmon Fisheries of Washington. Washington Department of Fisheries Technical Report No. 2, April, 1970.

The NMFS analysis selected the Brown, Sorhus and Gibbs value for evaluation of enhanced salmon stocks, and the Crutchfield and Schelle value for evaluation of protected or restored stocks. Subsequently, Meyer, Brown and Hsaio have updated these values, and developed related values per recreational salmon[53]. These values are recommended for the present analysis, and are presented in Table XII.

Table XII

Recommended Values per Sport Fish

--1983 Dollars--

Species	Value Per Enhanced Fish	Value per Protected or Restored Fish
	$/fish	
Chinook	93.37	128.08
Coho	93.37	128.08
Steelhead	125.68	172.37

The decision on which value to use will depend upon whether proposals to improve stock levels in the Klamath system are considered to return stocks toward normal levels (use the protected/restored value) or to increase stocks above normal levels (use the enhanced value)[54].

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53 P.A. Meyer, W.G. Brown and C.K. Hsiao, An Updating Analysis of Differential Sport Fish Values for Columbia River Salmon. A Report to the National Marine Fisheries Service, Portland, May, 1983.

54 For a fuller discussion of theoretical issues underlying these value differences, see, for example, W.D. Desvousges, V.K. Smith and M.P McGivney, A Comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvements. EPA Report 230-05-83-001, March, 1983, pp. 2-2 to 2-9.

V Subsistence, Social and Cultural Values

1. Values to Indian People

As noted, the value of fish to Indian people can be conceptually bounded by theories of consumer's surplus. However, fisheries have considerable religious and cultural meaning for affected tribes that render a complete statement of value in dollar terms impossible. The salmon traditionally provided both basic sustenance and served as a vehicle for status, enterprise, and wealth for Indian people. It also served as a significant focus for religious ceremonies.

> "...Boys learned the dozens of ways in which Hupa fishermen caught the salmon, lamprey eels, sturgeon, steelhead and trout which filled the river and streams in the Valley. Fishing privileges, like hunting rights, belonged to individuals and families. The men taught the boys the strict rules that governed the use of fishing areas. Then the boys learned to set up weirs and fishing platforms; to make and use both hand-held nets and larger nets which could be anchored in the bed of a river or stream; and to catch fish in basket traps and scooping baskets. The Hoopa speared fish with harpoons, shot them with bows and arrows, caught them with hooks and lines, and sometimes even dove into the river to catch them with their bare hands. "[55]

> "The major ceremonies of the Yurok reveal the following qualities:
> 1. The motive is to renew or maintain the established world. This purpose includes bountiful wild crops, abundance of salmon, and the prevention of famine, earthquakes, and flood. To a greater or less extent, the expression of these objects takes on the character of a new year's rite. This is particularly plain in the First Salmon Ceremony at Wetlkwau and the fish dam building at Kepel. "[56]

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[55] B. Nelson, Jr., Our Home Forever--A Hupa Tribal History. U. of Utah, Salt Lake City, 1978, pp. 16-17.

[56] A.L. Kroeber, Handbook of Indians of California. Dover Publications, New York, 1976 (Reprint), p.53.

"Each year eels and salmon traveled up the Trinity to the valley, and acorns ripened in the surrounding hills. Before the people of the valley gathered these foods, they held special ceremonies. The northern district had the responsibility for the First Eel Ceremony in the spring. After ten days of preparation, a spiritual leader from Takimildin went to a place in the north end of the valley near the entrance to the canyon. He spent the night there fishing for eels, praying for a large catch, and giving thanks for the bounty of the land. Then the people shared a feast of eels. For five days after the feast, the spiritual leader could not travel upstream. If he did, the eels might follow him out of the valley. When the first salmon came up the river in the spring, the southern district held the First Salmon Ceremony. Like the man who conducted the First Eel Ceremony, the spiritual leader from Medildin prepared himself with ten days of prayer. Then he fished for salmon at Sugar Bowl, south of the valley, and once again the people met for a feast.

Throughout the summer, after the First Salmon Ceremony, the people caught salmon in large triangular nets. In September or October, when the summer rains had ended, it was time to build the annual fish dam in the Trinity River for the fall salmon run. For thousands of years the Hupa had built this dam, one year at Medilkin, the next at Takimildin. Like the first food ceremonies, building this dam was a religious activity...Because they never took more than they needed, the annual dam did not deplete the river's supply or threaten the spawning runs."[57]

In these early times, fish on the Klamath were generally plentiful, and were caught only for own use, to feed family, friends and old people in the community, or to trade for other necessities. Above all a unity, a close cohesion with the water, fish, wildlife, roots, berries and other essential elements of their existence--often referred to by Indian peoples as "the land", prevailed.

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57 B. Nelson, Jr. op. cit., pp. 28-30.

> "The people's religious beliefs affected all that was said and done in the valley. Not only in special ceremonies, but in their daily lives, the Hupa observed beliefs which had passed from generation to generation for centuries. Prayer accompanied many activities. Hunters purified themselves before they took an animal's life. Travelers prayed for a safe journey. Spiritual leaders prayed for the protection of the land, the welfare of the people, and the harmony of the universe. This was the sacred center of Hupa life. The ceremonies, the beliefs, and the land where the people had come into being were the Hupa's greatest treasures, and each new generation learned to honor and care for them. "[58]

Over time, conditions for Indians along the river have changed. Guaranteed a homeland where they could live and prosper, the present difficult economic situation of the Indian people of the Hoopa Square and Extension has already been identified. Timber in the Extension is in non-Indian hands and is virtually logged off, while timber production from the Square has provided benefits insufficient to raise Hoopa well-being to acceptable levels.

The fish of the Klamath system thus provide sustaining food for the Hupa, Yurok and Karoks peoples. Further, Indians have particular skills in the catching, preserving and conserving of fish throughout the basin, enjoy fishing as an activity, and consequently possess a comparative advantage in pursuing such activity.

The cultural value of the fishery resource is further evidenced in a recent survey on the Hoopa Square[59]. In this survey, the approximately 380 respondents[60] made proper management of water resources (90 percent of respondents) and proper management of

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[58] Ibid. p. 35.

[59] Hoopa Valley Business Council, Hoopa Valley Survey, Hoopa, November, 1982.

[60] Number of usable responses varied slightly from question to question.

fisheries (89 percent of respondents) their top resource priorities. Other responses, indicative of the preferred Hoopa approach to resource management are presented in Table XIII.

Table XIII

Hoopa Responses on Resource Management Questions

Issue	Agree	Somewhat Agree	No Opinion	Somewhat Disagree	Disagree
	Response				
	% of Respondents				
1. What should be considered most important in forest management?					
1a. Cultural Resources	86.8	1.8	5.8	0.2	5.0
1b. Water	86.1	1.8	5.6	0.0	6.4
1c. Jobs	85.3	1.8	5.5	0.2	7.0
1d. Wildlife	84.9	2.9	6.7	0.5	4.8
1e. Fish	83.6	2.1	5.5	0.7	7.8
1f. Traditional Plant Uses	81.9	2.9	6.8	0.5	7.9
1g. Road Construction	81.3	3.1	6.6	1.0	7.7
1h. Dollar Return	77.1	2.3	6.9	1.0	12.5
2. Economics are more important than environmental concerns in the management of our forest resources.	20.8	9.6	13.5	6.5	49.4
3. Streamside buffers should be preserved along streams.	86.4	3.6	5.7	0.2	3.9

(Cont. next page)

Table XIII (Cont.)

Hoopa Responses on Resource Management Questions

Issue	Agree	Somewhat Agree	No Opinion	Somewhat Disagree	Disagree
	% of Respondents				
4. Timber Harvesting should maximize to produce the most income possible now, at the expense of a continuous income for future generations.	32.4	3.9	7.3	7.5	48.6
5. The Tribe should allow herbicide use on the reservation.	6.5	3.3	7.2	3.1	79.6

Source: See Note (59).

A strong legacy involving use of the "land", and use of its fish, wildlife and other natural attributes is evident in these responses.

Clearly, a salmon, whether caught and used in ceremony, caught and eaten or caught and sold, is highly valued by the Indian peoples of the Klamath basin.

> "The deer and the fish are the only things that will sustain our culture. This is why we dance. We follow through with this as close as we can. Year after year after year" [61]

61 Peter Jackson, Sr., a Yurok, at Requa, June 22, 1983.

> "The spirit people prepared this land for the Indian. When we came, some spirit people did not want to leave--and hid in the rocks, streams, mountains, and so on. Why would we destroy the salmon, when we would be destroying the spirit that made it possible to live here? ...We've lost everything but the water and the salmon. That's all we have left to make it on." 62

2. Value and Commercial Fishing as a Lifestyle

Benefits accruing to the commercial fishing sector from restoration of Klamath stocks are not confined solely to dollars. As the Oregon State University study indicates[63], fishermen in the Eureka and Fort Bragg area have deep-seated traditions, and often consider fishing not only as an activity, but as a way of life. The conclusion from that analysis is reported here.

> "Most people do not consider fishing to be a vocation alternative available to them or to their children. But when nonfishers were exposed to the operations and lifestyle of commercial fishing, they are frequently attracted. Almost all vessels are owned by the fisher-operator who has absolute authority aboard his craft--the high value placed on being one's "own boss" by some fishers runs deep in American tradition [Mayer, 1964].
>
> Some fishers claim that all their nonfisher friends (teachers, businessmen, etc.) want to abandon their careers and become fishers after hearing descriptions of the occupation. Indeed, many fishers themselves consider fishing to be exciting and far more enjoyable than a vacation--hardly "work" in the usual sense.

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62 Robley Schwenk, a Yurok, at Requa, June 22, 1983.

63 Oregon State University, op. cit. Volume A, pp. 15-49.

> Actually, when sociologists and industrial psychologists devise "ideal" working conditions or attempt to improve others, they usually do so by unwittingly injecting doses of the most salient conditions of commercial fishing: responsibility, recognition, social exchange, problem-solving and a close connection to the finished product [Price, 1964]. These conditions are simply characteristics of commercial fishing--similar conditions obtained in fisheries around the world. It is, therefore, not surprising that fishing has been described as "not simply an occupation, but a way of life, having more influence on the feelings of individuals and being more pervasive in their lives than most land bound occupations [Poggie, 1974]." [64]

Such values have not been the subject of intensive study on the California coast. They are nevertheless real, and form an important component of full value consideration in the renewal of Klamath river stocks.

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64 Ibid. p. 40. The subreferences contained in the quotation are to:

K. Mayer and S. Goldstein, "Manual Workers as Small Businessmen", Blue Collar World, edited by A. Shostak and W. Grumberg, Prentice- Hall, New Jersey, 1964, p. 537;

C. Price and D. Levin, "Work and Mental Health", Blue Collar World, op. cit. p. 402; and

J. Poggie and C. Gersuny, Fishermen of Galilee, the Human Ecology of a New England Coastal Community, University of Rhode Island Maritime Bulletin #17, Kingston, Rhode Island, 1974, p. 66.

3. Sport Fisheries and Subsistence

Earlier work by Bryan indicates that having fish for eating is a significant sport fishing motive[65] for salt water anglers. Recent work by Kershner[66], and specific to the Klamath river, identifies that sustenance is also a significant motivation for river sport anglers--particularly those over 45 years of age.

In an area such as the California north coast, where the economy is not buoyant, we would expect sport fishing to provide a significant food source for residents. However, Kershner's work suggests that fishing provides food for out-of-county fishermen of Klamath stocks as well--with smoking and canning identified methods for preservation of catch. Using average ocean and in-river sport catch estimates for fall chinook from Table I, it is estimated that present Klamath fall chinook produce over 100,000 annual pounds of edible salmon for sport fishermen. Coho, spring chinook and other species produce additional edible amounts annually.

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65 R.C. Bryan, The Dimensions of a Salt-Water Sport Fishing Trip, or What Do People Look for in a Fishing Trip Besides Fish? Environment Canada, Vancouver, 1974, p. 14.

66 J. Kershner, Characteristics and Attributes of Some Klamath River Anglers. Masters Thesis, Humboldt State University, Arcata, March, 1983.

4. Aesthetic Values Associated with the Existence of Klamath Fisheries

No direct work has been done to estimate an existence value for Klamath fisheries. Work has, however, been done concerning existence of fisheries stocks in California's Central Valley[67], on the upper Sacramento River[68] and on the upper Columbia River[69]. That work is likely generally applicable to the Klamath sytem, and suggests that if significant fisheries of the system were lost, a majority of residents would not consider themselves adequately compensated, regardless of the level of compensation offered.

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67 P.A. Meyer, Recreational/Aesthetic Values Associated with Selected Groupings of Fish and Wildlife in California's Central Valley, a Report to the U.S.Fish and Wildlife Service, Sacramento, November, 1980.

68 Meyer Resources, Inc., Economic Evaluation of River Projects, Volume III, Values for Fish, Wildlife and Riparian Resources, A Report for the California Resources Agency, Davis, December, 1982.

69 Meyer Resources, Inc., Recreational/Aesthetic Values Associated with Salmon and Steelhead of the Columbia River. A Report to the U.S. Bureau of Indian Affairs, Portland, May, 1982.

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ATTACHMENT 7

Klamath Management Zone Port Landing Losses

Since 1976-1980 Annual Average

Pounds Of Salmon Landed By The Commercial Troll Ocean Fishery For Major Klamath Management Zone (KMZ) Port Areas[1]

Year or Average of years	Eureka (CA)	Crescent City (CA)	Brookings (OR)
Salmon Landings (nearest thousands of dressed pounds)[2]			
Av. of 1976-1980	1,794	753	1,057
1995	26	5	55
1996	92	3	142
1997	14	*	73
1998	22	1	52
1999	27	3	80
2000	20	3	114
2001	61	3	152
2002	108	54	218
2003	7	37	142
2004[3]	64	304	267
Av. of 2001-2004	60	100	195

* = Fewer than 500 pounds

SALMON FISHERY LOSSES BY PORT AREA OVER TIME
(Average of Years 1976-1980 as compared to Average of 2001-2004 landings)

Port Area:		Decline (%) of Fishery
Eureka (CA)	=	97% LOSS
Crescent City (CA)	=	87% LOSS
Brookings (OR)	=	82% LOSS

[1] The port areas listed include landings in the following ports: Brookings also includes Port Orford and Gold Beach; Crescent City includes only Crescent City; Eureka also includes Trinidad and Humboldt Bay locations. Brookings is at the far northern end of the Klamath Management Zone, and thus would have received some landings from just north of the KMZ.

[2] Data from the Pacific Fishery Management Council (PFMC), *Review of 2005 Ocean Salmon Fisheries (2/05).* The KMZ coho fishery was closed completely in 1992 after years of increasing restrictions, so years after 1992 reflect only chinook landings. KMZ closures during 2005 and 2006 were almost complete.

[3] Preliminary numbers as of date of publication (2/05), many be slightly adjusted based on final figures

ATTACHMENT 8

Preliminary Economic Assessment of Dam Removal,
Kruze and Scholz (Jan. 2006)

Preliminary Economic Assessment of Dam Removal: The Klamath River

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1. INTRODUCTION

The Klamath River flows over 250 miles from its headwaters in southwestern Oregon through northern California to the coast, where it drains into the Pacific Ocean. The Klamath is one of only three rivers to pass through the Cascades and is the second largest river in California. It is divided into two distinct sections, the Upper and the Lower. A significant amount of water is diverted from the Upper Klamath River for agricultural irrigation within the federal Klamath Irrigation Project, while much of the Lower Klamath runs through the Klamath National Forest. The river and its fish, particularly salmon, are considered sacred by the Native Tribes that live nearby, including the Yurok, Hupa, Karuk and Klamath Tribes.

Historically, the river was considered prime habitat for a variety of species including: Chinook salmon, coho salmon, silver salmon, steelhead trout and Pacific lamprey. Once the third-largest river for salmon spawning on the West Coast, the Klamath River now produces only a fraction of its historic levels. Six dams, constructed between 1908 and 1962, truncate the river and prevent salmon, as well as other anadromous species, from moving upstream. The lowest dam, Iron Gate, sits at river mile 190 and is the current limit of upstream passage for fish moving upstream.

Before construction of the dams began, approximately 600 miles of river and stream channel above Iron Gate were accessible by anadromous fish runs.[1] Significant habitat still exists upstream of the Iron Gate Dam that is not being utilized, and the Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program identified the current lack of upstream passage created by the Iron Gate Dam as a significant impact on the Klamath River anadromous fishery.[2]

The original operating license for the Klamath River Hydropower Project received final approval in 1956 and is set to expire in February 2006. The Federal Energy Regulatory Committee (FERC) is currently overseeing the renewal process for another dam operating license. The Project, which includes the 6 dams on the Klamath River, is currently owned and operated by PacifiCorp, a subsidiary of Scottish Power. The dams collectively generate 151 megawatts of electricity, less than two percent of the power 8,300 megawatts generated by PacifiCorp facilities servicing customers in Oregon, Wyoming, Washington, California, Utah and Idaho.[3]

The FERC renewal application, completed in 2004 by PacifiCorp, did not include any provisions for passage of salmon to rivers and streams above the Iron Gate Dam. For a variety of reasons – including ecological, cultural, and economic factors – stakeholders, including tribes, conservationists, and commercial fishermen, contend that the removal of up to four dams would be a desirable outcome of the re-licensing process.

The purpose of this study is to provide a preliminary assessment of removal of the four Lower Klamath River dams. It will identify and begin to quantify the likely economic impacts, both positive and negative, that dam removal would have on local stakeholders, particularly Siskiyou County, as three of the four dams being considered for removal are located within its borders.

The specific objectives of this study are:

1. identify and quantify both the market and non-market values of dam removal to local stakeholders and to the region;
2. assess the economic impact dam removal would have on Siskiyou County;
3. ascertain the likely impact of dam removal on residential river-front properties; and
4. perform a comparative analysis that examines the costs and benefits associated with both the "status quo" and "without dam" scenarios.

Section 2 of this report examines the value of the Klamath River in its present state and the likely costs and benefits associated with a change in the status quo, as caused by removal of the four lowest dams. The costs of dam removal are discussed in Section 3; in particular, those associated with dam deconstruction, alternative power sources and property values. Section 4 identifies likely benefits of dam removal including: return of a free-flowing river, increases in fish populations and benefits to local Native tribes. When possible, the benefits are discussed in economic terms and quantified. The conclusion summarizes the likely impacts of dam removal on Siskiyou County and also notes topics for continued research.

2. PROPOSING A CHANGE

The North Coast Regional Water Quality Control Board (NCRWQCB) basin plan lists the following existing beneficial uses of the Klamath River[4], in no particular order:

- Municipal and domestic supply
- Agricultural supply
- Industrial service supply
- Industrial service
- Groundwater recharge
- Freshwater replenishment
- Hydropower generation
- Recreation, water contact and non-water contact
- Habitat, cold freshwater and warm freshwater
- Habitat, wildlife
- Preservation of rare and endangered species
- Migration of aquatic organisms
- Spawning, reproduction and/or early development

These multiple uses benefit an equally numerous and varied group of stakeholders including: local communities, Native tribes, farmers, commercial and sport fishermen, outdoor enthusiasts and conservationists, to name a few. Changes in river dynamics, including dam removal, have the potential to impact some, or all, of the benefits currently provided by the Klamath River, and ultimately local and regional stakeholders. For this reason, it is important to identify and, when possible, quantify the likely costs and benefits associated with removing the four lower dams on the Klamath River.

This study specifically examines the likely costs and benefits to Siskiyou County, California. It is important to note that as such there are some benefits to the County that may be costs to others. For example, the benefits the County would receive from spending associated with dam deconstruction also would be a cost to the entity responsible for paying for the removal. In instances where such a discrepancy occurs, we will try to describe the likely group(s) of gainers and/or losers.

2.1 Identifying Costs and Benefits

When considering the impact of dam removal, costs and benefits are normally associated with changes in a good or service. These goods and services (henceforth termed "goods") fall into two categories –

market goods and non-market goods. Market goods are defined as those that are bought and sold in a market setting and whose value is typically determined using the price associated with the good. In the case of dam removal, hydropower and commercial fishing are examples of goods and in both cases market transactions provide the data necessary to calculate the estimated costs and benefits.

There are also goods, such as recreational opportunities, subsistence fishing and environmental aesthetics, for which markets do not exist. These goods are known to have value to society, either positive or negative, and changes in their quantity or quality will affect those values. However, market data does not exist to measure the impact of such changes. To address this deficiency, a variety of non-market valuation techniques have been developed by economists and several will be discussed later in this study.

2.2 Estimating the Costs of Dam Removal

Dam removal costs can be broken down into three major categories; dam deconstruction, lost services and external. Dam deconstruction includes all costs directly associated with removal of the physical structure, and may include such things as removal of the physical structure, sediment disposal and storage, and the disposal of waste materials. In the case the four Klamath River Dams, the total value of deconstructing and removing the dams has been estimated by one study to be $35.6 million.[5] This particular estimate was based on the two assumptions; 1) sediments could be naturally eroded downstream, and 2) spoil sites could be located within 10 miles of each dam, and also does not include the costs associated with permitting, restoration or mitigation. These additional considerations have the potential to significantly increase the actual cost of removal.

A more recent study, though yet unpublished, estimates the total cost of removal for the four dams to be $100 million.[6] Both of these cost estimates will be discussed in greater detail in a subsequent section of the study.

The cost of removal, however, is not likely to be born by Siskiyou County, but rather produce benefits for the county through spending and job opportunities related to dam deconstruction. These benefits will be discussed in greater detail in the next section. It is important though to recognize that ultimately someone will be responsible for the cost of dam removal and for that entity the cost would be significant.

Description	Iron Gate	Copco 2	Copco 1	J.C. Boyle
Uses	Hydropower/ Flow	Hydropower	Hydropower	Hydropower
Year Built	1962	1925	1918	1958
River Mile	190	198.3	198.6	224.7
Generating Capacity (MW)	18	27	20	80
Material	Rockfill	Concrete	Concrete	Earthfill
Upstream Fish Passage	No	No	No	Yes
Downstream Fish Passage	No	No	No	Yes

Table 1: Klamath River dams considered for dam removal

Lost services provided by the dam are included in the second category of costs. Again, Siskiyou County would not be directly responsible for establishing an alternative power source, someone must. This cost could indirectly affect both Siskiyou County and its residents if changes in electricity costs were to occur because of the loss of hydroelectric power from the four dams and the switch to an alternative power source. For that reason, the value of lost services is also discussed here.

In the case of the four dams being considered for removal on the Klamath, this value would include the cost of finding an alternative source of energy that provides *at least* the same level and quality of power output. PacifiCorp's Final License Application estimates the annual cost of producing power under the new license to be $23.3 million, or almost $700 million for the entire life of the project.

Assuming a total generating capacity of 147.2 MW for the entire length of the project, Table 2 shows the PacifiCorp study estimates for replacing project power with power generated using alternative sources.

Source[7]	**Estimated Annual Cost (in millions)**
PacifiCorp Hydropower	$23.3
Natural Gas	$27.7
Cogeneration	$31
Wind	$26.7
Coal	$21.6

Table 2: Annual cost of power replacement using alternate fuel sources

A comparison of the estimated cost of the current project with the estimated costs using alternative sources suggests that using the most expensive alternative source (Cogeneration) would lead to increase in costs of $7 million per year. These estimates include both the initial outlay of capital for alternative resource development as well as the annual operating costs for the projects. As a cautionary note, increases in the cost of alternative power sources (i.e. increased cost of coal or natural gas) would almost certainly increase the actual cost of using an alternative power source.

However, the estimated annual cost of $23.3 million to continue the project does not include the installation of fish ladders and screen turbines on the four dams, which federal agencies could make a requirement of the relicensing agreement. PacifiCorp ran computer simulations to estimate the additional cost of such installations and put the figure at $100 million.[8] An addition of this type to the project would increase the annual cost of the project up another $3 million per year.[9] Inclusion of fish ladders and screen turbines as part of the relicensing agreement is a realistic assumption and is supported by the California Energy Commission (CEC). A recent CEC study concluded that, independent of a decision to relicense or decommission the Klamath dams, habitat improvement and restoration projects will be needed to mitigate currently degraded salmon habitats and address water quality issues.[10]

Another important Klamath River species is the Pacific lamprey, whose historic spawning habitat reached far up the river. Also known as "eel", the Pacific lamprey is an important subsistence food source for local Tribes along the Klamath River and its major tributaries, especially during the winter and early spring months when other fresh food sources such as salmon were not available. Local knowledge data gathered during interviews with tribal members suggests that dam installation is a major cause of declining lamprey populations.[11]

In January 2002, a petition was sent to the United States Fish and Wildlife Services for the listing of four lamprey species, including the Pacific lamprey, as "Endangered" throughout their range under the Endangered Species Act. The same year the Oregon Fish and Wildlife Commission added the Pacific lamprey to Oregon's protected species list.

Given this concern over the Pacific lamprey, it has been suggested that provisions for license re-approval may include not only fish ladders, but also ladders for the Pacific lampreys, which are considerably more expensive.[12] While cost estimates for these ladders are not currently available, the inclusion of these ladders in the re-licensing agreement would increase the cost of an approved project.

The final category of costs includes any external costs of removing the dam, such as costs resulting from changes in the environment, local economies, and/or jobs. Possible environmental effects of removing these dams may include loss of wildlife habitat on the reservoirs behind the dams, temporary mud flats, and the loss of a "lake view" for residential property owners with waterfront property, which will be discussed in greater detail later. Other concerns frequently related to dam removal are increased risk of flooding and loss of irrigation ability.

One misconception about the four lower dams is that their removal would have a negative impact on water supply for irrigation and/or increase the likelihood of flooding in the region. While the dams generate power, they do not supply flood control or water supply benefits.[13] A recent study concluded that even under a worst-case scenario, the likely effects of downstream sediment deposition and flooding risk would be minimal, so they will not be discussed here.[14]

According to the PacifiCorp Final Technical Report on Socioeconomic Resources, 19 individuals are currently employed in operation and maintenance on the Hydropower Project — 11 are full-time employees and 8 are seasonal.[15] The annual payroll for these employees is approximately $820,000. Estimates of employment levels under the proposed Project could not be found, but with the expected decommissioning of at least two developments (East Side and West Side) it is reasonable to assume that the number of employees is not likely to be greater than the current number. Removal of the dams, or the non-relicensing of the Project would almost certainly eliminate all existing jobs.

For the fiscal year 2002–03, Siskiyou County property taxes totaled in excess of $2.9 billion and revenues from PacifiCorp properties accounted for approximately 3.8%, paying $1.1 million in taxes.[16] Again, these values are for the current Project, not the proposed Project, but should accurately reflect revenue generated from a relicensed Project in that the only dam decommissioning proposed occurs outside of Siskiyou County.[1]

From a market cost-efficiency perspective, if the cost of continued operations becomes greater than the cost of dam removal and replacement of lost services, it may make economic sense for PacifiCorp to not renew their license.

2.3 Property Values

Another issue to consider is the effect dam removal would have on adjacent property values. Because the long-run impacts cannot be determined prior to dam, there is considerable uncertainty associated with this issue, and understanding the likely effects may be of critical importance for owners of bordering properties. While dam reservoirs are really an extension of the river, these property owners may view their property as "lake front" rather than "river front" and as such, worry that dam removal and the subsequent loss of the reservoir created by the impoundment will have a negative effect on property values.[17]

The literature on this issue is limited at best, but preliminary studies in Wisconsin, mainly on small dam removals, found that adjacent property values either remained constant or decreased briefly, but regained their entire value by the end of two years.[18] In fact, one study concluded that property values

[1] While not in the specific scope of this research, Klamath County, Oregon would lose approximately $70,050 (2002–03 dollars) in tax revenues from the removal of the J.C. Boyle Dam.

may actually increase after a dam removal that leads to improvements in water quality, river ecosystem restoration and/or provides new or improved recreational opportunities.[19]

Evidence is mixed, however, and the conclusions and recommendations of existing studies on the subject suggest the impact of dam removal on property values is best done on a case by base basis, and that what happens in one place will not necessarily hold true in another.

The difficulty with assessing the impact of dam removal on property values is two-fold. First, it requires calculation of property values over time, both before and after dam removal. It requires patience, as using only the assessed value of the home may not account for aesthetic changes to the property caused by dam removal and to gather sale prices after dam removal takes time and is dependent on the sale of homes in the area. To date, few opportunities have presented themselves where this type of time series research could be conducted.

Secondly, there are a significant number of variables affecting the value of any residential property including the real estate market, and the numerous characteristics of the property – location, square footage, acreage, number of bedrooms, number of bathrooms – to name a few. Frontage on water is only one of these characteristics. And to make matters more confusing, qualitative data from a Wisconsin study suggests that adjacency to any body of water, whether a lake or a river, is considered valuable.[20]

A joint publication by American Rivers and Trout Unlimited provided a series of questions for stakeholders to ask when considering the effect of dam removal on property values:

1. Who will own the reclaimed land following dam removal?
2. If the reclaimed land changes hands, will the new landowner pay local property taxes?
3. Will landowners gain a scenic view of the stream or river and associated riparian areas (e.g. wetlands and waterfowl)?
4. Will landowners have access to the restored river and reclaimed land for recreation? Will the public?[21]

Answers to questions such as these will not provide a definitive answer, but will help stakeholders and policymakers better understand whether the impacts on property values are more likely to be positive, negative or neutral.

Before delving deeper into possible changes in property values on the Klamath River, there are several related issues that first need to be addressed. The first is ownership of exposed lands. There are two reservoirs on the Lower Klamath with adjacent private residences; Copco Lake and Iron Gate Lake. Dam removal would eliminate these bodies of water, except for the natural riverbed, and submerged lands under the lakes would become exposed. PacifiCorp is the owner of the land under the reservoirs and therefore would be the owner of any land exposed by the draw-down of either the Copco or Iron Gate Lakes.

The final ownership of this land will inevitably impact surrounding property values. There are a variety of options for the previously inundated land, all of which would impact adjacent property values. PacifiCorp could 1) do nothing, 2) convert the land into a park or conservation easement, 3) sell the land, or 4) transfer the land to property owners or to the county. Conversion of the land to a park or conservation easement would provide non-market benefits to society and would likely help mitigate the negative impacts of dam removal on property values. Transfer of the land to the county, presumably to be used in a public capacity, or to private lake-front property owners as an extension of their current lot, would help mitigate lost property value and/or the associated property taxes.

If lakeside property owners obtain ownership of the previously inundated land either by purchase or through transfer, it would provide increased lot size, and a transition from lake-front to river-front property. In a conversation with the Siskiyou County assessor, Mike Mallory, he cautioned that many of the properties adjacent to the lake have long, narrow parcels with the residences set near the lake, and draw-down of the reservoirs could leave a distance of a quarter to half a mile between many of the homes and the new river channel.[22] Such a distance would likely prevent a river-view for owners able to purchase the uncovered land.

Property owners unable to gain ownership of the previously inundated land would lose both their lake frontage and river view/access. For these individuals, loss of access to water would likely lead to a decline in property values. This would be especially true if the land between their property and the river was purchased and/or developed by other individuals.

The impact of development on existing properties is uncertain, but the price received from the sale and development of the land would be counted on the benefit side of a cost-benefit analysis. This development could also increase property tax revenue from the area. In a conversation with Mike Mallory, he noted that there are a variety of obstacles to development in the area that should be considered though before assuming that the value of development will be sufficient to offset the property values lost by lake-front owners.[23]

Another group of property owners to consider are those that do not have lake-front properties, but own properties with lake-views. Properties with lake-views that do not gain river-views or river access after the dam removal may experience a decrease in property values also.

There is a second property value issue that deserves further analysis – poor water quality of the reservoirs, especially during the summer months when toxic algal blooms have occurred in recent years.[24] Studies examining the impact of water quality on property values found that water quality is a significantly explanatory variable in determining lakefront property values.[25], [26] A question to consider is what impact, if any, does the poor water quality of the Copco and Iron Gate Lakes have on property values, and would the improved water quality resulting from dam removal help offset the potential loss in value due to the removal?

3. Estimating the Benefits of Dam Removal

The primary benefits of dam removal are associated with the ability of the river to return to a free-flowing state. Reconnection of what were previously upstream and downstream sections of a river allows for the restoration of a variety of environmental services such as water quality, aquatic habitat, riparian species, etc. In economic terms, the values of restored environmental functions associated with dam removal fall into two main categories: market values and non-market values, which were discussed previously.

3.1 Klamath Fisheries

The Klamath was historically one of the largest salmon spawning rivers in the United States. According to Glen Spain, Northwest Director of the Pacific Coast Federation of Fishermen's Association, the river once produced an average of 880,000 spawning salmon and steelhead each year.[27] Another estimate suggests that historic counts of spawning salmon alone for the Klamath-Trinity system were between 650,000 and 1,000,000.[28]

Protecting and restoring natural ecosystem services, including salmon populations, in the Klamath River Basin is vitally important to a variety of local stakeholders as well as conservationists. Commercial and sport fishermen rely on the annual spawning runs to keep salmon fishing sustainable. For Native American tribes the river is the centerpiece of their culture, as well as a source of livelihood and subsistence food.

