Karuk Tribe Fishery Socioeconomics Technical Report

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

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Abbreviations and Acronyms

CDFG	California Department of Fish and Game
DRA	Dam Removal Alternative
EDRRA Model	Evaluation of Dam Removal and Restoration of Anadromy Model
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
IGD	Iron Gate Dam
KBRA	Klamath Basin Restoration Agreement
KRFC	Klamath River Fall Chinook
NAA	No Action Alternative
NMFS	National Marine Fisheries Service
PFMC	Pacific Fishery Management Council
SONCC Coho	Southern Oregon Northern California Coast Coho
TMDL	Total Maximum Daily Load
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service

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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 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. This report analyzes the effects of three alternatives that will be considered by the Secretary as they pertain to fishing opportunities for the Karuk Tribe:

- 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 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. 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 discusses the Karuk Tribe's historical reliance on fish and tribal cultural and social practices associated with fish. Section III focuses on changes in fisheries and related practices that have occurred since the historical period. Section IV evaluates the effects of the no action and action alternatives on Karuk fisheries and associated cultural and social practices. Section V summarizes results and conclusions of the previous sections, and Section VI provides a list of references cited in the report. Appendix A discusses the biological assumptions that underlie the analysis of tribal fishery effects.

II. Historical and Cultural Context
II.A. Fish

For the Karuk Tribe, the seasonal round of fishing historically included two runs of Chinook (spring and fall), two runs of lamprey (arriving in Karuk territory in April and June), three runs of steelhead, coho, sturgeon (which migrated up to Ishi Pishi Falls), trout (available year round), mussels, and crayfish (Karuk Tribe, undated, pp 6-7).

Karuk tribal members used a variety of fishing methods adapted to particular species and locations. Fish were harvested from platforms using large dip nets. Large basket traps with the

open end placed downstream were used to capture salmon and steelhead; smaller traps were used for suckers and trout. Harpoons were sometimes used, e.g., for salmon and steelhead in streams too small to allow netting (Karuk Tribe, undated, pp 11-12). Pacific lamprey were harvested with baskets (which attract lamprey by creating eddies in the water), dipnets (when the water is muddy or lamprey are close to shore), and gaffs and manual extraction (for lamprey climbing over rocks) (Lewis 2009, pp 11-13).

The Karuk built weirs at six locations "with only one weir being constructed per year, an indication of the labor-intensive nature of the undertaking" (Karuk Tribe, undated, p 9). "Karuk weirs took two weeks to construct, including preparation of the poles and logs. Once in place, the weir was left until removed by high water. Weirs offered the advantage of allowing a winter's supply of salmon to be caught for many families" (Karuk Tribe, undated, p 11).

The weir was operated in such a way as to allow adequate spawning escapement and sharing of the harvest with upstream fishermen:

- "Fishermen would block the weir then dip salmon which were nosing up against the weir. When enough fish had been taken in a day the weir would be opened to allow fish to go up stream to spawn" (Norman Goodwin as cited in Karuk Tribe, undated, p 70).

- "…we make sure that plenty of salmon have passed through to the spawning grounds. That's why we don't fish until the salmon have gotten through to Inam, so you would have fish for the next year" (Karuk Tribe, undated, p 13).

The best fishing spots were privately owned by single individuals or groups of individuals. The right to fish at those sites was subject to common rules and understandings regarding use and sharing of sites.

- "An owner might give someone else permission to fish there on the day or days when his turn would normally come. But no one was permitted to fish or to establish a new fishing place immediately downstream from a recognized fishing place….most inferior fishing places, and a few excellent ones were not privately owned but were open or public" (Kroeber and Barrett 1960: 3 as cited by Karuk Tribe, undated, p 5).

- "…ownership related strictly to the right to fish….The owner of rights at a particular fishery might sell all those rights in all or in part; might give away surplus fish and might allow others to fish at the site of his ownership. The concept of rights was not restricted to fishing sites but extended as well to acorn-gathering and hunting rights specific to certain areas" (Karuk Tribe, undated, p 6).

II.C. Associated Cultural and Social Effects

The Karuk Tribe actively engages in rituals that foster stewardship of fish and the river ecosystem:

- "The Karuk are known among Indian tribes of the western United States as the 'Fix-the-World People'. This term is derived from the annual Piky'avish Ceremonies, commonly

referred to as the World Renewal Ceremonies. This sequence of ceremonies is shared by the Karuk with the downriver Yurok and Hupa Tribes. The timing of the Piky'avish was related to the fall salmon run and at the time approaching the acorn harvest" (Karuk Tribe, undated, p 17).

