BIOLOGICAL OPINION

ACTION AGENCY: **U.S. Bureau of Reclamation**

ACTION: **Operation of the Klamath Project between 2010 and 2018**

CONSULTATION
CONDUCTED BY: **National Marine Fisheries Service, Southwest Region**

FILE NUMBER: **151422SWR2008AR00148**

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A. Background

Only a century ago, the resources of the Klamath basin provided essential subsistence and cultural values to Indian tribes as well as opportunities for commercial, recreational, and tribal salmon fisheries. For several generations, agriculture and timber industries relied on the certainty of available water and land resources to build communities and provide economic stability. Although these communities share similar features found in many rural areas, they also have a history of conflict as salmon runs have declined, and fishing and irrigation interests compete for limited supplies of water.

Today, the Klamath basin's hydrologic system consists of a complex of inter-connected rivers, lakes, marshes, dams, diversions, wildlife refuges, and wilderness areas. Alterations to the natural hydrologic system began in the late 1800s, accelerating in the early 1900s, including water diversions by private water users, water diversions by the Klamath Project operated by Reclamation, and by several hydroelectric dams operated by a private company, PacifiCorp. The first PacifiCorp development was constructed in 1918 (Copco Dam) on the Klamath and it operated under a 50-year license issued by the Federal Energy Regulatory Commission (FERC) until the license expired in 2006. Although Reclamation's Link River Dam and PacifiCorp's Keno Dam currently have fish ladders, none of PacifiCorp's dams were constructed with fish ladders sufficient to pass anadromous fish and, as a result, salmon and steelhead have effectively been blocked from accessing the upper reaches of the basin for close to a century. Beginning in 1956, Iron Gate Reservoir (the lowest dam in the system) flow releases were generally governed by guidelines outlined within the FERC license, commonly referred to as "FERC minimum flows." FERC's original license to PacifiCorp to operate its hydroelectric project on the Klamath River never underwent Endangered Species Act (ESA) consultation.

B. History of Consultation

Since 1999, NOAA's National Marine Fisheries Service (NMFS) and Reclamation have conducted three ESA section 7 consultations regarding the potential effects of Reclamation's proposed Project operations on SONCC coho salmon and its designated critical habitat. NMFS issued biological opinions in 1999, 2001, and 2002. Through agreements with PacifiCorp, the Reclamation consultations have guided specific flow releases below Iron Gate Dam (IGD) instead of FERC minimum flows.

1. <u>1999 Consultation</u>

On March 9, 1999, Reclamation requested formal section 7 consultation under the ESA on the effects of its Project Operations on SONCC coho salmon. On July 12, 1999, NMFS issued a final biological opinion on Project Operations through March 2000 that concluded the proposed one-year operation of the Project was not likely to jeopardize the continued existence of SONCC coho salmon or adversely modify designated critical habitat. After NMFS advised Reclamation on April 4, 2000, that it should request reinitiation of section 7 consultation, Reclamation responded in a letter dated April 26, 2000, that Reclamation had determined that its proposed flows were sufficient to avoid 7(d) foreclosures under the ESA.

2. 2001 Consultation

On January 22, 2001, Reclamation requested initiation of formal consultation on its proposed Project Operations to "cover the time period from when a BO is issued by NMFS until that BO is superseded by another consultation." On April 6, 2001, NMFS issued a final biological opinion that concluded that Reclamation's proposed Project Operations were likely to jeopardize the continued existence of SONCC coho salmon and adversely modify designated critical habitat. NMFS' biological opinion also provided a reasonable and prudent alternative (RPA) that included minimum instream flows at IGD for the period between April and September 2001.

In 2001, the combination of the NMFS biological opinion's minimum flow requirements, the U.S. Fish and Wildlife Service's (FWS) biological opinion requiring minimum lake levels in Upper Klamath Lake (UKL) for endangered sucker fish, and a severe drought in the Upper Klamath Basin precluded Reclamation from delivering water to Project water users for much of the 2001 irrigation season. As a result, the Departments of the Interior and Commerce requested that the National Academy of Sciences National Research Council (NRC) form a committee to evaluate the strength of scientific support for the 2001 biological assessment (BA) and biological opinions. The NRC Committee (Committee) on Endangered and Threatened Fishes in the Klamath River Basin conducted the review and released an Interim Report in February 2002 and a Final Report in 2004 that also assessed issues related to the long-term survival and recovery of the listed species. The Committee found substantial scientific support for the RPAs and associated Terms and Conditions issued by NMFS and FWS, except for portions requiring more stringent controls over water levels in UKL and flows at IGD (NRC 2002, 2004). The Committee also noted that Reclamation had not provided "substantial scientific support" for its own proposal of revised operating procedures which might have led to "lower minimum flows" at IGD.

3. 2002 Consultation

In March 2002, and one month after the Committee issued its Interim Report, Reclamation finalized a new BA that covered Project operations from May 31, 2002, to March 31, 2012, and requested consultation with NMFS and FWS. In its biological opinion finalized on May 31, 2002, NMFS concluded that Reclamation's proposed operations would likely jeopardize the continued existence of SONCC coho salmon. In coordination with Reclamation, the biological opinion also included a reasonable and prudent alternative that consisted of Reclamation operating the Project to ensure that IGD minimum flows increased gradually over 3 phases of the eight-year period described below.

During Phase I (May 2002-March 2005), Reclamation had to meet the minimum IGD flow requirements identified in Table 5.9 of Reclamation's 2002 BA for Project Operations. Also during Phase I, Reclamation had to develop a water bank, to augment the minimum IGD flow requirements, which must increase in size each year and reach 100 thousand acre-feet (TAF) by April 2005. During Phase II (April 2006 through March 2010), Reclamation had to meet 57 percent of the long-term IGD flow requirements identified in Table 9 of the RPA or the flow requirements identified in modified Table 5.9, whichever was greater. During Phase II, Reclamation had to also annually develop a 100 TAF water bank. By Phase III (April 2010 through March 2012), Reclamation had to implement the long-term IGD flows (NMFS 2002, Table 9)

Several fisheries groups, environmental organizations, and tribes, filed a lawsuit against Reclamation and NMFS in federal district court arguing that the structure of the RPA's phased-in flow requirements were not adequate to protect listed SONCC coho salmon. The district court later ruled that the NMFS alternative was arbitrary and capricious and did not fully explain how its implementation would avoid the likelihood of jeopardy to coho salmon. The district court's ruling was upheld on appeal by the Ninth Circuit Court of Appeals, which later remanded the case to the district court with instruction for the "issuance of appropriate injunctive relief." The district court then issued an injunction on March 27, 2006, ordering: (1) NMFS and Reclamation to reinitiate consultation on the Klamath Irrigation Project; (2) NMFS to issue a new biological opinion based on the current scientific evidence and the full risks to threatened coho salmon; and (3) Reclamation to limit Project irrigation deliveries if they would cause water flows in the Klamath River at and below IGD to fall below 100 percent of the Phase III flow levels specifically indentified by NMFS in its 2002 biological opinion (*i.e.,* Table 9 also referred to as "Phase III flows"), until the new consultation for the Klamath Irrigation Project is completed.

4. <u>2007/08 Consultation</u>

Over the past several few years, NMFS, FWS and Reclamation have worked together to better understand and consider the conservation needs of SONCC coho salmon in the Klamath River and Shortnose (*Chasmistes brevirostris*) and Lost River (*Deltistes luxatus*) suckers in the Upper Klamath Basin while also considering the water resource objectives of Reclamation's Project. NMFS understands the need for continued inter-agency cooperation to promote efficient utilization of limited water resources for listed species, refuges and Project water users and to better harmonize the analyses and any potential conditions imposed by the final biological opinions prepared by the FWS and NMFS.

On October 22, 2007, NMFS received Reclamation's final BA and request for formal consultation under section 7 of the ESA on Project Operations from 2008 to 2018. Despite having requested initiation of consultation, in its letter, Reclamation also explained that it would be considering future modifications to the Proposed Action to "provide for maximum flexibility to meet coho salmon needs." On November 14, 2007, NMFS responded to Reclamation's request for formal consultation and concurred we had enough information to proceed on the Proposed Action described in the BA. However, NMFS letter clarified that future modifications to the Proposed Action may constitute re-initiation of consultation and reset the consultation timeline. NMFS agreed to spend time working with Reclamation on evaluating alternatives to its Proposed Action.

After Reclamation provided Proposed Action alternatives, model runs and a new narrative description associated with those alternatives in November 2007, Reclamation, FWS, and NMFS met to discuss the new information. In December 2007, Reclamation decided not to modify its

Proposed Action and NMFS resumed its analysis of the original Proposed Action found in Reclamation's October 2007 BA.

NMFS released a draft Opinion on June 3, 2008, concluding that Reclamation's Proposed Action was likely to jeopardize the continued existence of SONCC coho salmon and likely to destroy or adversely modify its designated critical habitat. In our June 3, 2008 transmittal letter (NMFS 2008b) we stated that "NMFS is required to develop a reasonable and prudent alternative (RPA) to Reclamation's Proposed Action and in coordination with Reclamation." Reclamation provided its comments on our June 3 draft Opinion on June 20, 2008. NMFS, Reclamation, and the U.S. Fish and Wildlife Service continued to coordinate efforts to develop a reasonable and prudent alternative for coho salmon while also protecting suckers in Upper Klamath Lake and minimizing shortages to water users. NMFS provided its draft Opinion to the tribes on June 3, 2008, met with technical representatives of the Hoopa Valley Tribe and Yurok Tribe, and received comments on the draft Opinion from the Hoopa Valley Tribe and the Yurok Tribe on July 9, 2008. Considering these comments, NMFS revised its draft Opinion and prepared a draft reasonable and prudent alternative and discussed the draft Opinion and draft RPA with Reclamation and FWS on August 27, 2008. On October 6, 2008, Reclamation requested that NMFS extend the consultation duration until further notice. However, Reclamation also requested that "our staffs continue to exchange biological and technical data" in order to expedite the consultation process once it resumes. Several technical meetings were held and in November 2008, NMFS provided its revised draft RPA (referred to as "RPA2") to Reclamation, FWS and the tribes. Reclamation requested On March 4, 2010, Reclamation requested that NMFS finalize its biological opinion on the proposed operations of the Project from 2008 and 2010, consistent with RPA2 by March 15, 2010.

C. Key Consultation Considerations

1. Flow Study Documents

Since the publication of the NRC reports (2002, 2004), two new documents have been issued: (1) an estimate of natural or unimpaired flows in the Klamath Basin (Natural Flow Study); and (2) a model of the relationship of flows in the Klamath River to habitat available for anadromous salmonids (Hardy *et al.* 2006). Because the findings and conclusions of these two studies have the potential to influence scientific conclusions on the management of water in the mainstem Klamath River, the Department of Interior requested the NRC to evaluate them and their implications to the biota of the basin. In response, the NRC established the "Committee on Hydrology, Ecology and Fisheries of the Klamath River Basin." Released to the public in November 2007, and after Reclamation initiated consultation with NMFS, the Committee's 2008 report, "Hydrology, Ecology, and Fishes of the Klamath River Basin" presents: (1) a review and evaluation of methods and approaches used in the Natural Flow Study and the Hardy *et al.* (2006) report; (2) a review and evaluation of the implication of those studies' conclusions; and (3) an identification of gaps in knowledge and in the available scientific information. For these reasons, NMFS must carefully review and consider the Committee's conclusions regarding the scientific strengths and weaknesses of the two reports while developing this biological opinion.

2. Independent Peer Review

Because of the significance of Reclamation's Proposed Action and the complexity of NMFS' analysis, NMFS requested independent peer review of its draft opinion. NMFS received three independent reviews coordinated through the Center for Independent Experts (CIE). Generally, the independent peer reviews (Clair 2008, Hinch 2008, Potter 2008) identified the draft Opinion could be improved through further consideration of environmental variation that influences riverine processes of the Klamath River Basin including climatological trends, as well as consideration of other stochastic events that may occur in the eight-year action period. NMFS has addressed these and other comments of the CIE reviewers in this final Opinion.

This Opinion is based on information provided in Reclamation's October 2007 BA; published literature and reports including, but not limited to the NRC's (2004) "Endangered and Threatened fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery"; Hardy *et al.* (2006); NRC's (2007) "Hydrology, Ecology, and Fishes of the Klamath River Basin;" field investigations; and other sources of the best available scientific and commercial information. A complete administrative record of this consultation is on file at the NMFS' Arcata, California field office.

II. DESCRIPTION OF THE PROPOSED ACTION

Reclamation proposes to operate the authorized features and facilities of the Klamath Project (Project), to March 31, 2018, to store, divert, and manage flows of the Klamath and Lost Rivers. Project water is stored behind several dams in reservoirs or lakes within the Upper Klamath River Basin. An arrangement of operational rules and an Interactive Management (IM) process is proposed by Reclamation to manage the distribution of stored water and the flows of the Klamath and Lost Rivers.

The purpose of the Project is, during varying hydrological conditions, to fulfill Reclamation's legal responsibilities and obligations within the Klamath River basin. These legal responsibilities and obligations include: Tribal trust resources; ESA, senior water rights, project water users' contractual rights, National Wildlife Refuges, and other requirements mandated by law and within the authority of the Secretary of the Interior.

The following summarizes the Project as described in more detail in Reclamation's BA (Reclamation 2007); in a December 17, 2007, letter from P. Arroyave, Reclamation Area Manager, to I. Lagomarsino, NMFS Area Office Supervisor; and in a March 07, 2008, email from C. Karas, Reclamation Deputy Area Manager, to I. Lagomarsino, NMFS Area Office Supervisor.

A. Project Location

The Project is located in Klamath County, Oregon, and Siskiyou and Modoc Counties in northern California (Figure 1). The Project includes facilities to store, divert, and distribute water for irrigation, National Wildlife Refuges, and control of floods in the area. Water storage and diversion facilities in northern California include: Clear Lake Dam and Reservoir; Tule

Lake; and, the Lower Klamath Lake National Wildlife Refuge, while Gerber Dam and Reservoir, UKL, Link River Dam, and the Lost River, Miller, Malone, and Anderson-Rose Diversion Dams are located in Oregon.

Clear Lake Dam, Gerber Dam, and the Lost River Diversion Dam are operated by Reclamation. The Link River Dam is currently operated by the Pacific Power and Light Company in accordance with Project needs. The Anderson-Rose Diversion Dam is operated by the Tulelake Irrigation District, and the Langell Valley Irrigation District operates the Clear Lake, Malone and Miller Diversion Dams. There are 19 canals supported by the Project, which total 185 miles and have diversion capacities ranging from 35 to 1,150 cubic feet per second (cfs). The canals and associated pumping plants are operated by the various irrigation districts.

B. Water Storage

The Project has limited water storage capacity; therefore, Reclamation prioritizes annual refill of storage facilities. The main sources of Project water include the UKL, Clear Lake Reservoir, Gerber Reservoir, and the Lost River. There are also many minor streams in the area. The total drainage area, including the Lost River and the Klamath River watershed above Keno, Oregon, is approximately 5,700 square miles. The Project fills these lakes and reservoirs primarily from the spring snowmelt runoff, with peak inflows generally occurring in March and April.

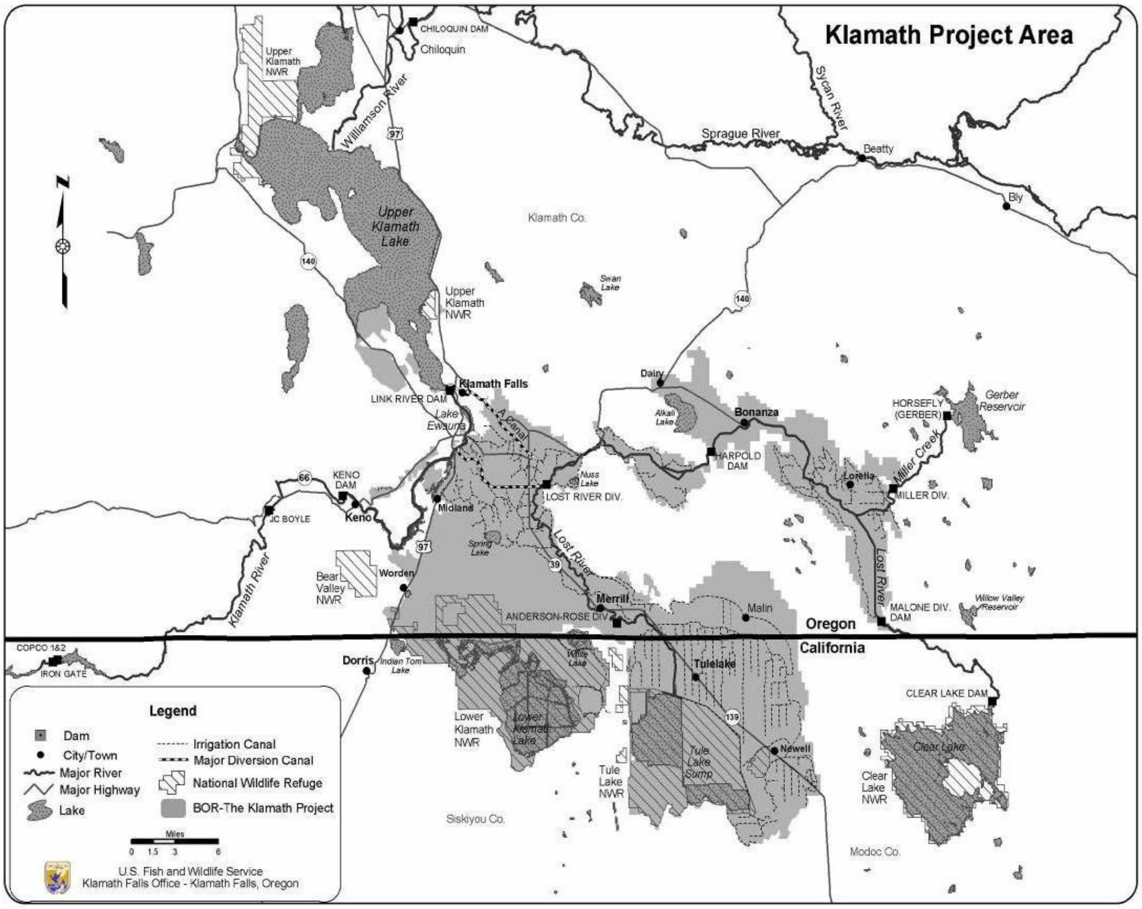

Figure 1. Upper Klamath River Basin of Oregon and California. Lands supplied by the Project's water storage and diversion system are shown as shaded area on the map (from FWS 2002).

C. Water Diversion

Project diversion of stored water occurs year-round. However, diversion of stored water primarily occurs from early April through mid-October. In the support of irrigated crop lands, water is diverted from UKL, through "A" Canal, and the Klamath River through the North and Ady Canals as well as the Lost River Diversion Channel. It is noted that North and Ady Canals are interrelated private facilities, not owned or operated by Reclamation. A portion of the diverted water is returned to the Klamath River through Reclamation's Lost River Diversion Channel and The Klamath Straits Drain (Figure 2)

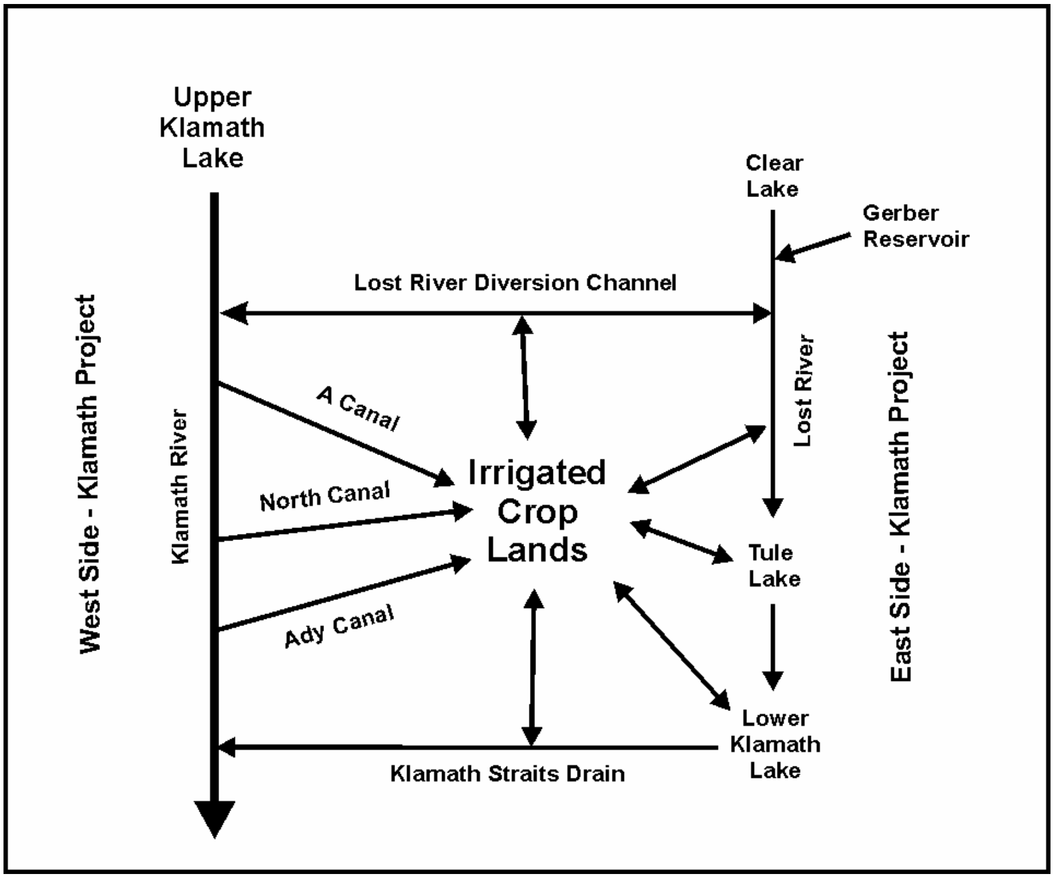

Figure 2. Schematic diagram showing the major movement of water in support of irrigated crop lands within the Project.

D. Manage Flows

The measuring point for water released from the Project is at IGD[1]. Water discharges (flows) at IGD will depend upon available stored water, application of the operational and proposed distribution rules, and spill. The operational rules give highest priority to meeting the minimum discharge levels identified in Table 1.

UKL has limited water storage capacity; therefore, Reclamation operates on an annual refill basis. To increase the likelihood of refilling the UKL, the Project has an operational target elevation for the UKL of no less than 4138 feet above sea level at the end of September. Additionally, the Project will place restrictions on the rate of change in discharge from IGD, commonly referred to as the ramp rate. When the flow at IGD is greater than 3,000 cfs, IGD ramp down rates will follow the rate of decline of inflows into UKL combined with accretions between Keno Dam and IGD. When the flows at IGD are above 1,750 cfs, but less than 3,000 cfs, IGD ramp down rate will be 300 cfs or less per 24-hour period and no more than 125 cfs per 4-hour period. When the flows at IGD are 1,750 cfs or less, IGD ramp down rate will be 150 cfs or less per 24-hour period and no more than 50 cfs per two-hour period.

Table 1. Proposed instantaneous minimum Klamath River flows (cfs) at IGD, minimum UKL elevations (ft), and UKL refill targets (ft).

	Klamath River	UKL	
Month	Proposed Minimum Flows below IGD (cfs)	Proposed Minimum Lake Elevations	Proposed Lake Refill Target Elevations
October	1,300		4139.1
November	1,300		4139.9
December	1,300		4140.8
January	1,300		4141.7
February	1,300	4141.5	4142.5
March	1,450	4142.2	4143.0
April	1,500	4142.2	
May	1,500	4141.6	
June	1,400	4140.5	
July	1,000	4139.3	
August	1,000	4138.1	
September	1,000	4137.5	

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[1] All references to flow at IGD are as measured at the USGS gage below IGD and include Bogus Creek accretions.

E. Operational Rules

The Project's operational rules, in order of priority, are to: (1) meet or exceed the minimum IGD flows; (2) meet or exceed the minimum UKL elevations; (3) sustain water diversions to meet contractual agreements between Reclamation and water users, including the National Wildlife Refuges; and (4) meet the UKL Refill Targets. Remaining water is identified as surplus water, also referred to as potential IM Water.

F. IM Process

Reclamation plans to use an IM approach to more effectively utilize the available IM water for the benefit of listed species. An IM approach refers to a system that allows communications between involved parties on a timely basis to make recommendations based on current data. Various federal, state, and tribal agencies will be invited to represent their interests on an IM Technical Team. The IM Technical Team will develop recommendations on the available IM water, distributing the water between augmentation of UKL elevations and the augmentation of flows at IGD.