There are a variety of factors that have likely contributed to declining salmon populations, including dam installation, logging activity near the river and the Klamath Irrigation Project in the Upper Klamath, as well as the low water flows and agricultural run-off associated with it. Evidence suggests though that dam installation is a major contributor to declining salmon populations. Removal of the four lowest dams, among other things, will open additional stretches of river for spawning of anadromous fish. Contrary to speculation, the conclusions of a 2005 study found that salmon, steelhead, Pacific lamprey and other species all historically migrated to these parts of the river and that there is currently unutilized spawning habitat available above the dams.[29]

It is generally agreed that dam removal would lead to an increase in salmon populations. What is not known is to what degree, or how quickly. The Pacific Fisheries Management Council keeps annual counts of the in-river salmon run. Counts for fall Chinook salmon, by far the largest run, are available from 1978 though 2004. Over that time the average in-river run was 107,100 salmon. However, recalculating the estimates using only the last 10 years (1995-2004), the average run increased to 145,200.

The Pacific Fisheries Management Council currently manages the fisheries of the Klamath River System. The paragraph below is taken directly from the PFMC 2005 Pre-season report and describes the current allocation with respect to the Klamath River fall Chinook salmon stocks.

- 50% (8,300 fish) of the available harvest to the Indian tribes of the Klamath-Trinity River Basin with Federally-recognized fishing rights (Yurok and Hoopa Valley tribes);
- 15% (1,200 fish) of the non-Indian harvest to the Klamath River recreational fishery;
- 85% (7,100 fish) of the non-Indian harvest to the ocean fisheries;
- 17.1% (1,200 fish) of the ocean harvest to the KMZ recreational fishery; and
- 50% each (2,200 fish) of the ocean commercial harvest of Klamath River fall Chinook in all areas to the States of California and Oregon.[30]

The earliest posted pre-season report (2001) has the same allocation split for Indian harvest and non-Indian harvest; each received 50% of the available harvest. However, distribution between ocean fishery and recreational fishery was different than that of 2005, with 39.5% of the non-Indian harvest going to the Klamath River recreational fishery and 60.5% going to the ocean fishery. The share of the ocean recreational fishery was the same, receiving 17% of the ocean allocation.

Because of these differences, and because allocation were not available for years before 2001, percent of allocation was determined by taking a 10-year average of percentages harvested by in-river recreation and Indian harvest. For the years 1994-2004, recreational fishermen on average caught 6% of the in-river run for fall Chinook salmon, while Native Tribes caught 19%. These values then allow us to estimate the average ocean fishery allocation (13%). The assumption that actual harvest level equals allowable harvest level will serve the purpose of this analysis by allowing catch rates to serve as a proxy for allocation rates.

While unutilized anadromous fish habitat currently exists above the Iron Gate Dam, the author was not able to locate information on the likely impact access to this section of the river would have on salmon populations. Based on the historic rates of 800,000 to 1,000,000, a reasonably conservative assumption would be that salmon populations would, on average, double. This assumption will be used in the following series of estimates.

Using the assumption that the average in-river runs of fall Chinook salmon double, the increases in harvest by the various fisheries (based on 25-year average and 10-year averages and a 72% spawning escapement rate) are shown in Table 3 below. This exercise is intended to be used only as a demonstration that increases in salmon will lead to increased harvest rates, and as discussed later, increases jobs and economic value.

	Percent of Allocation (10-year average)		**100% increase (10-year average)**
Total In-river Run	**100%**		**290,440**
Escapement Rate (10-year avg.)	72%		209,117
In-river Fisheries		28%	81,323
Non-landed Fish Mortality	2%		5,809
Native Tribes	19%		55,184
In-river Recreation	6%		17,426
Ocean Fisheries - Total	13%		37,757
▪ Ocean Recreation		17%	6,419
▪ Ocean Commercial		83%	31,338

Table 3: Estimated allowable harvest given a 100% increase in in-river run

While currently known for its fall Chinook salmon run, the Klamath River serves as habitat and spawning grounds for a variety of other fish species; spring Chinook salmon, coho salmon, silver salmon, Pacific lamprey, rainbow trout, and steelhead trout to name a few. The spring Chinook salmon, also known as "Springers" historically were more abundant than the fall Chinook. They are prized and revered by the local Klamath Tribes, but recent population surveys show they annual in-river runs have decreased to returns of only several hundred fish.[31]

Another species, the Klamath River coho salmon has had such severe population declines that it is currently listed as a threatened species under the Endangered Species Act (ESA). Steelhead populations have also experienced a serious decline, with the Klamath Mountain Province steelhead currently listed as a candidate for listing as a threatened species. As mentioned previously, the Pacific lamprey is also being considered for listing under the ESA.

Dam removal would almost assuredly have a positive impact on these and other Klamath River species and would most likely help to restore population counts. While these positive impacts have not been estimated or quantified here, these are values that need to be included on the benefit side of any cost-benefit analysis of dam removal.

3.2 Economic Benefits

The purpose of this section is to examine the economic impact of dam removal on Siskiyou County. Included in this analysis are changes in jobs and income related to expenditures associated with dam removal.

3.2.1 Jobs Related to Dam Removal-Related Expenditures

Three types of jobs need to be considered with calculating the economic impact of increased expenditures related to dam deconstruction: those directly created, those indirectly created, and those "induced" through the multiplier effect. For example, dam deconstruction would directly create jobs related to demolition of the dams and processing/transportation of materials and sediment. Those indirectly created in support industries might include jobs such as heavy equipment maintenance and repair, and project monitoring jobs. The final category of jobs is created not by the initial expenditures related to dam removal, but on expenditures made by those directly and indirectly employed in the deconstruction process. These jobs would most likely be in industries such as entertainment, food services, hotels and real estate. The multiplier effect accounts for each successive round of expenditures related to the initial expenditure. For example, a multiplier of 2 means that for each dollar spent initially, the successive rounds of spending lead to another dollar of spending, for an overall increase of two dollars to the local economy.[32]

This study uses the Regional Input-Output Modeling System (RIMS) II Multipliers for the State of California, as prepared by the CA Technology, Trade and Commerce Agency, Economic Strategy and Research.[33] Three of the dams considered for removal are located in California (Siskiyou County), while the fourth is located in Oregon. County-specific multipliers could not be found, nor Oregon multipliers and for this reason, California multipliers are used, which will provide at least a rough estimate.

Expenditures on dam deconstruction are assigned as "Construction" related spending. For this industry, it is estimated that for every $1 million spent there are approximately 21.5 jobs are created and that for every direct job created in the construction sector, there are an estimated 2.1249 indirect and induced jobs created for the total economy.

The California final demand multiplier for output is 2.3574. This represents the dollar change in output by the total economy for each $1 increase in the construction sector output. Using the estimate of $35.6 million as the value of expenditures related to dam deconstruction, the total economic benefits of the project can be calculated using the RIMS II multipliers. It is estimated that an additional 765 jobs will be created and the increase in economic out will be just under $84 million (See Table 5).

Another study[34] estimates the cost to be $100 million for removal of all four dams (See Table 4 for breakdown by dam). Using this estimate and the RIMS II multipliers, the economic benefits of dam removal can be estimated again. The number of jobs created is estimated to be 2,150, while total benefits to the economy exceed $235 million (See Table 5).

Dam	Estimated Cost (in millions)
Iron Gate	$54
Copco 2	$20
Copco 1	$9
JC Boyle	$17
TOTAL	$100

Table 4: Estimate of dam removal (Greinan, 2005)

If the estimated $17 million dollar cost for deconstruction of the JC Boyle dam is taken out of the calculations, the cost of removal for the three dams located in Siskiyou County is estimated at $83 million. While it is unlikely that the economic benefits of dam removal would be split directly down state or county lines, Table 5 also provide the estimated increase in jobs and economic output based only on removal of the Siskiyou County dams (Copco 1, Copco 2, and Iron Gate).

		Estimated Economic Benefit		
	Multiplier	Cost: $35.6 million (4 dams)	Cost: $100 million (4 dams)	Cost: $83 million (3 dams)
Total jobs created (per $1m)	21.5	765 jobs created	2,150 jobs created	1785 jobs created
Total increase in economy (per $1)	2.3574	$83,923,440	$235,740,000	$195,664,200

Table 5: Estimated economic benefits of dam removal

3.2.2 Estimates of the Value of Salmon

A 2001 study of the Upper Klamath Basin found the increasing salmon populations could also lead to an increase in jobs, with each additional 1,000 commercially caught salmon generating 1.5 jobs, while each 1,000 salmon caught recreationally support another 4 jobs.[35] Using the estimated harvests calculated previously, we can now estimate the associated increase in jobs.

	Current (10-year avg.)	100% Increase (10-year avg.)
Total in-river run	145,220	290,440
Native Tribes	27,592	55,184
In-river Recreation	8,713	17,426
Ocean Fisheries - Total	18,879	37,757
Ocean Recreation	3,209	6,419
▪ Ocean Commercial	15,669	31,338

Table 6: Estimated allowable harvests based on 100% increase in fall Chinook salmon runs

Using the 10-year average calculations, the resulting increase in commercially harvested salmon would be almost 16,000 and in recreational fisheries would be over 12,000 (combining ocean and in-river sport fishing). The associated increase in jobs would be 48 from recreational fisheries and 24 from commercial fisheries, for an estimated total of 71 additional jobs created by increased salmon harvests.

The same study provided estimates for the value of increased salmon harvest to the economy and calculated that if salmon populations increased in the Klamath River, each additional fish caught by anglers would be worth approximately $200 and $5–70 if caught by commercial fishers. The data in Table 6 show the estimate value to society of a 100% increase in salmon populations.

Fishery	Estimated value (based on 10-year avg.)
Recreation ($200/fish)	$4,417,592
Commercial ($5/fish)	$78,346
Total Value	$4,495,939

Table 7: Estimated value of increased recreational and commercial Chinook salmon harvests

These calculations are intended to serve as an example. Because it is not known exactly what increase in salmon populations will occur, we cannot give precise estimates. Those above are based on the assumption of a 100% increase in fall Chinook salmon populations, and do not account for increase in other Klamath River fisheries such as steelhead or rainbow trout. Increases in the populations of these species would undoubtedly lead to increased harvests and associated economic benefits as well.

3.2.3 Non-Use Value of Returning the Lower Klamath to a Free-Flowing River

Individuals may value dam removal even if they have never visited nor intend to visit the Klamath River. This type of value is known as a non-use value because an individual(s) can receive benefits even if there is no use of the good or resource. In other words, individuals may have a value for a free-flowing river even if they never fish, raft, swim or even visit the river. Included in the general definition of non-use values are existence values and bequest values. Existence value is frequently mentioned with respect to endangered resources, or when the proposed action may affect a resource in an irreversible way. Similarly, bequest value relates to the notion of preserving the good for use by future generations.

This analysis replicates the methods used for a study of non-use values related to dam removal on the Lower Snake River and uses benefit transfer methodology.[36] The goal of benefit transfer is to use existing values from a specific site(s) and transfer those values to another site with similar resource and policy conditions. Ideally, a non-use valuation study would be conducted in the Lower Klamath region and would gather data and values specific to that dam removal scenario. In this case, both time and financial constraints prevent such an analysis, so benefit-transfer will be used. While not exact, the approach provides a likely range of estimates associated with increased salmon populations resulting from dam removal.

Independent of the use values associated with dam removal on the Lower Klamath is the non-use value associated with restoring the river to a natural free-flowing form. This type of value may also include related benefits, such as ecosystem restoration and improved water quality that are associated with the return of the river to a more natural condition. In this analysis, rough estimates will be calculated though an application of results from existing literature to measure the non-use value of dam removal on the Lower Klamath.

A 1999 study in Colorado found that annual willingness-to-pay (WTP) for non-use values was $77 in 1983, or $147 in 2005, accounting for inflation.[37] In order to calculate the value per mile this value is divided by 555, the number of river miles being valued in the study. This yields a value of 26 cents per mile. Multiplying this by 35 river miles that would be opened by removal of the four lower dams yields a value of $9.10 per household per year.

According to the 2000 U.S. Census, the number of households in California was 11,502,870. Subtracting the number of households in the counties surrounding the Lower Klamath River yields a total of 11,351,108 households. Multiplying this by $9.10 yields an estimated non-use value for restoring the Lower Klamath River of $104,507,239.

Another study estimated the value of preserving the Black Canyon of the Upper Snake River from development.[38] This survey found that non-users had an annual WTP of $58 for preservation. Updating to account for inflation, and dividing by the number of river miles being valued, yields a per mile value of $1.06. This value is higher that that of the previous study because only residents of counties adjacent to the river were sampled. Again, multiplying this by the 35 river miles of the Lower Klamath yields a per household value of $37.10. This value can then be multiplied by the number of non-user residents in Siskiyou County, as the Lower Klamath River flows directly through it, and the surrounding counties of Modoc, Del Norte, Humbolt, Trinity and Shasta. The purpose of including only non-user residents is to avoid double counting.

No statistics were available for the number of users versus non-users in these counties, so estimates were calculated assuming that 50% of residents were users. Multiplying by $37.10 yields a non-user value by adjacent residents of just over $2,815,200. Even assuming 75% of the residents in these six counties were Klamath River users, the non-use value would be $1,407,600.

The aggregate non-use value by the region is finally calculated by adding the two estimates, or $107,322,424, for the return of a free-flowing Lower Klamath River. Even if 100% of residents in the surrounding six counties were users, the estimate non-use value for a free-flowing river would still be $104,507,200.

This is a conservative estimate in the sense that it does not include individuals who use the river for recreation but still independent of their usage still value the existence of a free-flowing river. However, the population of California is very diverse both in terms of socioeconomics and adjacency to the river and because of this, it is possible the estimate may overestimate the total value of a free-flowing river if WTP varies because of differences across different subcategories of the population. Finally, It should also be noted that this value is independent of any effect of dam removal on salmon populations and accounts only for the return of the river to its natural state.

3.2.4 Cultural and Tribal Values

Removal of the four dams on the Lower Klamath will provide a variety of positive benefits to local tribes. In the long run dam removal will provide the return of traditional fishing grounds and increased salmon harvests for ceremonial, subsistence and commercial use. Increased salmon consumption would also likely help improve diet and health of local Tribal members. The conclusions of a recent study of the Karuk diet found that their traditional diet has shifted dramatically.[39] In recent years, the primary cause has been denied access to traditional foods, of which salmon is a primary component. The study stated "the decline of eel and salmonoid populations that once supplied over half the Karuk diet has occurred within the lifetime of most adults today."[40] This altered diet has led to serious health affects, including increased rates of diabetes and heart disease, among Tribal members.

This lack of access to subsistence salmon also affects the ability of tribes to harvest for commercial purposes. At least for the Hoopa Tribe, there is currently no designation between catch for commercial, subsistence, or ceremonial purposes. Indian commercial catch is simply the amount of fish harvested that is not used for subsistence or ceremonial purposes.[41]

Increased salmon harvests would help mitigate the current situation, which forces tribe to choose between using salmon for subsistence or selling it commercially. Diet would also undoubtedly be improved with increased access to traditional foods such as salmon and eel.

The phrase "improvements to subsistence, commercial, and ceremonial salmon harvests" does not adequately describe the varied positive benefits local Tribes would see from dam removal. Further research is necessary to identify and, if possible quantify, those benefits, as the few mentioned here only begin to cover the issue.

3.2.5 Other Recreational Activities (Non-Fishing)

While ocean and river recreational sportfishing are two of the most popular recreational activities, the Klamath River also offers a variety of other recreational activities for outdoor enthusiasts. Whitewater rafting, boating, camping, gold mining, hiking and wildlife watching are all popular activities. Dam removal would inevitably impact reservoir activities such as water-skiing and boating, but it is difficult to assess what impact, if any, dam removal would have on participation levels and/or visitor days to the area. Preliminary evidence from personal communications suggests that whitewater rafting outfitters feelings are mixed on the subject, with some believing it will improve rafting experience and others wondering if flow levels will be too low during certain parts of the year.

The decrease in users or visitors days associated with reservoir loss may be offset or augmented by new users coming to sport-fish, and this is an area that requires further consideration and analysis. Impacts on recreation, either positive or negative, need to be identified and included in any cost-benefit assessment.

4. CONCLUSION

This analysis is a first-cut effort to identify and, when possible, quantify a number of the likely costs and benefits associated with removing the four lower dams on the Klamath River. This dam removal scenario involves a number of complex variables, and as it typical with dam removal decision-making, likely changes involve a great deal of uncertainty. The findings of this analysis are based on our best efforts to obtain and use current and relevant existing data; continued research on this topic would likely benefit from continued data collection and analysis. The purpose of this analysis is to increase understanding and decrease uncertainly related to the likely economic impacts of dam removal.

Table 7 lists the likely impacts of dam removal and based on the results of this study, the likely direction of the impacts for Siskiyou County in particular. Table 8 lists like impacts for other stakeholders.

Impact	Siskiyou County	In Economic Terms
Dam Deconstruction	▪ Positive – Jobs and Spending	(See local economy)
Power	▪ Neutral – Not responsible for finding alternative source ▪ Negative – If electrical rates increase	Unknown
Property Values	▪ Negative – Loss of lake view, uncertainty over property rights of land under reservoirs	Unknown
Fish Populations	▪ Positive	$4.5 million[2]
Local Economy	▪ Positive – Spending and jobs from deconstruction, increased tourism, visitors ▪ Negative – Loss of jobs and taxes from hydropower project	$172million[3] plus -$2million
Commercial Fishing	▪ Positive	(See fish populations)
Recreational Fishing	▪ Positive	(See fish populations)
Subsistence Fishing	▪ Positive	(See fish populations)
Cultural Values	▪ Positive	Unknown
Recreation (non-fishing)	▪ Unknown	Unknown
Free-flowing River	▪ Positive	$104 million

Table 8: Summary of the costs and benefits of dam removal to Siskiyou County

[2] Assuming a 100% increase in fish populations
[3] Assuming a dam deconstruction cost of $73 million

	Other Stakeholders
Dam Deconstruction	▪ Negative – PacifiCorp or other entity responsible for cost
Power	▪ Negative – PacifiCorp – If alternative power source costs more to operate ▪ Neutral to Positive – PacifiCorp –If alternative power source is cheaper
Property Values	▪ Negative – Property owners – Loss of lake view, uncertainty over property rights of land under reservoirs
Fish Populations	▪ Positive – Fisheries, Visitors, Environmentalists, Fish
Commercial Fishing	▪ Positive – Commercial fishers, processing plants
Recreational Fishing	▪ Positive – Sportfishers
Subsistence Fishing	▪ Positive – Local tribes
Cultural Values	▪ Positive – Local tribes
Recreation (non-fishing)	▪ Unknown
Free-flowing River	▪ Positive – Anyone who value a free-flowing river

Table 9: Summary of the costs and benefits of dam removal to other stakeholders

The issue of dam removal is complex and removal of a dam(s) has the potential to create a variety of impacts, some positive and some negative. Stakeholders and decision-makers alike would undoubtedly benefit from continued and/or additional research of the topics listed below.

- Estimate the current value of subsistence harvests and the increased value that would result from dam removal and the associated increase in salmon harvests
- Identify the likely direction (positive or negative) and magnitude of impact dam removal would have on recreational activities.
- Quantify the associated economic gain (loss) to the local economy based on visitor days and average visitor spending.
- If possible, quantify of the cultural and tribal values associated with dam removal.
- Estimate the impact of dam removal other species, not just fall Chinook salmon.
- Estimate the non-use value for salmon restoration/preservation
- Narrow down the estimated range of costs for dam removal and the estimated increase in salmon populations. Use these values to quantify the impact of such changes on the economy of Siskiyou County.
- Quantify the impact of increased salmon harvest on recreational and commercial fisheries and the associated benefits to Siskiyou County.

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ATTACHMENT 9

Huntington, C.,W., 2004. *Preliminary Estimates of the Recent and Historic Potential for Anadromous Fish Production Above Iron Gate Dam*

Clearwater BioStudies, Inc.

23252 S. Central Point Road Canby, Oregon 97013 (503) 266-8724

Technical Memorandum

To: Larry Dunsmoor, Biologist, Klamath Tribes

From: C.W. Huntington, Aquatic Biologist

Subject: ***Preliminary estimates of the recent and historic potential for anadromous fish production above Iron Gate Dam***

Date: 05 April 2004

The following memorandum provides ***preliminary estimates*** of the recent and historical potential for anadromous fish production, and specifically chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) production, in portions of the Klamath Basin upstream of Iron Gate Dam (IGD; at km 305.9) on the Klamath River. ***These estimates are intended to provide interim answers to several questions that have been posed about this production potential and that will ultimately be answered in a more authoritative way through collaborative modeling efforts now underway in the basin.*** First, how much anadromous fish habitat is present above IGD? Second, what is known about the recent potential of this habitat to produce chinook salmon and steelhead if fish passage and survival problems are resolved at dams and associated slack-water areas along the mainstem Klamath River? Finally, what was the historic production potential of that portion of the drainage basin situated upstream of Upper Klamath Lake (at approximately km 454) and how might restoration of some of this potential influence the capacity of the entire area upstream of IGD to produce anadromous fish?

Anadromous Fish Habitat Above Iron Gate Dam

Working with representatives of multiple governmental agencies, Tribes, non-governmental organizations, and PacifiCorp, I am in the process of compiling available information on habitat within streams in the drainage basin above IGD. Many of these streams are known to have supported anadromous fish prior to the construction of dams on the Klamath River, although detailed data on which reaches of which streams supported a particular anadromous species are frequently unavailable. For some streams, documentation of historic use by these fish is weak or lacking even though the streams would clearly have provided suitable habitat when in good condition. The lack of historic documentation reflects that fish runs into the area were eliminated or blocked before there was any effort to catalog their freshwater production areas.

At present, I have developed a preliminary list of streams and stream reaches above IGD that appear likely to have had historic potential to produce chinook salmon or steelhead trout. Identification of these streams and reaches has been based on recent stream survey data (from the Forest Service, Oregon Department of Fish and Wildlife [ODFW], and the California Department of Fish and Game [CDFG], on trout abundance and distribution data (from the Forest Service, ODFW, CDFG, and the Klamath Tribe), on water quality and riparian condition data (from the Oregon Department of Environmental Quality and the Klamath Tribe), on model-based estimates of natural flow regimes in the basin's streams (from the Oregon Department of Water Resources), on discussions with local biologists, on reports by Chapman (1981) and Fortune et al. (1966), and on my own professional judgment. The list of historic chinook and steelhead streams will likely be refined during the next few months, but should already provide a reasonable approximation of the areas that at one time provided habitat suitable for use by these two species. Streams above IGD undoubtedly provided important habitat for coho salmon (*O. kisutch*) and Pacific lamprey (*Entosphenus tridentata*) prior to dam construction, but these species have not been a focus of my data compilation effort. Coho salmon would likely have been restricted to streams in the lower-most portions of the drainage basin above IGD, and there are no records or anecdotal accounts of which I am aware that suggest coho were ever present above UKL. Habitat suitable for use by lamprey is widespread in the basin above IGD.

Table 1 gives a brief summary of the just-described list of historic chinook and steelhead streams in the drainage basin above IGD, with the kilometers of suitable habitat that appears to have once been present along the streams contrasted with estimates of recently suitable habitat that were reported by Chapman (1981) and by Fortune et al. (1966). The preliminary estimates of historic habitat total approximately 1183 km of steelhead streams and 635 km of chinook streams, with 1030 km (87%) of the steelhead streams and 502 km (79%) of the chinook streams found above UKL. Streams were classified as historic chinook habitat if they had Rosgen (1996) C, E, F, or B-type channels with low to moderate gradients (<4%), widths of at least 5 meters, (natural) median August flows >0.25 cms (>9 cfs), and adult access unimpeded by barriers (note: 73 km of potential habitat in the upper Sycan River system was excluded due to uncertainty as to whether adult chinook would be able to pass through Sycan Marsh during low flow years). These threshold conditions describe the smaller Pacific Northwest streams in which I have found adult spring chinook during the spawning season and sounded reasonable to multiple salmon biologists with whom I discussed the issue. Both spring and fall-run chinook were present historically in the drainage network above IGD, and habitat of variable quality is still present for both.

Table 1. Estimates of historic and recently suitable rearing habitat for chinook salmon and steelhead trout in streams within the drainage basin above Iron Gate Dam.

Stream	Preliminary estimates of historic habitat (km)		Recent steelhead and chinook habitat (km)	Steelhead and chinook habitat (km)
	Steelhead	Chinook	Fortune et al. (1966)	Chapman (1981)
Areas below Upper Klamath Lake (UKL)				
Klamath River	44.6 (109.9)	44.6 (109.9)	43.4	43.4 (88.5)
Jenny Creek	2.5	2.5	---	---
Fall Creek	1.9	1.9	---	---
Shovel Creek	4.7	4.7	4.0	---
Spencer Creek	15.0	14.2	13.7	---
Others	19.0	---	---	---
Total	**87.7 (153.0)**	**67.9 (133.2)**	**61.1**	**43.4 (88.5)**
Smaller Tributaries to UKL				
Wood River	32.5	32.5	30.2	17.7
Annie Creek	20.0	15.9	---	---
Sun Creek	21.4	8.4	---	---
Fort Creek	6.1	6.1	---	---
Crooked Creek	15.6	15.6	---	---
Agency Creek	3.4	3.4	---	---
Sevenmile Creek	30.4	29.8	27.0	---
Short Creek	2.7	1.0	---	---
Fourmile Creek *	21.6	21.6	---	---
Cherry Creek *	16.1	15.3	---	---
Threemile Creek *	8.2	3.5	---	---
Fourmile (Lake) Creek *	25.9	---	---	---
Denny Creek	9.3	---	---	---
Others	11.6	---	---	---
Total	**224.8**	**147.7**	**57.3**	**17.7**
Williamson River system (excluding Sprague)				
Williamson River	39.9	39.9	33.8	33.8
Spring Creek	3.9	3.9	4.0	3.2
Larkin Creek	6.4	3.2	---	---
Sunnybrook Creek	1.1	---	---	---
Total	**51.3**	**47.0**	**37.8**	**37.0**
Sprague River system				
Sprague River	136.1	136.1	49.9	123.1
N.Fk. Sprague River	57.9	44.4	44.2	19.3
Dead Cow Creek *	6.9	---	---	---
School Creek	6.1	---	---	---
Meryl Creek *	14.0	---	---	---
Fivemile Creek	33.3	21.4	---	---
S.Fk. Sprague River	55.5	36.2	18.2	19.3
Buckboard Creek	6.6	---	---	---
Whitworth Creek *	17.4	---	---	---
Brownsworth Creek *	20.8	---	---	---
Ish Tish Creek	10.9	---	---	---
Paradise Creek	10.3	---	---	---
Fishhole Creek *	57.8	---	---	---
Sycan River	122.1	62.1	---	---
Skull Creek	10.3	---	---	---
Paradise Creek *	34.4	---	---	---
Long Creek *	47.8	---	---	---
Snake Creek *	22.4	---	---	---
Whisky Creek	13.5	6.8	---	---
Trout Creek *	10.3	---	---	---
Copperfield Creek	8.4	---	---	---
Others	59.1	---	---	---
Total	**753.5**	**307.0**	**112.3**	**161.7**
All Streams Above Irongate Dam	**1117.3 (1182.6)**	**569.6 (634.9)**	**268.5**	**259.8 (304.9)**

Note: Values in parentheses include riverine habitat inundated by slack-water by existing dams. Values not in parentheses are for habitat areas that are not currently inundated by slack-water. Asterisks (*) identify streams where one or more tributaries not explicitly identified in the table are included in the estimate of historic habitat.

The Chapman (1981) and Fortune et al. (1966) estimates of anadromous salmonid habitat above IGD will be discussed in greater detail later in this memorandum, but it is clear from Table 1 that they suggest the suitability of far less habitat than is included in my preliminary estimate of the historic condition. Neither Chapman (1981) nor Fortune et al. (1966) estimated the presence of more than about a quarter of the combined length of anadromous salmonid streams that my preliminary estimates suggest was once present above IGD. In the case of Chapman (1981), this may partly reflect the severely flow-depleted character of many of the basin's streams and a lack of information at the time on historic (natural) flows for most tributary streams. Fortune et al. (1996) took a very conservative view of the habitat capability of the basin's streams, most of which had been significantly degraded, during the mid-1960s.

Recent Potential for Chinook Salmon and Steelhead Production Above Iron Gate Dam

There have been three previous estimates of the potential for anadromous fish production within various portions of the drainage basin above IGD. These include the following:

- An estimate of what is labeled "pristine production" of anadromous salmonids above Copco Dam on the Klamath River (km 319.1) by D.W. Chapman (1981) that upon inspection appears to reflect relatively recent production potential in the absence of dams on the mainstem Klamath and of other migratory barriers in the system;

- An estimate Fortune et al. (1966) made of the chinook and steelhead production potential for areas above the upstream end of Copco Reservoir (km 327.8) in the mid-1960s.

- A preliminary estimate of current production potential for chinook salmon between IGD and Spencer Creek (PacifiCorp 2004);

I will review these estimates briefly below, then capture information contained within them as well as from other data sources to provide multiple estimates of recent production potential for chinook salmon and steelhead trout in areas above IGD.

Chapman (1981)

Chapman (1981) worked on an accelerated schedule under contract to the Bureau of Indian Affairs to develop an estimate of anadromous fish production capability lost due to dam construction on the mainstem Klamath River. In assessing the situation, his report notes that the relatively constant flows found in streams of the Upper Klamath Basin should lead to above-average smolt yields, compared to other salmon and steelhead rearing areas. However, Chapman's estimates of the historic level of loss in anadromous production potential do not appear to me to represent pristine conditions within the Upper Klamath Basin, as suggested by the title of his report ("Pristine Production of Anadromous Salmonids – Klamath River"). Rather, the Chapman (1981) estimates probably represent something closer to recent production potential in the absence of dams, associated reservoirs, and artificial migration barriers, provided that fish are able to pass downstream successfully into and through Upper Klamath Lake during their seaward migration. Chapman estimated production potential above Copco Dam (essentially above IGD, given a paucity of suitable habitat between the two) based on 1980 (degraded) habitat conditions in the largest available stream channels. He thus accounted for only a relatively small portion of the combined length of potential anadromous fish streams outlined earlier in Table 1. In fact, within the report itself the author notes that his estimates were conservatively low with reference to "pristine" conditions because they (1) were based on modeling of habitat already degraded by human activities and (2) did not incorporate the historic production potential of many tributary streams that undoubtedly produced salmon and/or steelhead.

In developing his estimates, Chapman (1981) concluded that chinook and steelhead production would be limited by available rearing habitat. He then used an instream flow-based approach at representative (randomly selected) locations to estimate weighted usable rearing area (WUA) within defined habitat strata, applied specific smolt densities per WUA in order to estimate production potential of the rearing habitat within each of these strata, and assumed reasonable rates of marine survival to predict the ability of the drainage basin to produce adult chinook and steelhead. He judged the smolt densities used to estimate the potential to produce steelhead smolts to be very conservative for the basin because they did not account for the stable, alkaline, and extremely productive conditions found in the upper Klamath Basin. The smolt densities Chapman (1981) used for chinook were from studies Bjornn (1978) conducted in the spring-fed and highly productive Lehmi River, but were likely somewhat conservative because they were based on total habitat areas (in the Lemhi River) and not WUAs (as applied in the report).

Ultimately, Chapman (1981) appears to have estimated that in the absence of migratory impediments (including dams), 304.9 km of rearing habitat suitable for anadromous salmonid production in the drainage basin above the site of Copco Dam would have the capacity to support 597,437 chinook smolts, 21,508 returning adult chinook, 106,942 steelhead smolts, and 10,694 returning adult steelhead. Looking more closely at his estimates, Chapman (1981) found that 216.4 km of habitat above UKL appeared to have the capacity to produce 15,052 (70%) of the adult chinook and 8,447 (79%) of the adult steelhead that might have returned above the Copco site in the absence of migratory impediments.

Fortune et al. (1966)

Fortune et al (1966) reported the results of a study of chinook salmon and steelhead production potential upstream of Copco Reservoir that was overseen by a multi-party steering committee that was considering reintroduction of anadromous salmonids to areas above Copco Reservoir. The authors noted that a series of migratory impediments on the mainstem Klamath River, beginning with a log crib structure built at Klamathon (near the current site of IGD) in the late 1880s, severely impeded salmon and steelhead runs into upper portions of the Klamath Basin. These runs were then largely blocked at Klamathon by fish trapping operations initiated by the Bureau of Commercial Fisheries (BOF) in 1910, and completely excluded from the upper basin when Copco Dam was completed in 1917.