- "In one aspect, the ceremonies, as with other aspects of traditional perspective, are reenactments of acts of the ikxar'eeyavsa or immortal ones. In another sense these ceremonies go beyond symbolic reenactments and are themselves metaphors for close and careful husbanding of resources, of hard work, of making your own luck in the tradition of Karuk individualism, and of the seasonal lack of resources available to the people, even with the most careful of ritual observations" (Karuk Tribe, undated, p 17).

- "The conjunction of ritual, spiritual and technical elements for the management of sustained vigorous ecosystems resulted in a system of land management and cultural perspectives among the Karuk and the neighboring tribes which not only were not destructive of the natural systems within which they lived, but which in fact served consciously to enhance and enrich the diversity of these systems" (Karuk Tribe, undated, p 5).

- "Spring Chinook salmon are the subjects of the First Salmon Ceremony, performed in coordination between the Yurok and Karuk. This fish, whose importance has raised it to the totemic level, historically spawned as far north as the Williamson River. This portion of the drainage was available as spawning grounds prior to the damming of the Klamath River and the reconstruction of Klamath Lake in its present form. This First Salmon Ceremony was conducted around April when the fish first breeched the sandbar at the mouth of the Klamath, marking their transition from the Pacific Ocean back to the fresh water of the Klamath River. As these 'springers' make their way up river, the Karuk mark their arrival at Amekiarum, below the mouth of the Salmon River" (Karuk Tribe, undated, p 7).

Fishing also involved social responsibilities that (like the ceremonies) enhanced the significance of the activity:

- "In the past, when the native fishery at Ishi Pishi Falls was thriving, Karuk people would come together for the fish and associated ceremonies. Families would see each other, children would see their friends for the first time since the previous year's ceremonies. People came from out of the area, stories are shared when people were gathered at the ceremonies, so there is an intergenerational aspect of what happens when there are fish in the river" (Karuk Tribe, undated, p 23).

- "Even 50 years ago, participants have memories of catching 3,000-5,000 lampreys in one night during a peak run….As the fishers in their village, it was important for the eelers to give away most of their harvest to other community members, especially elders. With a catch of 3,000 during one night, an eeler would only come home with 100-150 lampreys because they had given the rest away" (Lewis 2009, p 20).

Fishing has an important connection to activities such as trade and barter. Like fishing, trade and barter has significance beyond the goods and services that are traded.

- "Trading networks not only allowed tribes to obtain resources which were relatively scarce in their own territory, but also developed alliances and solidarity between tribes" (Karuk Tribes, p 16).

- "Trading sites in neutral territory allowed for regular and peaceful trading between the different tribes. Trading also furthered development of complex societies made up of richer and poorer families and individuals. Food was an important object of trade and tribes including the Karuk traded the plant and animal foods of their territory with coastal tribes for fish and objectives such as Redwood canoes" (Karuk Tribes, undated, p 16).

III. Recent History
III.A. General Conditions

The Karuk Tribe has been federally recognized since 1979. Unlike the Yurok and Hoopa Valley tribes, the Karuk Tribe has never had a reservation (Karuk Tribes, undated, p 5). The Karuk Tribe currently owns 652 acres in trust status, and maintains offices in Orleans (Humboldt County) and Happy Camp and Yreka (Siskiyou County). Tribal enrollment was 3,427 in 2005. The unemployment rate (defined as the percentage of adults who are available for work but unemployed, regardless of whether or not they have recently looked for work) was 63 percent in 2005 (BIA 2005). Per capita income of Indians residing on the Karuk Reservation and off-Reservation trust lands and Indians residing in Siskiyou County (including but not limited to Karuk tribal members) in 1999 was $4,938 and $8,305 respectively – both lower than per capita income of the general population of Siskiyou County ($17,570). The percent of the population below the poverty level follows a similar pattern: 54 percent of Indians on the Karuk Reservation and off-Reservation trust lands, 32 percent of Indians in Siskiyou County, and 19 percent of the general Klamath County population (U.S. Census 2000).

III.B. Fish

The Karuk Tribe does not have federally recognized fishing rights. However, the California Fish and Game Commission allows tribal members listed on the current Karuk Tribal Roll to fish with traditional hand-held dip nets at their indigenous fishing site at Ishi Pishi Falls. Karuk tribal harvest is bound by California sport fishing regulations, including bag and possession limits (CDFG 2010, p 8).