1. <u>Determining Available IM Water</u>

Reclamation will determine the amount of IM water by applying the operational rules identified above and making adjustments based on other relevant information. The information Reclamation will use to determine available IM Water during the April through September period includes, but is not limited to: minimum IGD flows; current UKL inflows; Natural Resources Conservation Service (NRCS) UKL inflow forecast; current UKL elevation; UKL Refill Target elevations; minimum UKL elevations; Project water diversion obligations; soil moisture content; non-Project diversions and, other basin-wide hydrological and climatological information, including short-term weather forecasts.

Utilizing the above information, Reclamation will perform the following tasks to determine the amount of available IM Water. Tasks will be performed on a semi-monthly basis (twice a month) from April through September.

(1) Forecast the UKL inflow for the subsequent semimonthly period using the National Resources Conservation Service (NRCS) forecast and the inflow trend.

(2) In coordination with the Klamath Water Users Association and the managers of the National Wildlife Refuges, estimate Project demand for the subsequent semimonthly period.

(3) Forecast the Keno Dam to IGD accretions for the subsequent semimonthly period.

(4) Analyze potential augmentation of the minimum IGD flows and its corresponding effect on UKL elevations and water storage.

(5) The UKL elevation level augmentation will be considered that portion of the surplus water that was not explicitly used to augment river flows.

October through March, Reclamation will observe the targets for the refilling of UKL in determining the available IM Water. After factoring in the trends of inflow into the UKL during this period, any water above that needed to meet the targets for the refilling of UKL would be potentially available to augment the minimum IGD flows.

2. <u>IM Technical Team</u>

Reclamation proposes to invite key technical representatives within the Klamath River Basin to form an IM Technical Team. The team members and date of the first meeting will be established by March, 2008. The list of Technical Team participants will include staff from the three consulting Federal agencies (NMFS, FWS, and Reclamation) and may include other members such as: U.S. Geological Survey (USGS), Hoopa Valley Tribe, Karuk Tribe, Klamath Tribes of Oregon, Yurok Tribe, California Department of Fish and Game (CDFG), and, Oregon Department of Fish and Wildlife. These representatives from key federal and state resource agencies, tribes and stakeholders with expertise in the water and fish resources will formulate the IM Technical Team's recommendations.

The IM Technical Team will recommend how IM Water is distributed between augmentation of UKL elevations and the augmentation of flows in the mainstem Klamath River. Reclamation will manage the IM Water as recommended by an IM Technical Team, unless following the recommendation would result in a real threat to human health and safety.

Some examples of a recommendation that would result in a real threat to human health and safety include: the recommendation exceeds safe operation of facilities, there is an unacceptable risk of flooding, or the recommendation places the integrity of structures within the system at risk of damage or failure. For example, if a substantial increase in IGD releases were recommended, required notification of the public below the dam to ensure safety could result in a delay of the release.

As the IM Technical Team formulate their recommendation of a semimonthly distribution of IM water, they would consider factors including, but not limited to, the following: current and forecasted UKL inflows; current UKL elevations; major Klamath River tributary flows below IGD (*e.g.,* Shasta, Scott, Salmon and Trinity Rivers) based upon, in part, the previous two weeks trend; review of the most current biological data (*e.g.,* out migrant trap information, radio-tracking data, year-class strength and disease); water quality data, including air and water temperatures; assessment of the effects of potential beneficial and adverse impacts on species of concern of the recommended UKL elevations and recommended flows below IGD; and opportunity for experimental flows and effects to on-going studies. Reclamation's intent of using an IM Technical Team to determine distribution of IM Water is to better manage water to the benefit listed fish species and their designated critical habitat by including other resource managers in the decision making process and to make that process more transparent. Should the IM Technical Team be unable to reach an agreement on a recommendation, Reclamation would operate the project facilities based on the operational rules and the default distribution rules, as discussed below.

3. Modeling of the IM Process

In an attempt to simulate IGD flows and UKL elevations that should be realized from the Project operating under the operational rules and the proposed default distribution rules, Reclamation utilized its Water Resources Integrated Modeling System (WRIMS) Model. The following assumptions, or distribution rules, were used by Reclamation in modeling the IM process:

(1) Based on a precipitation index, the model estimated the water diversions necessary to meet contractual agreements between Reclamation and water users as outlined in Table 2

Table 2. Modeled Project Demands based on the Precipitation Index.

Feb-Mar Precipitation Index	A1 Demand [1] Apr-Mar (TAF)	Refuge Demand Apr-Mar (TAF)	Oct-Jan Precipitation Index	A2 Demand [2] Apr-Mar (TAF)
0.00 - 1.999	340	30	0.00 - 3.99	105
2.00 - 2.749	310	25	4.00 - 6.99	95
2.75 - 3.299	300	20	7.00 - 9.99	90
> or = 3.30	275	15	> or = 10.00	80

[1] A1 demand represents the Project deliveries through the A-Canal and Lost River Diversion Channel.

[2] A2 demand includes deliveries to areas served by the North and Ady Canals in the southwest portion of the Project. Ady and North Canals are privately owned and operated facilities with a water right separate from the Project water right.

(2) An allocation of water to augment flows at IGD above minimum levels was based on the computed surplus water supply that was likely to occur by the end of September. The surplus water supply is calculated in April as:

$$\textbf{Surplus Water Supply} = A + B - C - D + E - F \qquad (1)$$

A = The end-of-March storage in UKL.
B = UKL inflow, April through September (perfect foresight).
C = September target carryover storage.
D = Iron Gate minimum flow requirement, April through September.
E = Link River to IGD gain, April through September (perfect foresight).
F = Agriculture and National Wildlife Refuge demand, April through September.

3) In modeling, a portion of surplus water[2] was allocated to increasing IGD flows above the minimum levels. This portion was based on a seasonal water supply factor which is calculated in each time period as:

Seasonal Water Supply Factor = $G + H - I$ (2)

G = The end-of-previous time period storage in UKL.
H = The UKL inflow, "now" through September, (perfect foresight).
I = September target carryover storage.

This approach allows some adaptation to changing water supply conditions (*e.g.,* UKL inflows). The percentage of the April through September surplus water supply allocated to flow augmentation was interpolated relative to this continually updated seasonal water supply are depicted in Table 3. The IM water remaining after IGD flow has been augmented remains within UKL.

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[2] The UKL elevation level augmentation is considered that portion of the surplus water that was not explicitly used to augment river flows.

Table 3. The modeled percentage of the surplus water supply allocated to augmentation of minimum IGD discharge, by semimonthly or monthly period, May through September.

Semimonthly or Monthly Period [1]	If Seasonal Supply Factor in TAF was:	If Seasonal Supply Factor in TAF was:	If Seasonal Supply Factor in TAF was:	If Seasonal Supply Factor in TAF was:
May 1 – 15	0 to 790	790 to 920	920 to 1,181	above 1,181
May 16 – 31	0 to 728	728 to 850	850 to 1,069	above 1,069
June 1 – 15	0 to 661	661 to 775	775 to 949	above 949
June 15 – 30	0 to 579	579 to 687	687 to 853	above 853
July 1 – 15	0 to 501	501 to 604	604 to 756	above 756
July 16 – 31	0 to 434	434 to 530	530 to 685	above 685
August	0 to 363	363 to 458	458 to 609	above 609
September	0 to 256	256 to 349	349 to 498	above 498
Percent of Surplus Water Supply to augment the Iron Gate Discharge Flow is [2]:	20%	20% to 36%	36% to 35%	35%

[1] In modeling, there was no flow augmentation above IGD minimum flows in April. However, flows in excess of minimums did occur during spill events. Spills have historically occurred in April. The UKL elevation level augmentation will be considered that portion of the surplus water that was not explicitly used to augment river flows.

[2] The Project sets a cap on the maximum amount of IM water distributed to the river in order to ensure a certain level of confidence that irrigation shortages will not occur at a later date. Thus, the figure illustrates that as hydrologic conditions improve (*i.e.,* rainfall and storage improve), the IM process can be less conservative and allow a greater percentage of available water to the river.

4) In Reclamation's modeling, the distribution of the annual flow augmentation (amount of Surplus Water Supply to augment the minimum IGD discharge) was as indicated in Table 4.

Table 4. Distribution of Surplus Water Supply to augment the IGD discharge, May through September.

Semimonthly or Monthly Period [1]	Seasonal Supply Factor (in TAF)	Distribution of Surplus Water Supply to Augment the IGD Discharge	Seasonal Supply Factor (in TAF)	Distribution of Surplus Water Supply to Augment the IGD Discharge	Seasonal Supply Factor (in TAF)	Distribution of Surplus Water Supply to Augment the IGD Discharge	Seasonal Supply Factor (in TAF)	Distribution of Surplus Water Supply to Augment the IGD Discharge
May 1 - 15	0 to 790	33%	790 to 920	26%	920 to 1,181	15%	above 1,181	15%
May 16 - 31	0 to 728	33%	728 to 850	25%	850 to 1,069	15%	above 1,069	15%
June 1 - 15	0 to 661	10%	661 to 775	14%	775 to 949	22%	above 949	20%
June 15 - 30	0 to 579	10%	579 to 687	14%	687 to 853	22%	above 853	20%
July 1 - 15	0 to 501	3%	501 to 604	6%	604 to 756	7%	above 756	7.5%
July 16 - 31	0 to 434	3%	434 to 530	6%	530 to 685	7%	above 685	7.5%
August	0 to 363	3%	363 to 458	4%	458 to 609	4%	above 609	5%
September	0 to 256	5%	256 to 349	8%	349 to 498	9%	above 498	10%
Total	**-**	**100%**	**-**	**100%**	**-**	**100%**	**-**	**100%**

[1] In modeling, there was no flow augmentation above IGD minimum flows in April. However, flows in excess of minimums did occur during spill events. Spills have historically occurred in April.

(5) In modeling, there was no augmentation above IGD minimum flows in the months of October through April. However, flows in excess of minimums did occur during spill events. Spills have historically occurred as late as June. As noted earlier, the management of these spills may be possible through the IM process.

(6) The UKL elevation level augmentation was considered that portion of the surplus water that was not explicitly used to augment river flows.

4. An Example of Modeling of the IM Process

Table 5 shows the modeling results based upon the above operational assumptions (distribution rules) for the first year of Reclamation's simulation, 1961. This simulation was repeated for each year from 1961 through 2004. In this example, for 1961, the surplus water supply was calculated on April 1 as 267.7 TAF. Modeling assumed full implementation of the expanded UKL water storage, which includes the expanded water storage provided by incorporating the Williamson River Delta property and the Agency Lake/Barnes Ranches.

Table 5. Flow augmentation calculations using modeled assumptions (distribution rules) for the first year of Reclamation's simulation, 1961.

447.27	Iron Gate Dam Minimum Flow Requirements April-Sept
304.81	Agriculture and Refuge Demands Apr-Sep
123.45	Upper Klamath Lake Storage at Elevation 4138.0 ft
267.71	April 1 Surplus Calculation (560.14 + 436.6 + 146.5 - 447.27 - 304.81 - 123.45)

		A	B	C	D	E	F	G	H
	Semimonthly or Monthly Time Period	Upper Klamath Lake Storage (in taf)	Upper Klamath Lake Inflow (in taf)	Keno to Iron Gate Dam Gain (in taf)	Seasonal Water Supply Factor (in taf)	Percentage of Surplus Water to Augment Iron Gate Dam Flows	Annual Surplus to Augment Iron Gate Dam Flows (in taf)	Default Distribution	Augmentation of Iron Gate Dam Flows (in taf)
1	Mar 16-31	560.14							
2	Apr 1-15	574.13	54.7	16.5					
3	Apr 16-30	574.13	54.7	16.5					
4	May 1-15	565.09	47.1	17.3	778.00	20.0%	53.54	33%	17.7
5	May 16-31	555.71	50.2	18.5	708.21	20.0%	53.54	33%	17.6
6	Jun 1-15	525.58	41.0	11.7	634.96	20.0%	53.54	10%	5.4
7	Jun 16-30	494.64	41.0	11.7	563.84	20.0%	53.54	10%	5.4
8	Jul 1-15	443.30	19.5	2.8	492.74	20.0%	53.54	3%	1.6
9	Jul 16-31	388.81	20.8	3.0	422.83	20.0%	53.54	3%	1.6
10	Aug	326.95	48.1	21.7	348.39	20.0%	53.54	3%	1.6
11	Sep	300.07	59.4	26.8	238.37	20.0%	53.54	5%	2.7
12	Apr-Sep		436.6	146.5					

- Continued -

Column A – UKL storage in TAF.

Column B – UKL inflow.

Column C – Total gains (accretions) between Link River and IGD.

Column D – the model calculates the Seasonal Water Supply Factor.

Column E – using the value in column D and the distribution rules in Table 3, the model calculates the percentage of the surplus that will become the annual IGD flow augmentation.

Column F – multiply the value in column E by 267.71, the surplus water supply calculated on April 1.

Column G – Modeled distribution rules based on Table 4.

Column H – multiply the value in Column F by the value in Column G to get the flow augmentation for each time period (TAF).

5. Default Distribution Rules

The above approach was used in Reclamation's modeling to simulate implementation of the proposed IM process. This modeling approach was used in water years 1961 through 2004 to generate results that are displayed in the exceedence tables. These exceedence tables (Table 6 and Table 7) are designed to illustrate the predicted modeled monthly average IGD flows and UKL elevations levels under the Proposed Action. Exceedence tables are defined as the probability that flow (in cfs) will exceed a specified reference level during a given exposure time. The exceedence tables are an artifact of applying the operational rules and the distribution rules (assumptions) used in the model. However, if the IM process alters the distribution rules used in the above modeling, the attached exceedence tables would also change.

Reclamation proposes that the above distribution rules, based on comments received from the Services during the informal consultation process (N. Parker, Reclamation, email February 4, 2008; C. Karas, Reclamation, email March 7, 2008) are the default for the IM Technical Team to formulate their recommendations. The IM Technical Team recommendations could then convey how to modify this distribution of the IM Water. Below in our Analytical Approach, we describe assumptions of the proposed IM process and specifically identify expectations of the Proposed Action for our analysis.

Table 6. Modeled Proposed Action IGD flow exceedence in cfs.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	1300	1300	1300	1300	1300	1450	1500	1500	1400	1000	1000	1000
90%	1300	1300	1300	1300	1300	1450	1500	1500	1400	1000	1000	1000
85%	1300	1300	1300	1300	1300	1450	1500	1524	1408	1001	1001	1000
80%	1300	1300	1300	1300	1300	1687	1500	1603	1434	1008	1005	1006
75%	1300	1300	1300	1300	1300	2224	1500	1668	1455	1016	1008	1013
70%	1300	1300	1300	1300	1300	2360	1500	1803	1498	1029	1014	1024
65%	1300	1300	1300	1300	1323	2475	1592	1876	1520	1035	1017	1030
60%	1300	1300	1300	1309	1880	2537	1892	2028	1569	1050	1024	1041
55%	1300	1300	1345	1656	2473	2772	2270	2114	1594	1056	1028	1048
50%	1300	1300	1410	1751	2577	2812	2669	2289	1639	1070	1035	1060
45%	1300	1300	1733	2018	2728	2888	2880	2381	1670	1077	1038	1066
40%	1300	1300	1837	2242	3105	2949	2982	2455	1683	1082	1041	1071
35%	1300	1300	2079	2549	3505	3199	3212	2612	1699	1100	1050	1085
30%	1300	1434	2471	2578	3632	3784	3713	2802	1743	1118	1053	1089
25%	1300	1590	2908	2627	3822	4316	4136	2976	1782	1137	1058	1097
20%	1300	1831	2997	2908	3960	4813	4521	3352	1856	1152	1066	1135
15%	1300	2040	3078	3498	4762	5315	5239	3692	2194	1222	1093	1162
10%	1300	2875	3296	3948	5663	5950	5544	3885	2526	1369	1126	1246
5%	1300	3385	4923	6307	7172	6625	5939	4247	2667	1430	1147	1281

Table 7. Modeled Proposed Action UKL elevation exceedence in feet.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	4137.76	4138.05	4138.50	4139.44	4140.46	4141.27	4141.83	4141.47	4140.42	4139.38	4138.42	4138.00
90%	4137.87	4138.46	4139.14	4139.95	4140.98	4142.04	4142.53	4141.96	4140.64	4139.51	4138.47	4138.00
85%	4138.08	4138.89	4139.57	4140.63	4141.49	4142.64	4142.67	4142.23	4141.02	4139.65	4138.53	4138.00
80%	4138.31	4139.14	4140.15	4141.19	4141.93	4142.89	4142.91	4142.37	4141.17	4139.78	4138.62	4138.15
75%	4138.86	4139.45	4140.69	4141.48	4142.41	4143.15	4143.06	4142.52	4141.35	4139.98	4138.79	4138.32
70%	4139.00	4139.77	4140.97	4141.83	4142.56	4143.15	4143.22	4142.62	4141.53	4140.15	4139.30	4138.94
65%	4139.04	4139.87	4141.24	4142.02	4142.68	4143.15	4143.30	4142.64	4141.55	4140.30	4139.42	4139.08
60%	4139.62	4140.51	4141.31	4142.17	4142.70	4143.15	4143.30	4142.69	4141.72	4140.44	4139.47	4139.13
55%	4139.85	4140.60	4141.66	4142.30	4142.70	4143.15	4143.30	4142.92	4141.95	4140.72	4139.76	4139.68
50%	4140.09	4140.70	4141.70	4142.30	4142.70	4143.15	4143.30	4142.94	4142.05	4140.96	4140.05	4139.74
45%	4140.14	4140.75	4141.70	4142.30	4142.70	4143.15	4143.30	4142.97	4142.15	4141.02	4140.13	4139.91
40%	4140.26	4140.96	4141.70	4142.30	4142.70	4143.15	4143.30	4143.04	4142.18	4141.08	4140.25	4140.06
35%	4140.44	4141.18	4141.70	4142.30	4142.70	4143.15	4143.30	4143.12	4142.22	4141.32	4140.38	4140.17
30%	4140.66	4141.38	4141.70	4142.30	4142.70	4143.15	4143.30	4143.20	4142.29	4141.38	4140.67	4140.30
25%	4140.74	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.55	4141.53	4140.73	4140.38
20%	4140.84	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.59	4141.58	4140.75	4140.53
15%	4141.05	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.65	4141.61	4140.92	4140.65
10%	4141.14	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.76	4141.79	4141.04	4140.81
5%	4141.65	4141.39	4141.70	4142.30	4142.70	4143.15	4143.30	4143.30	4142.91	4141.89	4141.20	4141.07

G. Action Area

The action area means all areas to be affected directly or indirectly by the Proposed Action and not merely the immediate area involved in the action [50 CFR §402.02]. Direct effects include those resulting from interdependent or interrelated actions[3]. Indirect effects are defined as those effects that are caused by or will result from the Proposed Action and are later in time, but still reasonably certain to occur (50 CFR §402.02).

The action area for the Project begins at the confluence of the Wood River with Agency Lake, Klamath County, in south central Oregon, and extends approximately 240 miles downstream to the outfall of the Klamath River into the Pacific Ocean, at Requa, Del Norte County, California (see Figure 3, Appendix 1, Figures A-F). Project effects are likely to extend into the Pacific Ocean and affect listed marine species reliant on Klamath River anadromous salmonids as a food source.

The action area includes the historically accessible portion of the mainstem Klamath River to Iron Gate Dam (river mile (rm) 190). For analytical purposes, we organize the mainstem Klamath River into three mainstem reaches (*i.e.,* Upper, Middle, and Lower). Within the upper Klamath Basin, the action area includes Agency Lake, UKL, Lake Ewauna (the headwaters of the Klamath River), Lost River, and all Reclamation's facilities including diversion channels and reservoirs that currently or historically contained suckers.

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[3] Definitions from 50 CFR 402.02: Interdependent actions are those that have no independent utility apart from the action under consideration. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification.

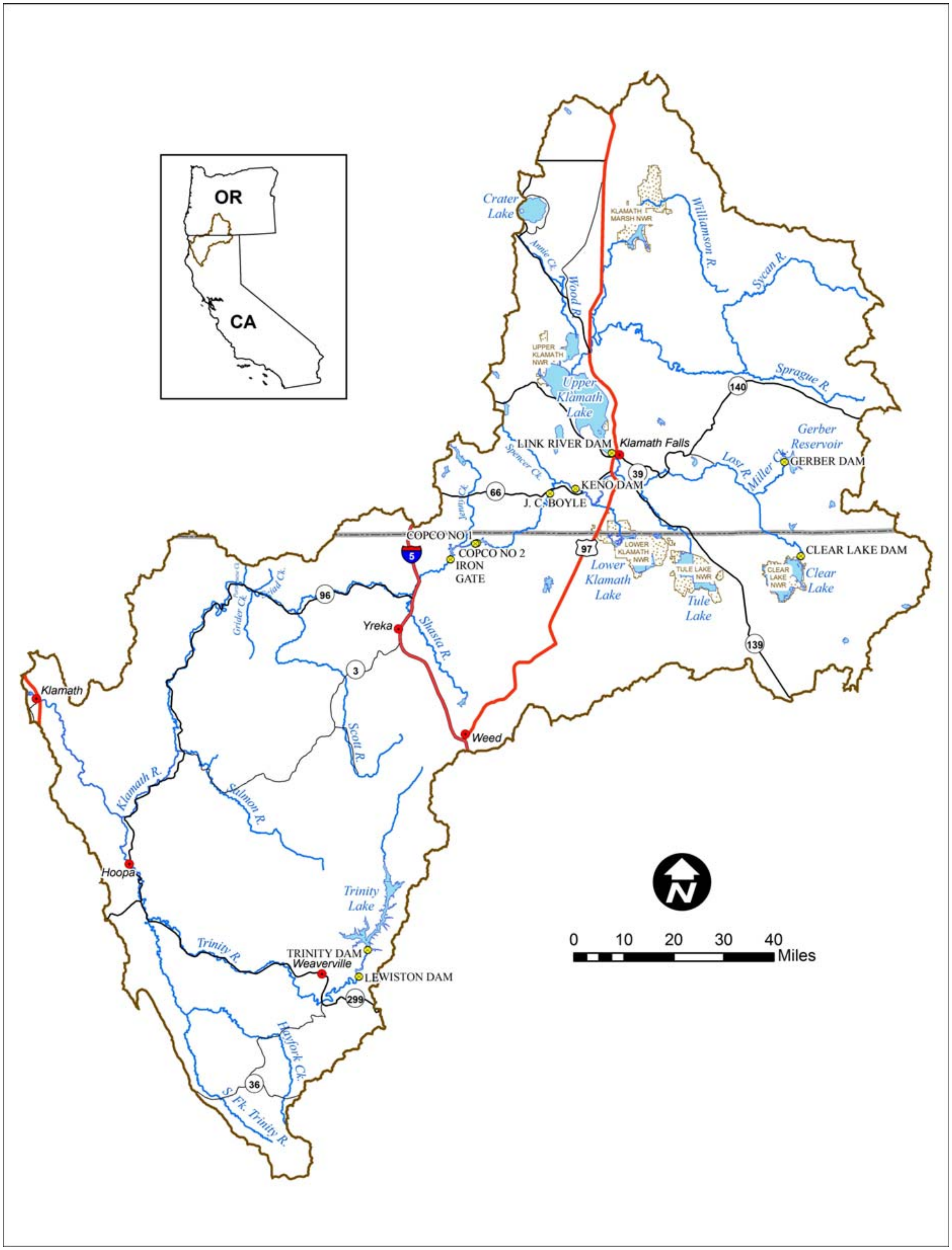

Figure 3. Map of the Klamath River Basin

III. ANALYTICAL APPROACH

Pursuant to section 7(a)(2) of the ESA, Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. Below, NMFS outlines the conceptual framework and key steps and assumptions utilized in the jeopardy and critical habitat destruction or adverse modification analyses.

A. Legal and Policy Framework

Section 7(a)(2) of the ESA and implementing regulations (50 CFR Part 402), and associated guidance documents (*e.g.,* Endangered Species Consultation Handbook, 1998) require biological opinions to present: (1) a description of the proposed federal action; (2) a summary of the status of the affected listed species and designated critical habitat; (3) a summary of the environmental baseline within the action area; (4) a detailed analysis of the effects of the Proposed Action on the affected species and critical habitat; (5) a description of cumulative effects (future non-federal actions that are reasonably certain to occur); and (6) a conclusion as to whether it is reasonable to expect the Proposed Action is not likely to jeopardize the listed species or result in the destruction or adverse modification of the species designated critical habitat. By regulation (50 CFR 402.02), the "effects of the action" include the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action that will be added to the environmental baseline. To evaluate whether an action is not likely to result in jeopardy to a listed species or result in the destruction or adverse modification of designated critical habitat, NMFS considers the combination of the status of the species and critical habitat, the "effects of the action," and the cumulative effects of reasonably certain to occur future non-federal actions. An action that is not likely to jeopardize the continued existence of the listed species is one that is not likely to appreciably reduce the likelihood of both the survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution (50 CFR 402.02). This Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the analysis with respect to critical habitat.