In assessing the remaining potential for chinook salmon and steelhead production above Copco Dam (now essentially above IGD, given the paucity of suitable habitat between the two), Fortune et al. (1966) reconnoitered much of the drainage basin upstream for suitable habitat. The authors then developed rough estimates of the numbers of adult fish (i.e., spawners) that could be supported by the quantities of spawning gravel they considered present in channels where the depths and velocities of streamflow were judged sufficient to meet the needs of spawning salmon and steelhead. They thus assumed that spawning habitat in the system would constrain anadromous salmonid production, a conclusion different than that reached by Chapman (1981). They also noted that it was difficult to differentiate areas above UKL used by the large adfluvial redband trout from those historically used by steelhead.

Ultimately, Fortune et al. (1966) concluded that there were 268.3 km of stream still capable of providing suitable salmon and steelhead rearing habitat (excluding reservoirs) in the Klamath Basin above Copco Reservoir. All but 20.5 km of these streams either contained or were downstream of spawning gravel. They estimated that there was about 92,140 m^2 of good spawning gravel and 107,610 m^2 of total spawning gravel present in areas still suitable for salmon and steelhead use above Copco Dam. This quantity of gravel was estimated by Fortune et al. (1966) to be capable of supporting about 4590 spawning pairs of chinook salmon and 3650 pairs of steelhead.

PacifiCorp (2004)

In a recent Final License Application for its Klamath River projects, PacifiCorp (2004) provided a brief summary of *recent and very preliminary* EDT-based modeling of the current potential for chinook salmon production in the Klamath system from IGD upstream to and including Spencer Creek, but extending no farther into the upper basin. This preliminary modeling accounted for only one of the anadromous species (chinook) for which there is production potential above IGD and included only a small portion of the potential chinook production area above IGD (see Table 1). PacifiCorp (2004) indicates that the modeling suggests that the relatively small area considered would return about 4,500 adult chinook to the spawning grounds with 100% dam and reservoir survival, and no harvest. With 100% dam survival, model-predicted reservoir survivals, and current harvest rates, the preliminary modeling suggests returns to the spawning grounds of approximately 487 adults.

Preliminary Estimates of Recent Potential for Chinook and Steelhead Production Above IGD

After considering the previously discussed estimates of recent potentials for chinook and steelhead production above IGD, and additional available data, I used a multi-method approach to develop what might be termed preliminary "best estimates" of the production potential for each species, assuming 100 percent dam passage and reservoir survival, and no harvest. The resultant estimates are outlined in Table 2 and will be discussed below. For chinook, I used six methods to estimate a potential run of adult fish returning to areas above IGD that ranged from 9,180 to 32,040, with a mean or "best estimate" value of 21,245 fish. For steelhead, I used four of the six methods utilized for chinook to develop estimates of potential adult returns to areas above IGD ranging from 7,460 to 9,550, with a "best estimate" of 8,645 fish. The estimates for both species depend substantially on the ability of juvenile fish to pass downstream successfully into and through UKL during their seaward migration, a critical unknown at present.

Table 2. Multiple preliminary estimates of recent potential for chinook and steelhead returns to the Klamath Basin upstream of Iron Gate Dam assuming 100 % dam passage and reservoir survival, and no harvest[1].

Estimation method	Adult chinook	Adult steelhead
Method 1. Chapman (1981) instream flow method, adjusted for the presence of existing dams and associated slack-water areas along the mainstem Klamath River.	18,220	9,550
Method 2. Fortune et al. (1966) spawning area method.	9,180	7,460
Method 3a. Similar adjacent watershed method, with recent adult counts for Shasta R. expanded to the area above IGD based on the ratio of suitable stream miles in the basin above IGD per Chapman (1981) and in the Shasta R system per West et al. (1990).	26,510	8,640
Method 3b. Similar adjacent watershed method, with recent adult counts for Shasta R. expanded to the area above IGD based on the ratio of suitable stream miles in the basin above IGD per Fortune et al. (1966) and in the Shasta R. system per West et al. (1980).	27,400	8,930
Method 4a. Watershed-wide expansion of PacifiCorp's (2004) EDT-based estimates of production potential for areas between Iron Gate Dam and Spencer Creek, based on relative production potentials estimated by Chapman (1981).	32,040	---
Method 4b. Watershed-wide expansion of PacifiCorp's (2004) EDT-based estimates of production potential for areas between Iron Gate Dam and Spencer Creek, based on relative production potentials estimated by Fortune et al. (1966).	14,130	---
Mean values	**21,245**	**8,645**

[1] All estimates depend substantially on the ability of juvenile salmon and steelhead to pass downstream successfully into and through Upper Klamath Lake, a critical unknown.

Estimation Method 1. Method 1 consisted of taking Chapman's (1981) instream flow-based estimates of chinook and steelhead production potential for areas above IGD and adjusting them downward to account for Fortune et al.'s (1966) estimates of the miles of recently suitable riverine rearing habitat in the mainstem Klamath River. This was necessary because Chapman's estimates of production potentials assumed 88.5 km of riverine rearing habitat and the absence of dams, whereas Fortune et al. (1966) indicated that only 43.4 km of the mainstem provided suitable riverine rearing habitat. The result was a 15% reduction in Chapman's original estimate of chinook production potential (to 18,220 adults) and an 11% reduction in his estimate of steelhead production potential (to 9,550 adults).

Estimation Method 2. Under this method I simply accepted Fortune et al.'s (1966) estimates of anadromous salmonid production potential above IGD: 9,180 adult chinook salmon and 7,460 adult steelhead trout. As indicated earlier, these estimates were based entirely on a conservative accounting of available spawning area. I believe that these estimates of production potential should be fairly conservative because of difficulty in anticipating those habitat patches that will be used by spawning fish and my perception that spawning habitat is unlikely to limit anadromous fish production in the area above IGD as a whole. Chapman (1981) reviewed information on streams in the area and concluded that rearing habitat, not spawning habitat, was likely to limit anadromous salmonid production.

Estimation Method 3a. Estimates of recent production potential made using Method 3a were based on recent weir counts of adult chinook and steelhead returning to the Shasta River watershed, California, and recent estimates of suitable stream kilometers for each of the two species in that watershed as well as in the drainage basin above IGD. The Shasta River provides a relatively good surrogate for areas above IGD because it has the most geographically proximate Klamath Basin watershed of substantial size still accessible to anadromous fish, it has supported a mix of anadromous species similar to that once present above IGD, and it is a spring-influenced system rich in nutrients that has been strongly affected by riparian degradation and irrigation withdrawals of water.

For chinook salmon, the mean Shasta River adult count for the 20-year period from 1983 through 2002 (3418 fish; A. Manji, CDFG, pers comm.) was adjusted upward to account for approximate ocean harvest rates of 15% and freshwater rates of about 30%, yielding a mean run without harvest of about 5,745 fish. This figure was then scaled up to estimate a potential 26,510 adults returning to areas above IGD. The scaling was based on the ratio between the 259.8 km of suitable stream habitat above IGD in Chapman's (1981) assessment and 56.3 km of streams that West et al. (1990) have identified as being used as chinook rearing habitat within the Shasta River watershed.

For steelhead, the mean of 1,972 adult fish returning to the Shasta River during the four-year period (1979-82) having the highest and most complete annual weir counts (KRIS database) was adjusted upward to account for an assumed harvest rate of 33% (Huntington 1988), yielding a mean run without harvest of 2,943 adults. This figure was then scaled up to a potential run of 8,640 adult steelhead returning to areas above IGD, based on the ratio between the 259.8 km of suitable stream habitat accounted for in Chapman's (1981) assessment and 88.5 km of streams that West et al. (1990) identified as being used as steelhead rearing habitat within the Shasta River watershed.

Estimation Method 3b. Method 3b was identical to Method 3a except that it used Fortune et al.'s (1966) estimates of suitable stream habitat (268.5 km for chinook salmon and the same quantity for steelhead trout), rather than those included in Chapman (1981), to scale the sizes of fish runs into the Shasta River up to those that might return to areas above IGD. Potential returns of adult fish calculated by this method were 27,400 chinook salmon and 8,930 steelhead.

Estimation Method 4a. This method expanded the recent and very preliminary EDT-based estimate that 4,500 adult chinook would return to that portion of the area above IGD that is below but includes Spencer Creek to the entire drainage basin above IGD. The basis for this extrapolation was the relative production potentials for these areas estimated by Chapman (1981). Method 4a yielded an estimate of 32,040 adult chinook returning to areas above IGD without harvest.

Estimation Method 4b. Method 4b was identical to Method 4a except that it used Fortune et al.'s (1996) estimates of the relative production potentials of differing areas within the drainage basin above IGD as the basis for expanding the EDT-based estimate. Method 4b yielded a potential run of 14,130 adult chinook returning to areas above IGD without harvest.

Historic Potential for Chinook and Steelhead Production above Upper Klamath Lake

The ecological setting, recent data on stream conditions and fish populations, Tribal accounts (e.g., see Lane & Lane Associates 1981), the Fortune et al. (1966) report, and historical information reported by Snyder (1931) all lead me to conclude that areas above UKL once supported chinook salmon, both spring and fall-run fish, and steelhead trout. The spring-run chinook apparently began disappearing early in the development of the Klamath Basin, most likely due to a combination of over-fishing, migratory impediments, and early habitat degradation. This was a pattern repeated in many areas of the Pacific Northwest and reflects that this race of fish was a primary focus of early Euro-American fisheries and highly sensitive to environmental disturbance. Substantial numbers of what were apparently fall-run chinook were still being harvested in Sprague River up until about 1910 (Lane & Lane Associates 1981), the year in which the BOF began attempting to block fish runs at Klamathon in anticipation of construction of Copco Dam.

I developed low and high-end estimates of historic returns of adult chinook and steelhead to the area above UKL, based on expansion from the highest counts of these two species recorded at the weir on Shasta River (i.e., at Shasta Racks). The intent of these estimates was to develop some preliminary numbers that would bracket historic production values for the area above UKL. My low-end expansions were simply based on the ratios of watershed areas between the Shasta River and each of three suitable production areas above UKL (Williamson River, Sprague River, and Wood River Valley). The high-end expansions were based on the ratios of measured mean annual flows between the Shasta River and the lower-most gauged sites for the same three areas above UKL. Flows were used as an expansion factor because areas with higher unit water yields can be more productive for anadromous salmonids. I used mean annual flows and not mean late season (e.g., August) flows, because late season flows at the downstream ends of the basins of interest may be irregularly affected by irrigation practices at present, particularly in the Shasta River watershed. The historic steelhead returns estimated for areas above UKL were reduced by 50% to account for competitive interactions with redband trout and uncertainties about how the steelhead would have partitioned habitat above UKL with redbands expressing an adfluvial life history. This adjustment of the estimated steelhead returns likely makes my estimates conservative, but I have no information at present upon which to decrement steelhead production to account for the presence of adfluvial redbands.

My preliminary estimates of historic chinook salmon and steelhead trout returns to areas above UKL are summarized in Table 3. The estimates of historic chinook returns ranged from nearly 150,000 adults to more than 400,000 adults, while those for historic steelhead returns ranged from about 6,850 adults to about 20,000 adults. My estimates for the production of both species would have been higher if adjusted for catch that was occurring downstream of the weir on Shasta River during the return years upon which the estimates were based, but I lacked useful information on fish harvest rates. The estimates for both species, and for chinook salmon in particular, might also have been higher if I had accounted for the historic (and unknown) seasonal production potential of UKL itself. Overall, I think that my lower estimate may be closest to the historic potential for chinook production above UKL and that my higher estimate may be closest to the historic potential for steelhead production above the lake. Depending on the outcomes of interactions between anadromous and adfluvial trout, historic steelhead runs into the area above UKL might have been higher than the range contained by my low and high estimates for this species.

Table 3. Preliminary estimates of historic chinook salmon and steelhead trout returns to areas above Upper Klamath Lake, Oregon.

Subbasin/production area	Drainage area (mi^2)	Mean annual flow (cfs)	Maximum adult return: Chinook (1931)	Maximum adult return: Steelhead (1940)	Estimated historic returns of adults: Chinook Low	Chinook High	Steelhead Low	Steelhead High
Shasta R.	793	185	61811	5657	61811		5657	
Upper Klamath (above Klamath L.)								
Williamson R. (below Klamath Marsh)	149	280	---	---	11614	93552	531	4281
Sprague R.	1580	586	---	---	123154	195791	5636	8959
Wood River Valley	192	445	---	---	14966	148681	685	6804
					149734	**438023**	**6852**	**20044**

The estimates of historic production potential provided in Table 3 suggest that much of the historic capacity to produce anadromous salmonids above the current site of IGD was found in areas above UKL. Restoration of even a portion of this potential would have a dramatic influence on the salmon and steelhead production capacity of the entire drainage basin above IGD. The degree to which this capacity might be restored has yet to be examined.

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ATTACHMENT 10

Huntington, C.W., 2006. *Estimates of Anadromous fish runs above Iron Gate Dam.*

Clearwater BioStudies, Inc.

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Technical Memorandum

To: Larry Dunsmoor, Biologist, Klamath Tribes

From: C.W. Huntington, Aquatic Biologist

Subject: Estimates of anadromous fish runs above the site of Iron Gate Dam

Date: 15 January 2006

The following memorandum is intended to provide updates on two elements of work that has been done to estimate the potential for anadromous fish production above the site of Iron Gate Dam (IGD). These elements include:

- Preliminary estimates of the historic potential for chinook production above Upper Klamath Lake (UKL) that were included in a technical memo I submitted to you in April 2004 (see Huntington 2004).

- Estimates of historic and recently suitable habitat for anadromous fish in streams within the drainage basin above IGD, per Table 1 of the technical memo referenced above (i.e., Huntington 2004).

Estimates of the historic potential for chinook production above UKL

My April 2004 memo to you provided a rough estimate of the probable magnitude of historic returns of chinook salmon to the drainage basin above UKL in order to highlight the substantial potential that the basin would have had before aquatic conditions were degraded. The memo indicated that the lower end of a range of ~150-440 thousand chinook returning to the basin seemed more probable to me, and that more authoritative estimates of production potential would be developed through collaborative modeling efforts that were already underway at the time.

Since the April 2004 memo was first distributed, I have become more familiar with areas upstream of Upper Klamath Lake and am even more convinced that historic returns of chinook to the basin above UKL were closer to the lower end of the range of values given in the memo, and not to the upper end. Since efforts to use the Ecosystem Diagnosis and Treatment (EDT) model to estimate the basin's potential to produce anadromous fish have shifted completely away from discussions of pristine (Template) conditions, it no longer seems likely that the model will be used to refine my preliminary estimate of the area's historic potential for producing chinook. With this in mind, I offer a "better estimate" of the upper basin's historic potential to produce chinook, below. The "better estimate" is based on the same algorithm used to calculate the lower end of the range of estimates given in Table 3 of the April 2004 memo, but includes two improvements. These improvements include: (1) a drainage area reduction to account for a probable lack of consistent chinook access to the 568 mi^2 watershed draining into Sycan Marsh and (2) an improved estimate of the 266 mi^2 area drained by potential chinook streams on the west side of UKL (versus the 192 mi^2 "Wood River Valley" referenced in the earlier memo).

Better estimate of historic chinook potential above UKL = 1,427 mi^2 (production area above UKL)
x 61,811 adults/793 mi^2 (Shasta R. drainage)
= 111,230 adult chinook

The "better estimate" just given is based on a single basic assumption: that similar drainage basins of a similar size will develop aquatic habitats and salmon populations that are also similar. As indicated in the April 2004 memo, this approach may not fully account for the historic (and unknown) seasonal production potential of UKL itself, which could have been considerable. As was the case for estimates of the historic chinook run given in the April 2004 memo, the "better estimate" reflects the upper basin's historic production potential for a composite of spring-run and summer-fall run chinook. Spring-run fish likely accounted for the majority of the upper basin's actual salmon production under pristine conditions, but were apparently in substantial decline by the early 1900s.

The existing potential for chinook production within the drainage basin above UKL is clearly much lower than the "better estimate" of its historic potential. While there are extensive opportunities for rehabilitating habitat above and in UKL, it is important to recognize that significant portions of the historic production potential is unlikely to be recovered.

Estimates of habitat suitable for use by anadromous fish above UKL

The April 2004 memo summarized what was known about the kilometers of streams above the site of IGD that were historically, and in multiple cases recently, suitable for use by chinook salmon and/or steelhead trout. While this information set a context for discussions of fish passage options for PacifiCorp's hydroproject, it did not differentiate between damaged historic habitats that might be rehabilitated versus those where rehabilitation efforts significant to salmon or steelhead would seem at best unlikely within the next ~30-50 years.

Table 1 represents an effort on my part to fill this gap. It provides a summary of the kilometers of streams above the site of IGD that are either currently thought to be suitable for use by anadromous fish or that it is thought could be rehabilitated to become functional for chinook salmon and/or steelhead trout within the time frame identified above. Identification of the streams and kilometers of habitat that could be rehabilitated into a functional condition was based on interactions with in-basin experts during 2004, and should be viewed as an approximation rather than an exact list. Actual success in rehabilitating anadromous fish habitat (both functional but degraded as well as non-functional habitat) would depend on allocations of resources and the cooperation of land managers and land owners, not simply technical feasibility.

Table 1. Estimates of the quantity (in kilometers) of recent and restorable habitat for anadromous fish in the drainage basin above the site of Iron Gate Dam.

	Estimates of potential anadromous fish habitat (km)		
Stream	**Existing**	**Existing plus recoverable**	**Comments**
Areas below Upper Klamath Lake (UKL)			
Klamath R.	44.6	44.6 (109.9?)	Value in parentheses includes habitat now inundated by slackwater.
Spencer Cr. *	23.6	23.6	
Shovel Cr. *	5.3	5.3	
Fall Cr.	1.4	1.4	
Jenny Cr.	1.8	1.8	
Others	21.1	21.1	
Total	**97.8**	**97.8 (163.1?)**	
Westside tributaries to UKL			
Wood R.	32.5	32.5	
Annie Cr.	---	19.9	Alterations and diversions affect access at present.
Sun Cr.	---	21.4	Alterations and bull trout barrier affect access at present; rehabilitation planned.
Fort Cr.	6.1	6.1	
Crooked Cr.	15.7	15.7	
Agency Cr.	1.3	1.3	
Sevenmile Cr.	30.4	30.4	Water diversions affect passage and would need to be modified.
Short Cr.	2.8	2.8	
Fourmile Cr.	---	16.7	
Cherry Cr. *	---	15.5	
Threemile Cr. *	---	8.1	
Recreation/Crystal Cr.	13.1	13.1	
Fourmile (Lake) Cr. *	---	---	Water exported to Rogue R. Basin.
Denny Cr.	---	---	Upper reaches suitable for use; bottomland reaches dysfunctional.
Total	**101.9**	**183.5**	
Williamson R. system (excluding Sprague)			
Williamson R.	37.4	37.4	
Larkin Cr.	6.4	6.4	
Sunnybrook Cr.	1.1	1.1	
Spring Cr.	4.0	4.0	
Total	**48.9**	**48.9**	
Sprague R. system			
Sprague R.	136.1	136.1	Much of mainstem strongly in need of rehabilitation.
N.Fk. Sprague R.	57.9	57.9	Lower-most reaches strongly in need of rehabilitation.
Dead Cow Cr. *	6.9	6.9	
School Cr.	6.1	6.1	
Cold Cr.	3.3	3.3	
Gearhart Cr. *	4.8	4.8	
Boulder Cr.	4.8	4.8	Steep and cold stream; will get only limited use (ODFW).
Sheepy Cr.	1.8	1.8	Steep and cold stream; will get only limited use (ODFW).
Meryl Cr. *	---	14.0	In need of substantial rehabilitation.
Fivemile Cr.	22.4	22.4	Lower-most reaches strongly in need of rehabilitation.
S.Fk. Sprague R.	55.5	55.5	Lower reaches very strongly in need of remedial actions.
Corral Cr.	2.5	2.5	
Camp Cr.	2.9	2.9	
Buckboard Cr.	6.6	6.6	
Whitworth Cr. *	17.4	17.4	
Brownsworth Cr. *	20.8	20.8	
Ish Tish Cr.	---	10.9?	Potential for rehabilitation uncertain.
Paradise Cr.	---	---	Rehabilitation appears infeasible.
Fishhole Cr. *	---	51.5?	Flow enhancement and other rehabilitation would be needed here.
Deming Cr.	---	---	ODFW considers the stream naturally isolated from the South Fork.
Sycan R. (above and within Sycan Marsh)	---	68.4?	Use of this habitat would require passage through Sycan Marsh.
Skull Cr.	---	10.3?	Use of this habitat would require passage through Sycan Marsh.
Paradise Cr. *	---	34.4?	Use of this habitat would require passage through Sycan Marsh.
Long Cr. *	---	45.2?	Use of this habitat would require passage through Sycan Marsh.
Sycan R. (below Sycan Marsh)	53.7	53.7	Strongly in need of rehabilitation.
Brown Springs Cr.	---	1.9	Rehabilitation of this small springbrook is in process.
Snake Cr. *	---	6.8	Rehabilitation may be infeasible.
Others	---	---	Multiple intermittent streams have uncertain anadromous potential.
Whisky Cr.	---	7.2	Rehabilitation of part of this springbrook will require major investments.
Rock Cr.	---	8.4	Lower-most reach of stream may be dysfunctional.
Trout Cr. *	11.3	11.3	
Whitehorse Cr.	---	3.2?	Rehabilitation of this small springbrook will be difficult but not infeasible.
Copperfield Cr.	---	---	Rehabilitation appears infeasible.
Others	---	---	Rehabilitation appears infeasible.
	421.4	**453.1 (669.3?)**	Value in parentheses includes areas within/above Sycan Marsh.
All Streams Above Iron Gate	**676.6**	**774.1 (1055.6?)**	Value in parentheses includes inundated areas and sites within/above Sycan Marsh.

* Streams that include additional unnamed tributaries with potential habitat.
? Kilometers of streams that may or may not be recoverable as habitat, depending on the circumstances.

Citations

Huntington, C.W. 2004. Preliminary estimates of the recent and historic potential for anadromous fish production above Iron Gate Dam. Technical memorandum to Larry Dunsmoor, Biologist, Klamath Tribes. Clearwater BioStudies, Inc., Canby, Oregon. 05 April 2004.

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ATTACHMENT 11

Klamath Index Selections from PFMC Klamath Salmon Management Plan

PACIFIC COAST SALMON PLAN

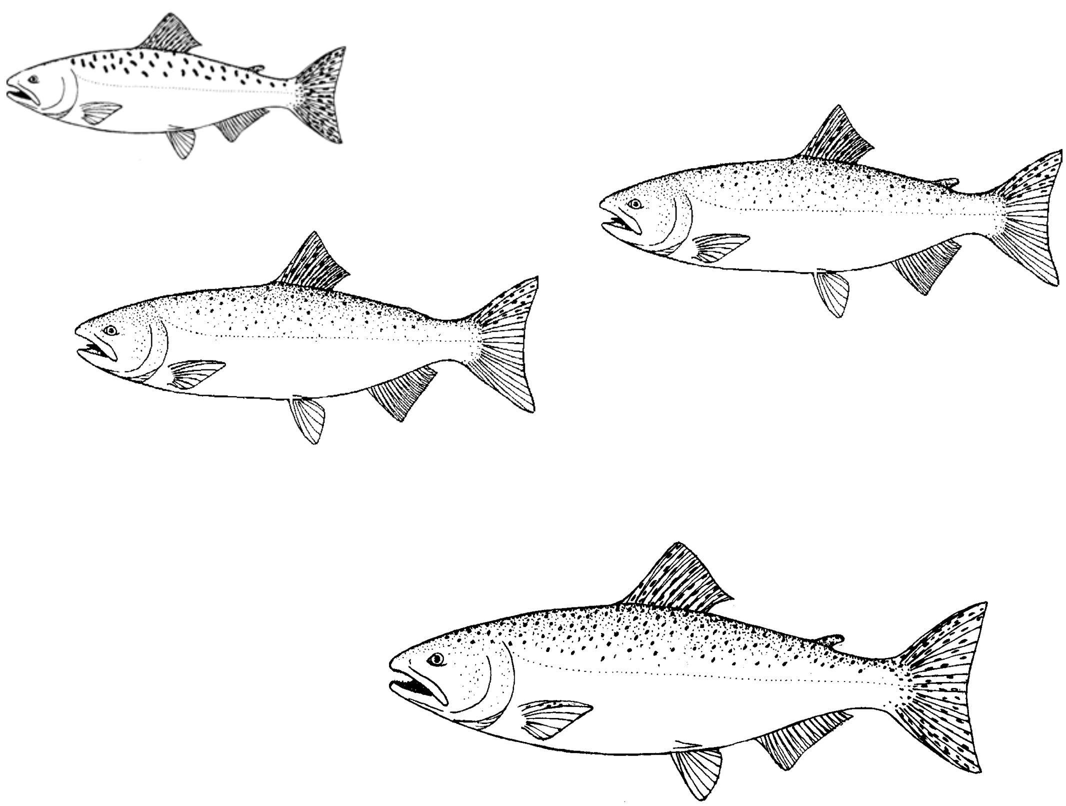
FISHERY MANAGEMENT PLAN FOR

COMMERCIAL AND RECREATIONAL SALMON FISHERIES

OFF THE COASTS OF WASHINGTON, OREGON AND CALIFORNIA

AS REVISED THROUGH AMENDMENT 14

(Adopted March 1999)



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September 2003

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SUPPLEMENTARY FMP DOCUMENTS

(Available from Council office and web site:www.pcouncil.org):

AMENDMENT 14 TO THE PACIFIC COAST SALMON PLAN, APPENDIX A:
IDENTIFICATION AND DESCRIPTION OF ESSENTIAL FISH HABITAT, ADVERSE IMPACTS, AND RECOMMENDED CONSERVATION MEASURES FOR SALMON

AMENDMENT 14 TO THE PACIFIC COAST SALMON PLAN, APPENDIX B:
DESCRIPTION OF THE OCEAN SALMON FISHERY AND ITS SOCIAL AND ECONOMIC CHARACTERISTICS

APPENDIX C TO THE PACIFIC COAST SALMON PLAN:
REVIEW OF OCEAN SALMON FISHERIES (Latest annual edition)

PRESEASON REPORT I:
STOCK ABUNDANCE ANALYSIS FOR OCEAN SALMON FISHERIES (Latest annual edition)

PRESEASON REPORT III:
ANALYSIS OF COUNCIL ADOPTED MANAGEMENT MEASURES FOR OCEAN SALMON FISHERIES (Latest annual edition)

LIST OF ACRONYMS AND ABBREVIATIONS

ASETF	Anadromous Salmonid Environmental Task Force
Council	Pacific Fishery Management Council
EEZ	exclusive economic zone (three to 200 miles offshore)
EIS	Environmental Impact Statement
ESA	Endangered Species Act
EFH	Essential fish habitat
ESU	Evolutionarily significant unit
FAB	Fisheries Advisory Board (established in U.S. v. Washington)
FMP	fishery management plan
FR	Federal Register
FRAM	Fishery Regulation Assessment Model
HC	Habitat Committee
KRSMG	Klamath River Salmon Management Plan
KRTT	Klamath River Technical Team
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MSP	maximum sustainable production
MSY	maximum sustainable yield
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPPA	Northwest Power Planning Act
OCN	Oregon coastal natural coho
ODFW	Oregon Department of Fish and Wildlife
OPI	Oregon Production Index
OY	optimum yield
PFMC	Pacific Fishery Management Council
PSC	Pacific Salmon Commission
RFA	Regulatory Flexibility Act
RIR	Regulatory Impact Review
SAS	Salmon Advisory Subpanel
Secretary	Secretary of Commerce
SEIS	Supplemental Environmental Impact Statement
SFA	Sustainable Fisheries Act
SRFCRT	Sacramento River Fall Chinook Review Team
SSC	Scientific and Statistical Committee
STT	Salmon Technical Team
TAC	total allowable catch
TALFF	total allowable level of foreign fishing
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife

3 CONSERVATION

"Conservation and management measures shall be based upon the best scientific information available."

Magnuson-Stevens Act, National Standard 2

3.1 SALMON STOCK CONSERVATION OBJECTIVES

"To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination"

Magnuson-Stevens Act, National Standard 3

To achieve optimum yield, prevent overfishing, and assure rebuilding of salmon stocks whose abundance has been depressed to an overfished level, this plan establishes, to the extent practicable, conservation objectives to perpetuate the coastwide aggregate of salmon stocks covered by the plan (Chapter 1). The Council's stock conservation objectives (to be achieved annually) and other pertinent stock management information are contained in Table 3-1 (following Section 3.2). Specific objectives are listed for natural and hatchery stocks that are part of the Council's preseason fishery option development process (Chapter 9), including all stocks listed under the federal ESA. The objectives may be applicable to a single stock or a complex of interrelated stocks (those sharing similarities in life-history traits, geographic distribution, habitat preferences and genetic characteristics). Stocks that are not included in the preseason analyses may lack specific conservation objectives because the stock is not significantly impacted by ocean fisheries or insufficient management information is available from which to assess ocean fishery impacts directly. In the latter case, the conservation objective for a managed stock may serve to provide for the conservation of a closely related stock unless, or until, more specific management information can be developed.

3.1.1 Basis

The Council's conservation objectives for natural stocks may (1) be based on estimates for achieving MSY, an MSY proxy, or MSP, or (2) represent special data gathering or rebuilding strategies to approach MSY and to eventually develop MSY or MSP objectives. The objectives have generally been developed through extensive analysis by the fishery management entities with direct management authority for the stock, or through joint efforts coordinated through the Council, or with other state, tribal or federal entities. Most of the objectives for stocks north of Cape Falcon have been included in U.S. District Court orders. Under those orders for Washington coastal and Puget Sound stocks (U.S. v. Washington, 626 F. Supp. 1405 [1985] and Hoh v. Baldrige No. 81-742 [R] C), the treaty tribes and WDFW may agree to annual spawner targets that differ from the MSP or MSY objectives. Details of the conservation objectives in effect at the time this FMP was approved are available in PFMC (1984), in individual amendment documents (see Table 1 in the Introduction), and as referenced in Table 3-1. Updated conservation objectives ane ESA consultation standards are available in the most recent Preseason Report I, (Appendix A, Table A-1), and Preseason Report III (Appendix A, Table A-3) produced by the STT.

The Council's fixed conservation objectives are generally expressed in terms of an annual fishery escapement believed to be optimum for producing MSY over the long-term. The escapement objective may be (1) a specific number or a range for the desired number of adult spawners (spawner escapement), or (2) a specific number or range for the desired escapement of a stock from the ocean or at another particular location, such as a dam, that may be expected to result in the target number of spawners. The current data gathering and rebuilding objectives may be expressed as fixed or stepped exploitation or harvest rates and may include spawner floors or severely reduced harvest rates at low abundance levels (e.g., Klamath River fall chinook), or as special requirements provided in National Marine Fisheries Service (NMFS) consultation standards for stocks listed under the ESA.

3.1.2 Changes or Additions

Conservation objectives are fixed measures of the FMP intended to provide the necessary guidance during the course of the annual preseason planning process to establish salmon fishing seasons that achieve optimum yield. However, changes or additions to the stock complexes and objectives for most natural stocks may be made without plan amendment if a comprehensive technical review of the best scientific information available provides conclusive evidence that, in the view of the Salmon Technical Team, Scientific and Statistical Committee (SSC), and the Council, justifies a modification. An exception is the 35,000 natural spawner floor for Klamath River fall chinook which may only be changed by FMP amendment. The Council may change objectives for hatchery stocks upon the recommendation of the pertinent federal, state, and tribal management entities. Federal court-ordered changes in objectives will also be accommodated without a plan amendment. Insofar as possible, changes for natural stocks will only be reviewed and approved within the schedule established for salmon estimation methodology reviews (completed at the November meeting prior to the season in which they are effective) and apart from the preseason planning process. The applicable annual objectives of Council-adopted rebuilding programs developed in response to an overfishing concern or the requirements of consultation standards promulgated by NMFS under the ESA may be employed without plan amendment to assure timely implementation. All of these changes will be documented during the Council's preseason planning process.

The Council considers established conservation objectives to be stable and a technical review of biological data must provide substantial evidence that a modification is necessary. The Council's approach to conservation objectives purposely discourages frequent changes for short-term economic or social reasons at the expense of long-term benefits from the resource. However, periodic review and revision of established objectives is anticipated as additional data become available for a stock or stock complex.

3.2 OVERFISHING CRITERIA

> *"Any fishery management plan . . . shall . . . specify objective and measurable criteria for identifying when the fishery . . . is overfished . . . and, . . . contain conservation and management measures to prevent overfishing or end overfishing and rebuild the fishery;"*
> *Magnuson-Stevens Act, § 303(a)(10)*

> *"The terms overfishing and overfished mean a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis."*
> *Magnuson-Stevens Act, § 3(29)*

In applying the Magnuson-Stevens Act definition of overfishing to salmon fisheries and establishing criteria by which to identify it, the Council must consider the uncertainty and theoretical aspects of MSY as well as the complexity and variability unique to naturally producing salmon populations. These unique aspects include the interaction of a short-lived species with frequent, sometimes protracted, and often major variations in both the freshwater and marine environments. These variations may act in unison or in opposition to affect salmon productivity in both positive and negative ways. In addition, variations in natural populations may sometimes be difficult to measure due to masking by artificially produced salmon.