While fish have been central to the daily life and culture of the Karuk Tribe, access to fish has declined from historical levels due to reductions in abundance and distribution and loss of access to traditional fishing sites. Karuk tribal members describe these changes as follows:

- The seasonal round at Ishi Pishi is much diminished and consists mostly of fall Chinook, available in modest numbers and for a very limited period (September only rather than the spring/summer/fall fishery that it had been historically). With regard to lamprey: "You're lucky if you can detect when the run is anymore, let alone when the peak is" (Leif Hillman as cited in Karuk Tribe, undated, p 78).

- "The Karuk used to fish with spears on creeks, but now the runs are down to a level where this is not feasible as spear fishing requires a lot of fish" (Norman Goodwin as cited in Karuk Tribe, undated, p 70).

- Salmon take longer coming up the river and arrive in poor condition: "…by the time they got to the falls they were at the point they normally look when they hit the dam. They were that sad. They were black, and they were faded out. They were fighting the heat of the water. They were going from creek to creek, staying where the water was cooler, but they were traveling. They were in sad shape. The meat was almost white when it should have been red" (Earl Aubrey as cited in Karuk Tribe, undated, p 68)

- "When I went down to the river in '51, the eels in springtime, you'd see them along the river bar below Rubens, all along they'd be floating down the river. On both sides, eels just floating (dead). In the sixties they would be caught in eddies and there would be thousands and thousands of dead eels floating in the eddies at Peckwan. By the 70's you didn't see them anymore (Mavis McCovey as cited in Karuk Tribe, undated, p 86).

- Lewis (2009, p 17) citing a Karuk eeler: "Even though they are from the same tribe, everyone has different eeling spots….There used to be family rights by clans….You don't see that anymore, there aren't enough fish to let that happen."

- "Participants remember that in the 1980s, an eeler was lucky to catch 50-100 lampreys, which was considered a lot. By the 1990s, they were lucky to harvest any….Eeling has become a form of recreation rather than a means of subsistence" (Lewis 2009, p 20).

III.C. Associated Cultural and Social Effects

The loss of fishing opportunities has affected the dietary habits and well-being of Karuk tribal members – as well as their cultural, ritualistic and social lives.

- The First Salmon Ceremony has not been practiced for many decades: "The culturally significant spring salmon ceremonies cannot be held if there are no spring salmon" (Karuk Tribe, undated, p 19).

- Quantities of fish harvested are not sufficient to meet subsistence needs, engage in trade and barter, or provide adequately for tribal elders.

- "The consequence of the decline in salmon as a resource has been a decline in activities and ceremonies relating to the salmon, including the decline in the spoken Karuk language" (Karuk Tribe, undated, p 19).

- "There is a loss of a sense of pride in being able to be a food provider as a salmon fisherman, and this pertains to other species as well. There is a sense of pride in having an identity and a role and doing what you were put here to do by the Creator, versus what happens to people's psychology and emotional and mental health when they are unable to fulfill that role. There is a huge mental health component to being able to provide, versus when you are not able to

provide. There is a shame of not having a space to fit into, especially for young people" (Karuk Tribe, undated, p 23).

- "While there are the cultural practices which are impacted, there are also social roles within families, where children and elders interact across families through barter and the provision of food to people outside the family. There are the health aspects of eating the fish, including the exercise of getting fish. There are significant psychological and mental health aspects to the presence of a healthy fishery. In the subsistence economy of the Karuk, food from the river is not just food, but it is healthy food" (Karuk Tribe, undated, p 25).

- "Today the assimilation of Native people to American mainstream lifestyles and food habits is being accelerated by an absence of traditional food (Olson 2001). The dramatic decline in eel and salmonid populations that once supplied over half the Karuk diet has occurred within the lifetime of most adults alive today" (Norgaard 2005, pp 21-22).

Water quality on the river is impaired relative to historical levels. This impairment affects not only fish populations but also the quantity and quality of resources (e.g., roots, plants) that are used for basket making and medicinal plants. Karuk tribal members are also concerned about water quality in terms of contact with the river. Basket makers wade in the river to collect basket materials such as willows and cottonwood, wash the materials in the river, and strip the willows with their teeth. Medicinal plants are often washed in the river and some water is consumed along with the plants. Also, the Piky'avish ceremonies (which require some participants to ritually immerse themselves in the river) extend into the summer months, when water quality is at its worst (Karuk Tribe undated, Gates and Novell 2011).