Recent court cases have reinforced the direction provided in section 7 regulations that NMFS must evaluate the effects of a Proposed Action within the context of the current condition of the species and critical habitat including other factors affecting the survival and recovery of the species and the functions and value of critical habitat. In addition, the Courts have directed that our risk assessments consider the effects of climate change on the species and critical habitat and on our prediction of the impacts of a Proposed Action. NMFS has considered the guidance provided by recent court decisions when crafting our analytical approach to this consultation.

Finally, NMFS evaluates a project's effect on a species' likelihood of both survival and recovery (the "jeopardy standard" at 50 CFR 402.02) by evaluating the species' risk of extinction. This tool and its relationship to the legal standard "likelihood of both survival and recovery" and the best available scientific information relating to viable salmonid populations (McElhany *et al.* 2000) are described in the *Ecological Conceptual Framework* section below.

B. Ecological Conceptual Framework

NMFS uses a conceptual model of the species and its critical habitat to evaluate the impact of proposed actions. For this consultation, this conceptual model is structured around the listed coho salmon and its designated critical habitat. Two other listed species may be affected by the Proposed Action (Southern DPS green sturgeon and Southern Resident killer whales), but those species are not examined in depth in this opinion for reasons described in the *Status of the Species and Critical Habitat* sections. For the species, the conceptual model is based on a hierarchical organization of individual fish, population unit, and evolutionarily significant unit (ESU). The guiding principle behind this conceptual model is that the likelihood of survival and recovery of a species is dependent on the likelihood of survival and recovery of populations which comprise the species (organized by diversity strata[4] comprising the species ESU); and the likelihood of survival and recovery of each population unit is dependent upon the fitness (growth, survival, or reproductive success) of the individuals that comprise that population.

A prerequisite for predicting the effects of a proposed action on a population and a species includes an understanding of the condition of the population and species in terms of their chances of surviving and recovering. To do this, we evaluate their current condition and assess their chances of recovery given their current condition and the existing and future threat regime. To assist in this evaluation we use the guidance provided in the *Viable Salmonid Populations* (VSP) document by McElhany *et al.* (2000). As defined in the VSP document, viability is the state in which extinction risk of a population is negligible over 100 years and full evolutionary potential is retained (McElhany *et al*. 2000). Importantly, a viable population (or species) is not necessarily one that has recovered as defined under the ESA. To meet recovery standards, the species may need to achieve higher levels of resiliency to allow for activities such as commercial harvest and the existing threat regime would need to be abated or ameliorated as detailed in a recovery plan. As a result, we evaluate the current status of the species to diagnose how near, or far, the species is from this viable state because it is an important metric indicative of a self-sustaining species in the wild, but we also consider the ability of the species to recover in light of its current condition and the status of the existing and future threat regime. Generally, NMFS folds this consideration of current condition and ability to recover into a conclusion regarding the "risk of extinction" of the population or species.

We equate the risk of extinction of the species with the "likelihood of both the survival and recovery of the species in the wild" for purposes of conducting jeopardy analyses under section 7(a)(2) of the ESA because survival and recovery are conditions on a continuum with no bright dividing lines. Similar to a species with a low likelihood of both survival and recovery, a species with a high risk of extinction does not equate to a species that lacks the potential to become

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[4] Diversity strata are defined as groups of populations that span the diversity of environments and distribution that currently exists or historically existed within the ESU.

viable. Instead, a high risk of extinction indicates that the species faces significant risks from internal and external processes and threats that can drive a species to extinction. Our jeopardy assessment, therefore, focuses on whether a proposed action appreciably increases extinction risk, which is a surrogate for appreciable reductions in the likelihood of survival and recovery.

NMFS uses the general life cycle approach outlined by the VSP report (McElhany *et al.* 2000) in this Opinion. NMFS uses the concepts of VSP as an organizing framework in this Opinion to systematically examine the complex linkages between project effects and VSP parameters while also considering and incorporating key risk factors such as climate change and ocean conditions. Four principal parameters were used to evaluate the risk of extinction risk of the SONCC coho salmon ESU: abundance, population growth rate (productivity), population spatial structure, and population diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of coho salmon (McElhany *et al*. 2000). These four parameters are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of jeopardy (50 CFR 402.02) and are used as surrogates for numbers, reproduction, and distribution. The fourth VSP parameter, diversity, relates to all three jeopardy criteria. For example, numbers, reproduction, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape-level scales.

For critical habitat, the organizational structure is generally based around the primary constituent elements or essential features of the critical habitat within the action area, the essential habitat types those features support within the action area as organized by reaches within the mainstem Klamath River, the area encompassing the diversity stratum[5] (Interior Klamath) in which the affected essential habitat features and types are found, and then the overall designated area of critical habitat at the ESU scale. The basis of the analysis is to evaluate the function and role of the critical habitat in the conservation of the species. As a result, the structure is organized around the structure of the species to be conserved. Importantly, NMFS bases the critical habitat analysis on the affected areas and functions of critical habitat essential to the conservation of the species and not on how individuals of the species will respond to changes in habitat quantity and quality.

C. Concept of the Natural Flow Regime

Throughout the sections of the Opinion, NMFS uses the concepts of a natural flow regime to guide the analytical approach. The natural flow regime of a river is the characteristic pattern of flow quantity, timing, rate of change of hydrologic conditions, and variability across time scales (hours to years), all without the influence of human activities (Poff *et al.* 1997). Variability of the natural flow regime is inherently critical to ecosystem function and native biodiversity (Poff

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[5] In cases where the extent of designated critical habitat is smaller than the boundaries of a defined area such as a diversity stratum, our analysis would focus on the extent of the designation within that area and not artificially extend critical habitat boundaries.

et al. 1997; Puckridge *et al.* 1998; Bunn and Arthington 2002; Beechie *et al.* 2006). Because aquatic species have evolved life history strategies in direct response to natural flow regimes (Taylor 1991; Bunn and Arthington 2002; NRC 2004; Beechie *et al.* 2006), maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species (Poff *et al.* 1997; Bunn and Arthington 2002). Understanding the link between the adaptation of aquatic and riparian species to the flow regime of a river is crucial for the effective management and restoration of running water ecosystems (Beechie *et al.* 2006), because humans have now altered the flow regimes of most rivers (Poff *et al.* 1997; Bunn and Arthington 2002).

The NRC (2005) identified four components of a natural flow regime, noting that not all of these components occur in a river in a given year: (1) *Subsistence flow* is the minimum flow needed during critical drought periods to maintain tolerable water-quality conditions and to provide minimal aquatic habitat space for the survival of aquatic species; (2) *Base flow* is the "normal" flow condition between storms; (3) *High-flow pulses* are short duration flows following storms; and (4) *Overbank flow* is an infrequent, high-flow event that breaches riverbanks. In this Opinion, NMFS uses these concepts of natural flow to inform our analysis of coho salmon response to past, current, and future hydrological conditions.

D. Risk Assessments

As described above, the regulations implementing section 7(a)(2) of the ESA direct NMFS to assess proposed project impacts on species and critical habitat in order to ensure that the proposed project is not likely to jeopardize the listed species or result in the destruction or adverse modification of critical habitat. In our biological opinions, NMFS conducts two separate but related analyses to make these determinations. To conduct these assessments, NMFS uses a basic exposure-response-risk framework adapted from other accepted risk analysis frameworks such as EPA 1992 and 1998.

Generally, NMFS first identifies the environmental "stressors" (physical, chemical or biotic) directly or indirectly caused by the proposed action to which coho salmon and critical habitat may be exposed, the nature of any exposure, and the life stages or essential habitat features exposed. Next, NMFS evaluates the likely response of coho salmon or critical habitat exposed to such stressors based on the best scientific and commercial information available, including observations of how past similar exposures have affected the species and habitat as described in the *Environmental Baseline*. Since habitat modification represents the primary mechanism by which the proposed action has potential effects on individual coho salmon and critical habitat, NMFS utilizes a habitat-based assessment in the *Analysis of Effects* section. By river reach and time of year, NMFS first describes the hydrological modifications that result from the Proposed Action in the action area using Reclamation's modeled flows. NMFS then examines the effects of these hydrological modifications to critical habitat and individuals of the species given the biological and ecological needs of coho salmon in the Klamath River as described in the *Environmental Baseline*. NMFS assesses whether the conditions that result from the Proposed Action, in combination with conditions influenced by other past and ongoing activities and natural phenomena as described in the *Environmental Baseline*[6], will affect the function and value of critical habitat or the growth, survival, or reproductive success (*i.e.*, fitness) of individual coho salmon. The final steps in NMFS risk assessments are described below in the sections reviewing the adverse modification and jeopardy risk assessments.

E. Destruction or Adverse Modification Risk Assessment Approach

To determine if the Project is likely to result in the destruction or adverse modification of designated critical habitat for SONCC coho salmon, we analyze the effects of the action on the elements of critical habitat identified as essential to the conservation of the species. In the *Status of the Species and Critical Habitat* sections, our critical habitat destruction or adverse modification risk assessment begins with a discussion of the biological and physical features (primary constituent elements or essential features) essential to the conservation of SONCC coho salmon at the ESU scale, the current conditions of such features, and the factors responsible for those current conditions. Next, in the *Environmental Baseline* section, NMFS discusses the current condition of critical habitat in the action area, the factors responsible for that condition, the conservation role of those specific areas, and the relationship of critical habitat designated in the action area to the entire designated critical habitat at the ESU scale to the conservation of the SONCC coho salmon ESU following the hierarchical organization outlined above in the *Ecological Conceptual Framework*. In the *Effects of the Action* section, NMFS analyzes the effects of the Proposed Action on critical habitat within the action area. This analysis builds on the habitat-based assessment described for the jeopardy analysis, above. That is, using the best scientific and commercial data available, we estimate the effect of the Proposed Action on water quantity/quality and instream habitat because these effects may influence substrate and sediment levels, water quality conditions, and other general conditions of watersheds that support the biological and ecological requirements of the species. If the effects of the Project, when added to the environmental baseline and combined with cumulative effects, are not reasonably likely to destroy or adversely modify the value of constituent elements essential to the conservation of SONCC coho salmon in the action area, then the action is not likely to destroy or adversely modify designated critical habitat as a whole. Conversely, if the conservation value of the affected essential habitat features in the action area is likely to be destroyed or adversely modified, NMFS must then determine whether the impacts reduce the function of the overall critical habitat at the ESU scale for the conservation of the species or reduce the current ability of the critical habitat to establish essential habitat features and functions. Different areas and features of critical habitat will have varying roles in the recovery of natural, self-sustaining salmon populations. For the final steps, NMFS evaluates whether, with implementation of the Proposed Action, critical habitat would remain functional to serve the intended conservation role for the SONCC coho salmon ESU or retain its current ability to establish those features and functions essential to the conservation of the species.

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[6] NMFS uses modeled “No Project” flows as the nearest approximation of environmental baseline conditions that will continue into the future for the duration of the Proposed Action. This tool is further described in the *Key Assumptions and Tools in NMFS’ Assessment* section.

F. Jeopardy Risk Assessment Approach

The jeopardy risk assessment begins with a diagnosis of the current status of the SONCC coho salmon ESU throughout its geographic range. In other words, NMFS evaluates the current risk of extinction of the SONCC coho salmon ESU given its exposure to human activities and natural phenomena throughout its geographic distribution. As discussed above, NMFS utilizes the VSP conceptual framework for this assessment. The diagnosis describes the species legal status, identifies existing threats, and details the distribution and trends of threats throughout the range of the SONCC coho salmon ESU. We describe the species status in terms of the VSP characteristics of the ESU and the diversity strata within the ESU that are affected by the Proposed Action. In addition, we consider the effects of ongoing changes in climate conditions and the influence of ocean conditions on the species. Because NMFS' opinion as to whether an action is or is not likely to jeopardize a species is based on the species-as-listed scale (ESU for coho salmon), the SONCC coho salmon diagnosis presented in the *Status of the Species and Critical Habitat* sections of this Opinion provides a point-of-reference that NMFS uses in its final steps in the jeopardy analysis within the *Integration and Synthesis* section of this Opinion.

Our jeopardy risk assessment continues with the *Environmental Baseline* section, which is designed to assess the current risk of extinction of coho salmon population units at the action area scale given their exposure to human activities and natural phenomena. As specified under section 7 regulations, the environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The *Environmental Baseline* section of this Opinion identifies the antecedent conditions, including those that likely have resulted from Reclamation's past and current operation of the Project, on individual coho salmon and the viability parameters of coho salmon populations at the action area scale. The evaluation of the current risk of extinction of each coho salmon population unit within the Klamath River Basin provides a reference condition at the population unit scale to which NMFS will add the effects of the Proposed Action. Because our jeopardy analysis must consider the effects of the Proposed Action within the context of the other impacts experienced by the species, some information provided in the *Environmental Baseline* section is also used to describe the conditions faced by the same individuals that will be affected by the future proposed operations of the Project. NMFS uses the analysis of how activities other than Project operations have impacted the fitness (growth, survival, or reproduction) of individual coho salmon to provide the context or condition of the animals that the proposed Project operations will impact for the next eight years.

The *Environmental Baseline* section is organized into several sequential parts. First, NMFS discusses the natural flow regime to summarize the conditions under which coho salmon evolved in the action area. We present this information to provide the reader with an understanding of the patterns and variability in flow within and between years that support the ecological requirements of coho salmon populations. This information is later used to discuss how coho salmon populations are expected to respond to the hydrological effects of the Proposed Action.

Second, existing scientific and commercial information related to the seasonal periodicity and life history traits and biological requirements of coho salmon within the Klamath River and its tributaries is presented. Understanding the spatial and temporal occurrence of coho salmon in the Klamath Basin and its tributaries is a key step in evaluating how coho salmon are exposed to current human activities and natural phenomena. NMFS next summarizes past and current human activities and describes how these activities influence current habitat conditions within each of the three mainstem Klamath River coho salmon population units (Upper, Middle, and Lower) in the action area. NMFS then describes how these habitat conditions influence the current risk of extinction of each population unit using the four key population viability parameters (*i.e.*, abundance, productivity, spatial structure, and diversity).

In the *Effects of the Action* section, NMFS evaluates the likely effects of the Proposed Action to coho salmon within the action area. We use the exposure and response framework described above to identify the probable risks that individual coho salmon will likely experience as a result of the Proposed Action.

Once we have determined how the Proposed Action when added to environmental baseline conditions will affect the fitness of individual coho salmon, the final steps in NMFS' jeopardy risk assessment are to evaluate whether these fitness consequences, in combination with cumulative effects and including future environmental variation, are reasonably likely to result in changes in the risk of extinction of Klamath River coho salmon population units. We complete this assessment by relying on the information available about the species and the specific population units in terms of current and needed levels of abundance, productivity, diversity, and spatial structure characteristics, as presented in the *Status of the Species and Critical Habitat* and the *Environmental Baseline* sections. For example, lower survival resulting from loss or reduction of rearing habitat may reduce abundance. This same reduction can reduce the productive capacity of the river system and impact the productivity of the population, or constrain the ability of individuals of the species to track environmental changes, affecting the diversity and spatial structure of the population. If a population unit is at high risk of extinction due to the current condition of one or more of these characteristics, negative impacts to those same vulnerable characteristics are more likely to increase appreciably the risk of extinction of a population unit. Impacts to less vulnerable characteristics or to a population unit facing a low risk of extinction (generally, a higher likelihood of being at or near a viable state) are less likely to increase the population's risk of extinction.

NMFS may conclude that an action is likely to jeopardize the species through one or more of at least two mechanisms: increases in the risk of extinction of the species or decreases in the chance that the species can become viable or recovered. If the effects of the action are reasonably likely to increase the risk of extinction of one or more of the Klamath River coho population units, we then assess whether this increase is reasonably likely to increase the risk of extinction of the species. Increases in the extinction risk of the species are considered appreciable reductions in the likelihood of both survival and recovery of the species. Conversely, if no increases in a population unit's risk of extinction are expected, we could conclude that the ESU is not appreciably affected by the Proposed Action. However, for the purposes of the jeopardy analysis, NMFS also assesses whether the Proposed Action is expected to reduce the likelihood of an affected diversity stratum contributing to the viability of the species by impacting the ability of one or more of the stratum's member populations to fulfill their intended role in stratum viability. The intended roles of all the populations in the ESU have not yet been defined through a recovery strategy for the species, however, each population within a diversity stratum is expected to fulfill one of two roles. For a stratum to be viable, 50 percent of the independent populations in the stratum must be viable (if there are three or less independent populations in a stratum, at least two of the independent populations must be viable; Williams *et al.* 2007). For example, the Interior- Klamath River Stratum will need three viable independent populations for the stratum to be viable. In addition, the total aggregate abundance of the core populations selected to satisfy this criterion must meet or exceed 50 percent of that historically predicted for the diversity stratum based on the spawner density for population viability. This second stratum criterion requires that proposed recovery scenarios must include historically independent populations that, by virtue of their size and location, were disproportionately important to stratum and ESU function and persistence. For populations not selected to satisfy the independent population criterion above, their role in stratum viability is that they must exhibit occupancy that indicates sufficient immigration is occurring from the core populations (Williams *et al.* 2007).

For the SONCC coho salmon ESU to be viable, each stratum must be viable (Williams *et al.* 2007). Following on the example above, if the effects of the Proposed Action reduce the likelihood that the Interior-Klamath River Stratum becomes viable through increases in the risk of extinction of one or more of its member populations, the likelihood that the SONCC coho salmon ESU could be viable is reduced based on the proposed viability criteria. Therefore, reductions in the likelihood of the Interior-Klamath River Stratum achieving viability are also reasonably likely to reduce the likelihood the SONCC coho ESU would achieve viability; which is to say that the likelihood of both the survival and recovery of the species would be appreciably reduced.

G. Key Assumptions and Tools of NMFS' Assessment

NMFS relied on certain assumptions when assessing effects of the Proposed Action on SONCC coho salmon and their critical habitat. While other assumptions can be found elsewhere in this biological opinion, the assumptions listed here possess a heightened importance in our ability to analyze effects of the Proposed Action. If new information indicates an assumption is invalid, Reclamation and NMFS may be required to re-assess effects of the Proposed Action on SONCC coho salmon and their critical habitat and reinitiation of consultation may be warranted.

1. Water Balance Modeling

Reclamation used the Water Resource Integrated Model (WRIMS) to estimate mainstem Klamath River flows at IGD that would likely be realized through implementation of the Proposed Action. WRIMS is a generalized water resources simulation model for evaluating alternatives in a water resources system. Reclamation provided us with a model run (run 36b) given a suite of assumptions (*e.g.,* surplus water distribution, anticipated Project demand), represented by monthly and bi-weekly time steps over a range of possible UKL inflow exceedences. The results of the model run were provided to us in varying forms and flow exceedence probabilities (Table 6). The flows in Table 6 form the basis of the expected flows that will result from the implementation of the Proposed Action over the eight-year action period. Below, we use this information to describe the flow related effects of Project Operations on coho salmon.

A number of assumptions and model rules are included in Reclamation's model run 36b. As described in the Proposed Action, Reclamation predicts project demand and uses varying sources of information to forecast inflow into UKL and surplus water. The model run prioritized future water allocation as follows: (1) IGD minimum flows and UKL minimum levels, (2) Project demands, and (3) UKL refill targets. Surplus water becomes available when actual UKL volume exceeds the refill target volume, and the model distributed this excess water to either UKL or IGD based on a set of distribution rules. Reclamation initially described this distribution of surplus water as an example of the expected outcome of the IM process (Reclamation 2007). However, in our comments on the final BA, we expressed concerns that Reclamation's approach provided us little assurance that the predicted flows would be realized in the future. Based on our comments, Reclamation has adopted the model rules of run 36b as default operational rules, and the resulting distribution of surplus (*i.e.,* IM) water currently represents the expected flows that will result from the implementation of the Proposed Action.

Reclamation has proposed an IM water management process to provide opportunity for the technical team to make flow and lake level recommendations in a more "real-time" fashion, to benefit species needs. In the event that the technical team recommends flows that deviate from the flows expected in Table 6, we assume they would result in benefits to coho salmon, thereby minimizing the effects described in this analysis, and at the least, recommendations will not result in effects to coho salmon greater than described in our effects analysis for a given exceedence value. Since we can not predict to what degree IM recommendations that deviate from the flows in Table 6 will occur in the future, we are reliant on the outcomes of the WRIMS run 36b as the best representation of future flows for our analysis. In the event that recommended flows would result in greater adverse effects to listed species or critical habitat than are considered in this opinion, re-initiation of section 7 consultation would be warranted.

2. Exceedence Values

Exceedence values were developed from the WRIMS model run (Table 6). Exceedence tables were developed through data sorting and ranking within time periods. Within a water year (*i.e.,* October-September), hydrologic conditions are likely to vary from month to month and, consequently, water year exceedence types would vary as well. Dry weather patterns resulted in reducing the April 1, 2008 average water year type forecast to a May 1, 2008 below average water year type forecast, resulting in appreciable reductions in minimum flows at IGD (3,025 cfs to 1,400 cfs). Under the proposed action, NMFS expects that within a water year, IGD flows will be adjusted to represent various exceedence forecasts and the hydrological shifts in response to conditions will not be as dramatic as under the current Phase III operations. In a wetter year, for example, although flows in April might be at a 40 percent exceedence level, flows in May might be at the 45 percent level, and so on, with the direction of change representative of recent climatological patterns. The calculation of exceedence levels will also be affected by a combination of anthropogenic factors including water use above UKL and Klamath Project demand, given that UKL elevations comprise a component of the seasonal water supply (see *Proposed Action* section).

NMFS evaluated the effects of the proposed operations across the entire year under all exceedence levels to determine the magnitude of project impacts when added to "no project" flows (described below). This evaluation allows NMFS to consider the effects of the action under all possible climate scenarios and to assess how project effects would vary under a variety of water year types and within years. Project effects on fish and specific areas at different times of the year and different climate conditions are described.

3. No Project Flows

To help NMFS analyze the effects of the Proposed Action, we utilize the predicted flows under the Proposed Action and a "No Project" flow condition based on Reclamation's modeling. No Project flows represent the water availability predicted to occur if Reclamation's action was not authorized, funded, or carried out. All other existing non-Reclamation actions influencing water availability remained in place for the analysis. Reclamation modeled UKL levels and Klamath River flows using a number of assumptions, including: (1) UKL will be a level pool and not affected by wind; and (2) the reef at Link River dam would be reconstructed, recreating the original reef elevation stage-discharge relationship. In our effects analysis, we use the No Project percent flow exceedences for the 1961 through 2006 period of record to describe the magnitude of the hydrologic effect of the Project by providing the baseline, or starting, condition of the river system to which we add the effects of proposed operations.

We have chosen an analytical approach that considers flows at IGD most likely to occur under the Proposed Action. We have considered the uncertainties associated with future water availability, and while Reclamation has proposed minimum flows that are certain to be met in the future, there is also certainty that surplus water will be available as well. For example, peak annual stream flows at IGD have exceeded 2500 cfs 42 of the 46 years in the 1961 through 2006 period of record. We consider Reclamation's model and the resulting outputs to reflect the flows reasonably certain to occur at IGD during the 10 year action. We therefore do not just analyze the effects of minimum flows on coho salmon, but rather consider a range of managed flows that are likely to occur under the Proposed Action. NMFS also analyzes the effect of the Proposed Action on the likelihood of experiencing over-bank flows that are outside of the discretion of Reclamation. However, we do not analyze the effect of these over-bank flows on resulting coho salmon habitat availability. In the event that operational assumptions are not accurate (*e.g.,* Project demands are greater than predicted), we anticipate future IGD flows will not be accurately represented by Table 6, and the effects of the Proposed Action on coho salmon may be less or greater than those described in this biological opinion.