3.2.1 General Application to Salmon Fisheries

In setting criteria from which to judge the conservation status of salmon stocks, the unique life history of salmon must be considered. Chinook, coho, and pink salmon are short-lived species (generally two to six years) that reproduce only once shortly before dying. Spawning escapements of coho and pink salmon are dominated by a single-year class and chinook spawning escapements may be dominated by no more than one or two-year classes. The abundance of year classes can fluctuate dramatically with combinations of natural and human-caused environmental variation. Therefore, it is not unusual for a healthy and relatively abundant salmon stock to produce occasional spawning escapements which, even with little or no fishing impacts, may be significantly below the long-term average associated with the production of MSY. This phenomenon has been observed in recent years for numerous salmon stocks, including Klamath River fall chinook and several Washington coho stocks.

Numerous West Coast salmon stocks have suffered, and continue to suffer, from an onslaught of nonfishing activities that severely reduce natural survival by such actions as the elimination or degradation of freshwater spawning and rearing habitat. The consequence of this man-caused, habitat-based variation is two fold. First, these habitat changes increase large scale variations in stock productivity and associated stock abundances, which in turn complicate the overall determination of MSY and the specific assessment of whether a stock is producing at or below that level. Secondly, as the productivity of the freshwater habitat is diminished, the benefit of further reductions in fishing mortality to improve stock abundance decreases. Clearly, the failure of several stocks managed under this FMP to produce at an historic or consistent MSY level has little to do with current fishing impacts and often cannot be rectified with the cessation of all fishing.

To address the requirements of the Magnuson-Stevens Act to clearly identify when a stock may be approaching an overfished condition or is overfished, the Council has established two separate criteria based on a stock's failure to meet its conservation objective. These criteria are denoted as a "conservation alert" and an "overfishing concern". The criteria for these two categories are based on the unique life history of salmon and the large variations in annual stock abundance due to numerous environmental variables. They also take into account the uncertainty and imprecision surrounding many estimates of MSY, fishery impacts, and spawner escapements. In recognition of the unique salmon life history, the criteria differ somewhat from the general guidance in the National Standard Guidelines (§ 600.310), but equal or exceed them in addressing the overfishing issue as it relates to salmon.

3.2.2 Conservation Alert

> *"A fishery shall be classified as approaching a condition of being overfished if, based on trends in fishing effort, fishery resource size, and other appropriate factors, the Secretary estimates that the fishery will become overfished within two years."*
>
> *Magnuson-Stevens Act, § 304(e)(1)*

To anticipate and react to potential stock declines which might lead to overfishing, the Council has established a conservation alert process with criteria and actions as described below.

3.2.2.1 Criteria

A conservation alert is triggered during the annual preseason process (Chapter 9) if a natural stock or stock complex, listed in Table 3-1, is projected to fall short of its conservation objective (MSY, MSY proxy, MSP, or floor in the case of some harvest rate objectives [e.g., 35,000 natural Klamath River fall chinook spawners]). While a projected one-year shortfall may be of little biological concern, it may also represent the beginning of production problems and is worthy of note to help prevent future stock decline.

3.2.2.2 Council Action

For all natural stocks which meet the conservation alert criteria, the Council will notify pertinent fishery and habitat managers, advising that the stock may be temporarily depressed or approaching an overfishing concern (depending on its recent conservation status), and request that state and tribal fishery managers identify the probable causes, if known. If the stock in question has not met its conservation objective in the previous two years, the Council will request the pertinent state and tribal managers to do a formal assessment of the primary factors leading to the shortfalls and report their conclusions and recommendations to the Council no later than the March meeting prior to the next salmon season.

The Council will take the following actions for stocks which trigger a conservation alert that do not qualify as exceptions under Section 3.2.4 (see Table 3-1):

1. Close salmon fisheries within Council jurisdiction that impact the stock.

2. In the case of Washington coastal and Puget Sound salmon stocks and fisheries managed under U.S. District Court orders, the Council may allow fisheries which meet annual spawner targets developed through relevant U.S. v. Washington, Hoh v. Baldrige, and subsequent U.S. District Court ordered

processes and plans, which may vary from the MSY or MSP conservation objectives. Other than the exceptions noted above, the Council may not recommend ocean salmon fisheries which are expected to trigger a conservation alert.

If postseason estimates confirm that a stock conservation objective is not met, a rebuilding program for the following year is implicit in the conservation objective since it is based on annually meeting MSY or MSP. In addition, the Council reviews stock status annually and, where needed, identifies actions required to improve estimation procedures and correct biases. Such improvements provide greater assurance that objectives will be achieved in future seasons. Consequently, a remedial response is built into the preseason planning process to address excessive fishing mortality levels relative to the conservation objective of a stock.

The Council does not believe that a one year departure from the MSY/MSP spawner objective for salmon affects the capacity of a stock to produce MSY over the long-term (i.e., does not constitute overfishing as defined by the Magnuson-Stevens Act). However, the Council's use of a conservation alert and the rebuilding effect of the conservation objectives provides for sound resource management and responds to the concept in the National Standard Guidelines for action to address overfishing concerns in any one year. The Council's conservation objectives which are used to trigger a conservation alert are generally based on MSY or MSP rather than a minimum stock size threshold. In this respect, the Council's management approach is more conservative than recommended by the National Standard Guidelines.

3.2.3 Overfishing Concern

> *"For a fishery that is overfished, any fishery management plan, amendment, or proposed regulations . . . for such fishery shall–(A) specify a time period for ending overfishing and rebuilding the fishery that shall–(I) be as short as possible, taking into account the status and biology of any overfished stocks of fish, the needs of the fishing communities, recommendations by international organizations in which the United States participates, and the interaction of the overfished stock within the marine ecosystem; and (ii) not exceed 10 years, except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the United States participates dictate otherwise. . ."*
>
> *Magnuson-Stevens Act, § 304(e)(4)*

The Magnuson-Stevens Act requires overfishing be ended and stocks rebuilt in as short a period as possible and, depending on other factors, no longer than ten years. For healthy salmon stocks which may experience a sudden reduction in production and/or spawner escapement, the limitation on fishing impacts provided by the Council's MSY or MSY proxy conservation objectives provide a stock rebuilding plan that should be effective within a single salmon generation (two years for pinks, three years for coho, and three to five years for chinook). However, additional actions may be necessary to prevent overfishing of stocks suffering from chronic depression due to fishery impacts outside Council authority, or from habitat degradation or long-term environmental fluctuations. Such stocks may meet the criteria invoking the Council's overfishing concern.

3.2.3.1 Criteria

The Council's criteria for an overfishing concern are met if, in three consecutive years, the postseason estimates indicate a natural stock has fallen short of its conservation objective (MSY, MSP, or spawner floor as noted for some harvest rate objectives) in Table 3-1. It is possible that this situation could represent normal variation, as has been seen in the past for several previously referenced salmon stocks which were reviewed under the Council's former overfishing definition. However, the occurrence of three consecutive years of reduced stock size or spawner escapements, depending on the magnitude of the short-fall, could signal the beginning of a critical downward trend (e.g., Oregon coastal coho) which may result in fishing that jeopardizes the capacity of the stock to produce MSY over the long term if appropriate actions are not taken to ensure the automatic rebuilding feature of the conservation objectives is achieved.

3.2.3.2 Assessment

When an overfishing concern is triggered, the Council will direct its STT to work with state and tribal fishery managers to complete an assessment of the stock within one year (generally, between April and the March

Council meeting of the following year). The assessment will appraise the actual level and source of fishing impacts on the stock, consider if excessive fishing has been inadvertently allowed by estimation errors or other factors, identify any other pertinent factors leading to the overfishing concern, and assess the overall significance of the present stock depression with regard to achieving MSY on a continuing basis.

Depending on its findings, the STT will recommend any needed adjustments to annual management measures to assure the conservation objective is met, or recommend adjustments to the conservation objective which may more closely reflect the MSY or ensure rebuilding to that level. Within the constraints presented by the biology of the stock, variations in environmental conditions, and the needs of the fishing communities, the STT recommendations should identify actions that will recover the stock in as short a time as possible, preferably within ten years or less, and provide criteria for identifying stock recovery and the end of the overfishing concern. The STT recommendations should cover harvest management, potential enhancement activities, hatchery practices, and any needed research. The STT may identify the need for special programs or analyses by experts outside the Council advisors to assure the long-term recovery of the salmon population in question. Due to a lack of data for some stocks, environmental variation, economic and social impacts, and habitat losses or problems beyond the control or management authority of the Council, it is likely that recovery of depressed stocks in some cases could take much longer than ten years.

In addition to the STT assessment, the Council will direct its Habitat Committee (HC) to work with federal, state, local, and tribal habitat experts to review the status of the essential fish habitat affecting this stock and, as appropriate, provide recommendations to the Council for restoration and enhancement measures within a suitable time frame.

3.2.3.3 Council Action

Following its review of the STT report, the Council will specify the actions that will comprise its immediate response for ensuring that the stock's conservation objective is met or a rebuilding plan is properly implemented and any inadvertent excessive fishing within Council jurisdiction is ended. The Council's rebuilding plan will establish the criteria that identify recovery of the stock and the end of the overfishing concern. In some cases, it may become necessary to modify the existing conservation objective/rebuilding plan to respond to habitat or other long-term changes. Even if fishing is not the primary factor in the depression of the stock or stock complex, the Council must act to limit the exploitation rate of fisheries within its jurisdiction so as not to limit recovery of the stock or fisheries, or as is necessary to comply with ESA consultation standards. In cases where no action within Council authority can be identified which has a reasonable expectation of providing benefits to the stock unit in question, the Council will identify the actions required by other entities to recover the depressed stock. Upon review of the report from the HC, the Council will take actions to promote any needed restitution of the identified habitat problems.

For those fishery management actions within Council authority and expertise, the Council may change analytical or procedural methodologies to improve the accuracy of estimates for abundance, harvest impacts, and MSY escapement levels, and/or reduce ocean harvest impacts when shown to be effective in stock recovery. For those causes beyond Council control or expertise, the Council may make recommendations to those entities which have the authority and expertise to change preseason prediction methodology, improve habitat, modify enhancement activities, and re-evaluate management and conservation objectives for potential modification through the appropriate Council process.

3.2.3.4 End of Overfishing Concern

The criteria for determining the end of an overfishing concern will be included as a part of any rebuilding plan adopted by the Council. Additionally, an overfishing concern will be ended if the STT stock analysis provides a clear finding that the Council's ability to affect the overall trend in the stock abundance through harvest restrictions is virtually nil under the "exceptions" criteria below for natural stocks.

3.2.4 Exceptions

> *"Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches."*

This plan contains three exceptions to the application of overfishing criteria and subsequent Council actions for stocks or stock complexes with conservation objectives in Table 3-1: (1) hatchery stocks, (2) stocks for which Council management actions have inconsequential impacts, and (3) stocks listed under the ESA.

3.2.4.1 Hatchery Stocks

Salmon stocks important to ocean fisheries and comprised exclusively of hatchery production generally have conservation objectives expressed as an egg-take or the number of spawners returning to the hatchery rack to meet program objectives. This plan recognizes these objectives and strives to meet them. However, these artificially produced stocks generally do not need the protection of overfishing criteria and special Council rebuilding programs to maintain long-term production. Because hatchery stocks can generally sustain significantly higher harvest exploitation rates than natural stocks, ocean fisheries rarely present a threat to their long-term survival. In addition, it is often possible to make temporary program modifications at hatcheries to assure adequate production to sustain the stock during periods of low abundance (e.g., sharing brood stock with other hatcheries, arranging for trapping at auxiliary sites, etc.). If specialized hatchery programs are approved in the future to sustain listed salmon stocks, the rebuilding programs would be developed and followed under the ESA .

3.2.4.2 Natural Stocks With Minimal Harvest Impacts in Council-Managed Fisheries

Several natural stock components identified within this FMP are subject to minimal harvest impacts in Council fisheries because of migration timing and/or distribution. As a result, the Council's ability to affect the overall trend in the abundance of these components through harvest restrictions is virtually nil. Components in this category are identified by a cumulative adult equivalent exploitation rate of less than five percent in ocean fisheries under Council jurisdiction during base periods utilized by the fishery regulation assessment models (1979-1982 for chinook and 1979-1981 for coho). Council action for these components, when a conservation alert or an overfishing concern are triggered, will consist of confirming negligible impacts of proposed Council fisheries, identifying factors which have led to the decline or low abundance (e.g., fishery impacts outside Council jurisdiction, or degradation or loss of essential fish habitat), and monitoring of abundance trends and total harvest impact levels. Council action will focus on advocating measures to improve stock productivity, such as reduced interceptions in non-Council-managed fisheries, and improvements in spawning and rearing habitat, fish passage, flows, and other factors affecting overall stock survival.

3.2.4.3 Stocks Listed Under the Endangered Species Act

The Council regards stocks listed as endangered or threatened under the ESA as a third exception to the application of overfishing criteria of the Magnuson-Stevens Act. The ESA requires federal agencies whose actions may jeopardize listed salmon to consult with NMFS. Because NMFS implements ocean harvest regulations, it is both the action and consulting agency for actions taken under the FMP. To ensure there is no jeopardy, NMFS conducts internal consultations with respect to the effects of ocean harvest on listed salmon. The Council implements NMFS' guidance as necessary to avoid jeopardy, as well as in recovery plans approved by NMFS. As a result of NMFS' consultation, an incidental take statement may be issued which authorizes take of listed stocks under the FMP that would otherwise be prohibited under the ESA.

The Council believes that the requirements of the ESA are sufficient to meet the intent of the Magnuson-Stevens Act overfishing provisions. Those provisions are structured to maintain or rebuild stocks to levels at or above MSY and require the Council to identify and develop rebuilding plans for overfished stocks. For many fish species regulated under the Magnuson-Stevens Act, the elimination of excess fishing pressure is often the sole action necessary to rebuild depressed stocks. This is, however, not the case for many salmon stocks and, in particular, for most listed populations.

Although harvest has certainly contributed to the depletion of West Coast salmon populations, the primary reason for their decline has been the degradation and loss of freshwater spawning, rearing and migration habitats. The quality and quantity of freshwater habitat are key factors in determining the MSY of salmon populations. The Council has no control over the destruction or recovery of freshwater habitat nor is it able to predict the length of time that may be required to implement the habitat improvements necessary to recover stocks. While the Council could theoretically establish new MSY escapement goals consistent with the limited or degraded habitat available to listed species, adoption of revised goals would potentially result in an ESA-listed stock being classified as producing at MSY and; therefore, not overfished under the Magnuson-Stevens Act. The Council believes that the intent of the ESA and the Magnuson-Stevens Act is the recovery of stocks to MSY levels associated with restored habitat conditions.

The Council considers the consultation standards and recovery plans developed by NMFS for listed populations as interim rebuilding plans. Although NMFS' consultation standards and recovery plans may not by themselves recover listed populations to historical MSY levels within ten years, they are sufficient to stabilize populations until freshwater habitats and their dependent populations can be restored and estimates of MSY developed consistent with recovered habitat conditions. As species are delisted, the Council will establish conservation objectives with subsequent overfishing criteria and manage to maintain the stocks at or above MSY levels.

3.3 SUPPLEMENTARY CONSERVATION INFORMATION

3.3.1 Endangered Species Act Listings

Since 1990, West Coast salmon fisheries have been modified to accommodate special requirements for the protection of salmon species listed under the federal ESA. The ESA listing of a salmon population may have profound consequences for the management of Council mixed-stock ocean fisheries since listed populations are often incidentally harvested with more abundant healthy populations. As additional stocks of salmon have been listed, the Council's preseason process has increasingly focused on protecting listed stocks. In applying the ESA to Pacific salmon, NMFS determined that a population segment of a salmon species must represent an evolutionarily significant unit (ESU) of that species in order to be eligible for listing. ESUs are characterized by their reproductive isolation and contribution to the genetic diversity of the species as a whole. NMFS establishes consultation standards for listed ESUs, which specify levels of incidental take that are not likely to jeopardize the continued existence of the ESU.

The Council must meet or exceed the requirements of the ESA, which is other applicable law. In addition to the stocks and conservation objectives in Table 3-1, the Council will manage all species listed under the ESA consistent with NMFS consultation standards or recovery plans to meet immediate conservation needs and the long-term recovery of the species. These standards are provided annually to the Council by NMFS at the start of the preseason planning process. In so far as is practical, while not compromising its ability to meet the requirements of the ESA, NMFS will endeavor to provide opportunity for Council and peer review of any proposed consultation standards, or the objectives of recovery plans, well prior to their implementation. Such review would ideally commence no later than the last Council meeting in the year immediately preceding the first salmon season in which the standards would be implemented.

Table 3-2 summarizes the relationships of the individual stocks and stock units managed under the FMP to the ESUs identified by NMFS in the course of ESA status reviews. With the exception of some hatchery stocks, the stocks managed under the FMP are generally representative of the range of life history features characteristic of most ESUs. The managed stocks therefore serve as indicators for ESUs and provide the information needed to monitor fishery impacts on ESUs as a whole. In some cases, the information necessary for stock specific management is lacking, leaving some ESUs without adequate representation. For these ESUs, it will be necessary in the immediate future to use conservative management principles and the best available information in assessing impacts in order to provide necessary protection. In the meantime, the responsible management entities should implement programs to ensure that data are collected for at least one stock representative of each ESU. Programs should be developed to provide the information that will permit the necessary stock specific management within five years of completion of this amendment.

TABLE 3-1. Conservation objectives and management information for natural and hatchery salmon stocks and stock complexes of significance to ocean salmon fisheries. Abundance information is generally based on the period 1994-1998. [a] (Page 2 of 15)

Stock	Conservation Objective[b] (to be met annually unless noted otherwise)	Subject to Council Actions to Prevent Overfishing	Other Management Information[c]
- - - CHINOOK - - -			
NORTHERN CALIFORNIA COAST - All fall and spring stocks of California streams north of the entrance to San Francisco Bay. Management of this stock complex is based primarily on meeting spawning escapements for natural fall chinook. Limited data is available except for the Klamath River. An assessment and monitoring program is under consideration by CDFG for stocks originating from the Smith, Eel, Mattole and Mad Rivers which might provide a more thorough management basis for the future. Significant water diversion problems in several drainages. In the Klamath River Basin, there is significant hatchery production of fall chinook and less so of spring chinook, resulting primarily from mitigation programs for dams constructed in both Upper Klamath and Trinity Rivers.			
Eel, Mattole, Mad, and Smith Rivers (Fall and Spring) Eel, Mattole and Mad River stocks - Threatened (1999)	Undefined. Indices of spawning abundance limited to one tributary of the Mad River and two tributaries of the Eel River. NMFS consultation standard/recovery plan for Eel, Mattole, and Mad River stocks not established at time of printing.	Indirectly. Data insufficient to define MSY criteria. CDFG developing an assessment and monitoring program. Conservation achieved by objective for Klamath River fall chinook which includes an inside allocation to tribal and sport fisheries which lowers ocean fishery impacts.	Depressed. Limited management data. Believed to occur in ocean fisheries off northern California and southern Oregon. Ocean fishery impacts incidental to fisheries for Sacramento and Klamath Rivers fall chinook. No preseason or postseason abundance estimates available.
Klamath River Fall (Klamath and Trinity Rivers)	33-34% of potential adult natural spawners, but no fewer than 35,000 naturally spawning adults in any one year. Brood escapement rate must average 33-34% over the long-term, but an individual brood may vary from this range to achieve the required tribal/nontribal annual allocation. Objective designed to allow a wide range of spawner escapements from which to develop an MSY objective or proxy while protecting the stock during prolonged periods of reduced productivity. Adopted 1988 based on Hubbell and Boydstun (1985); KRTT (1986); PFMC (1988); minor technical modifications in 1989 and 1996 (Table I-1). Natural spawners to maximize recruitment are estimated at 41,000 to 106,000 adults (Hubbell and Boydstun 1985).	Yes. A conservation alert or overfishing concern will be based on a failure to meet the 35,000 floor.	Abundance variable from high to depressed. Major contributor to ocean fisheries from Humbug Mt., OR to Horse Mt., CA (the KMZ) and to Klamath River tribal and recreational fisheries. Significant contributor to ocean fisheries from central Oregon to central California. Coastwide impacts are considered in meeting allocation requirements for Indian tribes with federally recognized fishing rights and the inland fishery. Specific management measures for this stock generally are implemented from Pigeon Pt., California to Florence, Oregon.
Klamath River Spring (Klamath and Trinity Rivers)	Undefined.	Indirectly. MSY criteria undefined. Productive potential protected by the objective for Klamath River fall chinook which includes an inside allocation to tribal and sport fisheries which lowers ocean fishery impacts.	Depressed. Believed to occur in ocean fisheries off northern California and southern Oregon (based on Trinity River Hatchery fish). Impacts incidental to ocean fisheries for Sacramento and Klamath Rivers fall chinook.

ATTACHMENT 12

Secretary of Commerce 2006 Fishery Failure Declaration

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

Declaration Concerning the Klamath River Fall Chinook Salmon Fishery

Klamath River fall Chinook (KRFC) is a key stock used by NOAA's National Marine Fisheries Service (NMFS) to manage the mixed stock ocean fishery off the Pacific Coast, in which salmon from different rivers of origin co-mingle in ocean waters and are harvested together. Fisheries disaster relief is covered by Section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act, which specifies that the Secretary, at the discretion of the Secretary or at the request of the Governor of an affected State or a fishing community, shall determine whether there is a Commercial Fishery Failure due to a Fishery Resource Disaster as a result of natural causes, man-made causes beyond the control of fisheries managers to mitigate, or undetermined causes. At the request of the Governors of Oregon and California in April 2006, I began an evaluation of the Klamath River fall Chinook. On July 6, 2006, I declared a Fishery Resource Disaster under section 308(b) of the Interjurisdictional Fisheries Act of 1986.

The conservation objective for KRFC established under the Pacific Coast Salmon Fishery Management Plan (Salmon FMP) requires a return of 33-34 percent of potential adult natural spawners, but no fewer than 35,000 naturally spawning adults, each year. In compliance with the Salmon FMP, a "conservation alert" is triggered when a stock is projected to fall below its conservation objective. Under such circumstances, the Pacific Fishery Management Council (Council) is required to recommend the closure of salmon fisheries within Council jurisdiction that impact the stock.

From 2001 through 2005, drought conditions in the upper Klamath Basin resulted in flow conditions in the mainstem Klamath River and tributaries representative of dry water years. As a result of the protracted drought and low flows in the mainstem Klamath River, in-river conditions allowed for the proliferation of endemic diseases, and both juvenile and adult Chinook salmon populations have experienced substantial mortality as a result of these epizootic events. The escapement of KRFC then fell below the 35,000 spawner escapement floor in 2004 and 2005.

A recent decline in ocean conditions, prolonged drought, and subsequent poor in-river conditions in 2002 and 2003, resulted in low numbers of age-3 and age-4 KRFC recruiting to the 2006 fishery. The 2006 preseason forecast of approximately 25,000 naturally spawning KRFC was close to the record low, and less than the minimum escapement of 35,000 required to allow fishing between Cape Falcon, Oregon, and Point Sur, California, (the Klamath impact area) under the Salmon FMP. A complete closure of the 2006 salmon fishery, in the Klamath impact area, was avoided through a collaborative effort by NMFS, Council, state, and tribal representatives to identify a limited fishery that would manage risks and address the conservation concerns for KRFC. NMFS issued a Temporary Rule for Emergency Action to implement very restrictive 2006 annual management measures for the west coast ocean salmon fisheries. These regulations close a majority of the commercial fisheries from Cape Falcon, Oregon, to Point Sur, California, from May 1 to August 31, 2006. As a result of the factors described above, the commercial salmon fishery and the shore-based support sector are enduring severe economic hardship this year in this significant part of the west coast (see Table 1 below). Accordingly, the scope of the Fishery Resource Disaster consideration includes this entire 700 mile stretch of coastline from Cape Falcon to Point Sur.

Table 1. Season Revenue (Ex-vessel) Compared to Historical Information from State Data

Management Area	2006	2001-2005 Average	High	Low
Oregon (South of Cape Falcon)	$1,240,000	$7,393,000	$10,090,000 (2004)	$5,116,000 (2001)
California	$1,696,000	$11,519,000	$18,383,000 (2004)	$5,225,000 (2001)
Total	*$2,936,000*	*$18,912,000*	*$28,473,000 (2004)*	*$10,341,000 (2001)*

The season restrictions reduced the fishing opportunity in the Klamath impact area by 71% from recent years. Due to weather and other factors, the actual number of fishing days by vessels has been even lower than expected. Based on information obtained from the States of Oregon and California, catch of salmon in this area will decrease by 88% this season from the recent years' average. Although the price per pound has been higher due to the limited supply, the resulting ex-vessel revenue this season will still drop by roughly 84% compared to the recent years' average.

In light of the foregoing facts, I find the economic losses in the commercial salmon fishery off Oregon and California caused by the low abundance of KRFC between Cape Falcon, Oregon, and Point Sur, California, in 2006 constitute a Commercial Fishery Failure due to a Fishery Resource Disaster. I find further this Fishery Resource Disaster is due primarily to natural causes, including drought, disease, and poor ocean conditions.

Therefore, I hereby declare that a Commercial Fishery Failure due to a Fishery Resource Disaster exists under section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended.

Carlos M. Gutierrez
August 10, 2006

ATTACHMENT 13

Governor Schwarzenegger Klamath Fishery Declaration of Emergency (2006)

A PROCLAMATION

BY THE GOVERNOR OF THE STATE OF CALIFORNIA

WHEREAS California's salmon runs are a vital component of our great State's resources that provide significant environmental, recreational, commercial, and economic benefits to the people; and

WHEREAS Klamath River Basin Chinook Salmon have been significantly impacted by poor ocean conditions, drought, water management, water quality, water flows, disease, and the elimination of access to historical spawning habitat; and

WHEREAS the Klamath Basin Chinook Salmon that commingle with other runs of salmon in ocean waters off of California and Oregon have been declining in abundance to a point where California's and Oregon's recreational, commercial, and tribal fisheries are being significantly constrained to conserve Klamath River Chinook Salmon; and

WHEREAS Klamath River Basin Chinook Salmon are predicted to have extremely low ocean abundance for 2006 in waters from Cape Falcon in Oregon to Point Sur in Monterey County, California, and in the Klamath River Basin; and

WHEREAS restoration of habitat and improved water quality and flows are critical to restoring an environment suitable to the long-term sustainability of the Klamath River Basin Chinook Salmon and other anadromous fish species; and

WHEREAS appropriate management of the Klamath River Basin Chinook Salmon population is critical to California's businesses, and local communities that provide goods and services in support of California's salmon fisheries; and

WHEREAS on April 5, 2006, I requested Secretary of Commerce Carlos Gutierrez to use his authority under the Magnusen-Stevens Fishery Conservation and Management Act to determine that there has been a commercial fishery failure due to a fishery resource disaster; and

WHEREAS on April 28, 2006, the National Marine Fisheries Service adopted an emergency rule to implement the recommendations of the Pacific Fisheries Management Council that resulted in severe restrictions on the commercial ocean salmon and Klamath Basin tribal and recreational fisheries and included restrictions on the recreational ocean salmon fishery; and

WHEREAS these restrictions will have significant impacts to California's commercial ocean salmon and in-river salmon fisheries and will result in severe economic losses throughout the State; and

WHEREAS the Department of Finance has determined that approximately $778,000 is continuously appropriated and available in the Small Business Expansion Fund (Fund 918) for disaster purposes under the Corporations Code section 14030 et seq.; and

WHEREAS the Small Business Expansion Fund's available monies can be leveraged to guarantee up to approximately $9.2 million in loans for disasters, including guaranteeing loans to prevent business insolvencies and loss of employment in an area affected by a state of emergency within the state; and

WHEREAS Governor Ted Kulongoski of Oregon and I signed The Klamath River Watershed Coordination Agreement along with the responsible federal agencies in order to address the impacts to the fisheries in the region and to develop a long-term management approach, common vision, and integrated planning associated with the Klamath Basin; and

WHEREAS the serious circumstances of the Klamath River Chinook Salmon run put at risk the livelihoods of families and businesses dependent upon them.

NOW, THEREFORE, I, ARNOLD SCHWARZENEGGER, Governor of the State of California, find that conditions of disaster or of extreme peril to the safety of persons and property exist within the California counties of Monterey, Santa Cruz, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Humboldt, Del Norte, and Siskiyou due to the poor ocean conditions, drought, water management, water quality, water flows, disease, and the elimination of access to historical spawning habitat and resulting from the significant restrictions that have been imposed on the State's salmon fisheries. Because the magnitude of this disaster will likely exceed the capabilities of the services, personnel, and facilities of these counties, I find these counties to be in a state of emergency, and under the authority of the California Emergency Services Act, I hereby proclaim that a State of Emergency exists in these counties.

Pursuant to this Proclamation, I hereby direct the Director of the California Department of Fish and Game and the Secretary of the Resources Agency to: (1) report to me immediately upon final action of the Department of Commerce and the California Fish and Game Commission on any further actions necessary to ensure the protection of the resource and of the economic livelihood of the fishery participants, tribes, and local communities; and (2) continue discussions for long-term restoration and management of the Klamath Basin with the State of Oregon, federal agencies (including the Secretaries of Commerce, the Interior, and Agriculture), tribal governments, and representatives from conservation, fishing, and agricultural organizations.

I FURTHER DIRECT the Secretary of the Business, Housing and Transportation Agency, with the cooperation of the Department of Finance, to activate the Small Business Disaster Assistance Loan Guarantee Program to guarantee loans to prevent business insolvencies and loss of employment in the counties of Monterey, Santa Cruz, San Mateo, San Francisco, Marin, Sonoma, Mendocino, Humboldt, Del Norte, and Siskiyou as a result of this State of Emergency.

I FURTHER DIRECT that as soon as hereafter possible, this proclamation be filed in the Office of the Secretary of State and that widespread publicity and notice be given of this proclamation.

IN WITNESS WHEREOF I have hereunto set my hand and caused the Great Seal of the State of California to be affixed this 6th Day of June 2006.

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ARNOLD SCHWARZENEGGER
Governor of California

ATTEST:

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BRUCE McPHERSON
Secretary of State

ATTACHMENT 14

Barthelow, John M., (2005). "Recent Water Temperature Trends in the Lower Klamath River, California," *North American Journal 0f Fisheries Management* 25:152-162 (2005)

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[Article]

Recent Water Temperature Trends in the Lower Klamath River, California

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Abstract.—Elevated water temperatures have been implicated as a factor limiting the recovery of anadromous salmonids in the Klamath River basin. This article reviews evidence of a multidecade trend of increasing temperatures in the lower main-stem Klamath River above the ocean and, based on model simulations, finds a high probability that water temperature has been increasing by approximately 0.5°C/decade (95% confidence interval [CI] = 0.42–0.60°C/decade) since the early 1960s. The season of high temperatures that are potentially stressful to salmonids has lengthened by about 1 month over the period studied, and the average length of main-stem river with cool summer temperatures has declined by about 8.2 km/decade. Water temperature trends seem unrelated to any change in main-stem water availability but are consistent with measured basinwide air temperature increases. Main-stem warming may be related to the cyclic Pacific Decadal Oscillation, but if this trend continues it might jeopardize the recovery of anadromous salmonids in the Klamath River basin.

The Klamath River basin (Figure 1) straddles the border between the states of Oregon and California. The basin drains an area of over 40,000 km^2 through varied landscapes. The upper reaches, above river kilometer (RKM) 375 (as measured from the outlet to the Pacific Ocean), are characterized by rain-shadowed lowlands holding extensive lakes and relic marshlands arising from a border of low mountains. The Klamath River drains these relatively flat valleys, flowing over 400 km through a tall, coastal mountain range that contributes several major tributaries from the flanks of dormant volcanoes and finally emptying through dense forests along the coastal plain into the Pacific Ocean. The middle and lower portions of the river (below RKM 308) are largely constrained within bedrock canyons and interspersed with minor alluvial reaches. Flows vary widely throughout the year; peak flows generally occur in December and January, and the lowest flows extend from June through September. Summer low flows below a series of hydropower facilities on the main-stem Klamath River are often held at Federal Energy and Regulatory Commission (FERC) mandated minima, about 20 m^3/s. Accretions are substantial along the river, however: average annual flows grow from $1{,}666 \times 10^6$ m^3/year as the river drains the upper basin to 15,768 10^6 m^3/year near the ocean. Historic hill slope and in-channel gold mining, extensive logging, and middle-basin hydropower development, coupled with wetland draining and diversions for agriculture in the upper basin, comprise the major watershed manipulations.