Despite these challenges, Karuk tribal members have been persistent in ensuring continuation of ceremonies, practices and values that have been a part of their world view for many centuries. As part of their stewardship responsibilities, the Karuk Tribe's Natural Resources Department engages in data collection, research and management pertaining to fish and wildlife, water quality, and habitat.

IV.Effects of Alternatives
IV.A. Alternative 1 – No Action
IV.A.1. Fish

Little change in harvest opportunity is expected under the no action alternative:

- Chinook: "Under conditions with dams, commercial and in-river harvest would continue as restrictions and quotas (met before escapement) allow as has occurred in the past" (p 4 of "Questions for Expert Panel on Chinook Salmon in the Klamath Basin" – Goodman *et al*. 2011).

- SONCC coho ESU: The Southern Oregon Northern California Coast (SONCC) coho Evolutionarily Significant Unit (ESU)[1] was listed as 'threatened' under the Endangered

[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).

Species Act (ESA) in 1997. Based on the viability criteria specified by Williams *et al.* (2008), the SONC coho ESU is not likely to be de-listed under current conditions (see Appendix A.1).

- Steelhead: "Current Conditions will not, in the short to medium term, result in an expansion of the [steelhead] fishery. Projecting harvest under the Current Conditions depends on the fate of the hatcheries and specifics of harvest policies into the future, which are insufficiently defined at this time" (Dunne *et al*. 2011, p 58) (see Appendix A.3.a).

- Pacific lamprey: "In the absence of dam removal, the habitat conditions described previously [for Pacific lamprey] will persist with only subtle changes due to foreseeable hydrological changes" (Close *et al*. 2011, p 23) (see Appendix A.4).

IV.A.2. Associated Cultural and Social Effects

Water quality improvement plans (known as Total Maximum Daily Loads or TMDLs) are in effect for various water bodies of the Klamath Basin. Water quality conditions that affect tribal cultural practices would continue to be impaired until such time as beneficial effects of the TMDLs are felt. Such beneficial effects are subject to considerable uncertainty and would not be fully realized for a number of decades (Water Quality Sub Team 2011). Consistent with the lack of change in harvest opportunities expected under the no action alternative, little change in associated cultural and social practices (as described in Section III.B and III.C) is likely to occur under this alternative.

IV.B. Alternative 2 – Full Facilities Removal of Four Dams

IV.B.1. Fish

Sedimentation and water quality changes associated with dam removal may have adverse short term effects on fish stocks that inhabit areas below the dams. However, these effects are generally expected to be short-lived:

- Chinook salmon: "Dam removal does not have a substantial multi-year adverse impact on mainstem Chinook salmon" (Goodman *et al*. 2011, p ii) (see Appendix A.2.d).

- SONCC coho ESU and steelhead: "The short-term effects of the sediment release will be sediment concentrations in the range of 1,000 to more than 10,000 milligrams per liter (mg/L), which will be injurious to upstream migrants of both species [coho and steelhead], and especially to any adult steelhead or 'half pounders' that hold or spawn in the mainstem. 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) (see Appendices A.1. and A.3.a).

- Pacific lamprey: "Because they live burrowed in the soft sediments, there will likely be minimal increases in larval mortality rates of existing Pacific lamprey larvae in the mainstem Klamath River after dam removal. The larvae will likely relocate or adjust their burrow tubes to maximize feeding and respiration" (Close et al. 2010, p 33) (see Appendix A.4).

Over the longer term, dam removal and successful implementation of the KBRA are expected to increase harvest opportunities for the Karuk Tribe (for species other than coho). These effects can be summarized as follows:

- Chinook: The Evaluation of Dam Removal and Restoration of Anadromy (EDRRA) model projects a 50 percent increase in tribal harvest under the action alternative; this increase is relative to the current allocation of Klamath fall Chinook received by the Yurok and Hoopa Valley tribes (Appendix A.2.a).). What this means for each individual tribe in the Basin is not clear. For members of tribes with federally recognized fishing rights, expanded harvest opportunity will likely take the form of additional subsistence and/or commercial fishing. Members of tribes without such rights are still able to fish recreationally and thus receive some (albeit smaller) benefit. Such harvest opportunities are much more likely to be realized on the Klamath River (rather than the Trinity), since the restoration associated with the action alternatives would occur on the Klamath. Thus Chinook availability is assumed to increase for each tribe residing on the Klamath River relative to what that tribe currently harvests.