4. Climate Change

Recent evaluations of trends in hydroclimatology suggest temporal changes in climate have changed the volume and timing of snowmelt runoff in the Upper Klamath watershed (Reclamation 2008). Declines in precipitation, beginning in 1950, combined with a seasonal warming trend that began in 1977 both represent climatological change that has influenced water availability throughout the mainstem Klamath River. Errors in gauging of the Link River by PacificCorp call into question the validity of using the 1961 through 2006 period of record as an accurate representation of future water availability and Project demand. In response, Reclamation has conducted statistical analyses and determined the current hydrology of the Upper Klamath Basin is still consistent with the historical period of record (1905 through 1912). Reclamation's preliminary conclusions include a determination that diversions of surface flow and the reclaiming of marshlands around UKL have resulted in significant changes to the hydrology of the Upper Klamath Basin, however they also concluded other changes resulting from resource development, including groundwater pumping, do not appear to be significant.

Reclamation concludes the 1961 through 2006 flow accounting records represents the historical period of record. They consider the modeled predicted flows at IGD by percent exceedences in Table 6 are the best representation of expected flows in the future. IGD flows are provided in 5 percent exceedence increments, and Reclamation (2008) anticipates that the implementation of the operational rules should not result in flows per time period that deviate between the next higher and lower exceedence value (*i.e.,* between the flow immediately higher and lower flow as represented in Table 6). NMFS is aware of the operational constraints that may result in flow fluctuations "within time periods," however we expect "within time period" flow fluctuations to stay within the range of flows identified by the next higher and lower exceedence values of the current exceedence level. The 95% exceedence values, however, are considered to be an instantaneous minimum flow. NMFS also expects the resulting average flow for each time period (i.e., bi-weekly or monthly) to meet or exceed the target flow value represented in Table 6.

NMFS assumes that Reclamation's modeled flows, based on the historic period of record, are representative of the conditions over the eight year action period. As part of our assessment, NMFS also considered the implications of a continuation of the pattern of warmer temperatures, decreased snow water equivalents (SWE), and earlier run-off peaks.

IV. STATUS OF THE SPECIES AND CRITICAL HABITAT

The Proposed Action may affect the Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*; April 7, 2006, 71 FR 17757), southern resident killer whale (*Orcinus orca*; April 4, 2007, 72 FR 16284), Southern DPS of Pacific eulachon (*Thaleichthys pacificus*, March 13, 2009, 74 FR 10857), SONCC coho salmon (June 28, 2005, 70 FR 37160), and critical habitat for SONCC coho salmon (May 5, 1999, 64 FR 24049). This opinion analyzes the effects of the Proposed Action on the Southern DPS of North American green sturgeon, Southern DPS of Pacific eulachon, SONCC coho salmon, and critical habitat for SONCC coho salmon. The effects of the Proposed Action to southern resident killer whales will be undertaken in a separate analysis.

A. Southern DPS Green Sturgeon

On April 7, 2006, NMFS listed the Southern DPS green sturgeon as threatened under the ESA (71 FR 17757). The Southern DPS currently consists of a single spawning population in the Sacramento River basin. Southern DPS green sturgeon travel long distances along the coasts of California, Oregon, and Washington and have been regularly observed as far north as the southern edge of Vancouver Island. Bays and estuaries for which NMFS has data on the presence of Southern DPS green sturgeon are: Humboldt Bay, Columbia River, Willapa Bay, and Grays Harbor. For most estuaries on the West Coast, there are either no data available and the presence of Southern DPS green sturgeon is uncertain, or data indicating presence of green sturgeon is available, but uncertainty exists whether the sturgeon are Southern DPS green sturgeon. In the meantime, NMFS expects that Southern DPS green sturgeon may be present in the following California bays and estuaries: Klamath River, Mad River, Eel River, Rogue River, Noyo Harbor, Tomales Bay, Half Moon Bay, Monterey Bay, and Morro Bay. This finding is based on NMFS' examination of the available data and inference of likely sturgeon presence based on the physical and chemical characteristics of these estuaries.

In summer and fall, Southern DPS green sturgeon may enter estuarine habitat, including the Klamath River, to forage on prey organisms. However, they are not anticipated to migrate beyond the estuarine habitat within the Klamath River. As described in the *Lower Klamath River Population Unit* subsection of the *Effects of the Action* section, below, the Project is not expected to adversely affect the physical, chemical and biological resources within the lower Klamath River. Therefore, NMFS concludes the Project is not likely to adversely affect Southern DPS green sturgeon individuals, and therefore is also not likely to jeopardize this species. Southern DPS green sturgeon critical habitat (October 9, 2009, 74 FR 195) is not designated in the Klamath River or affected by the Project. Southern DPS green sturgeon will not be considered further in this Opinion.

B. Pacific eulachon

On March 13, 2009, NMFS proposed listing the Southern DPS of Pacific eulachon (hereafter referred to as eulachon) as a threatened species (March 13, 2009, 74 FR 10857). This DPS encompasses all populations within the states of Washington, Oregon, and California and extends from the Skeena River in British Columbia (inclusive) south to the Mad River in Northern California (inclusive). Adult Pacific eulachon to have been recorded from several locations on the Washington and Oregon coasts, and were previously common in Oregon's Umpqua River, and the Klamath River in northern California (Hay and McCarter 2000, Willson *et al*. 2006, NMFS 2010).

Eulachon are a short lived, high fecundity, high mortality forage fish, and tend to have extremely large population sizes. Eulachon generally spawn in rivers that are either glacier or snowpack fed and that experience spring freshets. Spawning grounds are typically in the lower reaches of larger rivers fed by snowmelt and spawning typically occurs at night. Spawning occurs at between 0 to 10°C throughout the range of the species, and is largely limited to the part of the river that is tidally influenced (Lewis et al 2002). Entry into spawning rivers appears to be related to water temperature and the occurrence of high tides (Ricker et al 1954, Smith and Saalfeld 1955, Spangler 2002), and occurs in January, February, and March in the northern part of the DPS, and later in the spring in the southern parts of the DPS. It has been argued that because these freshets rapidly move eulachon eggs and larvae to estuaries, it is likely that eulachon imprint and home to an estuary into which several rivers drain rather than to individual spawning rivers (Hay and McCarter 2000). Eulachon eggs average 1 mm in size and are broadcast into the water column, attaching to a variety of substrates from sand to pea-sized gravel. Newly hatched young, transparent and 4-7 mm in length, are carried to the sea with the current (Hay and McCarter 2000). They rear in the pelagic zone and return to freshwater to spawn after 3 to 5 years at sea.

There are few direct estimates or fishery independent sources of abundance data available for eulachon, and there is an absence of monitoring programs for them in the United States. However, the combination of catch records and anecdotal information indicate that eulachon were present in large annual runs in the past and that significant declines in abundance have occurred. The Columbia River, estimated to have historically represented fully half of the taxon's abundance, experienced a sudden decline in its commercial eulachon fishery landings in 1993-1994 (WDFW and ODFW 2001, JCRMS 2007). Similar declines in abundance have occurred in the Fraser River and other coastal British Columbia Rivers (Hay and McCarter 2000, Moody 2008). In the Klamath River and the Umpqua River, eulachon were once abundant, but have declined to the point where detecting them has become difficult (NMFS 2010).

There has been no long term monitoring program targeting eulachon in California, making the assessment of historical abundance and abundance trends difficult (Gustafson *et al* 2008). Hubbs (1925) and Schultz and DeLacy (1935), described the Klamath River as the southern limit of the range of eulachon, and more recent compilations state that large aggregations of eulachon were reported to have once regularly occurred in the Klamath River (Fry 1979, Moyle et al. 1995, Larson and Belchik 1998, Moyle 2002). Larson and Belchik (1998) report that the last noticeable runs of eulachon were observed in the Klamath River in 1988 and 1989 by tribal fishers. This report also documented over 119 hours of staff time by the Yurok Tribal Fisheries Program sampling for eulachon in the lower Klamath River at five different sites where eulachon had been encountered in the past, without encountering a single eulachon. In January 2007, six eulachon were reportedly caught by tribal fishermen on the Klamath River (Dave Hillemeier, pers. Comm.).

In winter, Eulachon may enter the Klamath River estuary, to spawn. However, they are not anticipated to migrate beyond the estuarine habitat within the Klamath River. As described in the *Lower Klamath River Population Unit* subsection of the *Effects of the Action* section, below, the Project is not expected to adversely affect the physical, chemical and biological resources within the lower Klamath River. Therefore, NMFS concludes the Project is not likely to adversely affect Eulachon individuals, and therefore is also not likely to jeopardize this species. Eulachon will not be considered further in this Opinion.

C. SONCC Coho Salmon

For the latest status review of SONCC coho salmon, NMFS gathered a core group of scientists from the NMFS Northwest and Southwest Fisheries Science Centers, supplemented by experts on particular species from NMFS and other federal agencies, known as Biological Review Teams (BRTs). In a vote on the status of SONCC coho salmon, a majority (67 percent) of the BRT votes fell in the "likely to become endangered" category, and votes in the endangered category outnumbered those in the "not warranted" category by 2 to 1 (Good *et al.* 2005). Good et al. (2005) determined that the BRT remained concerned about low population abundance throughout the SONCC coho salmon ESU relative to historical numbers and long term downward trends in abundance; however, the paucity of data on escapement of naturally produced spawners in most basins continued to hinder risk assessment. Less-reliable indices of spawner abundance in several California populations reveal no apparent trends in some populations and suggest possible continued declines in others. Additionally, the BRT considered the relatively low occupancy rates of historical coho salmon streams (between 37 percent and 61 percent from brood years 1986 to 2000) as an indication of continued low abundance in the California portion of this ESU.

D. Coho Salmon Life History

Coho salmon adults migrate and spawn in small streams that flow directly into the ocean, or tributaries and headwater creeks of larger rivers (Moyle 2002; Sandercock 1991). Adults migrate upstream to spawning grounds from September through late December, peaking in October and November. Spawning occurs mainly in November and December, with fry emerging from the gravel in the spring, approximately 3 to 4 months after spawning. At a length of 38 to 45 mm, fry may migrate upstream a considerable distance to reach lakes or other rearing areas (Sandercock 1991, Nickelson *et al.* 1992). Juvenile rearing usually occurs in tributary streams with a gradient of 3 percent or less, although they may move up to streams of 4 percent or 5 percent gradient. Juveniles have been found in streams as small as one to two meters wide. They may spend 1 to 2 years rearing in freshwater (Bell and Duffy 2007), or emigrate to an estuary shortly after emerging from spawning gravels (Tschaplinski 1988). Coho salmon juveniles are also known to redistribute into non-natal rearing streams, lakes, or ponds, often following rainstorms, where they continue to rear (Peterson 1982). Emigration from streams to the estuary and ocean generally takes place from February through June, with the peak period being the end of April through May.

E. Range-Wide (ESU) Status and Trends of SONCC Coho Salmon

Reliable current time series of naturally produced adult migrants or spawners are not available for SONCC ESU rivers (Good *et al.* 2005). For a summary of historical and current distributions of SONCC coho salmon in northern California, refer to CDFG's (2002) coho salmon status review, historical population structure by Williams *et al.* (2006), as well as the presence and absence update for the northern California portion of the SONCC coho salmon ESU (Good et al. 2005).

The main stocks in the SONCC coho salmon ESU (Rogue River, Klamath River, and Trinity River) remain heavily influenced by hatcheries and have little natural production in mainstem rivers (Weitkamp *et al.* 1995; Good *et al.* 2005). The listing of SONCC coho salmon includes all within-ESU hatchery programs (June 28, 2005, 70 FR 37160). Trinity River Hatchery maintains high production, with a significant number of hatchery SONCC coho salmon straying into the wild population (NMFS 2001). Straying of Iron Gate Hatchery (IGH) coho salmon into important tributary streams is a frequent occurrence, with hatchery fish making up an average of 16 percent of recovered carcasses in the Shasta River (Ackerman and Cramer 2006). Weitkamp *et al.* (1995) estimated that the rivers and tributaries in the California portion of the SONCC coho salmon ESU had "recently" produced 7,080 naturally spawning coho salmon and 17,156 hatchery returns, including 4,480 "native" fish occurring in tributaries having little history of supplementation with nonnative fish. Combining the California run-size estimates with Rogue River estimates, Weitkamp *et al.* (1995) arrived at a rough minimum run-size estimate for the SONCC coho salmon ESU of about 10,000 natural fish and 20,000 hatchery fish.

All SONCC coho salmon stocks between Punta Gorda and Cape Blanco are depressed relative to past abundance (Weitkamp *et al.* 1995; Good *et al*. 2005). In the latest status review by NMFS, Good et al. (2005) concluded that SONCC coho salmon were likely to become endangered in the foreseeable future, this conclusion being consistent with an earlier assessment (Weitkamp *et al.* 1995).

F. Factors Responsible for SONCC Coho Salmon Decline

1. Major Activities

The major activities identified as responsible for the decline of coho salmon in Oregon and California and/or degradation of their habitat included logging, road building, grazing, mining, urbanization, stream channelization, dams, wetland loss, beaver trapping, artificial propagation, over-fishing, water withdrawals, and unscreened diversions for irrigation (May 6, 1997, 62 FR 24588). Existing regulatory mechanisms, including land management plans (*e.g.,* National Forest Land and Resource Management Plans, State Forest Practice Rules), Clean Water Act section 404 activities, urban growth management, and harvest and hatchery management all contributed by varying degrees to the decline of coho salmon due to the lack, or inadequacy, of protective measures. Below, some of these major activities are covered in more detail.

2. Disease and Predation

Disease and predation were not believed to have been major causes in the species decline; however, they may have had substantial impacts in local areas. Recent data on disease infection, such as ceratomyxosis, on juvenile coho salmon suggest it may have impacts on populations in the Klamath Basin. Higgins *et al.* (1992) and CDFG (1994) reported that Sacramento River pikeminnow have been found in the Eel River basin and are considered major threats to native coho salmon.

3. Artificial Propagation

The authors of this document acknowledge that issues relating to hatchery operations, such as the role of hatchery fish in the recovery of SONCC coho salmon, effects of hatchery releases on the overall productivity and abundance of SONCC coho salmon, and the goals of hatchery programs can be confusing. In writing this opinion, and subjecting it to outside review, it has become clear that hatchery operations have the potential to conflict with the wider goal of SONCC coho salmon recovery. It appears that there may be inconsistencies within certain policy documents, hatchery operations, and peer reviewed literature relating to the effects of hatchery fish on mixed populations of hatchery and naturally produced fish.

Three large mitigation hatcheries annually release approximately 14,215,000 hatchery salmonids into the rivers of the SONCC coho salmon ESU. Additionally, a few smaller hatcheries, such as Mad River Hatchery and Rowdy Creek Hatchery (Smith River) add to the production of hatchery fish in the SONCC coho salmon ESU. Both intra- and inter-specific interactions between hatchery salmonids and SONCC coho salmon may occur in the freshwater and saltwater environments.

Spawning by hatchery salmonids in rivers and streams is often not controlled (ISAB 2002). Hatchery fish also stray into rivers and streams, transferring genes from hatchery populations into naturally spawning populations (Pearse *et al.* 2007). This can be problematic because hatchery programs have the potential to significantly alter the genetic composition (Reisenbichler and Rubin 1999; Ford 2002), phenotypic traits (Hard *et al.* 2000; Kostow 2004), and behavior (Berejikian *et al.* 1996; Jonsson 1997) of reared fish. These genetic interactions between hatchery and naturally produced stocks can decrease the amount of genetic and phenotypic diversity of a species by homogenizing once disparate traits of hatchery and natural fish. The result can be progeny with lower survival (McGinnity *et al.* 2003; Kostow 2004) and ultimately, a reduction in the reproductive success of the natural stock (Reisenbichler and McIntyre 1977; Chilcote 2003; Araki *et al.* 2007), potentially compromising the viability of natural stocks via outbreeding depression (Reisenbichler and Rubin 1999; HSRG 2004).

Flagg *et al.* (2000) found that, except in situations of low wild fish density, increasing release numbers of hatchery fish can negatively impact naturally produced fish because naturally produced fish can get displaced from portions of their habitat. Competition between hatchery and naturally produced salmonids can also lead to reduced growth of naturally produced fish

(McMichael *et al.* 1997). Kostow *et al.* (2003) and Kostow and Zhou (2006) found that over the duration of the steelhead hatchery program on the Clackamas River, Oregon, the number of hatchery steelhead in the upper basin regularly caused the total number of steelhead to exceed carrying capacity, triggering density-dependent mechanisms that impacted the natural population. Competition between hatchery and natural salmonids in the ocean can also lead to density-dependent mechanisms that affect natural salmonid populations, especially during periods of poor ocean conditions (Beamish *et al.* 1997a; Levin *et al.* 2001; Sweeting *et al.* 2003).

4. Climate Change

Climate change is postulated to have a negative impact on salmonids throughout the Pacific Northwest due to large reductions in available freshwater habitat (Battin *et al.* 2007). Widespread declines in springtime SWE have occurred in much of the North American West since the 1920s, especially since mid-century (Knowles and Cayan 2004; Mote 2006). This decrease in SWE can be largely attributed to a general warming trend in the western United States since the early 1900s (Mote *et al.* 2005; Regonda *et al.* 2005; Mote 2006), even though there have been modest upward precipitation trends in the western United States since the early 1900s (Hamlet *et al.* 2005). The largest decreases in SWE are taking place at low to mid elevations (Mote 2006; Van Kirk and Naman 2008) because the warming trend overwhelms the effects of increased precipitation (Hamlet *et al.* 2005; Mote *et al.* 2005; Mote 2006). These climactic changes have resulted in earlier onsets of springtime snowmelt and streamflow across western North America (Hamlet and Lettenmaier 1999; Regonda *et al.* 2005; Stewart *et al.* 2005), as well as lower flows in the summer (Hamlet and Lettenmaier 1999; Stewart *et al.*2005).

The projected runoff-timing trends over the course of the 21st century are most pronounced in the Pacific Northwest, Sierra Nevada, and Rocky Mountain regions, where the eventual temporal centroid of streamflow (*i.e.* peak streamflow) change amounts to 20–40 days in many streams (Stewart *et al.* 2004). Although climate models diverge with respect to future trends in precipitation, there is widespread agreement that the trend toward lower SWE and earlier snowmelt will continue (Zhu et al. 2005; Vicuna et al. 2007). Thus, availability of water resources under future climate scenarios is expected to be most limited during the late summer (Gleick and Chalecki 1999; Miles et al. 2000). A one-month advance in timing centroid of streamflow would also increase the length of the summer drought that characterizes much of western North America, with important consequences for water supply, ecosystem, and wildfire management (Stewart *et al.* 2004). These changes in peak streamflow timing and snowpack will negatively impact salmonid populations due to habitat loss associated with lower water flows, higher stream temperatures, and increased human demand for water resources.

The global effects of climate change on river systems and salmon are often superimposed upon the local effects within river systems of logging, water utilization, harvesting, hatchery interactions, and development (Bradford and Irvine 2000; Mayer 2008; Van Kirk and Naman 2008). For example, total water withdrawal in California, Idaho, Oregon and Washington increased 82 percent between 1950 and 2000, with irrigation accounting for nearly half of this increase (MacKichan, 1951; Hutson *et al.*, 2004), while during the same period climate change was taking place. Climate change will likely complicate the recovery of SONCC coho salmon and make habitat conditions for SONCC coho salmon less favorable for survival, reproduction and growth.

5. Ocean Conditions

Variability in ocean productivity has been shown to affect fisheries production both positively and negatively (Chavez *et al.* 2003). Beamish and Bouillion (1993) showed a strong correlation between North Pacific salmon production and marine environmental factors from 1925 to 1989. Beamish *et al.* (1997b) noted decadal-scale changes in the production of Fraser River sockeye salmon that they attributed to changes in the productivity of the marine environment. Warm ocean regimes are characterized by lower ocean productivity (Behrenfeld *et al.* 2006; Wells *et al.* 2006), which may effect salmon by limiting the availability of nutrients regulating the food supply, thereby increasing competition for food (Beamish and Mahnken 2001). Data from across the range of coho salmon on the coast of California and Oregon reveal there was a 72 percent decline in returning adults in 2007/08 compared to the same cohort in 2004/05 (MacFarlane *et al.* 2008). The Wells Ocean Productivity Index, an accurate measure of Central California ocean productivity, revealed poor conditions during the spring and summer of 2006, when juvenile coho from the 2004/05 spawn entered the ocean (McFarlane *et al.* 2008). Data gathered by NMFS suggests that strong upwelling in the spring of 2007 may have resulted in better ocean conditions for the 2007 coho salmon cohort (NMFS 2008). In 2008 the coldest winter sea surface temperatures of the past 12 years were observed (and probably since the 1970s) and the earliest biological spring transition and highest northern copepod biomass of the past 13 years (NOAA 2010). However, the strong negative PDO began to weaken in June 2009 and abruptly turned positive in August; signaling a change from the very productive ocean conditions of the past two years to poor ocean conditions (NOAA 2010). After June 2009, the ocean began to warm significantly, leading to detrimental changes in the pelagic food web and likely high mortality of juvenile salmonids (NOAA 2010). As a result, expectations for returns of coho in 2010 are considerably lower due to warm sea–surface conditions throughout August 2009 (NOAA 2010). The quick response of salmonid populations to changes in ocean conditions (MacFarlane *et al.* 2008) strongly suggests that density dependent mortality of salmonids is a mechanism at work in the ocean (Beamish *et al.* 1997a; Levin *et al.* 2001; Greene and Beechie 2004).

6. Marine Derived Nutrients

Marine-derived nutrients (MDN) are nutrients that are accumulated in the biomass of salmonids while they are in the ocean and are then transferred to their freshwater spawning sites where the salmon die. The return of salmonids to rivers makes a significant contribution to the flora and fauna of both terrestrial and riverine ecosystems (Gresh *et al.* 2000), and has been shown to be vital for the growth of juvenile salmonids (Bilby *et al.* 1996, 1998). Evidence of the role of MDN and energy in ecosystems suggests this deficit may result in an ecosystem failure contributing to the downward spiral of salmonid abundance (Bilby *et al.* 1996). Reduction of

MDN to watersheds is a consequence of the past century of decline in salmon abundance (Gresh *et al.* 2000).

G. Risk of Extinction of SONCC Coho Salmon

A prerequisite for predicting the effects of a Proposed Action on a species includes an understanding of the condition of the species in terms of their chances of surviving and recovering, and whether the Proposed Action can be expected to reduce these likelihoods. In order to determine the current risk of extinction of the SONCC coho salmon ESU, we used the historical population structure of SONCC coho salmon presented in Williams *et al.* (2006) and the concept of VSP for evaluating populations described by McElhany *et al.* (2000). The work performed by Williams *et al.* (2006) is simply an extension of McElhany *et al.* (2000). While McElhany *et al.* (2000) introduced and described the concept of VSP, Williams *et al.* (2006) applied the concept to the SONCC coho salmon ESU. Williams *et al.* (2006) identified 45 historical populations within the SONCC coho salmon ESU, and further categorized the historical populations based on their distribution and demographic role (*i.e.,* independent, dependent, or ephemeral; Figure 4). Nineteen historical populations were characterized as Functionally Independent, defined as those sufficiently large to be historically viable-in isolation and whose demographics and extinction risk were minimally influenced by immigrants from adjacent populations. Twelve historical populations were characterized as Potentially Independent, defined as those that were potentially viable-in-isolation, but that were demographically influenced by immigrants from adjacent populations. Seventeen historical populations were characterized as Dependent, which are believed to have had a low likelihood of sustaining themselves over a 100-year time period in isolation. These populations received sufficient immigration to alter their dynamics and extinction risk. Finally, two historical populations were characterized as Ephemeral, defined as populations that were both small enough and isolated enough that they were only intermittently present.

Williams *et al.* (2007) calculated the minimum number of spawners for each SONCC coho population in order for a given population to be categorized at low risk for extinction, or considered a viable salmonid population (based on spatial structure and diversity). The abundance of spawners is just one of several criteria that must be met for a population to be considered viable. A population must meet all the low-risk thresholds to be considered viable. Williams *et al.* (2007), however, acknowledged that a viable salmonid population at the ESU scale is not merely a quantitative number that needs to be attained. Rather, for an ESU to persist, populations within the ESU must be able to track changes in environmental conditions. When the location or distribution of an ESU's habitat changes, a species can avoid extinction either by adapting genetically to the new environmental conditions, or by spatially tracking the environmental conditions to which it is adapted (Pease *et al.* 1989 *op. cit.* Williams *et al.* 2007). An ESU persists in places where it is able to track environmental changes, and becomes extinct if it fails to keep up with the shifting distribution of suitable habitat (Thomas 1994 *op. cit.* Williams *et al.* 2007). Therefore, Williams *et al.* (2006) provides a set of rules that will result in certain configurations of populations that will result in a viable ESU. First, using the historical populations, Williams *et al.* (2007) organized the independent and dependent populations of coho salmon in the SONCC ESU into seven diversity strata largely based on the geographical arrangement of the populations and basin-scale environmental and ecological characteristics.