At approximately 42°N, the Klamath River basin is situated far enough north to support a variety of coldwater fishes. However, the isolation of the upper basin from moderating coastal weather and frontal movement, the rapid 550-m drop in the river's elevation below Upper Klamath Lake compared to the surrounding terrain, and main-stem flows that originate from this very large (24,000–36,000 ha) and shallow (3 m) water body, all serve to position the Klamath River on an ecological ''edge'' with respect to water temperatures for coldwater fishes. Measured U.S. Geological Survey (USGS) gauge data reveals that mean monthly temperature in the lower Klamath River, the only portion currently accessible to anadromous salmonids, generally ranges from 3–6°C in January to 20–22.5°C in July or August. Monthly average daily maximum temperature is commonly above 23°C except in areas immediately below hydropower reservoirs or near the ocean. Temperature in the Klamath River is elevated with a greater frequency and remains elevated for a longer time than temperatures in adjacent coastal anadromous streams. Summer maxima in the lower Klamath River basin below the Trinity River confluence (RKM 70; Figure 1) may reach 26.6°C for up to 10 d/year, in contrast to most other nearby coastal rivers, both north and south of the Klamath River, that never exceed this temperature (Blakey 1966).

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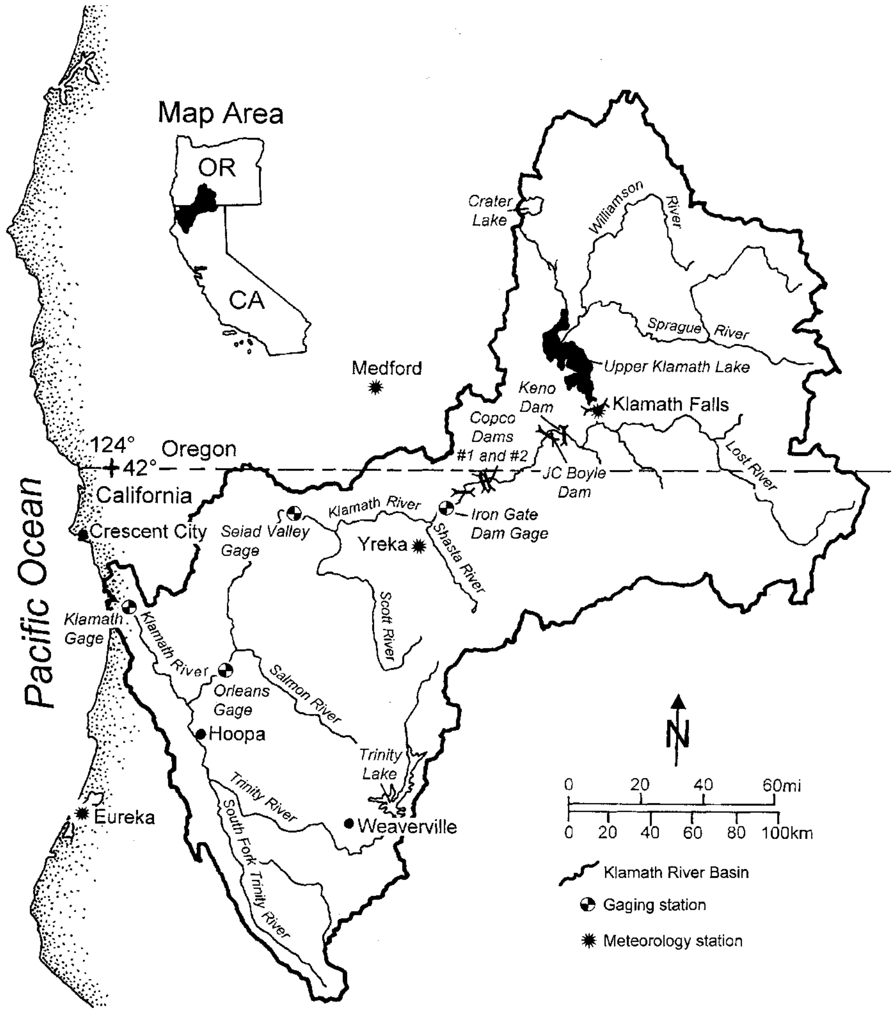

FIGURE 1.—Map of the Klamath River basin, Oregon and California, showing the approximate locations of major dams, water temperature gauges, and meteorological stations. The map was adapted with permission from the Water Education Foundation, Sacramento, California.

Elevated temperature is clearly problematic for salmonids (Brett 1952; USEPA 2003). Nehlsen et al. (1991) listed various salmonid stocks as either extinct or at risk in the Klamath River and two of its California tributaries, the Shasta and Scott rivers, along with many other coastal and inland streams. High temperature is among the many concerns for the successful recovery of salmonids in the Klamath River below Iron Gate Dam, the current upstream terminus of anadromous salmonid migration (CH2M Hill 1985; Klamath River Basin Fisheries Task Force 1991). Elevated temperatures have taken on a greater significance recently because of their potential link to disease outbreaks affecting both adult and juvenile salmonids in the Klamath River (Lynch and Risley 2003).

Researchers at the USGS were asked by the Klamath River Basin Fisheries Task Force to put together a decision support system (DSS) that links Klamath River basin hydrology, water quality, and fish production to create a better understanding of the range of water management opportunities and their potential consequences. Prior to the modeling effort, we reviewed the available data, concentrating on hydrology, water quality, species life history, and channel morphology. The resulting unpublished review confirmed the frequent occurrence of stressful temperatures for salmonids, and also suggested a basinwide warming of river temperatures of between 0.4°C and 0.6°C per decade. However, the estimated trend contained a large degree of uncertainty due to limitations inherent in the measured water temperature record, specifically the short duration of and large gaps in thermograph records, as well as ordinary intra-annual variability.

As a component of the DSS, a water temperature model was subsequently completed for approximately 400 km of the main-stem Klamath River from Upper Klamath Lake in Oregon to the river's mouth in California, incorporating the best meteorologic and hydrologic data readily available for the 40-year postdam period, water years (WY) 1962–2001 (Hanna and Campbell 2000; Campbell et al. 2001). This temperature model enabled a more complete estimation of mean daily water temperature in the lower Klamath River during periods of incomplete thermograph records, and features several biologically relevant metrics, such as degree-days, duration of high thermal exposures, and length of river with temperatures between specified values.

The objective of this article is to review measured data and model results for evidence, if any, of basinwide warming in the lower Klamath River below Iron Gate Dam during the postimpoundment period, 1962–2001. I assess historical water and air temperature records in the basin along with relevant hydrologic data, and evaluate the simulated water temperature and derived temperature metrics for trends.

Methods

Trend estimation.—All measured data and simulation results (described below) were analyzed with statistical software developed by Battelle Pacific Northwest Laboratory (Gilbert 1987: Appendix B). The software performs a nonparametric analysis that uses the seasonal Kendall test (Hirsch et al. 1982) to estimate trends in the annual data and Sen's (1968) slope estimator for monthly data. These tests are appropriate because the data need not conform to any particular distribution and may contain embedded cycles or exhibit serial correlation (Gilbert 1987). Unlike ordinary least-squares trend estimation, these techniques are therefore unbiased by nonnormal outliers, are relatively insensitive to a moderate amount of missing data, and are less likely to be biased by extreme events at the beginning or end of the time series (Fox et al. 1990; USEPA 1998).

Both methods are related to one another and are conceptually straightforward. The slopes of all possible data pairs (in time series order) are computed and ranked. From this ranked set, the median slope is the best estimate of the trend. Software output includes two-sided confidence intervals (CIs) about the ''true'' slope at the 0.05 level, obtained through nonparametric techniques developed by Sen (1968). Please refer to Gilbert (1987) for software details. Fox et al. (1990) performed a similar analysis to identify linear trends in another West Coast basin's streamflow and precipitation data. However, unlike Fox et al. (1990), I did not smooth any of the time series data.

Historical water temperature records.—The Klamath River basin contained 18 USGS water temperature gauges, each with differing periods of record (Table 1). Seventeen were for riverine stations and one represented Crater Lake, potentially useful because of its long-term data set. Daily maximum and minimum water temperature data for the 13 gauges having at least 10 years of data were extracted from the EarthInfo CD-ROM (EarthInfo, Inc. 1994), and were scanned to remove obvious transcription errors. Mean monthly water temperature was computed as the simple average of all measured minimum and maximum daily values if there were at least 25 d with measurements in that month; otherwise, the value was considered missing.

Simulated river temperature and metrics.—The System Impact Assessment Model (SIAM) DSS (Bartholow et al. 2003) was used to simulate mean daily water temperature on the main-stem Klamath River from Upper Klamath Lake to the ocean based on historical monthly flows and reservoir storage volumes (disaggregated to mean daily values) supplied by SIAM. Monthly flows and storage values were used because they meshed easily with the planning framework employed by the U.S. Bureau of Reclamation and because regulated flows in the Klamath River tend to be relatively constant from day to day except during large rainstorm events that generally occur in winter. The SIAM framework uses the U.S. Army Corps of Engineers Hydrologic Engineering Center's HEC-5Q model (USACE 1986) to estimate water temperatures. The HEC-5Q model is a one-dimensional model that simulates water quality in reservoirs vertically from the surface to the bottom and longitudinally downstream in rivers.

The data requirements for HEC-5Q are daily average temperature values of all inflowing waters and daily average meteorological data, including air and dew point temperatures, wind speed, and

TABLE 1.—Klamath River basin U.S. Geological Survey (USGS) gauges and data used in the preliminary scoping exercise. Estimated trends for stations with over 10 years of data were derived from Gilbert's (1987) technique. Trends in bold italics are statistically different from zero ($P < 0.05$). The four main-stem Klamath River gauges used in subsequent analyses are shown in italics. All stations are in California accept Crater Lake, which is in Oregon.

USGS gauge				
Number	Name	Years of record	Years available	Estimated trend (°C/year)
11530500	*Klamath River near Klamath*	1966–1981	16	0.050
11530300	Blue Creek near Klamath	1966–1978	13	0.000
11530000	Trinity River at Hoopa	1964–1984	21	***0.100***
11529000	South Fork Trinity River near Salyer	1963–1966	4	
11528700	South Fork Trinity River below Hyampom	1966–1979	14	***0.050***
11528500	Hayfork Creek near Hyampom	1961–1974	14	0.029
11528200	South Fork Trinity River near Hyampom	1961–1965	5	
11527000	Trinity River near Burnt Ranch	1962–1983	22	0.000
11525655	Trinity River below Limekiln Gulch	1985–1985	1	
11525600	Grass Valley Creek at Fawn Lodge	1985–1985	1	
11525500	Trinity River at Lewiston	1959–1983	25	0.010
11523000	*Klamath River at Orleans*	1966–1982	17	0.033
11522500	*Klamath River near Seiad Valley*	1964–1979	16	−0.014
11520500	Salmon River at Somes Bar	1966–1979	14	0.040
11517500	Shasta River near Yreka	1965–1979	15	−0.020
11516600	Cottonwood Creek at Hornbrook	1965–1971	7	
11516530	*Klamath River below Iron Gate Dam*	1963–1980	18	0.033
11492200	Crater Lake	1964–1993	30	***0.033***

cloud cover. Solar radiation is not a direct model input, but rather is calculated by a companion program based on the meteorologic data, time of year, and latitude. Boundary temperatures for unmeasured tributaries were derived from regression equations based on air temperature. A complete description of the methods used to set up the HEC-5Q model for the Klamath River can be found in Hanna and Campbell (2000).

The HEC-5Q model was calibrated for 1 year (1996) and validated for 2 years (1997, 1998) with the most reliable data available. Mean absolute errors were 1.0°C for 1996, 1.04°C for 1997, and 0.90°C for 1998. The model also performed well in capturing the essence of the river's seasonal thermal signature, as signified by the highly significant coefficient of determination (r^2) values (e.g., below Iron Gate Dam: $r^2 = 0.96$, $n = 7{,}354$, $P < 0.001$). Overall model bias was −1.1°C at gauge locations from Iron Gate Dam downstream (i.e., the model underestimated temperatures slightly), although temperature predictions for any single day at any single location over the 40-year simulation period contained more uncertainty (average absolute mean daily error, ~1.8°C), especially near the ocean in the tidal zone (Bartholow et al., in press).

For this analysis, the model's goodness of fit to measured data was examined for a temporal trend in the residuals (measured minus simulated water temperature values) that might inflate or deflate trend estimates. Monthly average residuals were calculated from daily values when there were 25 or more measured values per month, and were processed following Gilbert's (1987) methodology. In addition, the SIAM model was run to simulate a period of 10 consecutive years that had identical flow and meteorology regimes to see whether the modeled system might accumulate heat from year to year, falsely generating a trend due to a computation or implementation anomaly.

Daily water temperatures were simulated for the 40-year period, WY 1962–2001 (beginning the year after the last dam was put in place), and exported from SIAM for the four main-stem river locations highlighted in Table 1. In addition to river temperature, SIAM also calculated six biologically relevant metrics for the site immediately below Iron Gate Dam:

(1) the annual number of degree-days exceeding 15°C (e.g., a mean daily water temperature of 17°C counts as 2 degree-days),
(2) the annual number of non-overlapping events when water temperature exceeded 15°C for 7 d in a row,
(3) the annual number of days when water temperature exceeded 20°C,
(4) the annual first day in spring when water temperature reached 15°C,

(5) the annual last day in fall when water temperature reached 15°C, and
(6) the number of river kilometers from Iron Gate Dam to the mouth of the Klamath River with water temperature below 15°C averaged for the summer (1 May to 30 September).

The 15°C and 20°C thresholds in these metrics were chosen as representative of chronic and acute high temperatures for salmonids, based on values reported by the U.S. Environmental Protection Agency (USEPA 2003). Both thresholds are below lethal temperatures for most salmonid life stages, but they are associated with increasingly adverse effects such as sub-optimal growth rates, reduced swimming performance, increased disease risk, and impaired smoltification (USEPA 2003). Unlike Bartholow et al. (in press), who focused only on Chinook salmon *Oncorhynchus tshawytscha*, the first five metrics were calculated for the entire year because one or more life stages for all anadromous salmonids can occur in the Klamath River year-round (Leidy and Leidy 1984). Daily values for all temperatures and metrics were converted to average monthly values by use of utility programs and were subsequently processed with Gilbert's (1987) software.

Historical air temperature and hydrology records.—The HEC-5Q model uses daily average air temperature as one of its dominant inputs. The two closest air temperature stations to the main-stem Klamath River below Iron Gate Dam used by Hanna and Campbell (2000) were Yreka and Eureka, California; Yreka meteorology governs the upstream portions of the river and the maritime station at Eureka governs the river's lowest 50 km, approximately 32 km from the coast (per Lewis et al. 2000). However, because the Yreka station had missing data for air temperature and other required meteorological variables, Hanna and Campbell (2000) used regression techniques to translate some daily values from Medford, Oregon. To eliminate any possibility of contaminating this trend analysis with synthetic values, I used the most consistent source of raw data available (EarthInfo, Inc. 1995). Average monthly maximum and minimum air temperatures for Eureka, Yreka, and Medford and for Klamath Falls, Oregon, were extracted from this database for calendar years (CY) 1962 through 1993, the latest year available in the EarthInfo, Inc. (1995) database. Mean monthly air temperature values were computed from these values as before and were processed by use of Gilbert's (1987) methodology.

TABLE 2.—Estimated trends in simulated water temperature along the main-stem Klamath River and their 95% confidence intervals (CIs) for the 40-year period 1962–2001 (n = 480). Trend estimates at all stations had P-values ≤0.001. Note, however, that the most downstream station (Klamath River near Klamath) showed a significant trend in the analysis of measured less simulated residuals and was not considered trustworthy.

Station	Trend (°C/year)	95% CI
Klamath River below Iron Gate Dam	0.053	0.044–0.063
Klamath River near Seiad Valley	0.051	0.043–0.059
Klamath River at Orleans	0.048	0.039–0.057
Klamath River near Klamath	0.044	0.036–0.051

Another required input for HEC-5Q is hydrology. To detect whether water temperature trends might be due to changes in river flow, I examined the historical monthly average discharge records (WY 1962–2001) for Iron Gate Dam and processed these values by use of the same set of procedures applied to the other data.

Results

Historical Water Temperature Records

The historical gauge data for the 13 stations listed in Table 1 with more than 10 years of data implied an average basinwide warming trend of 0.026°C/year. However, estimated annual trends for individual stations (Table 1) and months (not shown) during the year varied widely. Two stations suggested small negative trends and two indicated no trend at all. Nine stations indicated positive annual trends. Only three stations (Crater Lake, South Fork Trinity River below Hyampom, and Trinity River at Hoopa) had trends that were statistically different from zero at the 0.05 level. If data from only these three stations are averaged, the estimated trend would be 0.06°C/year, but none of these stations is on the main-stem Klamath River and their period of record was inconsistent in both duration and timing. Thus, results from the historical temperature gauges were only *suggestive* of a trend, not statistically conclusive. Without the seemingly obvious trends evident by examining the simulation model's 40-year output (described below), this analysis would not have been continued.

Simulated River Temperature and Metrics

Table 2 indicates that annual water temperature trends derived from HEC-5Q model results have been increasing at each of the four main-stem lo-

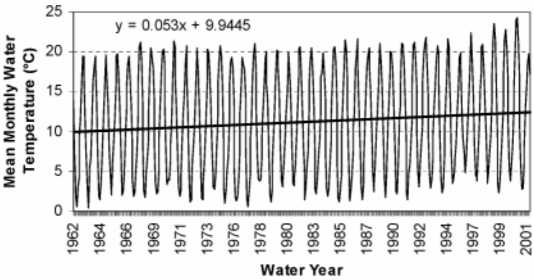

FIGURE 2.—Illustration of the increasing trend in simulated mean monthly water temperature below Iron Gate Dam on the main-stem Klamath River. Mean monthly values were computed from the HEC-5Q model's (USACE 1986) daily simulation results.

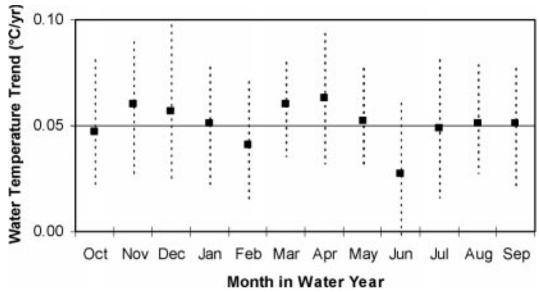

FIGURE 3.—Estimated monthly trends (with 95% confidence intervals) in the simulated mean monthly water temperature for the main-stem Klamath River near Seiad Valley from 1962 to 2001. June was the only month in which the trend was not significant at the 0.05 level. Mean monthly values were computed from the HEC-5Q model's (USACE 1986) daily simulation results.

cations but with slightly less of an increase in the downstream direction. Figure 2 provides an example of the trend observed for the river below Iron Gate Dam. Positive trends were found for each month of the year at all four stations (the Seiad Valley gauge trends are shown in Figure 3), and almost all months were significant at the 0.05 level. June trends were consistently non-significant.

Running the model for the consecutive 10-year period with identical annual flow regimes and meteorology indicated no interannual increase or decrease in thermal storage, confirming that the model's algorithms themselves were not falsely generating any trend. However, a careful examination of residuals (measured minus simulated temperatures) for the full historical period (1962–2001) did reveal some linear and cyclic trends. A small linear trend was identified at each of the four main-stem stations, but the residual trends at the three upstream-most stations were small (average, 0.003°C/year; n = 135–235) and none were significantly different from zero at the 0.05 level when tested with Gilbert's (1987) technique. At the Klamath River near Klamath, California, the linear trend in residuals was large (0.032°C/year; n = 134) and significantly different from zero. These results imply that the model does not introduce any significant trend of its own that would confound an estimate of basinwide warming at all but the most downstream, tidally influenced station. Because the inclusion of that station (Klamath River at Klamath) might influence reliable detection of basinwide trends, it was omitted from the remainder of the analysis.

Table 3 summarizes simulated temperature trends for the six different metrics at three stations along the main-stem Klamath River. Collectively, these metrics indicated that (1) cumulative exposures to stressful temperatures have been increasing in both number and duration; (2) the length of the annual period of potentially stressful temperatures has been increasing (i.e., summer effectively starts earlier in the spring and extends longer into the fall); and (3) the average length of river with suitable temperatures has been decreasing. There was generally a decreasing rate of change

TABLE 3.—Estimated annual trends in metrics derived from simulated water temperature below Iron Gate Dam on the main-stem Klamath River and their 95% confidence intervals (CIs; $P \leq 0.05$) for the 40-year period 1962–2001. See text for definitions of the calculated metrics. All metrics had 40 observations except for the spring and fall dates (n = 39).

Metric	Site	Annual trend	95% CI
Degree-days (>15°C)	Iron Gate Dam	5.55	2.89–8.68
	Seiad Valley	5.94	3.97–8.42
	Orleans	5.99	3.67–8.50
Chronic events (weeks)	Iron Gate Dam	0.09	0.05–0.15
	Seiad Valley	0.08	0.04–0.11
	Orleans	0.07	0.00–0.13
Acute events (d)	Iron Gate Dam	1.09	0.56–1.73
	Seiad Valley	0.91	0.36–1.37
	Orleans	0.81	0.29–1.20
Spring date (d)	Iron Gate Dam	−0.44	−0.75 to −0.18
	Seiad Valley	−0.43	−0.72 to −0.14
	Orleans	−0.33	−0.64 to −0.05
Fall date (d)	Iron Gate Dam	0.46	0.22–0.71
	Seiad Valley	0.31	0.07–0.56
	Orleans	0.25	0.05–0.47
Length of river below Iron Gate Dam <15°C (km)	Downstream of Iron Gate Dam	−0.82	−1.29 to −0.40

TABLE 4.—Estimated trends in measured air temperature in or near the main-stem Klamath River and their 95% confidence intervals (CIs) for calendar years 1962–1993. All stations had P-values $\leq$0.001 except Yreka (P = 0.357).

Station (months of data)	Trend (°C/year)	95% CI
Eureka, California (384)	0.056	0.042–0.066
Yreka, California (373)	0.000	−0.029–0.000
Medford, Oregon (366)	0.040	0.019–0.060
Klamath Falls, Oregon (382)	0.035	0.012–0.059

in these metrics in the downstream direction, although there were a few exceptions.

Historical Air Temperature and Hydrology Records

Estimated historical air temperature trends are given in Table 4. The variance in the estimated temperature trend was large across stations, and the Yreka station exhibited no air temperature trend at all. Interestingly, the rate of change appeared strongest at the downstream-most station, Eureka. This station's estimated trend was an increase of 0.056°C/year.

The estimated annual trend in discharge at Iron Gate Dam was quite small (−0.09 m^3/s per year) relative to typical flow rates (>28.32 m^3/s), but it was still significant (95% CI = −0.200 to −0.024 m^3/s per year; $P \leq 0.003$). Although several months showed some discharge trends approaching 1.4 m^3/s per year, most were negligible. Because of the small magnitude of estimated annual change in flow, it appeared unlikely that hydrologic changes could be responsible for trends detected in water temperatures.

Discussion and Conclusion

Best Estimate of Warming Trends

Thirteen USGS water temperature gauges had enough measured data to allow computation of trend statistics, but short records and large blocks of missing data resulted in few statistically significant trend estimates. A few stations with longer historical records did suggest a small, statistically significant warming trend beginning in the 1960s. In particular, Crater Lake (with the longest record) is well off the main-stem Klamath River and indicated a significant trend similar to on-river locations, suggesting that a warming trend, if present, might be basinwide and not related to any specific land use or water use factors. Because the records were short and incomplete, additional analysis was warranted. The best way to continue the analysis was to use a water temperature model to, in essence, fill and extend the record.

Filling the data record via simulation eliminated some of the uncertainty associated with the handling of missing data in the statistical analysis, and extending the record well beyond what was historically available strengthened the statistical power to estimate mean trends and their CIs simply because of increased sample size (Gilbert 1987). However, the use of a simulation model potentially interjects uncertainty because the model itself must introduce no trend of its own. No significant trend in model residuals (measured minus simulated temperatures) through time was detected except at the downstream-most station near Klamath, California. For this reason and because this location was also influenced by unmodeled tides, this station was not used in drawing conclusions about Klamath River basin warming even though its estimated trend was quite similar to those of the other three stations.

Aggregating all other stations from Table 2, it is estimated from the filled record that the average trend in main-stem water temperatures has been 0.5°C/decade (95% CI = 0.42–0.60°C/decade; $P \leq 0.001$) for the 40-year postdam period, 1962–2001. On average, this represents a 2°C increase during the period examined—a change with potentially significant ramifications for the aquatic community. This estimated trend is larger than that found for a British Columbia watershed by Morrison et al. (2002), who estimated a warming trend of about 0.22°C/decade from 1953 to 1998.

Uncertainty Inherent in the Estimated Trend

Many factors must be weighed when attempting to judge the uncertainty inherent in the trend estimate for the main-stem Klamath River. There are a variety of opinions about exactly which statistical methods possess the best ''power'' for attempts to tease trends from real-world data (USEPA 1998). No trend estimation technique, including the software developed by Gilbert (1987), can fully quantify uncertainty. None are immune from problems associated with the analysis period and length (i.e., when the analysis begins and when it ends) (Williams 1991); none can completely factor out serial correlation (Fox et al. 1990); and none can address potential biases in measured or estimated time series data (Gilbert 1987). Further, trends in measured (not simulated) data may be influenced by improvements in measurement precision or technique through time or, in the case of meteorologic data, by anthropomorphic changes at or near the location of instrumentation (Pielke et al. 2002).

Perhaps most importantly, this analysis relied heavily on a simulation model that, like all models, is an incomplete representation of reality and that exhibited a degree of serial correlation in the residuals that is probably indicative of the decadal-scale temperature oscillations widely reported in the literature on Pacific salmon (e.g., Beamish and Bouillon 1993). Though annual trend estimates at all stations listed in Table 2 were quite similar, they showed a small, unexplained decrease in the downstream direction. The apparent patterns in estimated seasonal or geographic trends could simply be random, but they might warrant further statistical analysis dealing with homogeneity, which was not explored here.

The bottom line is that the estimated trends for Klamath River basin warming in no way imply a permanent change in the system (Helsel and Andrews 1991), and the CIs about the estimate may be too narrowly prescribed. The analysis by Fox et al. (1990) that examined trends in San Francisco Bay outflows by use of similar procedures generated considerable discussion in the literature concerning statistical application, confidence in the results, and implications for the future (Helsel and Andrews 1991; Williams 1991; Fox et al. 1991a, 1991b). Further discussion of the current analysis may certainly be warranted.

Likely Causes of the Warming Trend

If there is a trend, what are its causes? Changes in hydrology have been found by some investigators to be related to regional climatic shifts, though generally at higher latitudes (Danard and Murty 1994; Morrison et al. 2002). However, there was very little indication that water temperature trends on the Klamath River were related to any systematic change in main-stem hydrology below Iron Gate Dam (although changes at a monthly scale may deserve additional attention). Instead, water temperature trends were supported by the estimates of basinwide air temperature warming that averaged 0.33°C/decade (95% CI = 0.11–0.46°C/decade) across all four stations in Table 4. Air temperature is very important in the HEC-5Q model both because it dominates mean daily heat exchange and because air temperature was used to calculate tributary inflow temperatures. Therefore, it is no surprise that any trend detected in air temperatures would have a direct effect on simulation-derived water temperature trends. Differences in the magnitude of estimated water and air temperature trends may be explained by other meteorological parameters known to be important in determining mean daily water temperature (e.g., dew point temperature, solar radiation, and wind speed, none of which were investigated here). It is also possible that temperature trends could be influenced by cumulative watershed changes (e.g., timber harvest), but watershed condition was not a direct input for HEC-5Q simulations. More likely, the difference between air and water temperature trends simply reflects the aggregate uncertainty in each estimate.

It is interesting that the data for Yreka, the station closest to the geographic center of the basin, did not indicate a statistically significant trend in air temperature. Translating some meteorological data from Medford to use as input for the model could have influenced estimated water temperature trends from the model results, but evidence for erroneous water temperature predictions was lacking. Although Medford is outside the Klamath River basin proper (Figure 1), it is physically quite close to a large portion of the watershed contributing ungaged accretions that account for about one-half of the river's flow at the ocean (Bartholow et al., in press). Crater Lake is also in close proximity to Medford, and we know from the analysis of historical data that this station's lengthy record showed a detectable and statistically significant positive trend in water temperatures through time (0.33°C/decade; Table 1). Therefore, the use of Medford meteorological data as a surrogate for Yreka data when necessary may have been appropriate.

Other Confounding Factors

How can a 40-year warming trend be put in perspective? There is evidence that periodic high temperatures occurred in the Klamath River basin in the 1900s prior to 1962. Risley and Laenen (1999) looked at even longer-term air temperature records at Klamath Falls and established that there was no difference in the median annual air temperature for the periods 1922–1950 and 1950–1996. This appeared to be due largely to a series of very hot years occurring in the 1930s that rivaled, but did not exceed, air temperatures recorded in the 1990s. More generally, researchers have noted a recurring climatic pattern in North Pacific Ocean temperatures at decadal time scales that affect continental surface air temperatures. This pattern, aptly named the Pacific Decadal Oscillation (PDO), has been shown to correlate to varying degrees with shifts in salmon production

(Mantua et al. 1997). The correlation is stronger for Alaska's salmon stocks and weaker for stocks in Washington, Oregon, and California. The period examined in this paper, 1962–2001, spans a detected PDO crossover point (1977) from cooler to warmer weather (Mantua et al. 1997) and may be a contributing factor to the trend detected in the Klamath River data, although the coefficient of determination between an annual PDO index and Klamath Falls air temperature was not strong ($r^2 = 0.2$). Nonetheless, if the polarity of the PDO shifts once again, periods of cooler weather may return to the Klamath River basin. If an additional warming trend was superimposed on the recurrent PDO signature, however, one would expect each succeeding air temperature peak and trough to be higher than the last. Klamath River basin waters would not likely continue warming at the same decadal rates reported here even if air temperatures continue to rise. Water temperature does not linearly parallel increases in air temperature but instead is S-shaped due to evaporative cooling and back radiation from the water's surface; above approximately 25°C, stream temperature begins to level with respect to rising air temperature, but not so much that it could not eventually reach 30°C or higher (Mohseni et al. 2002).

Potential Significance of the Warming Trend

Are the trends in water temperature important from a biological perspective? The various metrics derived from simulated water temperature (Table 3) point toward greater exposure (both in frequency and duration) to chronic and acute temperature thresholds that are potentially stressful to salmonids through both time and space. Below Iron Gate Dam, for example, considering both the onset of high temperatures in the spring and their conclusion in the fall, the period of the year when mean daily temperature exceeds 15°C has been increasing by 9 d/decade. This rate of change seems especially large, adding up to over 1 month during the 40-year period studied. In contrast, the decrease in average length of river with temperatures below 15°C (8.2 km/decade) does not appear to be as major an issue, but does demonstrate an incremental elimination of coldwater habitat.

In the Klamath River basin, elevated water temperatures can occur from May through October, a period of concern for many anadromous salmonids since eggs (deposited during fall spawning) and juveniles (out-migrating from late spring through summer) are thermally sensitive life stages. Upstream migrating and spawning adults may also be affected during the late summer. The months of June–September exhibit exceedingly poor water temperatures for any oversummering salmonids at most main-stem Klamath River locations in most years. For example, the mean monthly maximum daily water temperature from the historical data collected at Seiad Valley from 1964 to 1979 was 23.3°C in July, and daily extremes were as high as 29.5°C. In short, water temperature in the lower main-stem Klamath River is currently marginal for anadromous salmonids; their thermal resource is being ''squeezed'' in both space and time. Even the winter period is not immune, as warmer waters would be expected to speed egg and alevin maturation rates and to advance hatching times (Crisp 1981). Southern Pacific coastal salmon streams (below 56°N) are typically viewed as offering a nurturing growth opportunity for young salmon, demonstrated by the fact that they migrate to the ocean as young-of-the-year instead of yearlings as is common above 56°N (Taylor 1990). However, rivers as warm as the main-stem Klamath River might instead be viewed as thermally adverse, essentially requiring out-migration to avoid early- or oversummer death unless rearing fish can locate and take advantage of thermal refugia or coolwater tributaries.

Several researchers have discussed potential impacts of climate change on fishery resources; trends found in Klamath River basin water temperature and associated metrics are reminiscent of those discussions. Meisner (1990) and Sinokrot et al. (1995) pointed to potential losses in thermal habitat associated with warming, and Chatters et al. (1995) projected salmonid population declines accompanying a 2°C rise in temperature. Other biological communities appear to be undergoing shifts in their geographic range (e.g., Edith's checkerspot butterfly *Euphydryas editha*; Parmesan 1996) or changes in life history timing (e.g., flowering times for British plants: Fitter and Fitter 2002) in presumed response to changing climatic conditions. If water temperature trends of the magnitude found for the main-stem Klamath River continue in future decades, some stocks may decline to levels insufficient to ensure stock survival, as was discussed by Chatters et al. (1991) for the Columbia River basin and Eaton and Scheller (1996) for cold- and coolwater guilds in general.