  Fall run Chinook (which include hatchery as well as wild fish) is currently a much larger component of tribal harvest than spring Chinook, which is at low levels of abundance. A modest harvestable surplus of spring Chinook may become available under the action alternatives. This harvest opportunity would largely accrue to inriver (including tribal) fisheries, as the season structure of ocean fisheries does not provide much opportunity to harvest spring Chinook before they return to the river. Spring-run Chinook salmon are highly desirable for their fat content and have the potential to expand inriver harvest opportunities beyond the current season (see Appendix A-2).

- SONCC coho ESU: The SONCC coho ESU is listed as 'threatened' under the Endangered Species Act (ESA). This ESU is comprised of coho populations both inside and outside the Klamath Basin. The action alternatives are expected to lead to an increase in the viability of Klamath River coho populations and advance the recovery of the ESU. However, since these 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 (see Appendix A.1).

- Steelhead: Steelhead is expected to increase in abundance and extend its distribution to areas currently under the reservoirs and upstream to Keno Dam; expansion upstream of Keno Dam is promising but less certain (see Appendix A.3).

- Pacific lamprey: Pacific lamprey harvest potential below Keno Dam is expected to increase from one to ten percent over the long term due to habitat improvement and recolonization of the reach between Iron Gate Dam and Keno Dam. Harvest potential above Keno Dam is possible but less certain (see Appendix A.4).

IV.B.2. Associated Cultural and Social Effects

Fish population effects will provide greater opportunities for the Karuk Tribe to engage in subsistence fishing and associated cultural practices (e.g., sharing fish with elders, transmitting values to the next generation, trade and barter). Spring Chinook is of particular importance, as it could lead to revival of the traditional First Salmon Ceremony in the spring. Also, spring Chinook are highly desirable for their fat content and would provide quality benefits to the subsistence fishery and lengthen the duration of the seasonal round for salmon. Poverty and rural isolation have constrained the ability of tribal members to replace fish with healthy food alternatives. Improved fishing opportunities would increase opportunities for healthy food consumption.

Dam removal and KBRA are expected to expedite water quality improvements (TMDLs) being undertaken on the Klamath River under the no action alternative (Water Quality Sub Team 2011). In addition to fish population benefits, these changes are expected to enhance other Karuk practices such as basket making and use of medicinal plants, and to reduce tribal concerns pertaining to ritualistic immersion in river waters. Perhaps most importantly, the overall changes in water and fish populations would be emblematic of a better functioning river ecosystem, which is consistent with the Karuk view that stewardship pertains to the entire ecosystem.

The KBRA provides the Karuk Tribe with funding for fishery and habitat management and restoration, administration of fishery programs, and long-term economic revitalization (KBRA 2010, Part VII, p 170). These provisions would enhance economic self-sufficiency and self-determination and allow the Karuk Tribe to more fully engage in fishery and habitat management.

IV.C. 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. Thus the effects of this alternative on harvest opportunities for the Karuk Tribe are expected to be the same as Alternative 2.

V. Summary and Conclusions

For the Karuk Tribe, the action alternatives are expected to result in increased harvest opportunities, expand engagement in resource monitoring and management, enhance cultural values and practices, generate jobs and income, and provide greater opportunity for healthy food consumption (Table V-1).

Table V-1. Effects of the no action and action alternatives on the Karuk Tribe.		
Indicator	*No Action*	*Change from No Action*
Harvest opportunities		
• Chinook	Very low abundance of spring Chinook, moderate abundance of fall Chinook	Potential adverse short-term effect due to sedimentation associated with dam removal. Some increase in spring and fall Chinook after dam removal. Spring Chinook particularly valued for high fat content and potential to extend salmon season.
• Coho	ESA-listed	Improved viability of Klamath Basin coho but no change in listing status
• Steelhead	Stable/declining abundance	Potential adverse short-term effect due to sedimentation associated with dam removal. Increased abundance and distribution after dam removal.
• Pacific lamprey	Very low abundance	One to ten percent increase in harvest potential
• Sturgeon	Very low abundance	Limited documentation of potential effects
• Eulachon	ESA-listed	Limited documentation of potential effects
Engagement in resource monitoring and management	Active engagement in data collection, research and management pertaining to fish and wildlife, water quality, and habitat.	Engagement would be expanded and supported by new funding for fisheries and conservation management (KBRA section 32.2),
Cultural practices	No First Salmon Ceremony as traditionally practiced in the spring. Participation in Piky'avish ceremonies (including ritual immersion of ceremonialists and daily feasting) and other cultural practices (e.g., basket weaving, medicinal plants) impaired by limited fish abundance and poor water quality. Limited fishing opportunities impair ability to practice and	Return of spring Chinook would allow for revival of traditional First Salmon Ceremony in the spring. Increase in fish populations and expedited water quality improvements would enhance opportunities to engage in traditional harvesting, ceremonial and cultural practices and transmit those practices to younger generation.