In order for the SONCC coho salmon ESU to be viable, each of the diversity strata needs to be viable. Second, in order for a diversity stratum to be viable, at least two, or 50 percent of the independent populations (Functionally Independent or Potentially Independent), whichever is greater, must be viable, and the abundance of these viable independent populations collectively must meet or exceed 50 percent of the abundance predicted within the diversity stratum when it is at low risk of extinction (Table 8). Third, all dependent and independent populations not expected to meet the low-risk threshold within a diversity stratum must exhibit occupancy patterns that indicate sufficient immigration is occurring from the “core populations.” Finally, the distribution of extant populations, both dependent and independent, needs to maintain connectivity within and among diversity strata.

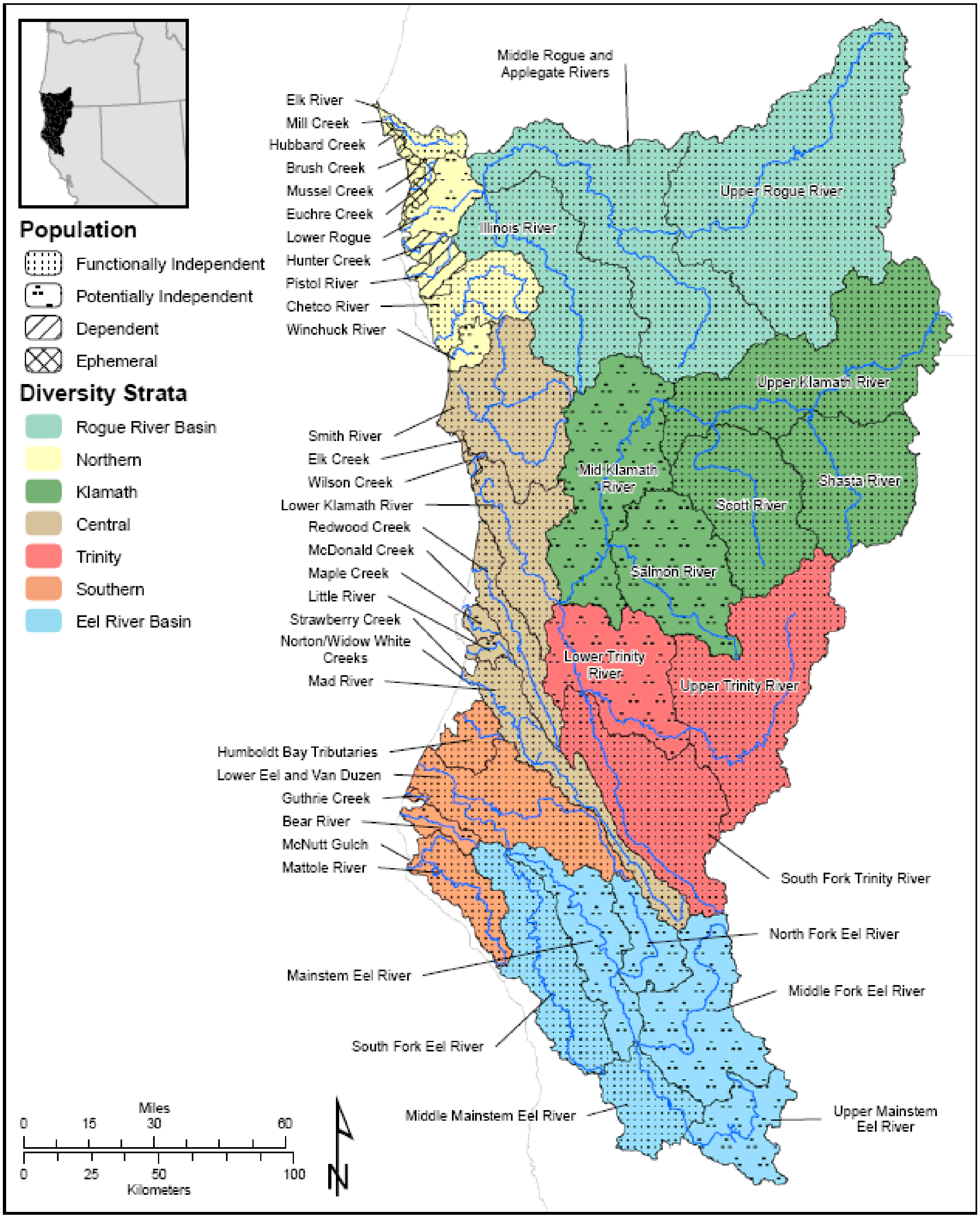


Figure 4. Diversity strata for populations of coho salmon in the SONCC ESU. From Williams *et al.* (2007).

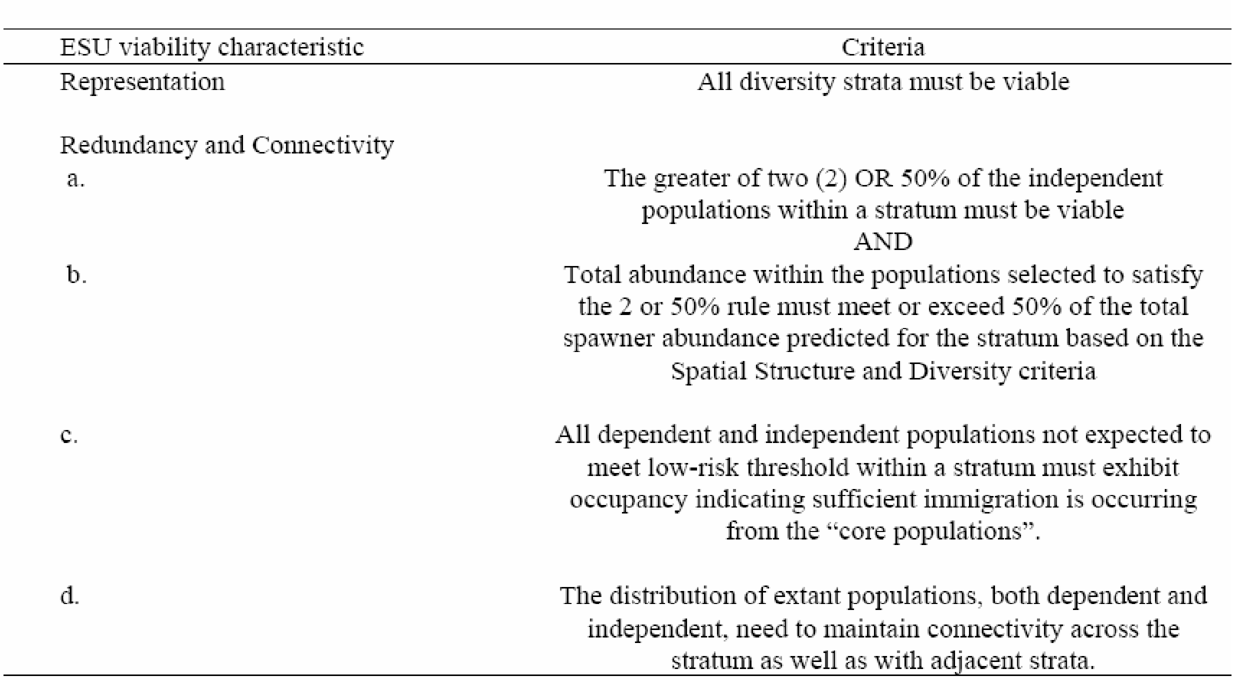
Four principal parameters were used to evaluate the extinction risk for threatened SONCC coho salmon: population size, population growth rate, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmon (McElhany *et al.* 2000). Guidelines have been defined for each of the four parameters to further the viability evaluation. Because some of the guidelines are related or overlap, the evaluation is at times necessarily repetitive. The following provides the evaluation of the risk of extinction for the threatened SONCC coho salmon ESU.

Table 8. Diversity strata of the SONCC coho salmon ESU, including the number of population types (F: functionally independent, P: potentially independent, D: dependent, and E: ephemeral) and the number of spawners needed to satisfy 50 percent of the total number of spawners in a strata needed to meet stratum viability. These data were taken from Williams *et al.* (2007).

	Population types (*n*)				50% Total
Diversity Strata	F	P	D	E	stratum spawners
Northern Coastal Basins	2	2	3	2	6,050
Central Coastal Basins	4	2	5	0	13,200
Southern Coastal Basins	3	1	2	0	11,000
Interior-Rogue River	3	0	0	0	22,650
Interior-Klamath	3	2	0	0	17,900
Interior-Trinity	2	1	0	0	6,350
Interior-Eel	2	4	0	0	13,950

Data compiled by Good et al. (2005) and CDFG (2002) indicate that the population abundance of virtually all diversity strata in the SONCC coho salmon ESU fall below 50 percent of the total number of spawners needed to meet stratum viability proposed by Williams *et al.* (2007). For an ESU to be viable, all the diversity strata within the ESU must be viable (Table 9).
While Williams *et al.* (2007) provided the number of spawners needed to meet stratum viability, quantitative metrics related to the VSP parameters other than population abundance were not given. However, to some extent, the condition of each individual VSP parameter is manifested in the in the current population abundance, because it is the keystone measure of viability; and Spatial Structure and Diversity criteria are embedded within the 50 percent total spawner abundance predicted for any given stratum (Table 9).

Table 9. Summary of ESU viability criteria for SONCC coho salmon.



ESU viability characteristic	Criteria
Representation	All diversity strata must be viable
Redundancy and Connectivity	
a.	The greater of two (2) OR 50% of the independent populations within a stratum must be viable AND
b.	Total abundance within the populations selected to satisfy the 2 or 50% rule must meet or exceed 50% of the total spawner abundance predicted for the stratum based on the Spatial Structure and Diversity criteria
c.	All dependent and independent populations not expected to meet low-risk threshold within a stratum must exhibit occupancy indicating sufficient immigration is occurring from the "core populations".
d.	The distribution of extant populations, both dependent and independent, need to maintain connectivity across the stratum as well as with adjacent strata.

1. Population Size

Information about population size provides an indication of the type of extinction risk that a population faces. For instance, smaller populations are at a greater risk of extinction than large populations because the processes that affect populations operate differently in small populations than in large populations (McElhany *et al.* 2000). One risk of low population sizes is depensation. Depensation occurs when populations are reduced to very low densities and per capita growth rates decrease as a result of a variety of mechanisms [*e.g.,* failure to find mates and therefore reduced probability of fertilization, failure to saturate predator populations (Liermann and Hilborn 2001). Depensation results in a negative feedback that accelerates a decline toward extinction (Williams *et al.* 2007).

Although the operation of a hatchery tends to increase the abundance of returning adults (June 28, 2005 70 FR 37160), the reproductive success of hatchery-born salmonids spawning in the wild can be less than that of naturally produced fish (Araki *et al*. 2007). As a result, the higher the proportion of hatchery-born spawners, the lower the productivity of the population, as demonstrated by Chilcote (2003). Chilcote (2003) examined the actual number of spawners and subsequent recruits over 23 years in 12 populations of Oregon steelhead with varying proportions of hatchery-origin spawners and determined ". . . a spawning population comprised of equal numbers of hatchery and wild fish would produce 63 percent fewer recruits per spawner than one comprised entirely of wild fish." Williams *et al*. (2007), considered a population to be at least at a moderate risk of extinction if the fraction of naturally spawning hatchery fish exceeds 5 percent. Populations have a lower risk of extinction if no or negligible ecological or genetic effects resulting from past or current hatchery operations can be demonstrated.

The most recent status review concluded SONCC coho salmon populations ". . . continue to be depressed relative to historical numbers, and [there are] strong indications that breeding groups have been lost from a significant percentage of streams within their historical range (Good *et al.* 2005)." Experts consulted during the status review gave this ESU a mean risk score of 3.5 (out of 5, with 5 being the highest risk) for the abundance category (Good *et al.* 2005), indicating its reduced abundance contributes significantly to long-term risk of extinction, and is likely to contribute to short-term risk of extinction in the foreseeable future. NMFS concludes this ESU falls far short of McElhany's 'default' goal of historic population numbers and distribution and is therefore not currently viable in regards to the population size VSP parameter.

2. Population Productivity

The productivity of a population (*i.e.,* production over the entire life cycle) can reflect conditions (*e.g.,* environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany *et al.* 2000). In general, declining productivity equates to declining population abundance. The most recent status review for the SONCC coho salmon ESU concluded data were insufficient to set specific numeric population productivity targets for viability (Spence *et al.* 2007, Williams *et al.* 2007). McElhany *et al.* (2000) suggested a population's natural productivity should be sufficient to maintain its abundance above the viable level (a stable or increasing population growth rate). This guideline seems a reasonable goal in the absence of numeric abundance targets.

SONCC coho salmon have declined substantially from historic levels. Experts consulted during the status review gave this ESU a risk score of 3.8 (out of 5, with 5 being the highest risk) for the growth rate/productivity VSP category (Good *et al.* 2005), indicating its current impaired productivity level contributes significantly to long-term risk of extinction and may contribute to short-term risk of extinction in the foreseeable future. As productivity does not appear sufficient to maintain viable abundances in many SONCC coho salmon populations, NMFS concludes this ESU is not currently viable in regards to the population productivity VSP parameter.

3. Spatial Structure

In general, there is less information available on how spatial processes relate to salmonid viability than there is for the other VSP parameters (McElhany *et al.* 2000). Understanding the spatial structure of a population is important because the population structure can affect evolutionary processes and, therefore, alter the ability of a population to adapt to spatial or temporal changes in the species' environment (McElhany *et al.* 2000). The most recent status review for the SONCC coho salmon ESU concluded data were insufficient to set specific population spatial structure targets (Spence *et al.* 2007, Williams *et al.* 2007). In the absence of such targets, McElhany *et al.* (2000) suggested the following: "As a default, historic spatial processes should be preserved because we assume that the historical population structure was sustainable but we do not know whether a novel spatial structure will be."

An ESU persists in places where it is able to track environmental changes, and becomes extinct if it fails to keep up with the shifting distribution of suitable habitat (Thomas 1994 *op. cit.* Williams *et al.* 2007). If freshwater habitat shrinks due to climate change (Battin *et al.* 2007), certain areas such as inland rivers and streams could become inhospitable to coho salmon, which would change the spatial structure of the SONCC coho salmon ESU, having implications for the risk of species extinction.

Relatively low levels of observed presence in historically occupied coho salmon streams (32 to 56 percent from 1986 to 2000) indicate continued low abundance in the California portion of the SONCC coho salmon ESU. The relatively high occupancy rate of historical streams observed in brood year 2001 suggests that much habitat remains accessible to coho salmon (June 28, 2005, 70 FR 37160). Brown *et al*. (1994) found survey information on 115 streams within the SONCC coho salmon ESU, of which 73 (64 percent) still supported coho salmon runs while 42 (36 percent) did not. The streams Brown *et al*. (1994) identified as presently lacking coho salmon runs were all tributaries of the Klamath River and Eel River systems. The BRT was also concerned about the loss of local populations in the Trinity, Klamath, and Rogue River basins (June 28, 2005, 70 FR 37160). CDFG (2002a) reported a decline in SONCC coho salmon occupancy, with the percent reduction dependent on the data sets used. Although there is considerable year-to-year variation in estimated occupancy rates, it appears that there has been no dramatic change in the percent of coho salmon streams occupied from the late 1980s and early 1990s to 2000 (Good *et al*. 2005). In summary, recent information for SONCC coho salmon indicates that their distribution within the ESU has been reduced and fragmented, as evidenced by an increasing number of previously occupied streams from which they are now absent (NMFS 2001). However, extant populations can still be found in all major river basins within the ESU (June 28, 2005, 70 FR 37160).

Experts consulted during the status review gave this ESU a mean risk score of 3.1 (out of 5, with 5 being the highest risk) for the spatial structure and connectivity VSP category (Good *et al.* 2005), indicating its current spatial structure contributes significantly to long-term risk of extinction but does not in itself constitute a danger of extinction in the near future. As the 'default' historic spatial processes described by McElhany *et al.* (2000) have likely not been preserved, due to the habitat fragmentation described above, NMFS concludes this ESU is not currently viable in regards to the spatial structure VSP parameter.

4. Diversity

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics. The more diverse these traits (or the more these traits are not restricted), the more diverse a population is, and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany *et al.* 2000). However, when this diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

The primary factors affecting the diversity of SONCC coho salmon appear to be the influence of hatcheries and out-of-basin introductions. In addition, some brood years have abnormally low abundance levels or may even be absent in some areas (*e.g.,* Shasta River and Scott River), further restricting the diversity present in the ESU. Experts consulted during the most recent status review gave this ESU a mean risk score of 2.8 (out of 5, with 5 being the highest risk) for the diversity VSP category (Good *et al.* 2005). This score indicates the ESU's current genetic variability and variation in life history factors contribute significantly to long-term risk of extinction but do not, in themselves, constitute a danger of extinction in the near future. NMFS concludes the current phenotypic diversity in this ESU is much reduced compared to historic levels, so by McElhany's (2000) criteria it is not currently viable in regards to the diversity VSP parameter.

5. SONCC Coho Salmon Status Summary

a. Abundance

In general, smaller populations face a variety of risks intrinsic to their low abundance levels. Our review of the status of SONCC coho salmon indicates that populations have declined well below historical levels. None of the seven diversity strata have enough returning adults to satisfy the low risk abundance threshold. A host of factors has been responsible for these declines. Rating VSP parameters on a scale from 1 to 5 (5 being the highest risk), the BRT found moderately a high risk of extinction related to species abundance with a mean matrix score of 3.5.

b. Population Productivity

The most recent data indicate continued declines in several populations of the SONCC coho salmon ESU (reduced or negative population growth rate), and an increase in Rogue River coho salmon populations. On a scale from 1 to 5 (5 being the highest risk), the BRT found a moderately high risk of extinction related to species population growth rates, with a mean matrix score of 3.8.

c. Population Spatial Structure

Recent information for SONCC coho salmon indicates that their distribution within the ESU has been reduced and fragmented, as evidenced by an increasing number of previously occupied streams from which they are now absent (NMFS 2001). However, extant populations can still be found in all major river basins within the ESU (June 14, 2004, 69 FR 33102). The BRT considered extinction risk to the species due to its spatial structure to be moderate (mean score = 3.1), on a scale from 1 to 5 (5 being the highest risk).

d. Diversity

The primary factors affecting the diversity of SONCC coho salmon appear to be the influence of hatcheries and out-of-basin introductions (Good *et al.* 2005). In addition, some brood years have abnormally low abundance levels or may even be absent in some areas (*e.g.,* Shasta River), further restricting the diversity present in the ESU (Good *et al.* 2005, Williams *et al*. 2007). The BRT considered extinction risks related to diversity (mean score = 2.8) to be moderate. The BRT's concern for the large number of hatchery fish in the Rogue, Klamath, and Trinity river systems was evident in the risk rating of moderate for diversity (Good *et al.* 2005).

e. Risk of Extinction of the SONCC Coho Salmon ESU

The precipitous decline in abundance from historical levels and the poor status of population viability metrics in general are the main factors behind the extinction risk faced by SONCC coho salmon. The cause of the decline is likely from the widespread degradation of habitat, particularly those habitat attributes that support the freshwater rearing life-stages of the species. A majority (67 percent) of BRT votes fell in the "likely to become endangered" category, although votes in the endangered category outnumbered those in the "not warranted" category by 2 to 1. The viability of an ESU depends on several factors, including the number and status of populations, spatial distribution of populations, the characteristics of large-scale catastrophic risk, and the collective diversity of the populations and their habitat (Lindley *et al.* 2007). Due to data limitations, Williams *et al.* (2007) were not able to assess the viability of the SONCC coho salmon ESU with the quantitative approach they proposed, however, they agree with the previous assessments in CDFG (2002a), Good *et al.* (2005), and Weitkamp *et al.* (1995) that SONCC coho salmon are likely to become endangered in the foreseeable future. Based on the above descriptions of the population viability parameters, and qualitative viability criteria presented in Williams *et al.* (2007), NMFS concludes that the SONCC coho salmon ESU is currently not viable and is at moderate risk of extinction.

H. SONCC Coho Salmon Critical Habitat Analysis

1. Summary of Designated Critical Habitat

Critical habitat for SONCC coho salmon includes all accessible waterways, substrate, and adjacent riparian zones between the Mattole River in California, and the Elk River in Oregon, inclusive (May 5, 1999, 64 FR 24049). Excluded are: (1) areas above specific dams identified in the FR notice; (2) areas above longstanding natural impassible barriers (*i.e.,* natural waterfalls); and (3) tribal lands.

In designating critical habitat, NMFS considers the following requirements of the species: (1) space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing offspring; and, generally, (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of this species (see 50 CFR 424.12(b)). In addition to these factors, NMFS also focuses on the known physical and biological features (essential features) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

Within the range of the SONCC coho salmon ESU, the life cycle of the species can be separated into five essential habitat types: (1) juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) areas for growth and development to adulthood; (4) adult migration corridors; and (5) spawning areas. Areas 1 and 5 are often located in small headwater streams and side channels, while areas 2 and 4 include these tributaries as well as mainstem reaches and estuarine zones. Growth and development to adulthood (area 3) occurs primarily in near-and off-shore marine waters, although final maturation takes place in freshwater tributaries when the adults return to spawn. Within these areas, essential features of coho salmon critical habitat include adequate: (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions (May 5, 1999, 64 FR 24049).

2. Factors Affecting Critical Habitat

a. Timber Harvesting

Substantial timber harvesting has occurred throughout the SONCC coho salmon ESU. In many SONCC coho salmon streams, lack of large woody debris results in decreased cover and reduced storage of gravel and organic debris. Lack of large woody debris (LWD) has also resulted in loss of pool habitat and a reduction in overall habitat and hydraulic complexity in a variety of coho salmon streams (CDFG 2002a). LWD also provides cover from predators and shelter from high flow events. Timber harvest actions combined with rainfall events can cause stream bank erosion, landslides, and mass wasting, resulting in higher sedimentation rates than historical amounts throughout the SONCC coho salmon range. This can cause a reduction in food supply, increases in fine sediments which can destroy spawning gravels, and increase severity of peak flows during storm season. The removal of overhead canopy cover results in increased solar radiation reaching the stream, which results in increased water temperatures (Spence *et al.* 1996). For example in Redwood Creek, in Humboldt County California, altered riparian function and channel aggradation due to land use have caused high water temperatures, making the mid-mainstem inhospitable for coho salmon rearing (Madej *et al*. 2006).

b. Migration Barriers

Stream crossings, such as culverts, that were not designed with fish passage truncate stream habitat on virtually all SONCC coho salmon river systems. Dry stream reaches due to changes in streamflow, diversions, or channel aggradation can also present seasonal barriers to migration.

c. Agricultural Operations

Conversion of many lowland areas for agricultural use has dramatically altered the form and function of streams. Agricultural operations have degraded habitat and limited both water quality and quantity, especially for interior population units in the Rogue and Klamath rivers. Channelization and stream straightening associated with flood control or agricultural operations reduces habitat by limiting stream complexity and increases stream velocities, which can be detrimental to both adult and juvenile coho salmon life stages.

Consumptive water use on many SONCC coho salmon streams has reduced stream flows in the summer and fall months, fragmented habitats, increased stream temperatures, interrupted geomorphological processes that maintain stream health, and created physical barriers to adult and juvenile migration. For example, water use in the Scott River Valley, California, has been associated with reductions in summer and fall base flow (Van Kirk and Naman 2008), which has been cited as a limiting factor in coho production in this stream (NRC 2003). Consumptive water use has also lowered the water table near affected streams, which has limited the ability of riparian plant species to proliferate, thereby exacerbating water temperature problems by increasing thermal radiation. Summer “pushup” dams are still utilized in agricultural and rural communities in the SONCC coho salmon ESU. These temporary dams can alter the streambed, create migration barriers, change stream temperature profiles, and temporarily increase sedimentation.

d. Rural and Urban Development

Substantial development and urbanization in the Rogue River Valley, coastal areas, and other parts of the SONCC coho salmon ESU contribute to habitat impairment. Loss of riparian vegetation, loss of tidal wetlands and floodplains, pollution, stream simplification, and consumptive water use are some of the aspects of urbanization that have degraded habitat of coho salmon near urban centers. Straightening and diking of once braided stream channels to facilitate flood control have reduced the amount of available habitat to rearing coho salmon juveniles, which is common throughout the ESU near small towns and cities. This has resulted in the loss of off-channel rearing and habitat areas that were once available to coho salmon. Riparian vegetation, which once helped shade small streams and rivers, has been removed, elevating stream temperatures. Runoff from city streets and urban lawns has increased nutrient loads in several streams and rivers, creating algae blooms that can eventually deplete the oxygen in a waterway.

e. Road Construction

Roads are a pervasive feature throughout the ESU and reflect a legacy of land use activities. For example, nearly all of the historic populations comprising the SONCC ESU are characterized by high road densities used to harvest timber. In many instances, ongoing maintenance of these roads is lacking or non-existent, leading to continuing impact. Where roads cross salmonid-bearing streams, improperly placed culverts have blocked access to many stream reaches. Landslides and chronic surface erosion from road surfaces are large sources of sediment across the range of the species. Roads also have the potential to increase peak flows with consequent effects on the stability of stream substrates and banks. The consequent impacts on habitat include reductions in spawning, rearing and holding habitat, and increases in turbidity. Cederholm *et al.* (1981) reported that the percentage of fine sediments in spawning gravels increased above natural levels when more than two and one-half percent of a basin area was covered by roads. Across the ESU, this excessive sediment has contributed to decreased survival to emergence as spawning gravels are filled with fine sediments, reduced carrying capacity for juvenile salmonids due to pool filling and reduced feeding and growth due to high turbidity levels.