Selection of a single thermal threshold as an indicator of the time when stocks may disappear from a specific geographic area is problematic (Poole et al. 2001; Dunham et al. 2003), but Eaton et al. (1995) listed mean weekly temperatures of

23.4°C for coho salmon *O. kisutch* and 24°C for Chinook salmon as thresholds above which disappearance becomes increasingly likely. Both simulations and measured data suggest that waters in the main-stem Klamath River below Iron Gate Dam, particularly at Seiad Valley and Orleans, are already at or above the 24°C mean weekly threshold, although this is not the case at Iron Gate Dam. This does not mean that cooler Klamath River basin tributaries could not continue to produce salmon, but natural stocks that rely on the main stem as a migration corridor in times of seasonally high temperatures may not survive if they cannot adapt. Lawson et al. (2004) made a similar observation about the survival of coho salmon in Oregon streams north of the Klamath River basin.

No one can say whether warming trends will continue or predict the magnitude and time frame of such trends. It appears certain, however, that if warming does continue, recovery of naturally reared anadromous salmonids in the Klamath River basin may become increasingly problematic. For the moment, discussion about the future of salmon remains heated.

Acknowledgments

J. P. Fox supplied the computer program developed by Gilbert (1987) that was used to test for temperature trends through time. Jeff Sandelin subsequently modified this program for my purposes, and I will make that software available to anyone who requests a copy. Brian Cade reviewed the statistical procedures, and Sharon Campbell, John Risley, and Lorrie Flint, along with three anonymous reviewers, offered many excellent comments on early drafts. Dale Crawford adapted the Klamath River basin map. Many others on our USGS team contributed to the development of the SIAM model.

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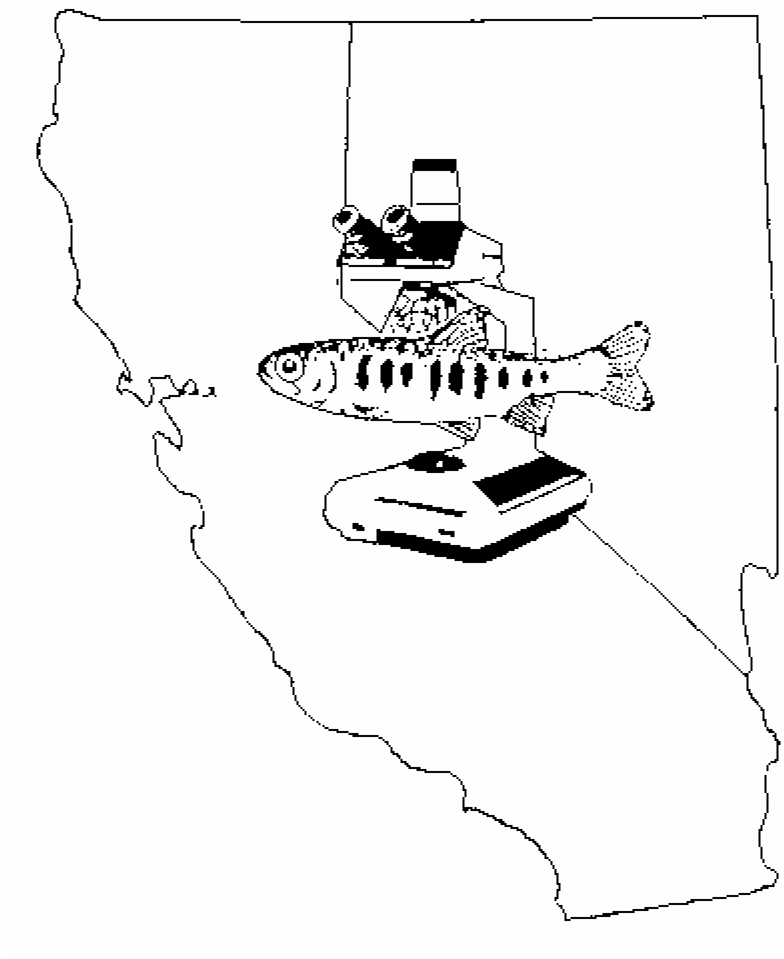
ATTACHMENT 15

Health Monitoring of Juvenile Klamath River Chinook Salmon (USFWS California-Nevada Fish Health Center, Nov. 2005)

FY 2004 Investigational Report:
Health Monitoring of Juvenile Klamath River Chinook Salmon



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Summary
Between 11 May and 27 July 2004, seven hundred and forty-five juvenile fall-run Chinook Salmon (*Oncorhynchus tshawytscha*) were collected for pathogen and physiological assays at 4 general locations in the lower Klamath River. Pathogens of interest included the bacterium *Flavobacterium columnare*, and myxozoan parasites *Parvicapsula minibicornis* and *Ceratomyxa shasta*. Only 2.4% of fish examined were infected with *F. columnare* suggesting it was not a significant problem in these fish in 2004. Expanding from trap efficiency data, we estimated that 45% of the population was infected with *C. shasta* and 94% of the population was infected with *P. minibicornis*. The high incidence of dual myxozoan infection (98% of *Ceratomyxa* infected fish), and associated pathology suggests that the majority of the *C. shasta* infected juvenile Chinook would not survive. The prognosis for *P. minibicornis* infection by itself is not well understood. Depending on the juvenile Klamath River salmon population size and smolt to adult return ratio, the effective number of adult salmon lost to *C. shasta* as juveniles could rival the 33,000+ adult salmon lost in the 2002 Klamath River Fish Die-off.

The correct citation for this report is:
Ken Nichols and J. Scott Foott. 2005. FY2004 Investigational report: Health Monitoring of Juvenile Klamath River Chinook Salmon. U.S. Fish & Wildlife Service California-Nevada Fish Health Center, Anderson, CA.

Introduction

The California-Nevada Fish Health Center, as a partner in the efforts to restore salmonid populations in the Klamath River basin, conducted pathogen and physiology monitoring of juvenile Klamath River Chinook Salmon (*Oncorhynchus tshawytscha*) since 1991. Pathogens associated with diseased fish in the Klamath River include bacteria (*Flavobacterium columnare* and motile aeromonid bacteria), digenetic trematodes (presumptive *Nanophyetus salmincola*) and myxozoan parasites (*Parvicapsula minibicornis* and *Ceratomyxa shasta*). Ceratomyxosis has been identified as the most significant disease for juvenile salmon in the Klamath Basin (Foott et al. 1999, Foott et al. 2003).

In this study we monitored the weekly incidence of *Ceratomyxa* and *Parvicapsula* infection in juvenile Chinook salmon during their spring emigration at several sites on the Klamath River. We expanded the observed incidence data to the juvenile Fall Chinook population using trap efficiency data. The utility of apparent clinical signs (pale gill, swollen abdomen and swollen kidney) for determining disease status of fish was also examined.

Methods

Sampling – During the spring and early summer of 2004, juvenile Klamath River Chinook Salmon were collected at Persido Bar (RM 81) and Big Bar (RM 51) by rotary screw trap. Fish were also collected at one beach seine site per week alternating between Big Bar and Persido Bar 11-May through 16-June. After 16 June, we were forced to target cooler water refuge sites near creek mouths (RM 50-81, Appendix I). Each week we attempted to examine 30 fish from each trap and 20 fish from the seine collection. Crews operating the traps would collect and hold live fish up to 48 hours prior to sampling depending on number of fish captured each day. Fish captured by seine were sampled immediately following capture.

Necropsy – Fish were euthanized in MS222, measured for fork length and examined for abnormalities. The degree of the abnormality was scored according to Table 1. Tissue samples were collected for bacteriology, ATPase, muscle RNA:DNA and histology assays.

Histology – Gastrointestinal tract (pyloric ceca and intestine) and kidney tissues were rapidly removed from the fish and immediately fixed in Davidson's fixative, transferred to 70 % ethanol after 24-48 hours, processed for 5 µm paraffin sections and stained with hematoxylin and eosin (Humason 1979). All tissues for a given fish were placed on one slide and identified by a unique code number. Each slide was examined at both low (40X) and high magnification (400X). The presence of the myxozoan parasites (*Ceratomyxa* and *Parvicapsula)* and degree of tissue inflammatory response to the parasites (lesions) were rated as 0 (normal or no inflammation), 1 (parasites and inflammatory response in less than 50% of tissue section), 2 (parasite induced inflammatory response in greater than 50% of tissue section), and 3 (entire tissue section demonstrating parasite infection and inflammatory response with little or no normal tissue structure). Individual fish were categorized as uninfected, lightly infected, or severely infected according to the presence of the parasites and lesion score for the target tissue (gastrointestinal tract for *Ceratomyxa* and kidney for *Parvicapsula)*.

Table 1. Abnormality scoring system used during necropsy.

Abnormality	Score
Pale Gill (Anemia)	0 = normal 1 = pale 2 = grey/white/tan – no pink
Gill Lesion	0 = normal, no lesion 1 = lesion present
Skin/Fin Hemorrhages	0 = normal, no hemorrhaging 1 = hemorrhaging of skin and/or fins
Distended Abdomen	0 = abdomen normal 1 = abdomen distended
Organ Hemorrhaging	0 = normal, no hemorrhaging 1 = hemorrhaging of one or more internal organs
Swollen Kidney (Nephritis)	0 = kidney normal concave shape 1 = kidney flat or slightly convex; some grey color 2 = kidney convex and grey

Bacteriology – If a fish exhibited signs of septicemia (hemorrhaging fins or skin, petechial hemorrhaging on organs) a sample of kidney tissue was inoculated onto Brain Heart Infusion agar slant tubes. Isolates were identified to genera by standard microscopic and biochemical tests (Lasee 1995). Corroboration of bacterial septicemia was performed by examining spleen imprints for large numbers of bacteria. Any fish with visible gill lesions was screened for *Flavobacterium columnare* (the causative agent of Columnaris disease) by examining a gram stained imprint of the lesion for characteristic long filamentous Gram negative rods.

ATPase – Gill Na^+, K^+-Adenosine Triphosphatase activity (ATPase) was assayed by the method of McCormick and Bern (1989). Briefly, gill lamellae were dissected and frozen at -70°C in sucrose-EDTA-Imidazole (SEI) buffer on dry ice. The sample was later homogenized, centrifuged and the pellet sonicated prior to the assay. ATPase activity was determined by the decrease over time in optical density (340 nm) as NADH is converted to NAD+. This activity was reported as µmole ADP/mg protein/hour as 1 mole of NAD is produced for each mole of ADP generated in the reaction. Gill Na-K-ATPase activity is correlated with osmoregulatory ability in saltwater and is located in the chloride cells of the lamellae. This enzyme system transports salts from the blood against the concentration gradient in saltwater.

Muscle RNA:DNA – A section of caudal muscle was assayed for RNA:DNA ratio by the method of Kaplan, Leamon and Crivello (2001). Briefly, approximately 0.5g of muscle was dissected and frozen on dry ice; the sample was later homogenized and digested in a buffered digest mixture. Quantity of RNA and DNA in the sample was determined by use of fluorescent dyes compared to ribosomal RNA (16S and 23S rRNA from *E. coli*) and lambda DNA standards. RNA:DNA ratios in white muscle are highly correlated with specific growth rate and are useful in detecting growth suppression in fish (Pickering and Pottinger 1995).

Expansion of pathogen incidence – The population estimate was based on Big Bar trap efficiency data provided by the USFWS Arcata Fish and Wildlife Office (Mark Magneson, personal communication). We used estimates of daily fish passage at the trap site to calculate the percent of the total population which passed the Big Bar trap each week (Figure 1). We then multiplied the weekly incidence of infection observed at the Big Bar trap (as a percent) by the percent of the population migrating past the trap each week, and summed these weekly estimates to produce the percentage of juvenile Klamath River Chinook Salmon passing Big Bar which were infected with either *Ceratomyxa* or *Parvicapsula*.

Estimates of the juvenile Chinook salmon population size were difficult to quantify due to poor recapture rates and low trap efficiency. Our population infection expansions were based on these mark-recapture experiments conducted at several times during our study. They were based on the best available information.

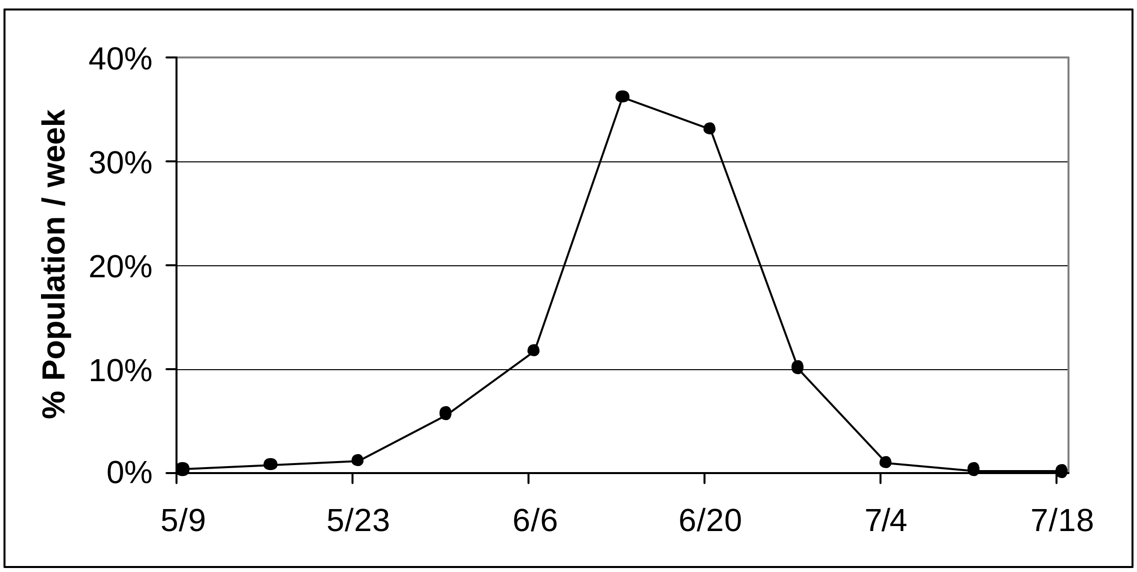

Figure 1. Percent of juvenile Klamath River Chinook Salmon emigration by week estimated at the Big Bar rotary screw trap (Mark Magneson, personal communication).

Statistical Analysis – Wilcoxon paired-sample test was used to determine if any sample sites tended toward higher weekly incidence of infection. Comparisons were made between Big Bar and Persido Bar traps and between Big Bar trap and seine sites to identify if the Big Bar trap was representative of all sample sites. Sample sites with less than 10 samples in a single week were not used in this analysis.

Results

Fish collection – The sample date, sites and number of fish collected are summarized in Table 2. Mean fork length demonstrated no consistent trend between sites, and increased from 52 mm to 89 mm during the first half of the study then remained fairly constant through the end of our study (Figure 2).

Table 2. Number of juvenile Klamath River Fall Chinook Salmon captured by rotary screw trap at Big Bar and Persido Bar, or beach seine (Seine). Seine location is noted for each week.

Week #	Sample Date	Big Bar	Persido Bar	Seine (location)
1	11-May	30	3	20 (Presido Bar)
2	19-May	31	12	20 (Big Bar)
3	25-May	29	29	19 (Presido Bar)
4	1-June	30	30	23 (Big Bar)
5	8-June	28	31	20 (Presido Bar)
6	16-June	27	30	23 (Big Bar)
7	22-June	30	26	18 (Camp Creek)
8	29-June	26	20	20 (Camp Creek)
9	6-July	27	25	0 (Camp Creek)
10	13-July	30	30	20 (Bluff Creek)
11	20-July	31	0	0 (Bluff Creek)
12	27-July	7	0	0
	Sub-totals	326	236	183 = 745 (total)

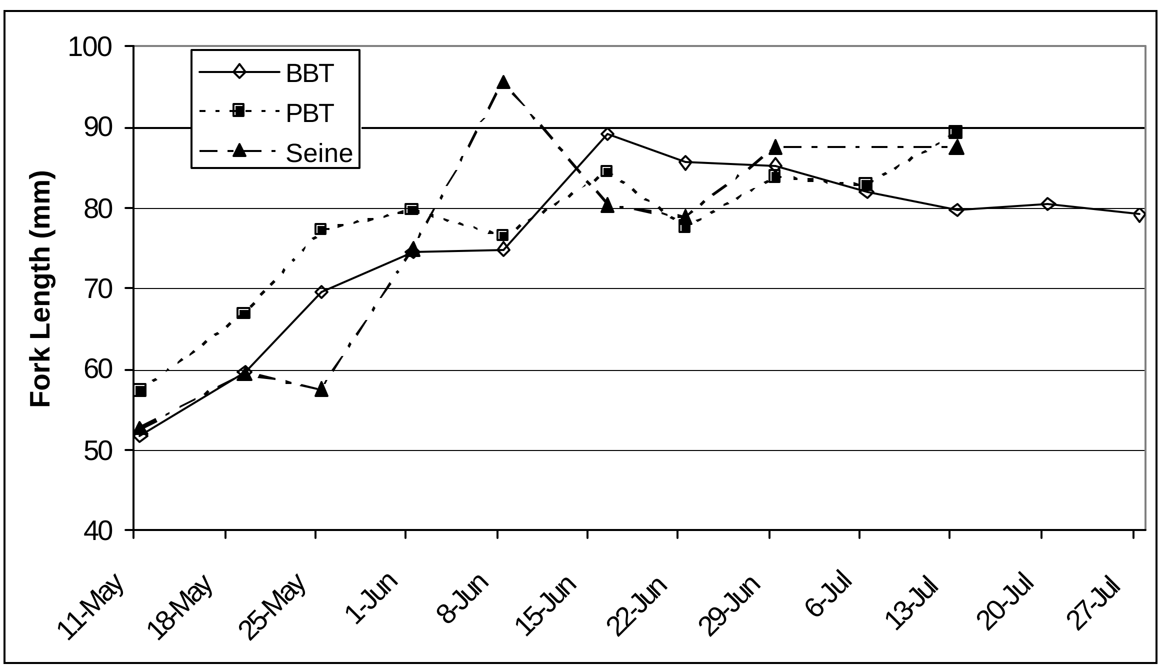

Figure 2. Mean fork length for juvenile Klamath River Chinook Salmon captured in the Big Bar trap (BBT), Presido Bar trap (PBT) and roving seine sites.

Ceratomyxa shasta – Weekly prevalence of infection for all sites combined ranged from 15% to 56%, with the peak observed in fish captured 19-May. Over half of the sample groups were categorized with a severe infection (Figure 3). Expanding from the trap efficiency data we estimated 45% of the population passing Big Bar was infected with *Ceratomyxa*. There were no significant differences in incidence of infection between Big Bar trap and Persido Bar trap (P=0.074) nor between Big Bar trap and seine sites (P=0.098).

Parvicapsula minibicornis – Weekly prevalence of infection for all sites combined ranged from 36% to 93% with the peak observed in fish captured on 16-June (Figure 4). Expanding from the trap efficiency data we estimated 94% of the population passing Big Bar was infected with *Parvicapsula*. There were no significant differences in infection rates between the Big Bar trap and Persido Bar trap (P=0.203), nor between Big Bar trap and seine sites (P=1.0).

Correlation of field observations to histopathological lesions – Observations made during field collections were not diagnostic to a fish's specific parasite infection. Three clinical signs of disease (pale gill, swollen kidney, and swollen abdomen) noted during necropsy were related to each of the four criteria recorded from histological examination (*C.shasta* positive, *P.minibicornis* positive, intestinal lesion, and kidney lesion). These associations were demonstrated by the statistical significance of each pairing of clinical sign to histological condition in Table 3 ((P<0.01, one-tailed Fisher exact test). Dual parasite infections influenced the lack of diagnostic value for clinical signs.

Bacterial infections – Signs of bacterial septicemia were observed in 4 of 745 fish examined (0.5%). A motile *Aeromonas sp*. (presumptively *Aeromonas hydrophila*) was isolated from the other two of the four affected fish. Gill lesions suggestive of *F. columnare* infection were observed in 18 of 745 fish examined (2.4%). Typical *F. columnare* bacteria were observed in 15 of 18 gill imprints.

Gill ATPase –Gill Na^+, K^+-ATPase activities ranged between 1.7 and 4.3 μmole ADP/mg protein/hour and with peak values observed 19-May (Figure 5). No consistent trend was seen with time or water temperature. There were no significant differences between fish caught by trap or seine on the same sample date (P>0.05, t-test) so all samples from each day were pooled. *P. minibicornis* and *C. shasta* infections had no detectable effect on ATPase activity levels.

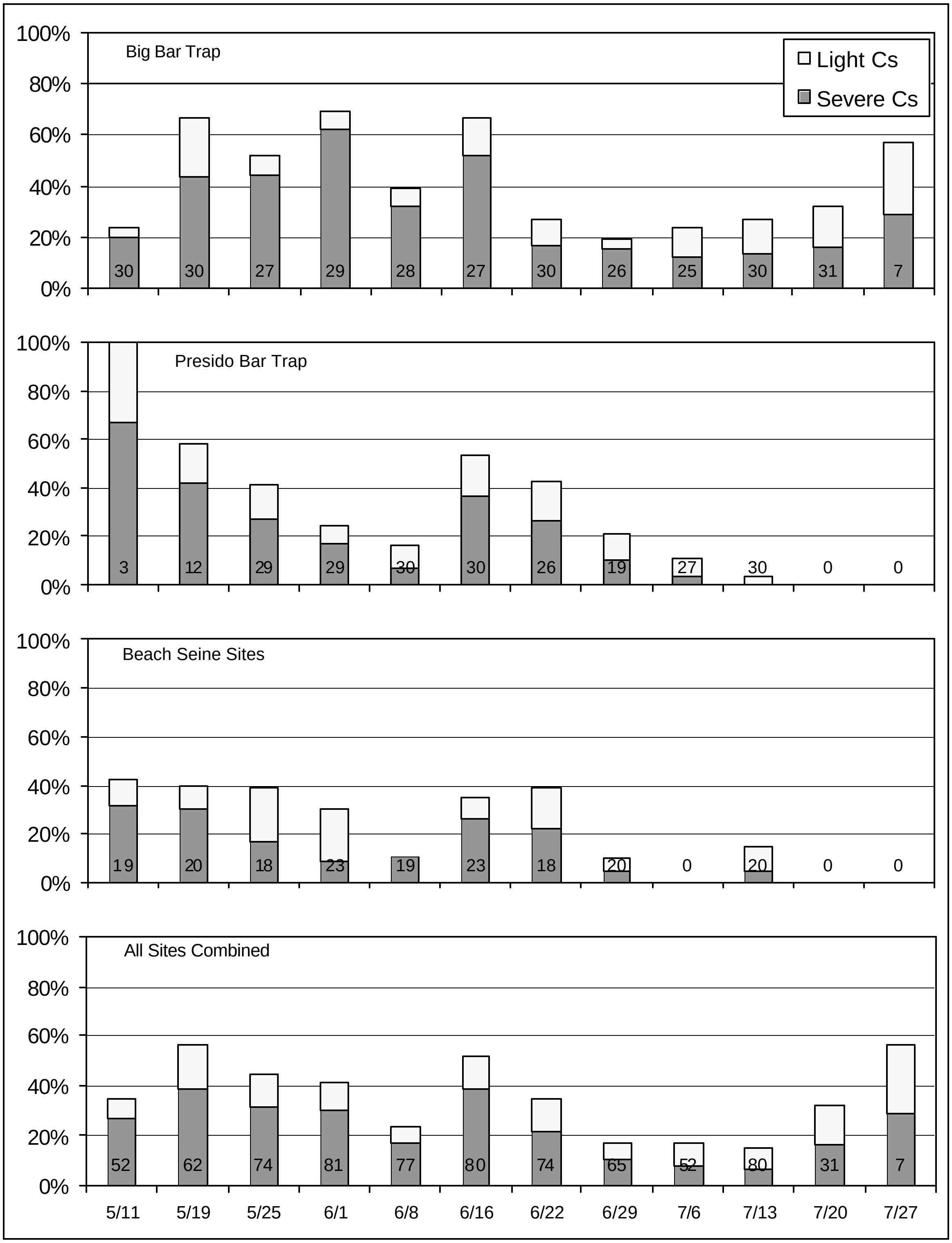

Figure 3. Percent of juvenile Klamath River Chinook Salmon with light and severe infections of *Ceratomyxa shasta* as indicated by examination of intestine by histology. Severe infections were indicated by greater than 50% of the intestinal tract demonstrating an inflammatory response associated with the parasite. Data is presented as percent of fish infected (light + severe) with number of samples in the base of each bar.

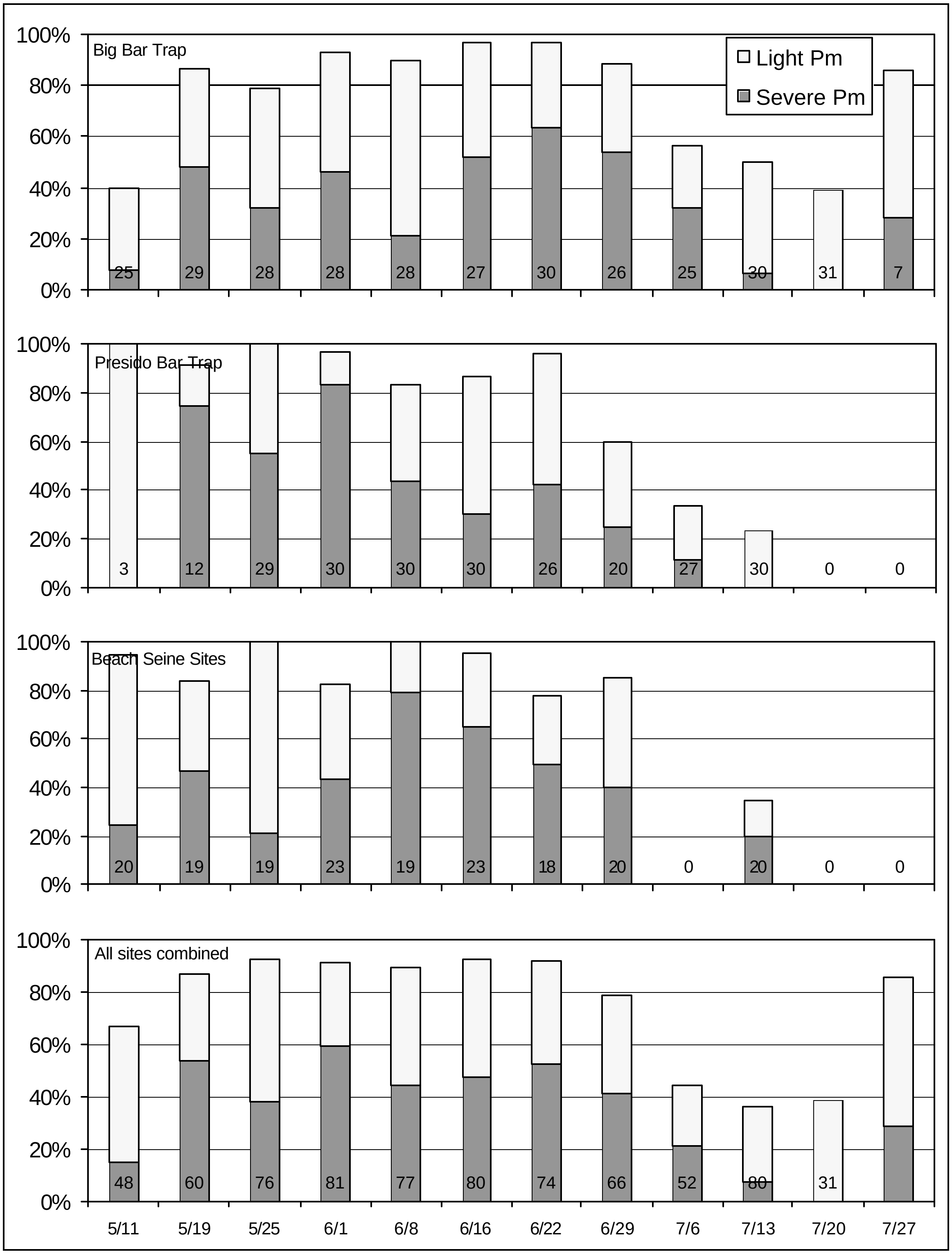

Figure 4. Percent of juvenile Klamath River Chinook Salmon with light and severe infections of *Parvicapsula minibicornis* as indicated by examination of kidney sections. Severe infections were indicated by greater than 50% of the section demonstrating an inflammatory response associated with the parasite. Data is presented as percent of fish infected (light + severe) with number of samples in the base of each bar.

Table 3. Frequency a clinical sign of disease (pale gill, swollen abdomen, swollen kidney) or histopathological condition (*Cs*+, IL, *Pm*+ or KL) co-occurred. Numbers in bold text were significantly greater (P<0.01, one-tailed Fisher exact test) than all samples combined (bottom row). Due to fish condition or problems with lab assay we did not have complete observations of signs and conditions for every fish; therefore, sample number (N) is approximate (±2.8%). All data is reported as percent of the true sample number.

		Percent Co-occurrence with:						
Clinical Sign or Condition	N	PG	SA	SK	*Cs*+	IL	*Pm*+	KL
Pale Gill (PG)	54		**15%**	**35%**	**78%**	**59%**	**96%**	**62%**
Swollen Abdomen (SA)	30	**27%**		**40%**	**70%**	**47%**	**97%**	**77%**
Swollen Kidney (SK)	142	**13%**	8%		28%	13%	**95%**	**72%**
Cs Infected *(Cs+)*	252					**67%**	**98%**	45%
Intestine Lesion (IL)	169				**100%**		**99%**	47%
Pm Infected *(Pm+)*	561				**44%**	**30%**		**48%**
Kidney Lesion (KL)	270				42%	29%	**100%**	
All Samples	744	7%	4%	19%	34%	23%	77%	37%

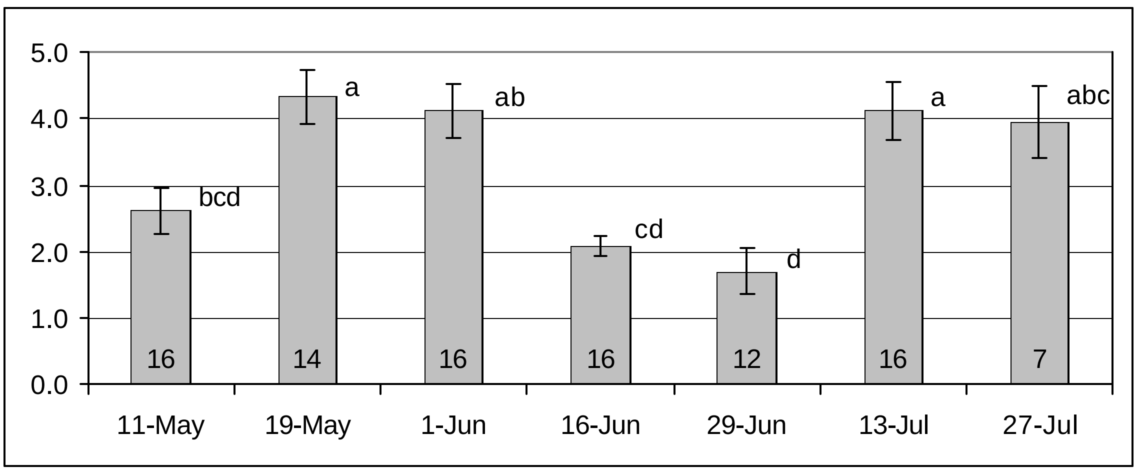

Figure 5. Gill Na+, K+-ATPase values (μmole ADP/mg protein/hour) for juvenile Klamath River Chinook Salmon collected in the Spring and Summer of 2004. Data presented as mean ±SE with sample number in base of each bar. Letters, not in common, indicate statistical differences between groups (p<0.05, ANOVA and Tukey test).

RNA:DNA – Mean muscle RNA:DNA tended to increase through the sampling period (Figure 6). This estimate of specific growth rate was not affected by *P. minibicornis* or *C. shasta* infection. Muscle RNA:DNA values correlated with sample date, fork length, and mean daily water temperature (all P<0.001, n=109). There was no correlation with gill ATPase (P=0.716, n=51).