	transmit traditional harvest methods and values (sharing fish with elders) to younger generation.	
Employment, income, standard of living	Employment provided by Karuk Tribe's Natural Resources Department.	Increased employment and income opportunities associated with funding for fisheries and conservation management and economic development study (KBRA Sections 32.2, 33.1, 33.2). Increased subsistence fishing opportunities would improve standard of living, expand opportunities for trade and barter, and enhance food security for tribal members (particularly important for elders).
Health	Subsistence fishing opportunities very limited in terms of quantity and length of season. Poverty and rural isolation constrain ability to replace fish with healthy food alternatives.	Greater opportunity for healthy food consumption associated with enhanced subsistence fishing opportunities.

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Appendix A – Biological Assumptions

This Appendix discusses the effects of the no action and action alternatives on a number of species historically and/or currently harvested by the Karuk Tribe: SONCC coho, Klamath River fall and spring Chinook, steelhead , and Pacific lamprey. A number of expert panels were convened to evaluate these effects. The conclusions of those panels, as well as advice from the Biological Subgroup (a team of federal biologists) and results of several biological models, were used to inform this evaluation.

A.1. 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 sediment concentrations in the range of 1,000 to more than 10,000 milligrams per liter (mg/L), which will be injurious to upstream migrants of both species [coho and steelhead], and especially to any adult steelhead or 'half pounders' that hold or spawn in the mainstem. 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.

A.2. 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).

A.2.a. 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 beginning in 2020, 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 Fishery Management Plan (Figure A-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).

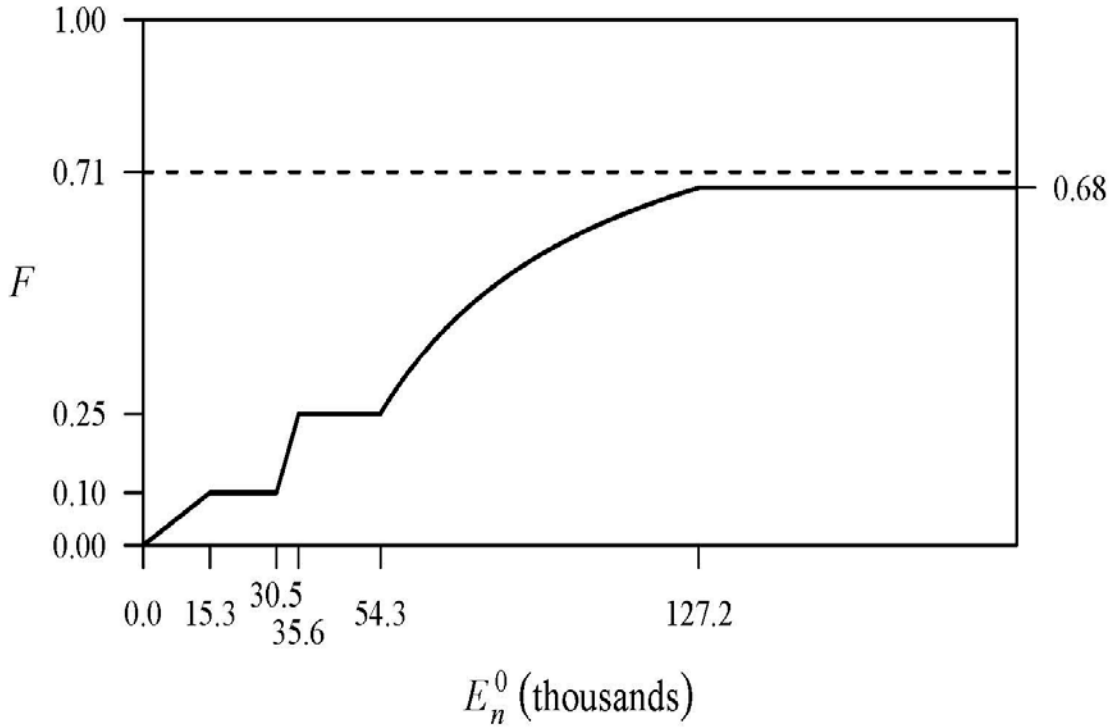

Figure A-1. Harvest control rule used in the EDRRA model (E_n^0 = natural area adult escapement in the absence of fisheries, F = exploitation rate) (graphic by Michael Mohr, NMFS).