Spawning areas have been degraded due to sedimentation, alteration of stream flows, and migration barriers. Across the ESU, this excessive sediment has contributed to decreased egg to fry survival as spawning gravels are filled with fine sediments. Mass wasting, or the catastrophic and generally episodic delivery of large volumes of sediment to streams, is a major component of sediment delivery to streams (Spence *et al.* 1996), which can negatively affect spawning areas. Alteration of runoff, due to land use activities, can accelerate surface flows from hillsides to stream channels (Chamberlin *et al.* 1991, McIntosh *et al.* 1994). These accelerated flows can increase summer base (low) flows (Keppeler 1998) and increase peak flows during rainstorms (Ziemer 1998). Removal of vegetation reduces evapotranspiration, which can increase the amount of water that infiltrates the soil and ultimately reaches the stream. One possible effect is increased scour of redds, reducing the success of adult salmonid spawners, as peak flows are increased due to management activities and legacy roads.

f. Watershed Restoration

There are various restoration and recovery actions underway across the ESU aimed at improving habitat and water quality conditions for anadromous salmonids. Watershed restoration activities have improved freshwater critical habitat conditions in some areas, especially on Federal lands. For instance the California Department of Fish and Game created both a multi-stakeholder Coho Recovery Team to address rangewide recovery issues, and a sub-working group [Shasta –Scott Recovery Team (SSRT)] to develop coho salmon recovery strategies associated specifically with agricultural management within the Scott and Shasta Rivers to return coho salmon to a level of viability so that they can be delisted. In addition, the five northern California counties affected by the Federal listing of coho salmon (which includes Humboldt County) have created a 5 County Conservation Plan that will establish continuity among the counties for managing anadromous fish stocks (Voight and Waldvogel 2002). The plan identifies priorities for monitoring, assessment, and habitat restoration projects. The Bear Creek Watershed Council (Rogue River tributary) is developing restorative, enhancement, and rehabilitative actions targeted at limiting factors. Similarly, several assessments have been completed for the Oregon coast in coordination with the Oregon Watershed Enhancement Board. These plans and assessments are helping to reduce, or stabilize, sediment inputs into streams throughout the ESU. Additionally, in areas where riparian vegetation has been replanted or enhanced, stream temperatures and cover for salmonids has been positively affected.

3. Current Condition of Critical Habitat at the ESU Scale

Because the diversity of life history strategies of coho salmon include spending one and sometimes up two years rearing in freshwater (Bell and Duffy 2007), they are especially susceptible to changes within the freshwater environment, more so than fall-run Chinook salmon for example, which migrate to the ocean shortly after emerging from spawning gravels. The condition of habitat throughout the range of SONCC coho salmon is degraded, relative to historical conditions. While some relatively unimpaired streams exist within the ESU, decades of intensive timber harvesting, mining, agriculture, channelization, and urbanization have altered coho salmon critical habitat, sometimes to the extent that it is no longer able to support one or more of the life stages of coho salmon. Below, we provide a summary of the condition of the essential habitat types necessary to support the life cycle of the species (May 5, 1999, 64 FR 24049).

a. Juvenile Summer and Winter Rearing Areas

Juvenile summer and winter rearing areas should contain adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, and space. These essential features are necessary to provide sufficient growth and reasonable likelihood of survival to smoltification. In the SONCC coho salmon ESU, juvenile summer rearing areas have been compromised by low flow conditions, high water temperatures, insufficient dissolved oxygen concentration levels, excessive nutrient loads, invasive species, habitat loss, disease effects, pH fluctuations, sedimentation, removal or non-recruitment of large woody debris, stream habitat simplification, and loss of riparian vegetation. Winter rearing areas suffer from high water velocities due to excessive surface runoff during storm events, suspended, removal or non-recruitment of large woody debris and stream habitat simplification. Changes to streambeds and substrate, as well as removal of riparian vegetation have limited the amount of invertebrate production in streams, which has in turn limited the amount of food available to rearing juveniles. Some streams in the ESU remain somewhat intact relative to their historical condition, but the majority of the waterways in the ESU fail to provide sufficient juvenile summer and winter rearing areas.

b. Juvenile Migration Corridors

Juvenile migration corridors need to have sufficient water quality, water quantity, water temperature, water velocity, and safe passage conditions in order for coho salmon juveniles and smolts to emigrate to estuaries and the ocean, or to redistribute into non-natal rearing zones. Adequate juvenile migration corridors need to be maintained throughout the year because smolts emigrate to estuaries and the ocean from the early spring through the late summer, while juveniles may redistribute themselves at any time in response to fall freshets or while seeking better habitat and rearing conditions. In the ESU, juvenile migration corridors suffer from low flow conditions, disease effects, high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution. Low DO levels, excessive nutrient loads, insufficient pH levels and other water quality factors also afflict juvenile migration corridors.

c. Adult Migration Corridors

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover/shelter and safe passage conditions in order for adults to reach spawning areas. Adults generally migrate in the fall or winter months to spawning areas. During this time of year, suspended sediment makes respiration for adults difficult. Removal or non-recruitment of woody debris and stream habitat simplification has limits the amount of cover and shelter needed for adults to rest during high flow events. Low flows in streams can physically hinder adult migration, especially if fall rain storms are late or insufficient to raise water levels enough to ensure adequate passage. Poorly designed culverts and other road crossings have truncated adult migration corridors and cut off hundreds of miles of stream habitat throughout the SONCC coho salmon ESU. While adult migration corridors are a necessary step in the lifecycle for the species, the condition of this particular essential habitat type in the ESU is probably not as limiting, in terms of recovery of the species, as other essential habitat types, such as juvenile summer and winter rearing areas.

d. Spawning Areas.

Spawning areas for SONCC coho salmon must include adequate substrate, water quality, water quantity, water temperature, and water velocity to ensure successful redd building, egg deposition and egg to fry survival. Coho salmon spawn in smaller tributary streams from November through January in the ESU. A widespread problem throughout the ESU is sedimentation and embedding of spawning gravels, which makes redd building for adults difficult and decreases egg-to-fry survival. Excessive runoff from storms, which causes redd scouring, is another issue that plagues adult spawning areas. Low or non-recruitment of spawning gravels is common throughout the ESU, limiting the amount of spawning habitat.

e. SONCC Coho Salmon Critical Habitat Summary

The current function of critical habitat in the SONCC coho salmon has been degraded relative to its unimpaired state. Although there are exceptions, the majority of streams and rivers in the ESU have impaired habitat. Additionally, critical habitat in the ESU often lacks the ability to establish essential features due to ongoing human activities. For example, large dams, such as IGD on the Klamath River, California, stop the recruitment of spawning gravels, which impacts both an essential habitat type (spawning areas) as well as an essential feature of spawning areas (substrate). Water utilization in many regions throughout the ESU reduces summer base flows, which limits the establishment of several essential features such as water quality and water quantity.

V. ENVIRONMENTAL BASELINE

The environmental baseline includes "the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR 402.02). The environmental baseline provides a reference condition to which we add the effects of operating the Project, as required by regulation ("effects of the action" in 50 CFR 402.02). The evaluation in the *Environmental Baseline* of the current extinction risk for each coho salmon population within the Klamath River Basin, and the condition of critical habitat for each population provides a reference condition at the population scale to which NMFS will later add the effects of the Proposed Action in the *Integration and Synthesis* section of the Opinion to determine if the action is expected to affect the population's risk of extinction. In addition, the effects of all past and present ongoing activities, other than the operation of the Project that will affect individual coho salmon or the essential features of critical habitat are carried forward through the eight-year period of analysis for this action to form the context or baseline to which we add the expected effects of the Proposed Action. This future baseline forms the starting point for an assessment of how changes in individual fitness and condition of essential features of critical habitat affect the species and overall critical habitat designation. For this analysis, the action area includes the historically accessible portion of the mainstem Klamath River to coho salmon (to Iron gate Dam river mile 190) to the Pacific Ocean.

The biological requirements of SONCC coho salmon in the action area vary depending on the life history stage present at any given time (Spence *et al.* 1996; Moyle 2002). For this consultation, the biological requirements for SONCC coho salmon are the habitat characteristics that support successful adult spawning, embryonic incubation, emergence, juvenile rearing, holding, migration and feeding in the action area. Generally, during salmonid spawning migrations, adult salmon prefer clean water with cool temperatures and access to thermal refugia, dissolved oxygen (DO) near 100 percent saturation, low turbidity, adequate flows and depths to allow passage over barriers to reach spawning sites, and sufficient holding and resting sites. Anadromous fish select spawning areas based on species-specific requirements of flow, water quality, substrate size, and groundwater upwelling (Sandercock 1991). Embryo survival and fry emergence depend on substrate conditions (*e.g.,* gravel size, porosity, permeability, and DO concentrations), substrate stability during high flows, and, for most species, water temperatures of 14ºC or less (Quinn 2005). Habitat requirements for juvenile rearing include seasonally suitable microhabitats for holding, feeding, and resting (Moyle 2002). Migration of juveniles to rearing areas requires access to these habitats. Physical, chemical, and thermal conditions may all impede movements of adult or juvenile fish (Moyle 2002).

The Klamath River Basin covers approximately 1,531 square miles of the mainstem Klamath River and associated tributaries (excluding the Trinity, Salmon, Scott and Shasta River sub-basins) from the estuary to Link River Dam. Although anadromous fish passage is currently blocked at IGD, coho salmon once populated the basin at least up to and including Spencer Creek at river mile (rm) 228 (Hamilton *et al.* 2005). Today, coho salmon occupy a small fraction of their historical area (NRC 2004) due to migration barriers and habitat degradation.

Tributary rearing habitat currently accessed by Klamath River coho salmon is compromised to some degree, most commonly by high instream sediment concentrations or impaired riparian communities (see NMFS 2007a for review). High instream sediment concentrations can fill pools and simplify instream habitat, whereas impaired riparian habitat can exacerbate streamside erosion rates and hinder wood input to the stream environment (Spence *et al.* 1996). Both of these processes are common within the Middle and Lower Klamath Population Units, where wide-scale timber harvest has occurred in many tributary basins.

This *Environmental Baseline* section is organized into three parts. First, we describe the connection between the life history traits of coho salmon within the Klamath River and the natural flow regime. Next is a synopsis of the general factors currently affecting coho salmon and its habitat within the entire Klamath River basin, followed by a detailed description of the current habitat conditions within Klamath River Population Units and the past and current impacts that influence those conditions. The final section details the current risk of extinction of the Upper, Middle and Lower Klamath Population Units, as well as the Shasta and Scott Population Units.

A. Connection of the Natural Flow Regime to Coho Salmon Life History

A universal feature of the hydrographs of the Klamath River and its tributaries is a spring pulse in flow followed by recession to a base flow condition by late summer (NRC 2004). This main feature of the hydrographs has undoubtedly influenced the adaptations of native organisms, as reflected in the timing of their key life-history features (NRC 2004). The natural flow regime of a river is the characteristic pattern of flow quantity, timing, rate of change of hydrologic conditions, and variability across time scales (hours to multiple years), all without the influence of human activities (Poff *et al.* 1997). Variability of the natural flow regime is inherently critical to ecosystem function and native biodiversity (Poff *et al.* 1997; Puckridge *et al.* 1998; Bunn and Arthington 2002; Beechie *et al.* 2006). Life history diversity of Pacific salmonids *Oncorhynchus spp*. substantially contributes to their persistence, and conservation of such diversity is a critical element of recovery efforts (Beechie *et al.* 2006). The findings of Waples *et al.* (2001) support the conclusion of Beechie *et al.* (2006) because they found life history and genetic diversity showed a strong, positive correlation with the extent of ecological diversity experienced by a species. The analysis by Williams *et al.* (2006) suggested that substantial environmental variability (*e.g.* wet coastal areas and arid inland regions) within the Klamath River Basin resulted in nine separate populations of coho salmon (see *Status of the Species*). Because aquatic species have evolved life history strategies in direct response to natural flow regimes (Taylor 1991; Waples *et al.* 2001; Beechie *et al* 2006), maintenance of natural flow regime patterns is essential to the viability of populations of many riverine species (Poff *et al.* 1997; Bunn and Arthington 2002). Understanding the link between the adaptation of aquatic and riparian species to the flow regime of a river is crucial for the effective management and restoration of running water ecosystems (Beechie *et al* 2006), because humans have now altered the flow regimes of most rivers (Poff *et al.* 1997; Bunn and Arthington 2002). Additionally, ongoing climatological condition has and will continue to alter streamflow patterns, primarily by making the timing of peak runoff earlier in the year (Stewart *et al.* 2004). When flow regimes are altered and/or simplified, the diversity of life history strategies of coho salmon can be reduced, because life history and genetic diversity have a strong, positive correlation with the extent of ecological diversity experienced by a species (Waples *et al.* 2001). Any reductions in salmonid life history diversity can have implications for their persistence (Beechie *et al.* 2006).

The historic flows of the Klamath River were the hydrologic condition under which coho salmon evolved prior to anthropogenic factors that have altered the hydrological regime. The annual historic hydrological regime of the Upper Klamath River was relatively smooth, with high flows in winter and spring that declined gradually during summer and then recovered in fall (Hecht and Kamman 1996). This pattern reflected the seasonal cycle of fall and winter precipitation and spring rainfall and snowmelt in the basin (Risley and Laenen 1999).

Average daily flows for the 1905-1912 period of record at Keno illustrate the natural flow variation that likely existed prior to the Project (Figure 5). Although data for entire years exists for the period 1906-1911, four years that represent a variety of precipitation levels are shown to limit clutter of the graph. This period of record, although thought to be wetter than normal, is useful for illustrating hydrograph shape and features of the hydrograph such as the point at which low summer base flow was historically reached. Base flows generally incrementally increased through the fall and winter as rainfall events raised the water table and added variability to the hydrograph. In April and May river discharge typically increased as snowmelt from mountainous areas caused the river to swell. Base flows through the spring and summer gradually decreased until reaching minimum flows in the beginning of September.

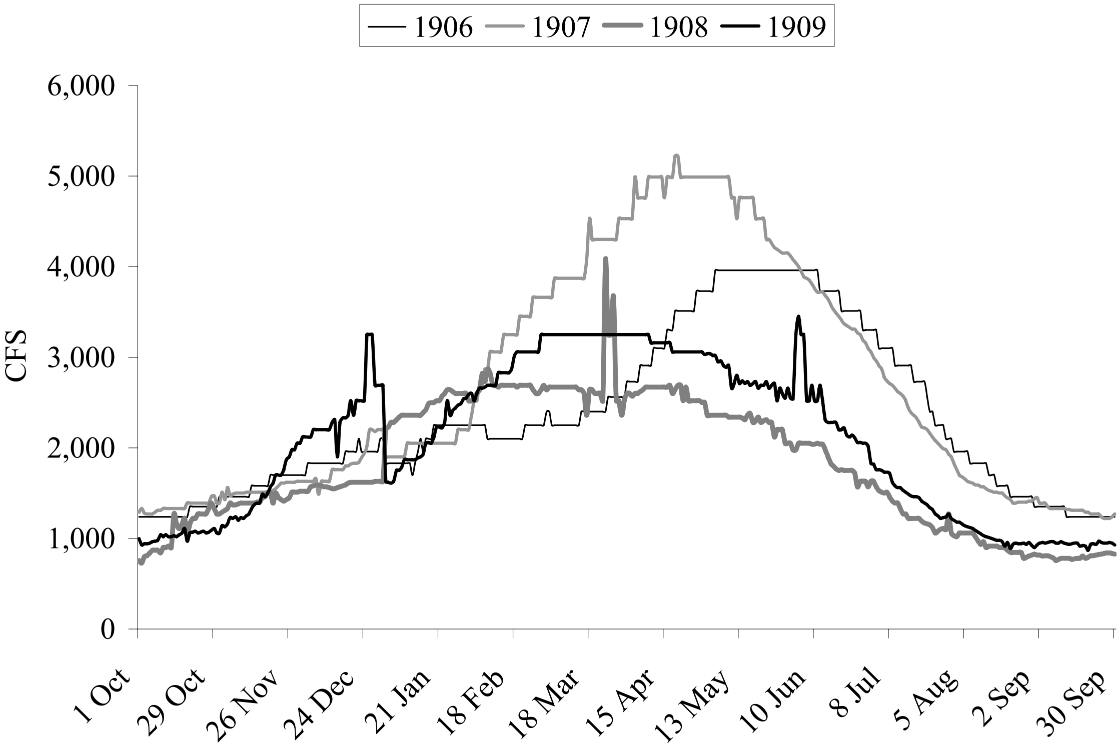


Figure 5. Klamath River discharge at Keno, Oregon (USGS gage data).

Farther downstream in the coastal zone of the Lower Klamath Basin, the hydrologic pattern of the Klamath River is primarily dominated by rainfall events in the fall and winter which affect discharge. Although there are no empirical river discharge data downstream of Keno, Oregon prior to implementation of the Project, modeling results of flows near IGD without the project show similar patterns to discharge at Keno, Oregon (Figure 6). Spring peaks from snowmelt in tributary basins provided a predictable increase in discharge, typically near the end of April (NRC 2004), with base flows reaching a minimum in the beginning of September. In the middle and lower portions of the Klamath River, discharge responded rapidly to rainfall events due to the relatively short length of lower tributary sub-basins (*e.g.,* Salmon River). Historic Klamath River hydrology was diverse, with a range of hydraulic conditions and habitats which in turn supported a variety of life history stages throughout the year (Figure 7). Interior populations of coho salmon (*e.g.,* Upper Klamath, Shasta, Scott) that persisted within spring-fed hydrologic systems experienced instream conditions that differed from those populations located in the coastal zones (*e.g.,* Lower Klamath Population).

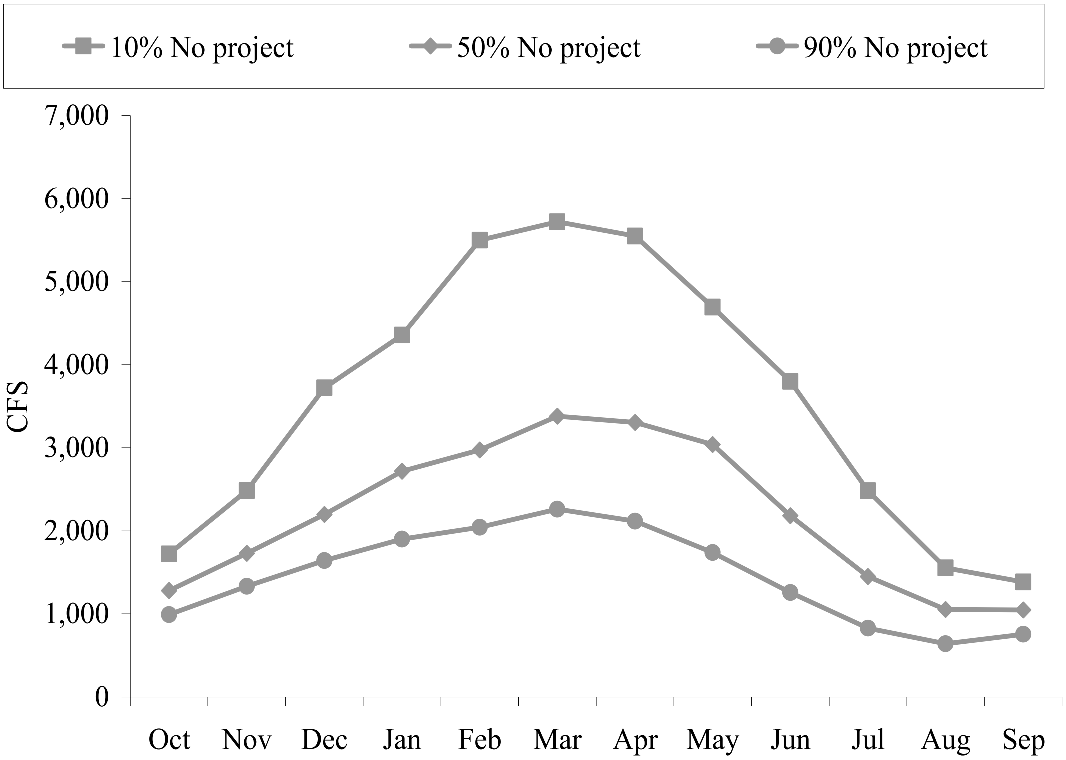


Figure 6. Estimated monthly flow exceedences at IGD without Project operations (data provided by Reclamation).

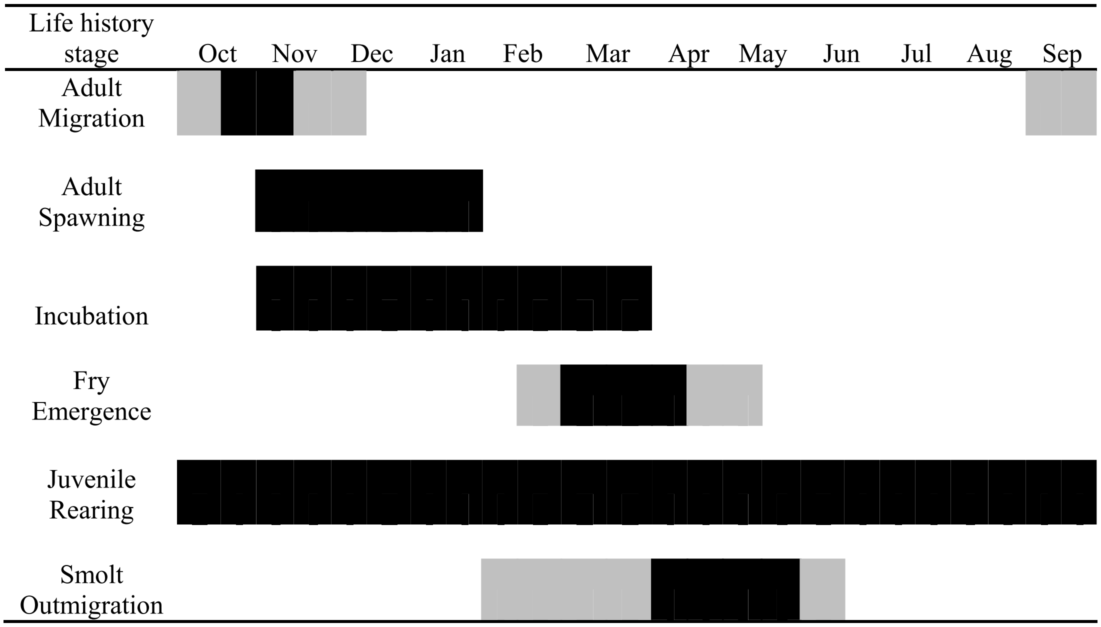


Figure 7. Life stage periodicities for coho salmon within the Klamath River Basin. Black areas represent peak use periods, those shaded gray indicate non-peak periods (Sources: Leidy and

Leidy 1984; NRC 2004; FWS 1998).

B. Life History and Habitat Requirements of Coho Salmon Within the Action Area

1. Periodicity

Coho salmon were once numerous and widespread within the Klamath River basin (Snyder 1931), but now the small populations that remain occupy limited habitat within tributary watersheds and the mainstem Klamath River below IGD (CDFG 2002a; NRC 2004). Coho salmon utilize varied freshwater habitat largely based upon life-stage and season (Sandercock 1991; Quinn 2005). However, habitat use can also be influenced by the quality of existing habitat and watershed function, factors which likely play a large role in coho salmon survival.