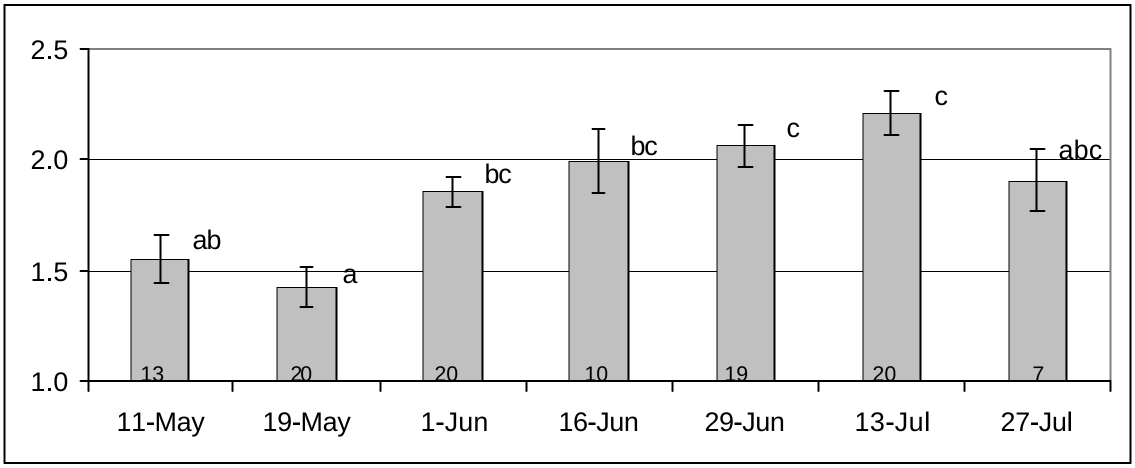

Figure 6. Mean muscle RNA:DNA values from juvenile Klamath River Chinook Salmon. Data is presented as mean ±SE and samples number in the base of each bar. Letters, not in common, indicate statistical differences between groups ($p<0.05$, ANOVA and Tukey test).

Discussion

Representative sampling of out-migrant population - In a given week, similarity in both pathogen prevalence and physiological data, observed between sample groups collected by either seine or rotary screw at different sites, provides confidence that our results accurately estimate the health status of juvenile Chinook salmon in the Klamath River during the spring of 2004. Comparative trends in both *Ceratomyxa* and *Parvicapsula* infection were observed at all sample sites. Similar trends were also noted for gill ATPase activity and RNA – DNA ratios from salmon taken at the different sites during the same sample week. Fish size was similar at all sites and demonstrated the expected pattern of rearing to a sufficient size for salt water entry and then emigrating (Wallace and Collins, 1997).

Potential bias – A collection bias towards healthier fish at the trap sites is a possibility as dead fish were not included in these samples. Fish in a severe disease state are likely to die prior to sampling. It was necessary for the trap crew to hold fish in a live box before we arrived for sampling, and during this holding period we routinely observed 10-20% mortality in the live box. Seine fish were sampled immediately following capture and were not affected by this practice.

Unknown influence of tributary populations on disease observations – The history of each sampled fish is largely unknown to us as only five marked hatchery salmon were collected in 2004. Previous examinations of juvenile salmon from the Shasta, Scott, and Trinity River have not detected *Ceratomyxa shasta* infections (National Wild Fish Health Survey 2005, Foott et al. 2002, Nichols et al. 2003). If we assume that parasite infection is primarily focused in the mainstem Klamath River, then the time of entry and duration of exposure to the mainstem river would be a major determinant in disease. The marked decline in *C.shasta* infection observed between 29-June and 13-July could be influenced by an influx of healthy smolts from a Klamath tributary (Figure 3). We noted a distinct group of fish captured in the 6-July sample (all sites). Histologically these fish demonstrated no inflammation of the adipose tissue or other characteristics associated with the stress of rearing at warm water temperatures. We hypothesize that many of salmon collected on 6-July had recently reared in a cool water environment.

Drops in the pathogen incidence data in late May and again in late June may represent pulses of fish with a different origin. The sudden dip in gill ATPase activity with no correlation with disease incidence or water quality also supports this theory. These pulses of fish and corresponding changes in infection rates demonstrate the potential bias towards one segment of the population by sampling over a limited time frame. The expanded population infection rates for both parasites were heavily weighed towards the infection rates during the month of June as this is when the majority of smolts passed the Big Bar trap (Figure 1). Since most of the fish observed during this migration peak were of hatchery origin, our estimated population infection rates primarily represent these hatchery fish. Prior to Iron Gate Hatchery smolt releases in mid-May, the infection rates in naturally produced Chinook for *Ceratomyxa* and *Parvicapsula* were 20-60% and 40-100% respectively. Increased marking effort of both the hatchery and tributary populations would allow for analysis of the disease risk as a function of river entry and days of exposure.

Limited diagnostic value of clinical signs - In observations of clinical signs and histopathological conditions we introduced an intentional bias. Only those fish which clearly demonstrated abnormalities were considered “sick”. Examples of this include observations of pale gills, swollen kidneys and histological lesions where we scored the abnormalities on a zero-two or zero-three scale with zero being normal. We only considered the scores of 2 or more to be abnormal even through those fish with a rating of one were showing some signs of abnormality. In these cases we considered a score of one to be transitional to a more severe disease state.

The clinical signs of disease we tracked (pale gills, swollen abdomen, and swollen kidney) demonstrated only marginal utility in identifying sick fish. Pale gill is a result of anemia which could be produced by intestinal hemorrhage (ceratomyxosis) or insufficient erythropoiesis due to kidney inflammation (*Parvicapsula* infection). Similarly, swollen abdomen occurs when the fish is unable to maintain its water balance and the peritoneum fills with ascitic fluid. Damage to kidney or the intestine can induce this condition. Dual infections further complicate the diagnostic picture. There may be some benefit in monitoring clinical signs to track population health over time, but the researcher should be aware that many fish without clinical signs were infected and would later progress into a disease state.

Flavobacterium columnare - The one clinical sign with diagnostic value was gill erosion that is often associated with *Flavobacterium columnare* infection. *Flavobacterium columnare* was not a significant health issue in this section of river during 2004 (2.4% incidence of infection). Past fish health examinations at Big Bar has found *F. columnare* to be a more significant problem with up to 20% incidence of infection (Nichols et al. 2003). It was associated with fish kills on the Klamath River most notably during an adult salmon fish die-off which occurred in 2002 (Guillen 2003a).

Low survival is expected in the estimated 45% of the juvenile Klamath River Chinook Salmon infected with *Ceratomyxa.* The progress of *Parvicapsula* infection in juvenile Chinook salmon is not well understood and this is an important question given the high incidence of infection (94%) observed in this study. We conclude that the juvenile Klamath River Chinook population experienced a high mortality prior to their migration to the ocean below our sample reach. There could be some level of mortality above our sample reach which went undetected in our sampling. Depending on the population size and smolt to adult return ratio, the effective number of adult salmon lost to *C. shasta* as juveniles rivaled the 33,000+ adult salmon lost in the September 2002 Klamath River Fish Die-off (Guillen 2003b).

Recommendations for future studies:

- Determine the prognosis of *Parvicapsula* infection.
- Determine the infections rates in other reaches of the Klamath.
- Determine the effects of disease on specific tributary populations.
- Determine the areas of the mainstem Klamath River where most of the fish are dying.

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Notes

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Appendix I

Sample site, date, number and clinical signs of disease observed in juvenile Klamath River Fall Chinook Salmon during the Spring and Summer of 2004.

Site	Date	n	Pale Gill[1]	Gill Les.[2]	Dist. Ab.[3]	Ext. Hem.[4]	Int. Hem.[5]	Sw. Kid.[6]
Big Bar Trap	5/11	30	3%	0%	0%	0%	N/A	N/A
	5/19	31	7%	0%	3%	0%	N/A	N/A
	5/25	29	3%	3%	0%	0%	3%	7%
	6/1	30	30%	0%	3%	0%	0%	21%
	6/8	28	18%	11%	0%	4%	4%	32%
	6/16	27	11%	4%	15%	0%	7%	26%
	6/22	30	17%	3%	7%	7%	7%	57%
	6/29	26	4%	0%	12%	0%	8%	27%
	7/6	27	0%	0%	0%	0%	0%	28%
	7/13	30	0%	7%	0%	0%	0%	0%
	7/20	31	0%	10%	0%	3%	0%	0%
	7/27	7	0%	0%	0%	0%	29%	0%
Presido Bar Trap	5/11	3	66%	0%	0%	0%	N/A	N/A
	5/19	12	17%	0%	0%	0%	N/A	N/A
	5/25	29	7%	3%	0%	0%	0%	14%
	6/1	30	10%	0%	3%	0%	0%	30%
	6/8	31	3%	0%	3%	0%	0%	39%
	6/16	30	0%	3%	3%	0%	3%	40%
	6/22	26	7%	4%	12%	0%	15%	38%
	6/29	20	20%	5%	10%	0%	25%	25%
	7/6	25	0%	0%	0%	4%	0%	0%
	7/13	30	7%	0%	0%	7%	0%	0%
Presido Bar Seine	5/11	20	0%	0%	0%	0%	N/A	N/A
Big Bar Seine	5/19	20	5%	0%	0%	5%	N/A	N/A
Presido Bar Seine	5/25	19	11%	0%	0%	0%	0%	0%
Big Bar Seine	6/1	23	13%	4%	0%	0%	0%	13%
Presido Bar Seine	6/8	20	10%	0%	5%	0%	5%	70%
Big Bar Seine	6/16	23	9%	4%	13%	0%	13%	30%
Camp Creek Seine	6/22	18	6%	0%	17%	6%	6%	50%
Camp Creek Seine	6/29	20	0%	5%	20%	5%	10%	10%
Camp Creek Seine	7/6	0	N/A	N/A	N/A	N/A	N/A	N/A
Bluff Creek Seine	7/13	20	0%	0%	0%	0%	0%	0%

Notes:

1. Pale gill = gills had lost typical red color. Gills were tan or grey color. Gills with were pink or red coloration were considered normal.
2. Gill lesion = focal discoloration on gill possibly due to *Flavobacterium columnare* infection.
3. Distended abdomen = Abdomen notably swollen or inflated.
4. External hemorrhaging = pinpoint hemorrhaging on skin or at base of fins
5. Internal hemorrhaging = pinpoint hemorrhaging on visceral fat, organs or peritoneum
6. Swollen kidney = kidney notably inflated (nephritis)

ATTACHMENT 16

Klamath River Juvenile Salmonid Health Monitoring, April-August 2007, (USFWS California-Nevada Fish Health Center, Sept. 2008)

U.S. Fish & Wildlife Service

California-Nevada Fish Health Center
FY 2007 Investigational Report:

Klamath River Juvenile Salmonid Health Monitoring, April-August 2007

Ken Nichols, Kimberly True, Ryan Fogerty and Lisa Ratcliff

September 2008

US Fish and Wildlife Service
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SUMMARY

The California-Nevada Fish Health Center led a cooperative study to monitor the incidence of two myxozoan parasites (*Ceratomyxa shasta* and *Parvicapsula minibicornis*) in juvenile salmonids within the Klamath River during the spring and summer of 2007. This study utilized two complementary assays: Quantitative real-time Polymerase Chain Reaction (QPCR) for its high sensitivity and efficiency, and histology to assess disease state and provide continuity with previous studies. In juvenile Klamath River Chinook Salmon out-migrants, *C. shasta* incidence of infection peaked at 68% during mid June and *P. minibicornis* reached 100% during late May. In marked (coded wire tagged) hatchery Chinook smolts recaptured within the Klamath River, *C. shasta* was detected in 68% of Iron Gate Hatchery (IGH) origin smolts and 14% of Trinity River Hatchery (TRH) origin smolts; *P. minibicornis* was detected in 83% of IGH smolts and 58% of TRH smolts. Infection incidence in coded wire tagged smolts from IGH peaked the 5th week following release and subsequently declined suggesting the death of infected fish. Coho salmon also were susceptible to infection by both parasites; with 48% *C. shasta* and 65% *P. minibicornis* incidence of infection observed in naturally produced young-of-the-year. Compared to Klamath River salmonid health monitoring conducted in 2004 – 2006, incidence of *C. shasta* was below average, and incidence of *P. minibicornis* was above average.

The correct citation for this report is:
Nichols K, K True, R Fogerty and L Ratcliff. 2008. FY 2007 Investigational Report: Klamath River Juvenile Salmonid Health Monitoring, April-August 2007. U.S. Fish & Wildlife Service California – Nevada Fish Health Center, Anderson, CA. Available online: http://www.fws.gov/canvfhc/reports.asp.

INTRODUCTION

As a partner in the efforts to restore salmonid populations in the Klamath River basin, the California-Nevada Fish Health Center has conducted pathogen monitoring of juvenile Klamath River salmonids since 1991. Pathogens associated with diseased fish in the Klamath River include bacteria (*Flavobacterium columnare* and motile aeromonads), a digenetic trematode (presumptive *Nanophyetus salmincola*), myxozoan parasites (*Parvicapsula minibicornis* and *Ceratomyxa shasta*) and external parasites (Walker and Foott 1992; Williamson and Foott 1998). Ceratomyxosis (due to *C. shasta*) has been identified as the most significant disease for juvenile salmon in the Klamath Basin (Foott et al. 1999; Foott et al. 2004). Significant kidney damage (glomerulonephritis) has been associated with *P. minibicornis* infection; however, the prognosis of such infections has not been thoroughly studied in juvenile salmonids.

Ceratomyxa shasta and *P. minibicornis* are myxosporean parasites found in a number of Pacific Northwest watersheds (Hoffmaster et al. 1988; Bartholomew et al. 1989; St.-Hilaire et al. 2002; Jones et al. 2004; Bartholomew et al. 2006). The lifecycles of both parasites include the polychaete host, *Manayunkia speciosa*, and salmonids (Bartholomew et al. 1997; Bartholomew et al. 2006). *Ceratomyxa shasta* infection can occur from spring through fall at water temperatures greater than 4°C, although is most active above 11ºC (Ching and Munday 1984; Hendrickson et al. 1989; Bartholomew et al. 1989). Studies conducted in 2004, 2005 and 2006 suggest that *P. minibicornis* has seasonality similar to that of *C. shasta,* while its actinospore concentration and infectivity appears greater than *C. shasta* (Foott et al. 2006; Nichols and Foott 2006; Nichols et al. 2007; Nichols and True 2007; Bartholomew et al. 2007).

In this study we monitored the weekly incidence of *C. shasta* and *P. minibicornis* infections in juvenile Chinook (*Oncorhynchus tshawytscha*) and coho (*Oncorhynchus kisutch*) salmon over 24 weeks of the spring and summer out-migration period. Two complementary assays were utilized: Quantitative real-time Polymerase Chain Reaction (QPCR) for its high sensitivity and efficiency, and histology to assess disease state and provide continuity with previous studies.

METHODS

Fish Collection

Fish collection occurred from 19 April through 22 August, 2007, with a total of 1890 fish examined from the Klamath and Trinity Rivers. Sample reaches and cooperators performing collections are summarized in Table 1. Where possible, fish capture was performed at existing juvenile salmonid out-migration monitoring sites, but supplemental seining or electrofishing was required to achieve our target sample size in some weeks. Fish from multiple sites within each reach and captured over several days were combined into a weekly sample group.

A portion of the Chinook salmon released from the two hatcheries in the basin were marked with an adipose fin clip, and implanted with a coded-wire-tag (CWT). Iron Gate Hatchery (IGH) on the Klamath River released 5.4 million fall Chinook (5.8% CWT) from 18-31 May. Trinity River Hatchery (TRH) located near Lewiston on the Trinity River released 3.0 million spring and fall Chinook (24% CWT) in a week long volitional release from 1-8 June. Heads from any CWT Chinook recovered were assigned unique identification numbers to track lab assay results to individual CWT fish. The US Fish and Wildlife Service, Arcata FWO excised and read the CWT's. The release date for a given CWT group was used to determine weeks since release for individual marked fish. Chinook without adipose fin clips (unmarked) could have been of either hatchery or natural origin.

Table 1. Sample reach location and cooperating agencies performing collections.

Reach	River Miles	Primary collector(s)
Klamath River mainstem		
Iron Gate Dam to Shasta	Klamath 190-177	USFWS and Karuk Tribe
Shasta to Scott	Klamath 177-143	USFWS and Karuk Tribe
Salmon to Trinity	Klamath 66-44	Karuk Tribe
Trinity to Estuary	Klamath 44-4	Yurok Tribe
Klamath Estuary	Klamath 4-0	Yurok Tribe
Trinity River		
Upper – Lewiston Dam to North Fork	Trinity 111-73	Hoopa Tribe
Lower - North Fork to Klamath	Trinity 73-0	USFWS and Yurok Tribe

Target sample numbers for the QPCR assay varied depending on the reach and species sampled. In Klamath reaches above the confluence of the Trinity River the first 30 Chinook encountered per reach and all CWT Chinook were collected each week. In Klamath reaches below the Trinity confluence any adipose clip marked fish encountered were collected. Any juvenile coho salmon encountered in the Klamath River above the Trinity River confluence were collected under endangered species Section 10 permit 1068. In the Trinity River, 60 Chinook were collected in late May and again in late June.

Following capture and preliminary examination by collection crews, fish were euthanized, placed in a plastic bag labeled with date and reach, and arranged between frozen gel pack sheets. At the end of the day, samples were transferred to a freezer until they could be shipped frozen to the CA-NV Fish Health Center laboratory.

Each week personnel from the CA-NV Fish Health Center would accompany the samplers in one or more reaches to collect 10 randomly selected juvenile Chinook for the histology assay. Following preliminary examination by the collection crew, the fish were euthanized, and target tissues were preserved in individually identified 50 ml tubes containing Davidson's fixative. Only unmarked fish were collected for the histology assay.

Laboratory Assays

Necropsy – In the laboratory fish were thawed, measured for fork length, and tissue samples were collected. The intestine (both small and large intestine) and kidney from each fish were removed and combined into an individually numbered 2 ml cluster tube. Due to limited tube volume, total sample weight was limited to 1.0g (tissue weight ranged from 0.01g to 1.0g). Tissue samples were then frozen until DNA extraction was performed.

Histology – Tissues (kidney and intestine) for histological examination were fixed for 24 hours in Davidson's fixative, transferred to 70% ethanol after 24 hours for storage, processed for 5µm paraffin sections and stained with hematoxylin and eosin (Humason 1979). All tissues for each fish were placed on one slide and identified by a unique code number. Each slide was examined at both low (40X) and high magnification (400X). A composite infection and disease rating was developed based on the degree of tissue inflammation associated with the presence of the parasites. A similar histology rating system has been used in Klamath monitoring studies since 2004 (Nichols and Foott 2006; Nichols et al. 2007; Nichols and True 2007). *Ceratomyxa shasta* infections were rated as clinical (parasite present and inflammatory tissue in >33% of the intestine section), subclinical (parasite present, but inflammatory tissue in <33% of intestine section) or uninfected (no *C. shasta* detected). *Parvicapsula minibicornis* infections were rated as clinical (parasite present and glomerulonephritis in >33% of the kidney section), subclinical (parasite present, and inflammation in <33% of the kidney section) or uninfected (no *P. minibicornis* detected).

DNA extraction – Combined intestine and kidney tissues were digested in 1ml NucPrep Digest Buffer containing 1.25 mg/ml proteinase K (Applied Biosystems, Foster City, CA) at 55ºC for 1 hour with constant shaking. A subsample of digested tissue homogenate was diluted 1:33 in molecular grade water (MGW) and extracted in a 96 well filter plate system (Applied Biosystems Model 6100 Nucleic Acid Prep Station). Due to dilution the weight of tissue entering extraction was limited to 3.0mg given the maximum 1.0g sample weight mentioned above. Extracted DNA was stored at -20ºC until the QPCR assays were performed.

QPCR assay – Samples were assayed in a 7300 Sequence Detection System (SDS) (Applied Biosystems), using probes and primers specific to each parasite. The combined tissues were tested for *C. shasta* 18S rDNA using TaqMan Fam-Tamra probe and primers (Hallett and Bartholomew 2006). The combined tissues were tested for *P.minibicornis* 18S rDNA utilizing TaqMan Minor-Grove-Binding (MGB) probe and primers (True et al. in press). Reaction volumes of 30uL, containing 5uL DNA template, were used for both assays under the following conditions: 50ºC for 2 min; 95ºC for 10 min; 40 cycles of 95ºC for 15 s and 60ºC for 1 min. Standards, extraction control and no template control wells (MGW) were included on each assay plate. Cycle threshold (C_T) values were calculated by the SDS software (v 1.3.1, Applied Biosystems). Preliminary lab trials examining the dynamic range and endpoint of the assays indicated a C_T of 38 and minimum change in normalized fluorescent signal of at least 10,000 units was a reliable indicator of amplification. These thresholds were conservative and underestimate the true incidence of infection for both parasites; however, we believe that any light infections that may have been missed likely had no biologically significant impact on the survival of the animals (True et al. in press; Nichols and True 2007).

Interannual Comparisons

Using the composite histology disease rankings, a comparison of disease incidence and severity between years was possible. Juvenile Klamath River Fall Chinook Salmon historically began out-migration in February, peaked in mid-June, and were captured in large numbers within the Klamath Estuary from June through mid August (Leidy and Leidy 1984; Wallace and Collins 1997). For interannual comparisons of parasite infection, we limited the data to fish captured during the months of May, June and July and from sites in the Klamath River above the confluence with the Trinity River. Limiting the data set in this way offered several advantages:

- These months bracketed the typical peak of Fall Chinook out-migration and included the monitoring periods from previous years
- Infection incidence during the “tails” of the migration (typically lower infection rates in early spring) were not given the same weight as the peak of migration
- The Trinity population was excluded as it is largely *C. shasta* uninfected
- Our target sample size was typically met during this period reducing sample variation due to small sample size

RESULTS

Chinook Salmon

Histology Assay

Ceratomyxa shasta infections were first detected by histology the week of 29 April in 20% (2/10) of fish sampled in the Shasta to Scott reach (Table 2). The peak incidence of infection and clinical ceratomyxosis were both observed the week of 10 June in the Shasta to Scott reach where 50% (5/10) of juvenile Chinook were *C. shasta* infected with 80% (4/5) of the infections rated as clinical. Infection incidence declined in late June and no infections were detected after the week of 22 July. Overall, this parasite was detected in 16.4% (25/152) of Chinook from the Klamath River, with intestinal lesions symptomatic of clinical ceratomyxosis observed in 68% (17/25) of the infected Chinook.

Parvicapsula minibicornis infections were first observed during the week of 15 April in 60% (6/10) of fish sampled in the Shasta to Scott reach (Table 3). Incidence of infection reached 100% (10/10) by the week of 27 May. The peak incidence of clinical glomerulonephritis was 80% (8/10) observed the week of 24 June. Infection incidence remained high through the last week of sampling; however, clinical glomerulonephritis declined in late July. Overall, *P. minibicornis* was detected in 76.3% (116/152) of Chinook sampled in the Klamath, with clinical glomerulonephritis observed in 47.4% (55/116) of the *P. minibicornis* infected Chinook.

QPCR Assay

The earliest detection of *C. shasta* infections was in the week of 29 April. Prevalence remained below 40% until early June. Peak incidence was 68% in Chinook captured above the Trinity confluence during the week of 17 June (Figure 1).

Ceratomyxa shasta was detected in 3% (5/168) of juvenile Trinity Chinook sampled within the Trinity River (Table 4). All were very light infections near the detection threshold of the QPCR assay. Three of the infected fish were captured at the North Fork site in the Upper Trinity reach while the other two infected fish were captured at the Willow Creek site in the Lower Trinity. All 5 *C. shasta* infected Chinook were captured after hatchery release and were of either hatchery or natural origin.

Parvicapsula minibicornis infections were detected from the first Klamath samples taken the week of 15 April. *Parvicapsula minibicornis* incidence reached 100% in the Klamath above the Trinity confluence on 20 May and remained high through the end of the study (Figure 2).

Parvicapsula minibicornis was detected in 41% (54/132) of juvenile Trinity Chinook captured in the Trinity River (Table 4). *Parvicapsula minibicornis* was detected in fish from both the Upper and Lower Trinity reaches before and after hatchery release. Peak prevalence of 88% (14/16) was observed in fish from the Lower Trinity reach in late June.

Marked Hatchery Fish

A total of 103 IGH and 332 TRH CWT marked smolts were collected between 30 May and 18 August. The IGH smolts were captured between Iron Gate Dam and the Klamath Estuary from one to 12 weeks following release. The TRH smolts were captured in the Klamath River between the Trinity River confluence and Klamath Estuary from 3 to 11 weeks following release. All CWT smolts were analyzed by QPCR assay.

Table 2. Incidence of *Ceratomyxa shasta* infection by histology in juvenile Chinook salmon captured in the Klamath River between Iron Gate Dam (IGD) and the Estuary, during spring and summer of 2007. Fish were considered infected (*Cs*+) if *C. shasta* was detected in histological examination of intestinal tract (pyloric ceca, small and large intestine). Fish with inflammation in >33% of the intestinal section were rated as clinically diseased (Clinical).

Sample Reach		15 Apr	29 Apr	13 May	27 May	3 Jun	10 Jun	17 Jun	24 Jun	8 Jul	15 Jul	22 Jul	5 Aug	12 Aug	19 Aug	Total
Shasta to Scott	*Cs*+	0/10	2/10	0/10	1/10		5/10		0/10							8/60
	Clinical	0/10	2/10	0/10	1/10		4/10		0/10							7/60
Salmon to Trinity	*Cs*+					3/10		4/9		1/10	1/2			0/10		9/41
	Clinical					2/10		2/9		0/10	1/2			0/10		5/41
Klamath Estuary	*Cs*+							4/10		2/11		2/10	0/10		0/10	8/51
	Clinical							3/10		1/11		1/10	0/10		0/10	5/51
Total	*Cs*+	0/10	2/10	0/10	1/10	3/10	5/10	8/19	0/10	3/21	1/2	2/10	0/10	0/10	0/10	25/152
	Clinical	0/10	2/10	0/10	1/10	2/10	4/10	5/19	0/10	1/21	1/2	1/10	0/10	0/10	0/10	17/152

Table 3. Incidence of *Parvicapsula minibicornis* infection by histology in juvenile Chinook salmon captured in the Klamath River between Iron Gate Dam (IGD) and the Estuary, during spring and summer of 2007. Fish were considered infected (*Pm*+) if *P. minibicornis* was detected in histological examination of the kidney. Fish with glomerulonephritis in >33% of the kidney section were rated as clinically diseased (Clinical).

Sample Reach		15 Apr	29 Apr	13 May	27 May	3 Jun	10 Jun	17 Jun	24 Jun	8 Jul	15 Jul	22 Jul	5 Aug	12 Aug	19 Aug	Total
Shasta to Scott	*Pm*+	6/10	7/10	6/10	10/10		10/10		9/10							48/60
	Clinical	0/10	3/10	6/10	5/10		7/10		8/10							29/60
Salmon to Trinity	*Pm*+					9/10		5/9		8/10	2/2			5/10		29/41
	Clinical					5/10		2/9		6/10	1/2			0/10		14/41
Klamath Estuary	*Pm*+							8/10		6/11		9/10	8/10		8/10	39/51
	Clinical							7/10		2/11		0/10	2/10		1/10	12/51
Total	*Pm*+	6/10	7/10	6/10	10/10	9/10	10/10	13/19	9/10	14/21	2/2	9/10	8/10	5/10	8/10	116/152
	Clinical	0/10	3/10	6/10	5/10	5/10	7/10	9/19	8/10	8/21	1/2	0/10	2/10	0/10	1/10	55/152

Table 4. Incidence of *C. shasta* and *P. minibicornis* infection in Chinook salmon captured in either the lower (North Fork Trinity to confluence with Klamath) or upper (Lewiston Dam to North Fork Trinity) reaches on the Trinity River. Screening for the parasites was performed by QPCR of a combined kidney and intestine sample for individual fish.

Week	27 May	27 May	3 June	3 June	24 June	8 July	Total
Reach	Lower	Upper	Lower	Upper	Lower	Lower	
Cs incidence	0/31	0/30	1/30	3/30	1/30	0/30	5/181
Pm incidence	0/16	4/17	0/16	NA	14/16	13/18	31/83

Ceratomyxa shasta was detected by QPCR in 68% (70/103) of CWT marked IGH smolts as early as 6 days post hatchery release (Figure 3). Incidence of *C. shasta* infection by QPCR in IGH smolts peaked at 100% (30/30) in the 5th week following release. Overall prevalence of *P. minibicornis* infections was 83% (69/83), reached 100% (2/2) by the third week following release, and remained high through the last IGH smolt recovery 12 weeks after hatchery release.

Ceratomyxa shasta was detected by QPCR in 13.6% (45/332) of the TRH smolts recovered in the Lower Klamath River. Infected fish were detected in the Klamath River within 3 weeks of release (Figure 4). Incidence of *C. shasta* infection by QPCR in TRH smolts peaked at 46% (12/26) 5 weeks after release and decreased beginning the 6th week. *Parvicapsula* infections were detected in 57.7% (191/331) of the TRH smolts recovered in the Lower Klamath River. Incidence of infection peaked in the 5th and 11th weeks after Trinity River Hatchery release at 85% (22/26) and 100% (5/5), respectively.

<u>Interannual Comparisons</u>

Compared to studies performed in 2004, 2005 and 2006 (Nichols and Foott 2006, Nichols et al. 2007, Nichols and True 2007), the incidence of *C. shasta* by histology was below average, and incidence of *P. minibicornis* was above average in juvenile Chinook (Table 5 and 6).

Coho Salmon

<u>QPCR Assay</u>

Ceratomyxa shasta was detected in 48% (25/52) of natural young-of-the-year (YOY) coho, and no infections (0/26) were detected in the yearling juvenile coho. The first detection of *C. shasta* occurred the week of 13 May, and the majority of *C. shasta* infected coho were captured during mid to late May in the Shasta to Scott reach (Table 7).

Parvicapsula minibicornis was detected in 65% (20/31) of natural YOY coho, and 71% (17/24) of yearling juvenile coho. The first detection of *P. minibicornis* by QPCR occurred the week of 29 April, and the majority of *P. minibicornis* infected coho were captured from early May through early June in the Shasta to Scott reach (Table 7).

Table 5. Comparison of *Ceratomyxa shasta* prevalence in juvenile Klamath River Chinook from 1994-2006 assayed by histology. Percentages indicate proportion of the total samples (N) in which the parasite was detected (Infected) or had an intestinal lesion associated with an infection (Clinical). Only fish sampled in May-July and captured above the Trinity confluence were included to aid comparisons between years.

	1994-2002	**2004**	**2005**	**2006**	**2007**	**Average 2004-2007**
Infected	20%-50%	34%	35%	21%	21%	28%
Clinical	n/a	23%	21%	18%	15%	19%
N	156	735	134	112	81	n/a

Table 6. Comparison of *Parvicapsula minibicornis* prevalence in juvenile Klamath River Chinook from 1995-2006 assayed by histology. Percentages indicate proportion of the total samples (N) in which the parasite was detected (Infected) or had an intestinal lesion associated with an infection (Clinical). Only fish sampled in May-July and captured above the Trinity confluence were included to aid comparisons between years.

	1995-2002	**2004**	**2005**	**2006**	**2007**	**Average 2004-2007**
Infected	47%-88%	77%	92%	58%	81%	77%
Clinical	n/a	37%	65%	29%	53%	46%
N	176	731	134	112	81	n/a

Table 7. Incidence of *C. shasta* and *P. minibicornis* infection in young-of-the-year (YOY) and yearling Coho salmon captured in the Klamath River between the Shasta and Scott Rivers. Screening for the parasites was performed by QPCR of a combined kidney and intestine sample.