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.

Table A-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).[2]

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 +50 percent for the tribal fishery. The annual increase varies by subperiod, with harvest increasing by +8 percent prior to dam removal (2012-2020), peaking at +68 percent during the 12 years after dam removal when the fishery is still influenced by hatchery production (2021-32), then diminishing somewhat to +55 percent during 2033-61 after hatchery influence dissipates in 2032. The average harvest increases during the latter two subperiods (+68 percent during 2021-32, +55 percent during 2033-61) are higher than the average +50 percent increase experienced over the entire period (Table A-1).

Table A-1. EDRRA model results for the tribal fishery under the no action alternative (NAA) and dam removal alternative (DRA)

Model Results	*Time Period*			
	2012-61	*2012-20*	*2021-32*	*2033-61*
50th percentile harvest: % diff between NAA and DRA	+50%	+8%	+68%	+55%
5th percentile harvest: % diff between NAA and DRA	-60%	-81%	-50%	-58%
95th percentile harvest: % diff between NAA and DRA	+886%	+512%	+1000%	+955%
Average # years when DRA harvest > NAA harvest: % diff between NAA and DRA	70%	54%	78%	72%
Average # years when pre-harvest adult natural spawning escapement ≤ 30,500: % diff between NAA and DRA	-66%	-4%	-79%	-80%

Source: EDRRA model outputs provided by Hendrix (2011).
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

EDRRA model results indicate that the 5th percentile harvest value for the DRA is 60 percent lower than the 5th percentile value for the NAA and that the 95th percentile harvest value is 886 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

[2] 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).

of the simulation to both the NAA and DRA. The results in Table A-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 72 percent respectively).

The harvest control rule incorporated into the EDRRA model (Figure A-1) limits the harvest 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 A-1).

A.2.b. 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).

A.2.c. 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).

A.2.d. Chinook Expert Panel

With regard to short term impacts of dam removal, the Chinook Expert Panel indicated that "Dam removal does not have a substantial multi-year adverse impact on mainstem Chinook salmon" (Goodman *et al.* 2011, p ii).

With regard to longer term effects, the 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[3] 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).

[3] 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).

A.3. Steelhead

Biological effects of the alternatives on Klamath River steelhead are evaluated on the basis of results of an Expert Panel convened in December 2010 to evaluate the effects of the alternatives on steelhead and coho (Dunne *et al*. 2011) and conclusions of the Biological Subgroup (Hamilton *et al*. 2011) regarding steelhead.

A.3.a. Coho/Steelhead Expert Panel

The Coho/Steelhead Expert Panel did not expect current conditions to be conducive to expansion of the steelhead fishery:

> "Current Conditions will not, in the short to medium term, result in an expansion of the fishery. Projecting harvest under the Current Conditions depends on the fate of the hatcheries and specifics of harvest policies into the future, which are insufficiently defined at this time" (Dunne *et al*. 2011, p 58).

Dam removal activities are expected to be injurious to steelhead; however, these effects are expected to be short-term.

> "The short-term effects of the sediment release will be sediment concentrations in the range of 1,000 to more than 10,000 milligrams per liter (mg/L), which will be injurious to upstream migrants of both species [coho and steelhead], and especially to any adult steelhead or 'half pounders' that hold or spawn in the mainstem. 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 Panel anticipates a long-term increase in abundance and distribution of steelhead under the action alternatives, provided certain conditions are met.

> "If the Proposed Action is implemented effectively, and the other related actions occur [e.g., Total Maximum Daily Load (TMDL)], then the response of steelhead may be broader spatial distribution and increased numbers of individuals within the Klamath system. This assessment is based on the likelihood of steelhead being given access to substantial new habitat, steelhead being more tolerant than coho to warmer water, the fact that other similar species (resident redband/rainbow trout) are doing well in the upstream habitat, and that steelhead are currently at lower abundances than historical values but not yet rare" (Dunne *et al*. 2011, pp ii-iii).