2. Adult migration and spawning

Adult coho salmon typically begin entering the lower Klamath River in late September (but as early as late August in some years), with peak migration occurring in mid-October (Ackerman *et al.* 2006; Table 10). . They move into the portion of the mainstem from IGD to Seiad Valley from the late fall through the end of December (FWS 1998). Many returning adults seek out spawning habitat in sub-basins, such as the Scott, Shasta and Trinity rivers, as well as smaller mainstem tributaries throughout the basin with unimpeded access, functional riparian corridors and clean spawning gravel. Coho salmon generally migrate when water temperature in the range of 7.2º to 15.6ºC, the minimum water depth is 18 cm, and the water velocity does not exceed 2.44 m/s (Sandercock 1991). However, coho salmon have been known to migrate at water temperatures up to 19ºC in the Klamath River (Strange 2008). Coho salmon spawning within the Klamath River basin usually commences within a few weeks after arrival at the spawning grounds (NRC 2004) between November and January (Leidy and Leidy 1984).

Coho salmon spawning has been documented in low numbers and as early as November 15 within the mainstem Klamath River. From 2001 to 2005, Magneson and Gough (2006) documented a total of 38 coho salmon redds (egg "nests" within streambed gravels) between IGD (rm 190) and the Indian Creek confluence (rm 109), although over two-thirds of the redds were found within 12 rm of the dam. Many of these fish likely originated from IGH. Progeny of mainstem spawning coho salmon likely experience reduced survival compared to fish produced from tributary spawners (Simondet 2006). Accordingly, Simondet (2006) suggested the survival of these fish would be higher if the fish could utilize higher quality habitat upstream of IGD rather than mainstem habitat below IGD of a lower habitat quality. The amount of mainstem spawning habitat below IGD has been reduced since construction of the dam because, for one thing, the introduction of spawning gravel from upstream sources has been interrupted.

The condition of spawning habitat in tributaries below IGD is generally poor, with many streams suffering from elevated instream sediment concentrations and impeded upstream passage (usually resulting from poorly functioning road crossings, see NMFS 2007a for overview). However, small pockets of suitable spawning and rearing habitat within some streams exist throughout the Klamath Basin. For instance, several mid-size tributaries contain accessible, high quality coho salmon habitat, including Bluff, Red Cap, Boise, Camp, and Blue Creeks (NMFS 2007a). The Shasta and Scott Rivers were once highly productive coho salmon watersheds (CDFG 2002a), but agriculture and timber operations have degraded habitat conditions within both basins (CDFG 2002a; NRC 2004).

3. Egg Incubation and Fry Emergence

Coho salmon eggs typically hatch within 8 to 12 weeks following fertilization, although colder water temperatures may lengthen the process (Bjornn and Reiser 1991). Upon hatching, coho salmon alevin (newly hatched fish with yolk sac attached) remain within redds for another 4 to 10 weeks, further developing while subsisting off their yolk sac. Once most of the yolk sac is absorbed, the 30 to 50 millimeter fish (then termed "fry") begin emerging from the gravel in search of shallow stream margins for foraging and safety (NRC 2004). Within the Klamath River, fry begin emerging in mid-February and continue through mid-May (Leidy and Leidy 1984; Table 10).

4. Juvenile Rearing

a. Fry

After emergence from spawning gravels within the mainstem Klamath River, or as they move from their natal streams into the river, coho salmon fry distribute themselves upstream and downstream while seeking favorable rearing habitat (Sandercock 1991). Further redistribution occurs following the first fall rain freshets as fish seek stream areas conducive to surviving high winter flows (Ackerman and Cramer 2006; YTFP unpublished data). Coho salmon fry have been found occupying habitats with water velocities of 0.0-1.07 m/s, with the most heavily utilized habitats having water velocities of 0.1 to 0.5 m/s (Hardy *et al.* 2006). They use areas with water depths of 0.06 to 0.88 m, with the most utilized habitats having water depths of 0.21 to 0.4 m (Hardy *et al.* 2006). Coho salmon fry are thought to grow best at water temperatures of 12 to 14ºC (Moyle 2002). They do not persist for long periods of time at water temperatures from 22ºC to 25ºC (Moyle 2002 and references therein), unless they have access to thermal refugia. Temperatures greater than 26ºC are invariably lethal (Moyle 2002). Large woody debris and other instream cover are heavily utilized by coho salmon fry (Nielsen 1992; Hardy *et al.* 2006), indicating the importance for access to cover in coho salmon rearing.

b. Parr

As coho salmon fry grow larger (50-60 mm) they transform physically (developing vertical dark bands or "parr marks"), and behaviorally begin partitioning available instream habitat through aggressive agonistic interactions with other juvenile fish (Quinn 2005). These 50 to 60 mm fish are commonly referred to as "parr," and will remain at this stage until they migrate to the ocean. Typical parr rearing habitat consists of slow moving, complex pool habitat commonly found within small, heavily forested tributary streams (Moyle 2002; Quinn 2005). When rootwads, large woody debris, or other types of cover are present, growth is bolstered (Nielsen 1992), which increases survival. Water temperature requirements of parr are similar to that of fry.

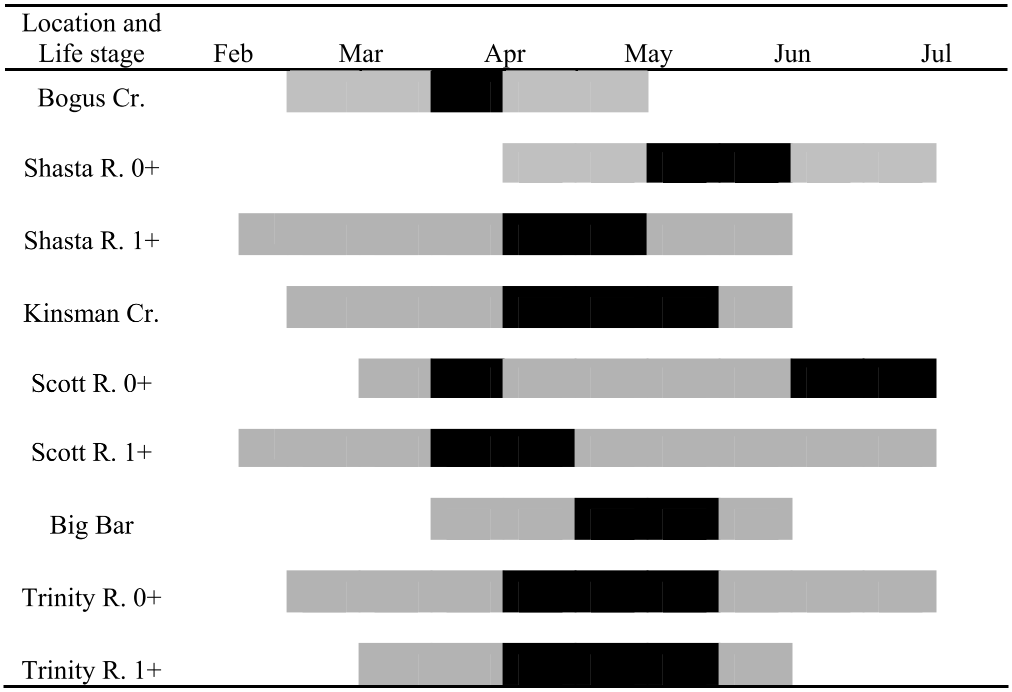
Some coho salmon parr redistribute following the first fall rain freshets, when fish seek stream areas conducive to surviving high winter flows (Ackerman and Cramer 2006; YTFP unpublished data). The Yurok Tribal Fisheries Program (YTFP) and the Karuk Tribal Fisheries Program (KTFP) have been monitoring juvenile coho salmon movement in the Klamath River using passive integrated transponder (PIT) tags. Some coho salmon parr, tagged by KTFP, have been recaptured in ponds and sloughs over 90 river miles away in the lower 6-7 miles of Klamath River. The PIT tagged fish appear to leave the locations where they were tagged in the fall or winter following initial fall freshets before migrating downstream in the Klamath River to off-channel ponds near the estuary where they are thought to remain and grow before emigrating as smolts the following spring (Voight 2008). Several of the parr (~65 mm) that were tagged at locations like Independence Creek (rm 95), were recaptured at the Big Bar trap (rm 51), which showed pulses of emigrating coho salmon during the months of November and December following rainstorms (Soto 2008). Some PIT-tagged parr traveled from one stream and swam up another, making use of the mainstem Klamath during late summer cooling events. Summer cold fronts and thunderstorms can lower mainstem temperatures, making it possible for juvenile salmonids to move out of thermal refugia during cooling periods in the summer (Sutton *et al.* 2004)

Juvenile coho salmon (parr and smolts) have been observed residing within the mainstem Klamath River downstream of IGD within the Upper Klamath Population Unit throughout the summer and early fall in thermal refugia during periods of high ambient water temperatures (>22ºC). Mainstem refugia areas are often located near tributary confluences, where water temperatures are 2 to 6°C lower than the surrounding river environment (NRC 2004, Sutton *et al.* 2004). Habitat conditions of refugia zones are not always conducive for coho salmon because several thousand fish can be crowded into small areas, leading to predator aggregation, increasing competition, and thereby triggering density dependent mechanisms. Robust numbers of rearing coho salmon have been documented within Beaver and Tom Martin Creeks (rm 163 and 143, respectively; Soto 2007), whereas juvenile coho salmon have not been documented, or documented in very small numbers, utilizing cold water refugia areas within the Middle and Lower Klamath Population Units (Sutton *et al.* 2004). No coho salmon were observed within extensive cold-water refugia habitat adjacent to lower river tributaries such as Elk Creek (rm 107), Red Cap Creek (rm 53), and Blue Creek (rm 16) during past refugia studies (Sutton *et al.* 2004). However, Naman and Bowers (2007) captured 15 wild coho salmon ranging in size from 66 mm to 85 mm in the Klamath River between Pecwan and Blue creeks near cold water seeps and thermal refugia during June and July of 2007.

5. Juvenile outmigration

Migrating smolts are usually present within the mainstem Klamath River between February and the beginning of July, with April and May representing the peak migration months (Table 10). Migration rate tends to increase as fish move downstream (Stutzer *et al.* 2006). Yet, some coho salmon smolts may stop migrating entirely for short periods of time if factors such as water temperature inhibit migration. Within the Klamath River, at least 11 percent of wild coho salmon smolts exhibited rearing-type behavior during their downstream migration (Stutzer *et al.* 2006). Salmonid smolts may further delay their downstream migration by residing in the lower river and/or estuary (Voight 2008). Sampling indicates coho salmon smolts are largely absent from the Klamath River estuary by July (NRC 2004).

Table 10. Juvenile coho salmon emigration timing within the Klamath River and tributaries. Black areas represent peak migration periods, those shaded gray indicate non-peak periods. Data for Bogus Creek (rm 190), Kinsman Creek (rm 147), and Big Bar (mainstem; rm 51) were from BOR (2008), life stage was not specified. Data for the Shasta (rm 177) and Scott (rm 143) rivers were from Chesney (2007). Data for the Trinity River (rm 43) were from Pinnix *et al.* (2007).



Many coho salmon parr migrate downstream from the Shasta River and into the mainstem Klamath River during the spring months after emergence and a brief (<3 month) rearing period in the Shasta River (Chesney *et al.* 2007). Water diversions and agricultural operations cause a loss of habitat (decrease in flow, increase in water temperature) in the Shasta River in the summer months and subsequent displacement of young of the year coho salmon from the Shasta River canyon (Chesney *et al.* 2007). In several different years, personnel from CDFG noticed a distinct emigration of 0+ (sub yearling, ≤1 year of age) smolts around the week of May 21 on the Shasta River. Analysis of scales samples indicates that most of these fish are less than one year old (Chesney *et al.* 2007). Unlike the 0+ coho parr in the canyon that are leaving the Shasta River due to loss of habitat, these fish appear to be smolting.

The United States Geological Survey (USGS) and FWS have recently conducted studies aimed at estimating the survival of coho salmon smolts in the Klamath River. In 2006, the overall estimate of apparent survival of 157 wild and 116 radio-tagged hatchery coho salmon from IGD to rm 20.5 was 68.4 percent (95 percent confidence interval (CI) = 0.613 to 0.756) (Beeman 2007). The current data and models indicate little support for a survival difference between hatchery and wild fish in 2006, but considerable model uncertainty exists (Beeman 2007). Survival was lower in the reach from IGH to the Scott River than in reaches farther downstream (Beeman 2007). In 2007, estimated apparent survival of 123 hatchery radio-tagged coho salmon from IGD rm 20.5 was 70 percent (95-percent CI = 0.586 to 0.814), which was comparable to the 2006 results (FWS, unpublished data).

The variability of early life history behavior of coho salmon recently observed by Chesney *et al.* (2007) and by the Yurok and Karuk tribes mentioned in the sections above is not unprecedented; coho salmon have been shown to spend up to two years in freshwater (Bell and Duffy 2007), migrate to estuaries within a week of emerging from the gravels (Tschaplinski 1988), enter the ocean at less than one year of age at a length of 60 to 70 mm (Godfrey *et al.* 1975), and redistribute into riverine ponds following fall rains (Peterson 1982). Taken together, the research by the Yurok and Karuk tribes, plus the research from outside the Klamath Basin, indicate that coho salmon in the Klamath River exhibit a diversity of early life history strategies, utilizing the mainstem Klamath River throughout various parts of the year as both a migration corridor and a rearing zone.

C. Activities Affecting SONCC Coho Salmon and their Critical Habitat in the Action Area

1. Klamath Project

a. Hydrologic alteration

In 1905, Reclamation began developing an irrigation project near Klamath Falls, Oregon. Marshes were drained, dikes and levees were constructed (NRC 2007), and the level of UKL was raised in 1922. Starting around 1912, construction and operation of the numerous facilities associated with the Project significantly altered the natural hydrographs of the upper- and lower-Klamath River. The Project now consists of an extensive system of canals, pumps, diversion structures, and dams capable of routing water to approximately 220,000 acres of irrigated farmlands in the Upper Klamath River Basin.

Hecht and Kamman (1996) analyzed the hydrologic records for similar water years (pre- and post-Project) at several locations. The authors concluded that the timing of peak and base flows changed significantly after construction of the Project, and that the operation increases flows in October and November and decreases flows in the late spring and summer as measured at Keno, Seiad, and Klamath USGS gage sites. Their report also noted that water diversions in areas outside the Project boundaries occur as well. IGD was completed in 1962 to re-regulate flow releases from the Copco facilities, but it did not restore the "pre-project" hydrograph. Rather, base flows were altered. Fall flows were slightly increased while spring and summer flows were substantially reduced. The Iron Gate, California modeled dataset clearly shows, a decrease in the magnitude of peak flows, a two-month shift in timing of flow minimums from September to July, as well as reduction in the amount of discharge in the summer months. By truncating the range of flows that led to diverse coho salmon life history strategies, changes in the annual hydrology had a pronounced effect on coho salmon populations.

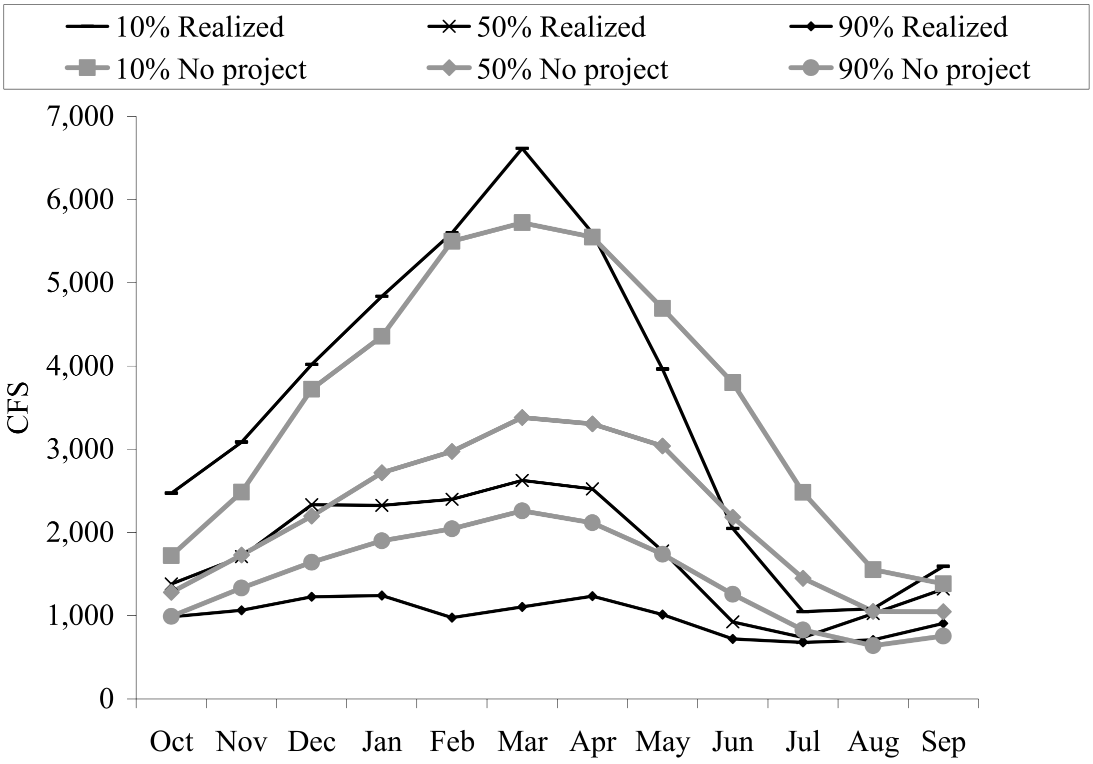


Figure 8. Estimated monthly flow exceedences without Project operations (No project, reef in place) at IGD and actual flow exceedences at IGD (Realized) averaged from 1961 to 2006. Data provided by Reclamation.

Although monthly flow values can be useful for general river-basin planning, they are not useful for ecological modeling for river habitats, because monthly average flows mask important flow variability that may exist only for a few days or less (NRC 2007). In order to address this shortcoming in analyzing monthly flow data, Figure 9 is presented to examine daily historic and current Klamath River discharge patterns at Keno, Oregon.

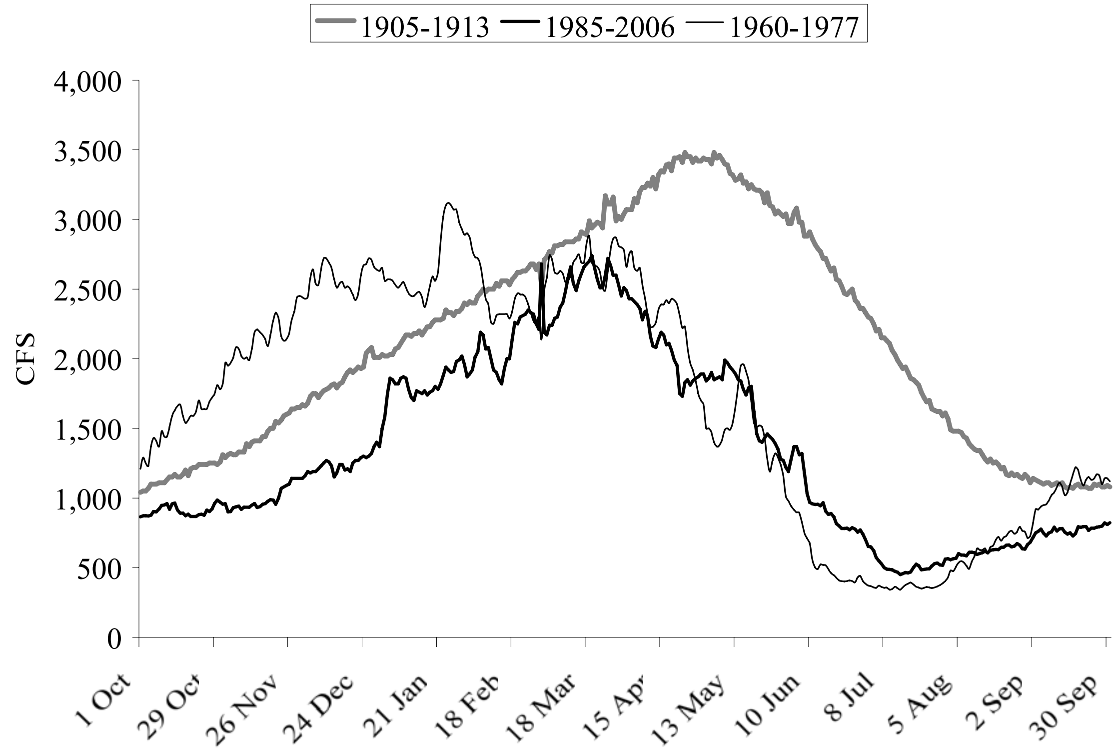


Figure 9. Average daily Klamath River discharge at Keno, Oregon, during three different time periods. The 1905-1913 dataset represents historic, relatively unimpaired river flow, while two more modern time periods represent discharge after implementation of the Project.

Data in Figure 9 are averages of daily discharge across years for three different time periods. The 1905 to 1913 period represents historic, unimpaired flows in the Klamath River. However, diversions to the A-Canal of the Project began in 1906, so the 1905 to 1913 period does not represent completely unimpaired flow. Also shown in Figure 9 are two more modern periods, 1960 to 1977 and 1985 to 2006. These two different modern time periods are shown because the Pacific Decadal Oscillation (PDO) cycled through a cool phase (increased snowpack and streamflow) from the mid-1940s to 1976 and through a warm phase (decreased snowpack and streamflow) from 1977 through at least the late 1990s (Minobe 1997; Mote 2006). By using these two different modern time periods, we can examine the effects of the Project under relatively wet (1960-1977) and relatively dry (1985-2006) climate conditions. These data in Figure 9 show that, regardless of climate conditions, there is now a lower magnitude of peak discharge in the Klamath River at Keno, Oregon, with a shift of more than one month, from the end of April, to the middle of March. Additionally, there is far less discharge (water quantity) during the spring and summer. Historically, river discharge did not reach base (minimum) flow, until September. Whereas after implementation of the Project, minimum flows for the year occur in the beginning of July, a shift earlier in base flow minimum of roughly two months. The high degree of variability in the two more modern period hydrographs is probably due to Pacificorp operations which operated Link River and Keno Dams for power production

b. Current Flow Schedule

Downstream of IGD, flow volumes under the current flow regime are consistent with Phase III flows as outlined within the NMFS 2002 biological opinion for the Project (Table 11; Figure 10).

Table 11. Long-term minimum flows at IGD for five water year types recommended by NMFS.

Month	Water Year Type (values in minimum daily cfs)				
	Dry	Below Average	Average	Above Average	Wet
October-February	1,300	1,300	1,300	1,300	1,300
March	1,450	1,725	2,750	2,525	2,300
April	1,500	1,575	2,850	2,700	2,050
May	1,500	1,400	3,025	3,025	2,600
June	1,400	1,525	1,500	3,000	2,900
July-September	1,000	1,000	1,000	1,000	1,000

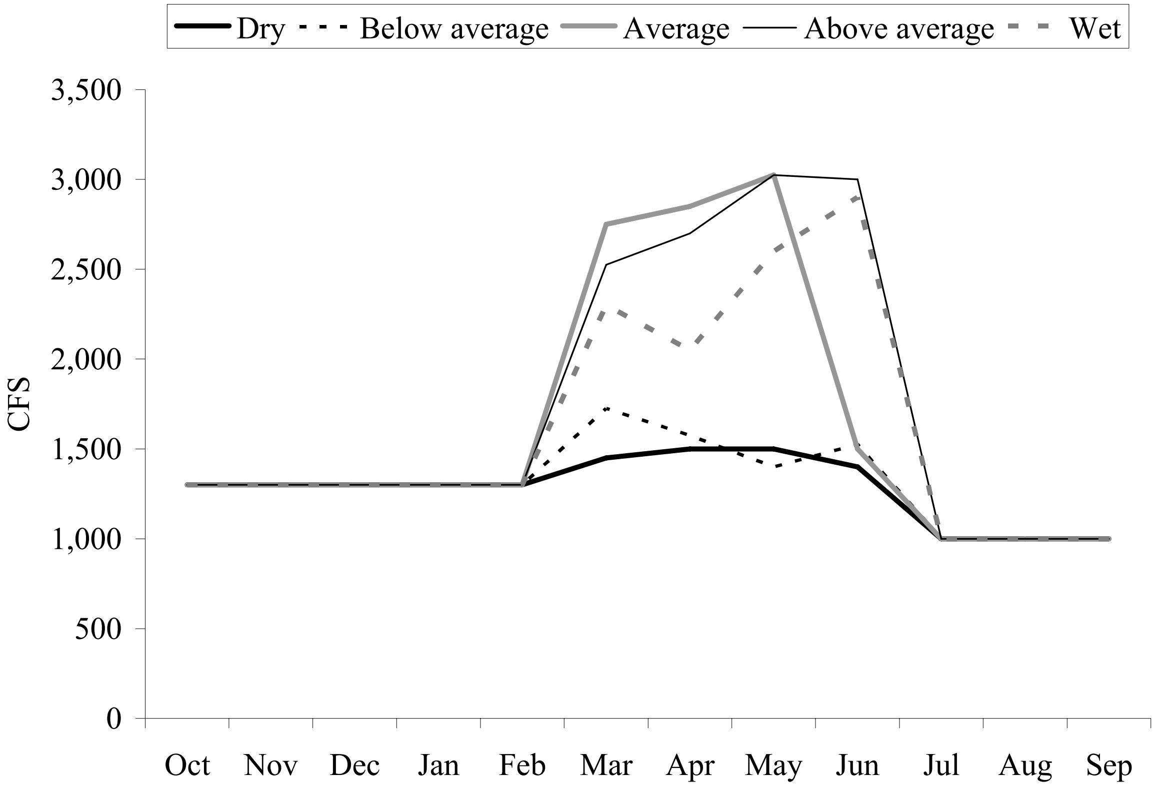


Figure 10. Long term minimum flows recommended by NMFS by water year type at IGD (from NMFS 2002).