	C. shasta		***P. minibicornis***	
Week Beginning	**YOY**	**yearling**	**YOY**	**yearling**
15 April		0/2		0/2
22 April		0/3		0/3
29 April	0/1	0/5		1/3
6 May	0/6	0/14	2/6	14/14
13 May	11/16	0/2	2/2	1 / 2
20 May	6/7		5/5	
27 May	4/5		5/5	
3 June	2/5		4/4	
10 June	1/2		2/2	
17 June	1/6		0/6	
24 June	0/4		0/1	
Total	**25/52 (48%)**	**0/26**	**20/31 (65%)**	**17/24 (71%)**

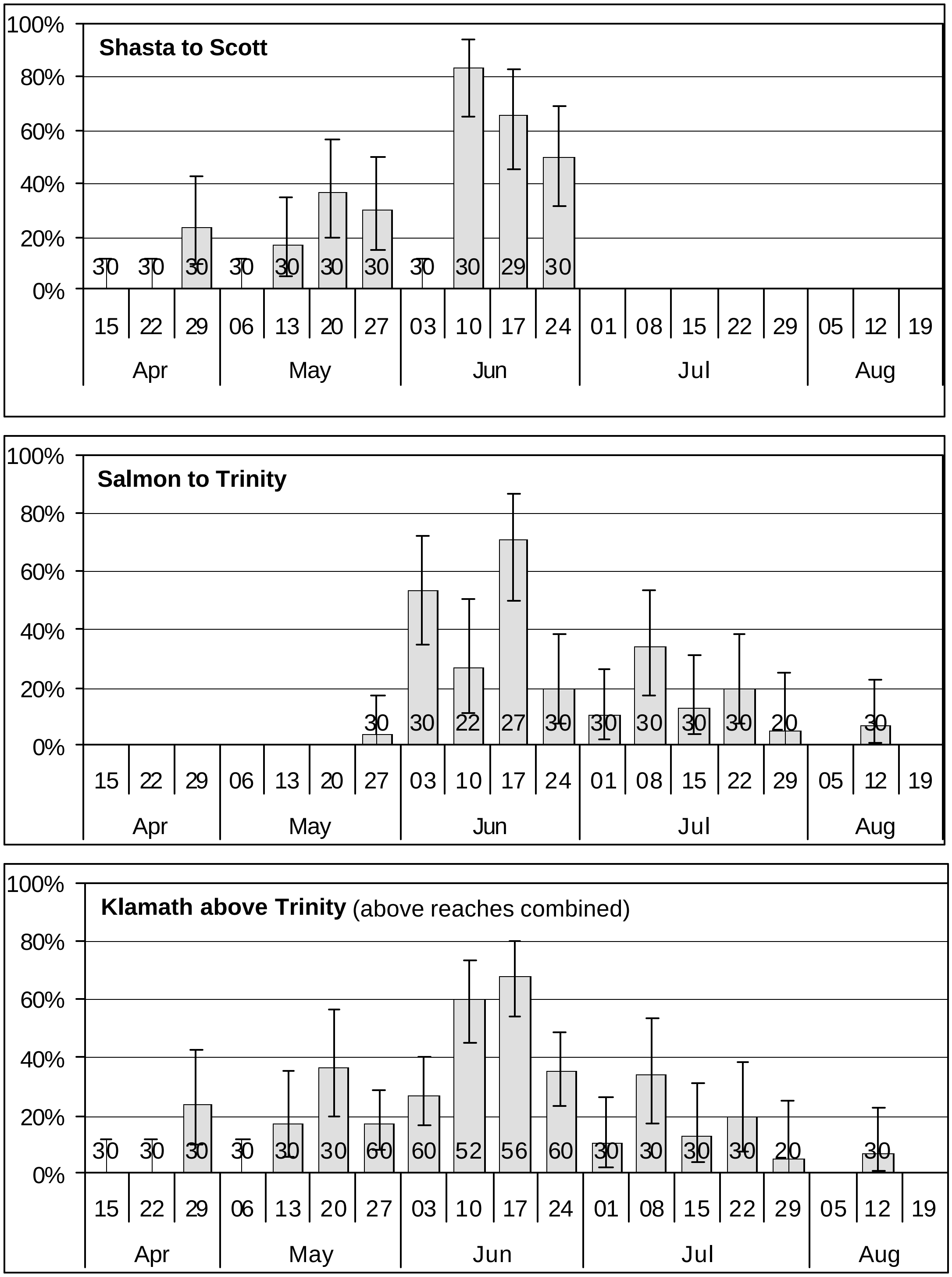

Figure 1. Incidence of *Ceratomyxa shasta* infection assayed by QPCR in juvenile Chinook salmon. Fish were captured in two reaches of the Klamath River above the Trinity River confluence (Shasta R. to Scott R., Salmon R. to Trinity R.) during the spring and summer of 2007. Sample number (n) is listed near the base of each bar. Whiskers indicate 95% confidence interval.

Figure 2. Incidence of *Parvicapsula minibicornis* infection assayed by QPCR in juvenile Chinook salmon. Fish were captured in two reaches of the Klamath River above the Trinity River confluence (Shasta R. to Scott R., Salmon R. to Trinity R.) during the spring and summer of 2007. Sample number (n) is listed near the base of each bar. Whiskers indicate 95% confidence interval.

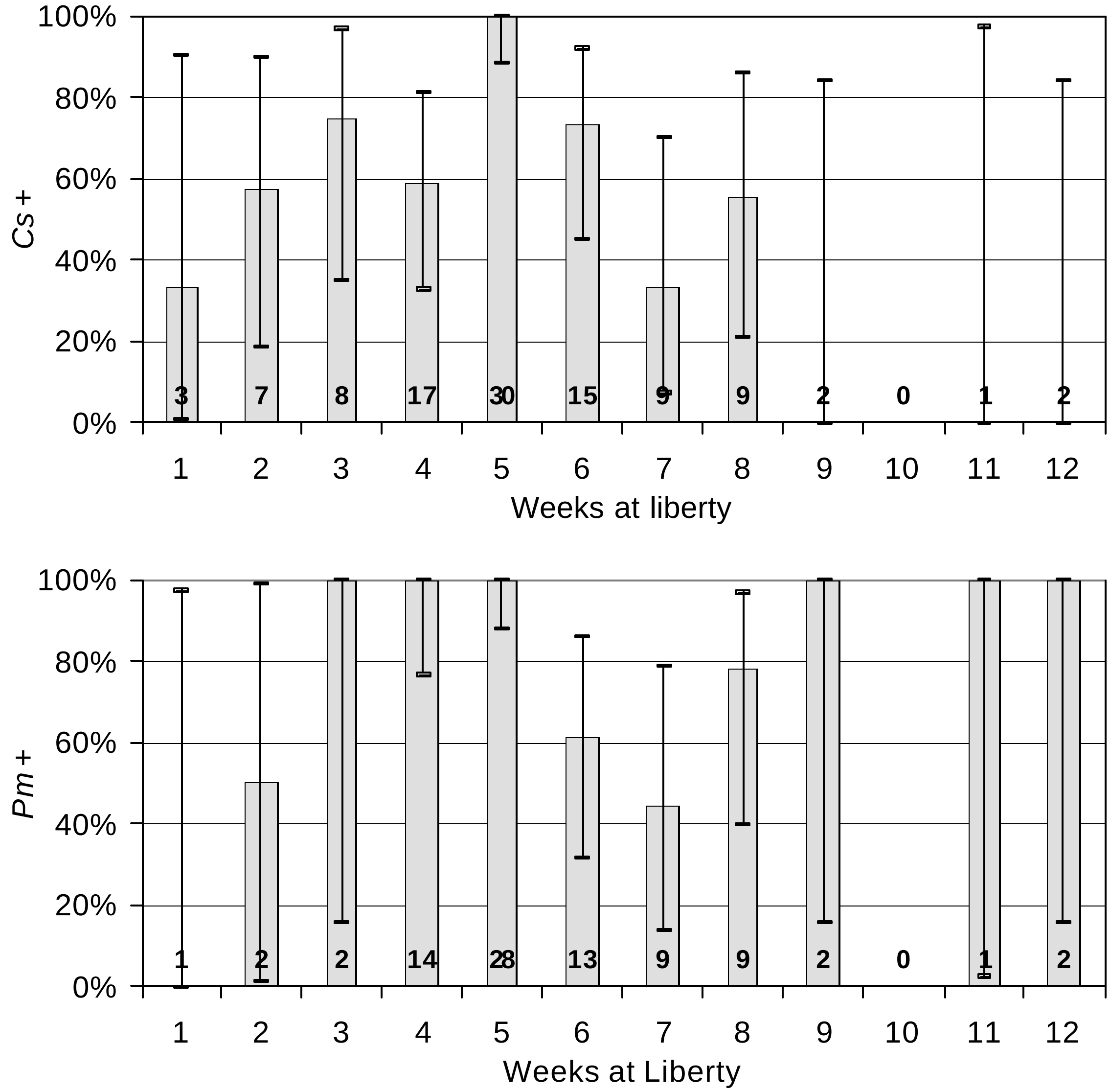

Figure 3. Prevalence of *Ceratomyxa shasta* (*Cs*) and *Parvicapsula minibicornis* (*Pm*) infections in Iron Gate Hatchery origin CWT juvenile Chinook assayed by QPCR. Fish were recaptured in the Klamath River from Iron Gate Dam to the estuary from 1-12 weeks after hatchery release (Weeks at Liberty). Sample number (n) is listed near the base of each bar. Whiskers indicate 95% confidence interval.

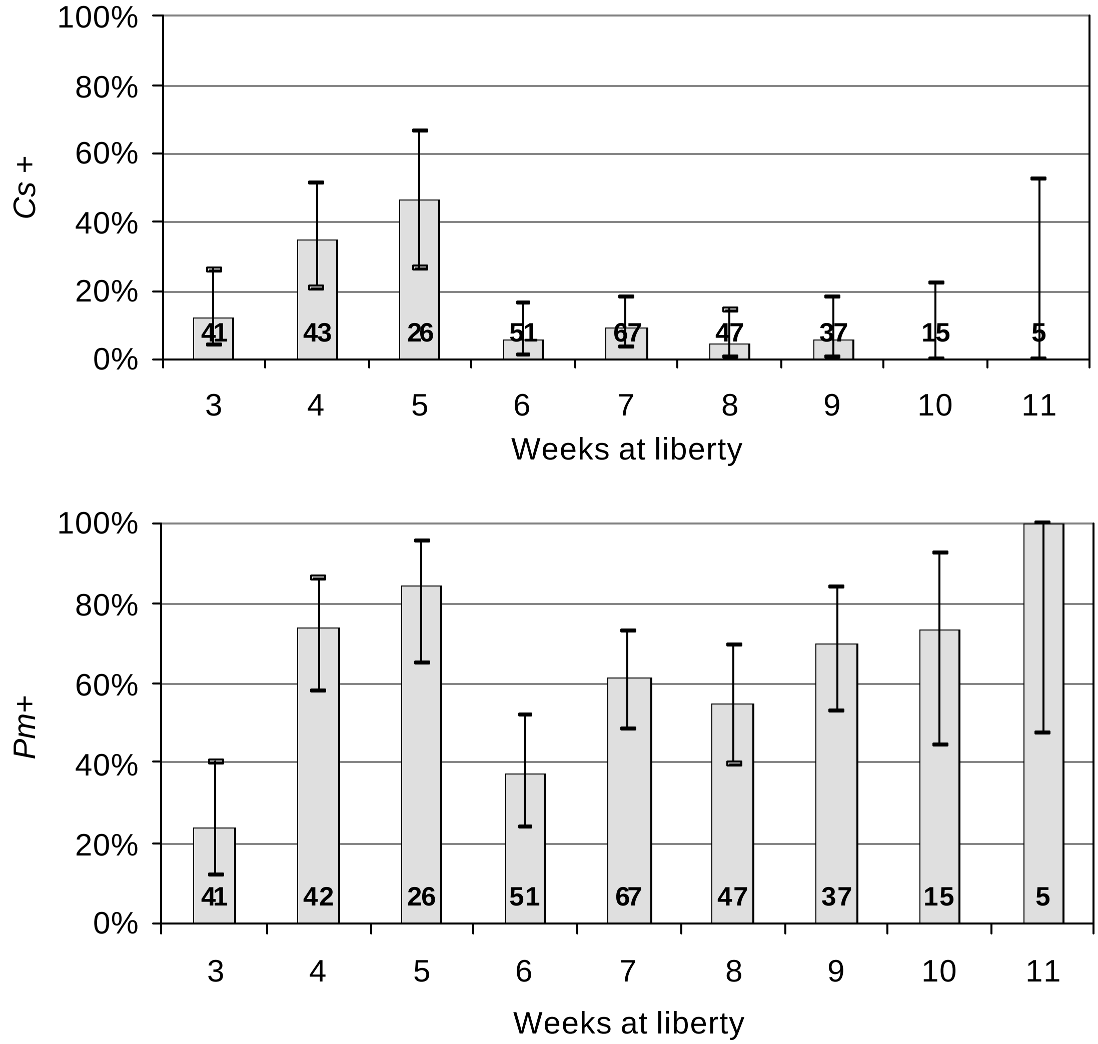

Figure 4. Prevalence of *Ceratomyxa shasta* (*Cs*+) and *Parvicapsula minibicornis* (*Pm*+) infections in Trinity River Hatchery origin CWT juvenile Chinook assayed by QPCR. Fish were recaptured in the Klamath River below the confluence with the Trinity River from 3-11 weeks after hatchery release (Weeks at Liberty). Sample number (n) is listed near the base of each bar. Whiskers indicate 95% confidence interval.

DISCUSSION

Mortality due to infection

The pattern of incidence of both *C. shasta* and *P. minibicornis* indicates moderate mortality in juvenile salmon out-migrating from the Klamath River in 2007. Infection prevalence (particularly *C. shasta*) declined following the peak of infection suggesting a loss of infected fish from the population. It was possible the decline in infection prevalence was due to the influx of uninfected fish from tributaries. However, the loss of infected fish over time was also evident in CWT marked IGH smolts. This similar pattern of infection incidence in known (CWT) and unknown (unmarked) origin fish was most likely due to disease associated mortality in both groups. Past sentinel studies where Chinook salmon were exposed for 72 hours in the Shasta to Scott reach resulted in 82% mortality in less than three weeks at 16ºC, and mean survival time decreased at warmer water temperatures (Udey et al. 1975; Foott et al. 2004).

Prognosis of *Ceratomyxa* and *Parvicapsula* infections

Low survival was expected from fish diagnosed with *C. shasta* infection by histology. No signs of recovery from the *C. shasta* infections were observed in intestines examined by histology during this study (data not shown). This suggests that a significant portion of the infected fish develop debilitating disease before reaching the ocean.

The prognosis of *P. minibicornis* infection in juvenile Chinook salmon is not well understood and is an important question given the high prevalence of infection. We have observed signs of healing and recovery even in severe *P. minibicornis* infections by histology (intact nephrons in clinically infected fish, data not shown). Fish may have recovered if they survived the anemia and osmoregulation problems associated with glomerulonephritis.

The high prevalence of *P. minibicornis* infections results in nearly all *C. shasta* infected fish having dual infections. We speculate that nephron inflammation (due to *P. minibicornis*) and intestinal hemorrhage (due to *C. shasta*) would act synergistically to increase the risk of lethal disease in dual infected fish.

Residence time and infection prevalence

Marked hatchery fish allowed us to relate the residence time in the river to the infection rates for both IGH and TRH origin juvenile Chinook. *Ceratomyxa shasta* was detected in recaptured IGH smolts within the first week following release from the hatchery. Iron Gate Hatchery Chinook were not inspected before release in 2007, so the pre-release infection prevalence was unknown. These early infections may represent infections acquired either in the hatchery or soon after release. The incidence of *C. shasta* infection among IGH smolts peaked within 5 weeks of release. The decline in infection prevalence beginning 6 weeks after hatchery release was likely due to mortality of infected fish. Over half of the IGH smolts sampled were *C. shasta* infected during their 190 mile out-migration. The incidence of *P. minibicornis* infections in IGH smolts jumped to 100% within 3 weeks of hatchery release and remained high through the last IGH smolt recaptures. A similar trend was observed in 2006 and 1995 IGH smolts out-migrants (Nichols and True 2007; Foott et al. 1999). These IGH smolts could be viewed as surrogates for naturally produced tributary smolts (i.e. Bogus Creek, Shasta River, Scott River) out-migrating through the Klamath. The disease risk to parr rearing in the Klamath prior to out-migration was likely higher.

Among TRH smolts, overall incidence of *C. shasta* was low (13%) and *P. minibicornis* was moderate (58%). Infection trends were similar to that seen in IGH smolts with peak infection 5 weeks after hatchery release and a decline in incidence beginning 6 weeks following release. While this may be due to mortality of infected fish as observed in IGH smolts, this decline in incidence may also be due to large numbers of TRH smolts leaving the Trinity and migrating quickly through the Lower Klamath without having time to become infected.

<u>Conclusions</u>

This study indicates *C. shasta* prevalence was below average and *P. minibicornis* prevalence was above average for May-July of 2007 compared to previous Klamath fish health monitoring studies (Nichols and Foot 2006; Nichols et al. 2007; Nichols and True 2007). Naturally produced Chinook became infected with both parasites while rearing in the mainstem Klamath during March and April, but the incidence remained low during this period in 2007. Both parasites were found in naturally produced young of the year coho salmon rearing within the mainstem Klamath, and the incidence of *C. shasta* in young of the year coho appears greater than for Chinook during May. Infection prevalence in coded wire tagged smolts from both hatcheries peaked the 5th week following release and subsequently declined. This was seen as indicative of a loss of infected IGH smolts. With lower incidence of infection for both parasites and the ability to move quickly through the Lower Klamath, Trinity smolts faired better than their Klamath cohorts.

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AUTHOR ROLES

The contributions of each author have been summarized below.

- Ken Nichols – project coordination, study design, data management, histology analysis, assembly and editing of final report
- Kimberly True – QPCR methods, QPCR QA and QPCR data certification
- Ryan Fogerty – necropsy, field collection coordination, histology processing, DNA extraction, preparation and preliminary analysis of results, tables and figures
- Lisa Ratcliff – necropsy, DNA extraction, QPCR assay

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APPENDIX
Paraphrased Reviewer's Comments

Comment: Both parasites were detected in the first week after hatchery release from IGH. Was pathogen screening conducted at IGH or TRH prior to release.
Authors' Reply: No pathogen screening was conducted in either hatchery population prior to release; however, from previous studies and ongoing work conduced in 2008 it is known that hatchery fish can have light infections of both parasites. The text was changed to reflect this possibility.

Comment: Figures 1 and 2 present weekly pathogen incidence above the Trinity confluence. Is there similar data for fish captured below the Trinity?
Authors' Reply: Only CWT Chinook were collected in the Klamath below the Trinity. Above the Trinity both CWT and random unmarked Chinook were collected. Only the random Chinook were included in estimates of parasite incidence.

Comment: Previous sentinel studies were discussed. It should be noted how long fish were exposed so readers can get a sense of how long it takes for fish to become infected with lethal doses of the pathogens.
Authors' Reply: The study referenced in the discussion used a 72 hour exposure period. This has been added to the text.

Comment: Any explanation for the huge difference in *Cs* vs *Pm* infection prevalence in TRH CWT smolts?
Authors' Reply: The prevalence of *Pm* was higher than *Cs* in all groups. This difference may have been larger in the Trinity origin Chinook, but we do not have data to indicate why at this time. No changes were made to the text.

Comments: Any thoughts on why there was such a steep decline in infection prevalence 5 weeks after hatchery release in TRH fish compared to IGH fish?
Authors' Reply: The text was changed to suggest TRH smolts could escape infections if they moved quickly through the Lower Klamath.

Comment: The QPCR assay is semi-quatitative. Why have you chosen to report the incidence of infection but not the severity of the infections by QPCR?
Authors' Reply: The histology assay has been rated using a similar system for the last 4 years and that data was presented to describe the severity of the infection. The methods used in tissue collection and digestion were modified each year to optimize the QPCR assay. More work is needed to identify the levels of infection by QPCR associated with disease and mortality. As the assay is developed we plan to report the levels and prognosis of the infections.

Comment: Was the same histology methodology used in previous years? It would be useful to reference it.

Authors' Reply: Yes, a similar methodology has been used for histology since 2004. The text of the methods section has been changed to reflect this and reference the earlier studies.

Comment: Results report trends at sites, but no discussion of differences or trends across sites was presented.
Authors' Reply: Since the fish were migrating downstream comparisons between sites would essentially be a discussion of trends over time. For trends over time the best data available was CWT marked Chinook since these fish had a common origin and known release date. No changes were made to the text.

Comment: Text refers to the average incidence of infection and references tables 5 and 6. The tables do not support easy interpretation of this.
Authors' reply: The tables have been changed to include a simple average of 2004-2007.

Comment: Are you inferring that the histology fish are useful to examine proportions of the population that are clinical? Should you recognize that fish captured for histology may have been those that are the easiest to capture?
Authors' reply: It was necessary to keep sample collection simple to avoid unnecessary burdens on field crews; the collection of fish for the histology and QPCR assays was performed randomly. Any bias was likely due to our stated capture methods. The capture methods did not change significantly, and any bias would remain throughout the study.

Comment: Using OSU's water sampling results might strengthen the conclusion that infected fish were dying in June resulting in the declining prevalence of infection and clinical disease.
Author's reply: The focus of this report was to describe the data we collected. The OSU spore count data would be interesting to correlate with our disease data. The OSU's data speaks to a specific time and place where the fish became infected. Mortality would follow by several weeks and we do not know where the fish spent that time which would complicate any correlation of the data sets.

ATTACHMENT 17

Letter to FERC from the Pacific Fishery Management Council (PFMC) dated April 24, 2006

This letter is a Secured File that cannot be electronically attached to this Master Document, but will be submitted for the record separately. It is incorporated herein by reference and may also be obtained directly from the Pacific Fishery Management Council's web site at:

http://www.pcouncil.org/habitat/habdocs/FERC_Klamath_M_Salas.pdf

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April 24, 2006

Ms. Magalie R. Salas, Secretary
Federal Energy Regulatory Commission
888 First St., N.E., Room 1A
Washington, DC 20426

RE: Docket Number P-2082 (Pacific Fishery Management Council's Essential Fish Habitat [EFH] Recommendation for the Klamath Hydropower Project)

Dear Ms. Salas:

The Pacific Fishery Management Council (Council) hereby submits its EFH recommendations and formal comments on the relicensing of the PacifiCorp hydroelectric project on the Klamath River. The recommendations are the result of focused deliberation at the Council's March and April meetings, including extensive public testimony and expert advice from scientific and fishery-related advisory bodies. We understand that we may have missed a recent deadline for these comments, but due to the timing of the established public Council process, this is the earliest we are able to provide them. We ask that you give them your full consideration.

For the reasons below, the Council recommends that the Federal Energy Regulatory Commission (FERC) order the decommissioning and removal of Iron Gate, Copco 1, Copco 2, and J.C. Boyle dams on the Klamath River. We ask that you proceed with the development of a decommissioning plan, in consultation with resource agencies, tribes, and other interested parties, that provides full restoration of habitat in and below the project dams and reservoirs. FERC should also consider including mitigation funds to restore future anadromous habitat above the project.

This recommendation is consistent with National Marine Fisheries Service's (NMFS) recommendation pursuant to Section 10(a) of the Federal Power Act (FPA): "The Licensees shall develop and implement a plan to remove the lower four Project dams..., restore the riverine corridor, and bring upstream and downstream fish passage facilities at Keno Dam into compliance with NMFS guidelines and criteria within 10 years of license issuance, expiration, or surrender."[1, 2]

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[1] National Marine Fisheries Service (March 24, 2006). Letter and Attachments from Rodney McInnis to Magalie Salas re: *Comments, Recommended Terms and Conditions and Preliminary Prescriptions for the Klamath Hydroelectric Project, FERC Project 2082*. Page C-4.

[2] We understand that the Keno and Link Dams are not currently being relicensed, and are limiting our recommendations at this time to the four lower dams. However, in the long term, the Council calls upon FERC to improve conditions for anadromous fish in the Klamath River by addressing the operations of Keno and Link Dams.

Background

During the last several years, the Council has written frequently to FERC, the U.S. Bureau of Reclamation, and the U.S. Department of the Interior regarding impacts of Klamath River management on salmon habitat.[3] Although anadromous fish stocks fluctuate naturally, it is now clear that factors associated with hydropower generation, including lack of fish passage and water quality impacts, have had a consistent and increasingly detrimental impact on Klamath River salmon. The Council believes the operations of the full complex of dams in the Klamath River basin can be the limiting factor for anadromous salmonids abundance, and are likely the controlling anthropogenic factor during drought years. Therefore, we believe changes in the effects of these dams offer the greatest opportunity to increase population abundance.

The Council's concerns about dam operations have been heightened in recent years by the low abundance of naturally spawning fall Chinook salmon. As you may know, ocean salmon fisheries on the West Coast target a complex of stocks from various rivers that have consistently produced harvestable surpluses. Under the Council's salmon fishery management plan, fisheries in this ocean complex are managed to achieve the spawning objective of the weakest stock, which has frequently been Klamath River natural fall Chinook. In 2004 and 2005, abundance was so low that the spawning escapement fell below the 35,000 conservation objective in both years. Unfortunately, in 2006 it is expected that the Klamath natural fall Chinook stock abundance will fall even further, to a disastrously low level.

In 2005, fishing off most of Oregon and California was virtually halved to meet the Klamath River fall Chinook natural spawning objective. This year, ocean salmon fishing in this area will be cut back a further 75% to protect these fish. The inriver recreational fishery on adult fall Chinook will be closed in 2006. Inriver tribal fisheries will also be severely affected. The cutbacks and closures adopted by the Council to protect these Klamath River fish will have enormous economic and social impacts on West Coast fishing communities. The effects are so severe that the Governors of the States of Oregon and California have formally called for the Secretary of Commerce to declare a fishery disaster, as provided for under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) §312(a).

Basis for Council Recommendation

There is both a legal basis for the Council's recommendation and a strong rationale to justify it. Legal standing for the Council's recommendation is provided by the MSA. Under §305(b)(3)(B), the Council is obligated to comment on activities that are likely to substantially affect EFH for salmon.[4] In turn, the Federal government is obligated to consider the Council's recommendations and to reply

[3] December 15, 2005, to U.S. Bureau of Reclamation (BOR) on management of Klamath water flows; April 21, 2005 to U.S. Department of the Interior (DOI) on flow management and essential fish habitat (EFH) in the Klamath basin; April 23, 2004 to FERC on EFH concerns related to PacifiCorp Klamath River Hydroelectric Project FERC-2082; July 7, 2003 to BOR on EFH concerns related to the Klamath project; April 23, 2003 letter to the DOI related to water flows in the 2003 Klamath operations plan; April 22, 2003 to FERC on relicensing rules; December 4, 2002 to the DOI and Secretary of Commerce on the adverse impacts of reduced flows to Klamath salmonids; May 13, 2002 to FERC on EFH conservation responsibilities; April 22, 1999 to BOR on the Klamath project environmental impact statement. Letters available at http://www.pcouncil.org/habitat/habdocs.html.

[4] "[Each Council] shall comment on and make recommendations to the Secretary and any Federal or State agency concerning any such activity that, in the view of the Council, is likely to substantially affect the habitat, including essential fish habitat, of an anadromous fishery resource under its authority." MSA§305(b)(3)(B)

in writing within 30 days.[5] The rationale for the Council's recommendation includes the Council letters and background considerations referred to above and the information provided below.

We understand that the Klamath hydropower project is now operating under an annual license, and that any new long-term license may be in effect for up to 50 years. The Council does not make recommendations for interim annual licenses in this letter, though we believe that until a long-term license is granted, FERC should protect and fully mitigate damages to anadromous salmonids and their habitat with the dams in place. Some recommendations from others, such as those provided by NMFS and U.S. Fish and Wildlife Service pursuant to Section 10(j) of the Federal Power Act for interim modifications to hatchery management and ramping rates, may be appropriate. However, the Council will address recommendations for interim licenses in a separate letter following further public process and discussion.

The Council's recommendation for dam removal is made with the recognization that several factors beyond FERC's jurisdiction can harm Klamath River anadromous stocks.[6] Water withdrawal practices reduce water availability downstream, and timber harvest practices, road building, parasites, and other factors impact stocks. We further recognize that some recommend fish passage at the project dams instead of their removal.

The Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program clearly identifies the lack of passage through and beyond the project area as a significant limitation on the Klamath River anadromous fish resource[7]. Under the current license, the lower three project dams (Iron Gate, Copco 1 and Copco 2) are not equipped with fish passage facilities, and the facilities at J.C. Boyle Dam do not conform to accepted passage criteria. PacifiCorp's proposed license under FERC does not provide passage for anadromous fish.

Lack of fish passage at the Klamath Project facilities blocks access to more than 400 miles of migration, spawning, and rearing habitat for salmon, steelhead and Pacific lamprey, including access to channel areas inundated by the project, access to tributary habitat within the project area, and access to currently-blocked habitat in the upper watershed[8]. The habitat within and above the project area was historically an important producer of spring Chinook, fall Chinook and coho. Reintroducing anadromous fish above the current barrier of Iron Gate Dam is a key component of Klamath River Basin restoration. We understand significant resources are now being directed toward improving potential habitat in the Upper Klamath Basin above Upper Klamath Lake.

Even with fish passage at each of the projects, the following dam-related problems within and below the project area would remain unaddressed:

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[5] "Within 30 days after receiving a recommendation under subparagraph (A), a Federal agency shall provide a detailed response in writing to any Council commenting under paragraph (3) and the Secretary regarding the matter. The response shall include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on such habitat..." MSA§305(b)(4)(B)

[6] National Research Council (2004). *Endangered and Threatened Fishes in the Klamath River Basin – Causes of Decline and Strategies for Recovery.* Washington, D.C.: U.S. Department of Interior and U.S. Department of Commerce.

[7] Klamath River Basin Fisheries Task Force and William M. Kier Associates, 1991. *Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program.*

[8] We recognize that Keno dam, upstream of the project area, now blocks most upper watershed habitat for anadromous salmonids.

- Loss of spawning and rearing area in the Klamath River between Iron Gate and J.C. Boyle dams
- Effects of hydroelectric peaking operations, including reduced flows in bypassed reaches; effects of large flow fluctuations in peaking reaches; reduced abundance of macroinvertebrates; restricted fish movement; decreased water quality; and fish stranding
- Impacts of water impoundment, including changes to water temperature, dissolved oxygen, and nutrient loads; gravel depletion; altered flood flows; and enhanced conditions for toxic algae blooms and parasitic disease vectors
- Alteration of the natural hydrologic regime, including loss of thermal refugia and ecosystem function

In summary, the Council believes removal of the dams is a necessary step in recovering currently unsuitable habitat in the project reach, in providing access to suitable habitat upstream of the project, and in normalizing water conditions below Iron Gate Dam.

Costs and Benefits

The value of ocean fisheries is high when Klamath natural Chinook are abundant, but can be much lower when Klamath fish constrain the catch of other healthy stocks. The Council estimates that between 1970 and 2004, the average annual personal income impacts of the recreational and commercial ocean salmon fishery in the area where Klamath fish are found amounted to $92 million. The constraints on the fishery in 2006 caused by the need to protect Klamath River natural fall Chinook are expected to reduce the value of this fishery to less than $33 million. In contrast, the Klamath hydropower project produces 163 megawatts with an annual net economic value of $16.3 million.[9] NMFS notes that the "generating capacity provided through continued Project operations is nominal...relative to the watershed level of benefits to aquatic resources and regional and national priorities for restoring anadromous salmonids."[10] The California Energy Commission reviewed the effects of full or partial decommissioning and concluded that "because of the small capacity of Klamath hydro units... removal of these units will not have a significant reliability impact on a larger regional scale."[11]

Providing fish passage would be a major endeavor, with cost estimates ranging up to $200 million.[12] The cost of dam removal has been estimated at $35.8 million.[13] Based on these estimates, it is not clear that providing fish passage is a superior economic alternative to dam removal.

It may not be appropriate to directly compare the loss of $59 million in the ocean salmon fishery in one year, due to the low abundance of Klamath River Chinook, with the $16.3 million in power generated annually at the four project dams and the $35.8 million cost of dam removal. However, it may well be that the annual value of the portion of the fishery affected by Klamath River Chinook compares favorably to the annual value of the electrical power. It may also compare favorably with the cost of dam removal, given the number of years that fishery benefits will accrue after the dams

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[9] California Energy Commission (2004). California Energy Commission Staff Comments on PacifCorp's Final License Application to the FERC for the Klamath Hydroelectric Project, FERC No. 82.
[10] National Marine Fisheries Service (March 24, 2006), op. cit.
[11] California Energy Commission, op. cit.
[12] PacifiCorp spokesman Dave Kvamme in "A Good Week for Klamath Salmon." *Sacramento Bee*, March 30, 2006, page A3.
[13] G&G Associates (2003). *Klamath River Dam Removal Investigation*. Seattle, Washington: G & G Associates.

are removed. Further, it must be noted that a comprehensive economic analysis of the benefits of dam removal needs to include the benefits of habitat improvement to all Klamath River fish populations, not merely one stock (naturally spawning fall Chinook) in one fishery (the ocean salmon fishery).

Conclusion

The Council believes the proposed relicensing of this project will have substantial adverse impacts on EFH in the Klamath River. The project causes harm to salmon habitat; to the health of fish stocks; to commercial, recreational, and tribal fisheries; and to fishing communities along the Oregon and California coasts and in the Klamath River basin. Consequently, the Council recommends that FERC order the immediate decommissioning and removal of the four lower Klamath River dam structures and full restoration of habitat affected by the dams and reservoirs.

Sincerely,

Donald O. McIsaac
Executive Director

JDG:rdd

c: Council Members
Habitat Committee
FERC Required Service List Distribution
Salmon Advisory Subpanel
Salmon Technical Team
Scientific and Statistical Committee
Dr. Donald McIsaac
Dr. John Coon
Council Staff Officers
Ms. Eileen Cooney
Ms. Jane Hannuksela
Ms. Mariam McCall
Mr. Judson Feder
Ms. Corinne Pinkerton
Mr. Phil Dietrich