The Panel notes, however, that long-term positive effects are subject to a number of uncertainties:

> "The Panel identified six principal obstacles to drawing convincing conclusions between the two alternatives: (1) insufficient specificity of the KBRA; uncertainties about (2) fish passage through Keno Reservoir and Upper Klamath Lake, (3) hatchery effects, (4) disease, and (5) water demand responses to KBRA; and (6) limited understanding about coho and

steelhead abundances, migration patterns, and factors affecting survival at each life stage" (Dunne *et al.* 2011, p iii).

A.3.b. Biological Subgroup

The Biological Subgroup concluded that the action alternatives would likely lead to expansion of the steelhead fishery above the current dam sites.

> "…it is likely that access under the without dams and with the KBRA management scenario would create a sport fishery for anadromous species, in particular steelhead, above IGD [Iron Gate Dam]" (Hamilton *et al*. 2011, p 68).

The Subgroup expects the action alternatives to be more beneficial to steelhead than to other anadromous species due to steelhead's habitat adaptability and disease resistance.

- "Because of their ability to navigate steeper gradient channels and spawn in smaller and intermittent streams (Platts and Partridge 1978), steelhead would realize the extent of anadromous habitat gain to a greater degree than other species" (Hamilton *et al*. 2011, p 51).

- "For steelhead, habitat above IGD [Iron Gate Dam] has the potential to increase returns by 6,800 to 20,000 spawners (Table 1). Disease problems in the Klamath River are far less likely to interfere with steelhead returns than with salmon returns, as Klamath steelhead trout are resistant to *C. Shasta* (Administrative Law Judge 2006)" (Hamilton *et al*. 2011, p 112).

A.4. Pacific Lamprey

Biological effects of the alternatives on Pacific lamprey are evaluated on the basis of results of an Expert Panel convened in July 2010 to evaluate the effects of the alternatives on that species (Close *et al*. 2010). The Panel distinguished between short and long term effects and effects downstream and upstream of Keno Dam.

The Panel expects the short-term adverse effects of sedimentation associated with dam removal to be minimal:

> "Pacific lamprey larvae utilize soft fine substrate for approximately 4-6 years in freshwater streams. Because they live burrowed in the soft sediments, there will likely be minimal increases in larval mortality rates of existing Pacific lamprey larvae in the mainstem Klamath River after dam removal. The larvae will likely relocate or adjust their burrow tubes to maximize feeding and respiration" (Close *et al*. 2010, p 33).

The Panel also considered long term effects, distinguishing between areas downstream and upstream of Keno Dam. While noting a potential 14 percent increase in Pacific lamprey habitat downstream of Keno, the Panel indicated that harvest potential would be somewhat less:

> "However, larval habitat quality in the reach between Iron Gate Dam and Keno Dam will be less desirable than in downstream reaches currently available to anadromous lamprey, making the increase in lamprey production as the result of dam removal and KBRA in this

reach alone less than 14 percent. When also considering that Conditions without Dams and with the KBRA might lead to an increase in productivity below Iron Gate Dam also (due to a potential increase in spawning habitat upstream of Iron Gate Dam and reestablishment of natural sediment dynamics downstream of Iron Gate Dam), the Panel then roughly estimated that there might be a total increase of production of outmigrant lamprey (and hence harvest potential) in the range of 1 to 10 percent relative to Conditions with Dams. Within the range of 1 to 10 percent, the production of lamprey in this extended range downstream of Keno Dam will depend on the survival of adults in the ocean and the success of the KBRA (Close *et al*. 2010, pp 45-46).

The Panel also noted the potential for Pacific lamprey to colonize the area above Keno Dam:

> "This area [upstream of Keno] was historically accessible to anadromous fishes, but the historical occurrence of Pacific lamprey is unresolved and investigations have only confirmed Pacific lamprey up to at least Spencer Creek. Nevertheless, improvements to fish passage scheduled for Keno Dam may open the upper Klamath River Basin to Pacific lamprey irrespective of their historical occurrence[4]….but the Panel does not know to what extent or over what time frame such increases could translate into increased harvest potential" (Close *et al*. 2010, p 46).

[4] Larval pheromones that guide lamprey to a given river are not species-specific. Thus Pacific lamprey could potentially colonize an area not previously occupied based on pheromones emitted by other lamprey populations that inhabit that area (Close *et al*. 2010, p 32).