Actual daily flows during the period of Phase III implementation (March 27, 2006 through February 20, 2008) have varied from minimums to over 10,000 cfs as a result of spill events due to additional water availability (Figure 11). The years, 2006 and 2007 were classified as wet and below average, respectively, indicating that even in less than average water year types, flow augmentation may occur in spring. However, the extended periods of steady state flows in fall, winter, and summer are indicative of the loss of flow variability under current water operations.

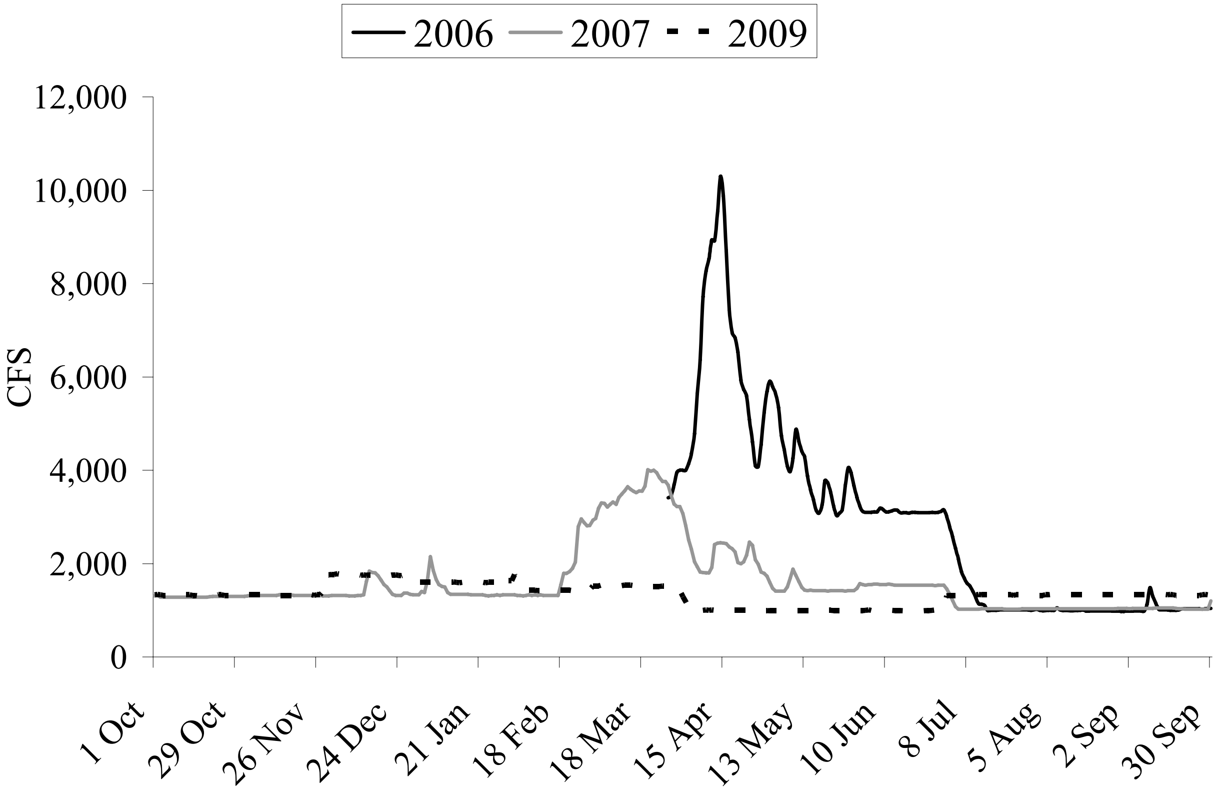


Figure 11. Average daily flows at IGD under Phase III (USGS Gage Data) under three recent water years.

c. *Effects of Phase III Flows on Coho Salmon*

(1) October through February. During this time of year, adult coho salmon enter the Klamath River and begin their spawning migration. Adequate passage conditions must be provided in the mainstem and depending on meteorological conditions, IGD releases may affect passage conditions from IGD to estuary. Juvenile coho salmon are also likely to rear and migrate through the mainstem Klamath River during the fall and winter period, and IGD flows may affect the essential features of juvenile coho salmon rearing habitat.

NMFS (2002) concluded that the FERC minimum IGD flows of 1,300 cfs for the period of October through February were appropriate to provide adequate flows for migration of adult coho salmon. NMFS based this conclusion on limited measurements and observations by biologists. Hardy and Addley (2001) similarly found that fall-run Chinook salmon spawning habitat would be adequate in the IGD to Shasta River reach under this IGD discharge. NMFS assumed that mainstem passage, tributary access, and spawning habitat for adult coho salmon would also be adequate under this IGD flow regime.

NMFS (2002) did not analyze the effects of October through February minimum flows on juvenile coho salmon and their critical habitat. Rearing habitat availability for coho salmon parr and pre-smolts is likely to be limited at times when IGD flows are at or near the minimum 1,300 cfs. These effects to juvenile coho salmon and their critical habitat are described in the following *Effects of the Action* section.

(2) March through June. NMFS developed March through June long-term minimum flows by using coho salmon flow-habitat relationship information described in Hardy and Addley (2001) based on the assumption that providing more rearing habitat in the Klamath River main-stem would result in population growth. In developing March through June long-term flow minimum flows, NMFS focused on conditions to provide adequate migration flows and rearing habitat for coho salmon smolts. NMFS (2002) concluded smolt survival would increase with increasing spring flows.

NMFS (2002) determined that without a metric for determining the precise mainstem Klamath River flows required to provide adequate flows for smolts, appropriate smolt holding habitat and flow conditions would be provided if adequate coho fry habitat is also provided for the following reasons. Since coho fry and smolts co-occur during periods of the year that historically had peak river flows, both life stages would have likely evolved life history characteristics that would have optimized their survival. Therefore, providing adequate habitat conditions for one life stage would likely produce adequate habitat conditions for the other. Therefore, NMFS (2002) used the availability of coho fry habitat as a surrogate for coho smolt habitat conditions.

NMFS' March through June long-term minimum flows generally provide 80 percent of the maximum available habitat that would occur under the estimated unimpaired flow conditions for each of the five water year types. NMFS (2002) concluded this level of habitat availability would be sufficient to avoid impacts to coho salmon populations. NMFS (2007b) also concluded the current Phase III flow regime ensures flow levels during the critical late spring period will provide water quality and fluvial conditions that protect migrating juvenile coho salmon.

NMFS has acknowledged that March through June Phase III flows as sufficient to support coho salmon reproduction, abundance and distribution in the mainstem Klamath River below IGD (NMFS 2002, NMFS 2007b). Current ramping rates at IGD were also considered to be protective of rearing and migrating coho salmon within the lower river (NMFS 2002). However, riparian recruitment within the first several miles below IGD was expected to be impaired by the typically fast recession of the spring hydrograph, since the root growth of newly established vegetation is unlikely to keep up with the rapidly lowering water table (FERC 2006, NMFS 2007b).

(3) July through September. In the development of NMFS' long-term minimum flows for the July through September period, NMFS weighed the uncertainty associated with anticipated effects of flows to coho salmon summer rearing habitat in the mainstem with Hardy and Addley's (2001) recommendation to provide minimum dry summer flows of 1,000 cfs and higher summer flows in wetter years. NMFS (2002) concluded a long-term minimum flow of 1,000 cfs should be released from IGD during the July through September period in all water year types. NMFS based this determination on the expectation that a 1,000 cfs summer minimum flow is likely to maintain the integrity of mainstem thermal refugia, although NMFS conceded that this determination was based on limited information and required further studies on the effects of summer mainstem flows on thermal refugia (NMFS 2002).

d. Project Water Consumption

The Average Apr-Sept agricultural net diversions of the Project were 269 TAF for the period 1985 to 2002, significantly more than the 217 TAF for the period 1962-1984 ($P = 0.015$; Mayer 2008). However, BOR asserted that Apr-Sept agricultural net diversions of the Project were 287 TAF for the period 1985 to 2002 and 243 TAF for the period 1962-1984 (email correspondence from BOR to I. Lagomarsino). From 1962 to 2000, the positive trend in net diversion to the Project was significant (Figure 12, $P = 0.035$). This increase in consumptive use could be due to changes in irrigation and cropping patterns and/or climate change (Mayer 2008).

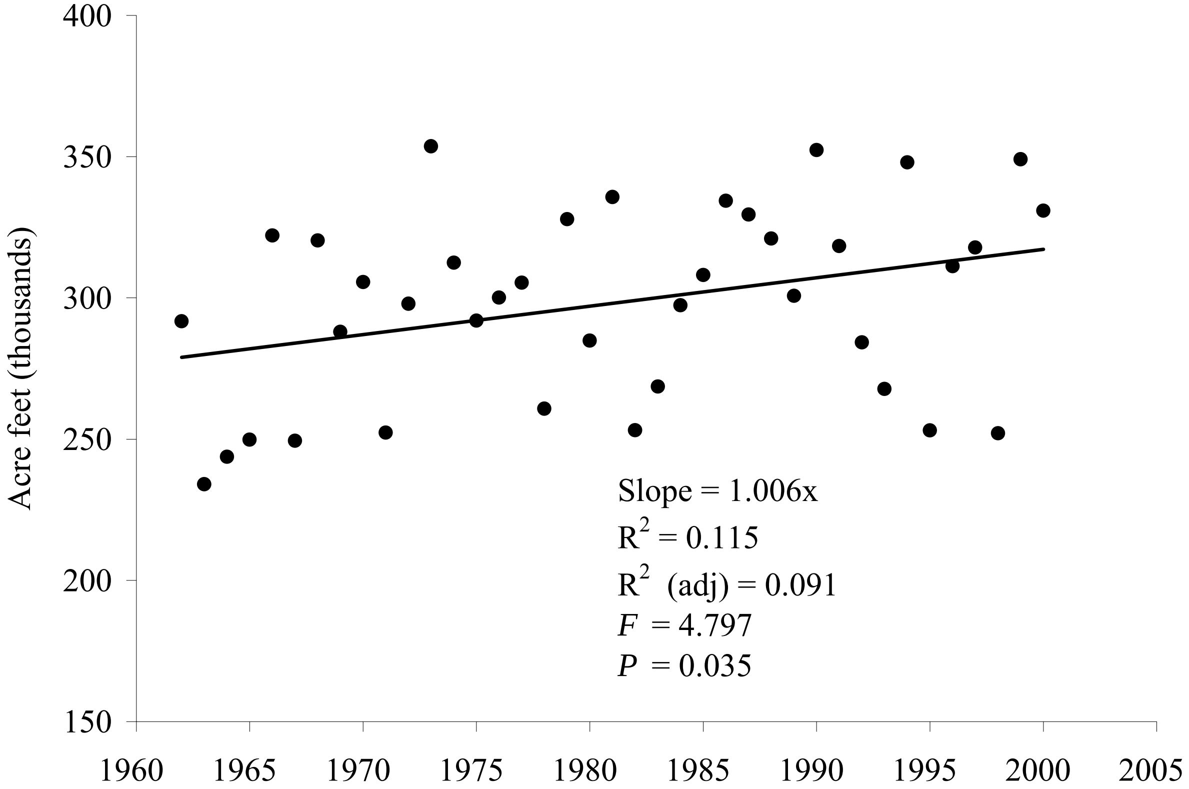


Figure 12**.** Estimated gross Project water diversion (TAF) from April to September, 1962 to 2000. The data do not include Lost River Diversion Canal or Straits Drain returns. The data were provided by Jon Hicks (BOR) then corrected for serial autocorrelation.

e. Water Storage

Although Reclamation has not proposed a land idling component of the Water Bank Program, new storage capabilities, such as the recent additions of approximately 68,000 AF of water storage on Agency Lake/Barnes Ranches and 28,800 AF on the Nature Conservancy's Williamson River Delta Restoration will likely continue (Reclamation 2007). Reclamation also plans to continue the partnership with the Lower Klamath National Wildlife Refuge, which allows for the storage of 12,000-15,000 AF of water. From 2003 to 2007, the years when the water bank was functioning, there was greater outflow from UKL lake and greater river flow at Keno than would have been expected based on the historic relationship (Mayer 2008).

2. Agriculture

Crop cultivation and livestock grazing in the upper Klamath River Basin began in the mid-1850s. Since then, valleys have been cleared of brush and trees to provide more farm land. By the late 1800s, some native perennial grasses were replaced by non-native species. This, combined with soil compaction, resulted in higher surface erosion and greater peak water flows in streams. Other annual and perennial crops cultivated included grains, alfalfa hay, potatoes and corn.

Besides irrigation associated with the Project, other non-Project irrigators operate within the Klamath River Basin. Irrigated agriculture both above and surrounding UKL consists of approximately 180,000 acres. Estimated average consumptive use is approximately 350,000 acre feet per year. Current agricultural development in the Shasta River Valley consists of approximately 51,600 acres of irrigated land. Estimated consumptive use of irrigation water by the crops is approximately 100,000 acre feet per year. Actual diversions would exceed the consumptive use of the crops due to irrigation application efficiency, conveyance losses in the system and surface evaporation. Current agricultural development in the Scott River Valley, which has increased significantly since the 1970s, consists of approximately 29,000 acres of irrigated land with an estimated annual irrigation withdrawal of approximately 81,070 acre feet per year (Van Kirk and Naman 2008). Agricultural diversions in both the Shasta and Scott rivers in some years, especially dry water years, can virtually dewater sections of these rivers, impacting coho salmon within these streams as well as those in the Klamath River.

A series of diversion dams on the Trinity River, a tributary of the Klamath River, transfers water from the Klamath River Basin to the Sacramento River Basin. The difference in elevation between the Trinity River and the Sacramento River facilitates generation of hydroelectric power. Starting in 1964 and continuing until 1995, an average of 1.2 million acre feet per year, or 88 percent of the Trinity River flow, was diverted into the Central Valley Project within the Sacramento River Basin. This diversion contributed to the decline of coho salmon populations within the Klamath River Basin. Currently, 51 percent of Trinity River flow is diverted to the Sacramento Basin (TRFE 1999).

There are two other diversion systems within the Klamath River Basin. Fourmile Creek and Jenny Creek diversions transfer water from the Klamath River Basin into the Rogue River Basin. Estimated annual (1960-1996) out of basin diversions from the Fourmile Creek drainage of the Klamath River basin to the Rogue River Basin was approximately 4,845 acre-feet. Net out of basin diversions from the Jenny Creek drainage of the Klamath River Basin to the Rogue River Basin were approximately 22,128 acre-feet (38,620 acre-feet exported - 16,492 acre-feet imported). Thus the total average annual (1960 to 1996) diversions from the Klamath River Basin to the Rogue River Basin was 26,973 acre-feet (La Marche 2001).

As the value of farm lands increased throughout the Klamath River Basin, flood control measures were implemented. During the 1930s, the U.S. Army Corps of Engineers implemented flood control measures in the Scott River Valley by removing riparian vegetation and building dikes to constrain the stream channel. As a result of building these dykes (banking), the river became more channeled, water velocities increased, and the rate of bank erosion accelerated. To minimize damage, the Siskiyou Soil Conservation Service planted willows along the stream-bank and recommended channel modifications take place which re-shaped the stream channel into a series of gentle curves. The effectiveness of these actions has not yet been measured.

There has been a recent decline in UKL outflows since the 1960s, which may be due to increasing diversions, decreasing net inflows, or other factors (Mayer 2008). There have been declines in winter precipitation in the upper Klamath Basin in recent decades and declines in upper-Klamath Lake inflow and tributary inflow, particularly base flows (Mayer 2008). Declines in tributary base flow could be due to increase consumptive use, in particular, groundwater utilization, and/or climate changes. Agricultural diversions from the lake have increased over the 1961 to 2007 period, particularly during dry years (Mayer 2008). Declines in Link River flows and Klamath River at Keno flows in the last 40-50 years have been most pronounced during the base flow season (Mayer 2008), the time when Project demands are the greatest. It is well known that Project demands increase in dry years (Mayer 2008). Given climate warming, effects to coho salmon due to agriculture may increase during the 10 year action period due to increasing water demand, expected reduced snowpack and water availability, and increasing evapo-transpiration rates.

Consumptive use of water is expected to negatively impact one or more of the VSP criteria for the interior Klamath population units because it reduces summer and fall discharge of tributaries that the populations utilize (Van Kirk and Naman 2008); and low flows in the summer have been cited as limiting coho salmon survival in the Klamath Basin (CDFG 2002a; NRC 2004). Agricultural operations can negatively impact critical habitat of coho salmon by reducing the quality and quantity of water and water temperature available to rearing juveniles during the summer months. Specifically, the spatial structure, population abundance, and productivity can be impacted by agricultural activities.

3. <u>FERC relicensing</u>

In 2004, PacifiCorp filed an application with the Federal Energy Regulatory Commission (FERC) for a new license for its Klamath Hydroelectric Project, which includes four dams on the mainstem Klamath River. PacifiCorp' application did not include provisions for volitional fish passage. Under its Federal Power Act authorities, NMFS and the U.S. Department of the Interior issued modified prescriptions for fishways and recommended certain fishery protection, mitigation and enhancement measures in the FERC relicensing proceeding on January 26, 2007, including a mandatory condition for volitional fish passage. Therefore, under a new license, PacifiCorp would be required to retrofit its four dams with fish ladders.

PacifiCorp' relicensing effort also brought together a diverse group of interests to resolve the Klamath River Basin's long-standing conflicts over limited supplies of water resources. The group consisted of Counties, irrigation districts in the upper Klamath Basin, tribes, conservation and fishing organizations, and federal and state agencies. On February 18, 2010, these diverse parties, including PacifiCorp, came together to sign the Klamath Hydroelectric Settlement Agreement (KHSA) and the Klamath Basin Restoration Agreement (KBRA). The KBRA is intended to: (1) restore and sustain natural fish production and provide for full participation in ocean and river harvest opportunities of fish species throughout the Klamath Basin; (2) establish reliable water and power supplies which sustain agricultural uses, communities, and National Wildlife Refuges; and (3) contribute to the public welfare and the sustainability of all Klamath Basin communities. The KHSA lays out a process for additional studies, environmental review, and a determination by the Secretary of the Interior by March 31, 2012 regarding whether removal of four dams owned by PacifiCorp: (1) will advance restoration of the salmonid fisheries of the Klamath Basin; and (2) is in the public interest. Subject to an affirmative determination by the Secretary, removal of the dams is targeted for 2020 in order to provide for planning, permitting, and ratepayer funding. The KHSA and KBRA together represent the largest dam removal project and river restoration effort in U.S. history.

Removal of PacifiCorp' Hydroelectric facilities are dependent on a determination by the Secretary of the Interior (Secretarial Determination). Prior to the Secretarial Determination, the Secretary of the Interior, in cooperation with the Secretary of Commerce, shall conduct certain actions, including review under the National Environmental Policy Act and further appropriate studies as necessary to determine whether to proceed with Facilities Removal. Based on those actions, the Secretary of the Interior, in cooperation with the Secretary of Commerce, shall use best efforts to determine by March 31, 2012, whether, in his judgment, specific conditions have been satisfied; and "Facilities Removal (i) will advance restoration of the salmonid fisheries of the Klamath Basin, and (ii) is in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes. If the Secretary of the Interior makes an affirmative determination related to these conditions, he must designate a Dam Removal Entity (DRE), subject to provisions regarding concurrence by the States of Oregon and California related to the Secretarial Determination and the designation of the DRE. The DRE must complete a plan for Facilities Removal and perform Facilities Removal in accordance with applicable permits and other requirements. Facilities Removal is scheduled to occur in 2020, subject to listed assumptions and conditions related to funding.

Under the KHSA, prior to Facilities Removal, PacifiCorp will continue to operate its Klamath Hydroelectric Project in accordance with specific terms and a schedule of "Interim Measures". The following Interim Measures are intended to provide benefits to SONCC coho salmon:

(1) PacifiCorp will establish a fund of a least $500,000 per year to be administered in consultation with the CDFG and NMFS to fund actions within the Klamath Basin designed to enhance the survival and recovery of coho salmon and focused on the three coho populations most effected by the Hydroelectric Project (*i.e.*, Upper

Klamath, Shasta, and Scott coho populations). PacifiCorp funded $500,000 of habitat improvement projects in 2009.

(2) PacifiCorp will implement turbine venting on an ongoing basis beginning in 2009 to improve dissolved oxygen concentrations downstream of Iron Gate dam. PacifiCorp will develop a standard operating procedure in consultation with NMFS for turbine venting operations and monitoring.

(3) PacifiCorp will fund the development and implementation of a Hatchery and Genetics Management Plan (HGMP) for the Iron Gate Hatchery.

(4) In coordination with NMFS, USFWS, States and Tribes, PacifiCorp and Reclamation will annually evaluate the feasibility of enhancing fall and early winter flow variability to benefit salmonids downstream of Iron Gate Dam, subject to both PacifiCorp's and Reclamation's legal and contractual obligations.

(5) PacifiCorp will establish a fund in the amount of $500,000 in total funding to study fish disease relationships downstream of Iron Gate Dam.

(6) PacifiCorp shall provide one-time funding of $100,000 to convene a basin-wide technical conference on water quality by February 18, 2011. The purpose of this measure is to improve water quality in the Klamath River during the Interim Period leading up to dam removal. The emphasis of this measure shall be nutrient reduction projects in the watershed to provide water quality improvements in the mainstem Klamath River, while also addressing water quality, algal and public health issues in Project reservoirs and dissolved oxygen in J.C. Boyle Reservoir. Between February 18, 2010 until the date of the Secretarial Determination, PacifiCorp will spend up to $250,000 per year to be used for studies or pilot projects developed in consultation with the Implementation Committee regarding the following: a) Development of a Water Quality Accounting Framework, b) Constructed Treatment Wetlands Pilot Evaluation, c) Assessment of In-Reservoir Water Quality Control Techniques and d) Improvement of J.C. Boyle Reservoir Dissolved Oxygen

4. Timber harvest

In general, timber management activities allow more water to reach the ground, and may alter water infiltration into forest soils such that less water is absorbed or the soil may become saturated faster, thereby increasing surface flow. Road systems, skid trails, and landings where the soils become compacted may also accelerate runoff. Ditches concentrate surface runoff and intercept subsurface flow bringing it to the surface (Chamberlin *et al.* 1991; Furniss *et al.* 1991). Significant increases in the magnitude of peak flows or the frequency of channel forming flows can increase channel scouring or accelerate bank erosion.

Several forest practices and management plans have been enacted in the Klamath Basin. The Northwest Forest Plan (NFP) is an integrated, comprehensive design for ecosystem management, intergovernmental and public collaboration, and rural community economic assistance for federal forests in western Oregon, Washington, and northern California. Since adoption of the NFP in 1994, timber harvest and road building have decreased dramatically on federal lands within the range of the Northern spotted owl, including federal lands within the Klamath River Basin [*i.e.,* Six Rivers, Klamath, and Shasta-Trinity National Forests] and road decommissioning has increased.

Along the lower Klamath River, Green Diamond Resource Company owns and manages approximately 265 square miles of lands below the Trinity River confluence for timber production. The company has completed an HCP for aquatic species, including SONCC coho salmon, and NMFS issued an ESA section 10(a)(1)(B) Incidental Take Permit on June 12, 2007. The HCP commits Green Diamond to repairing approximately half of its high- and moderate-priority road sites, property-wide, over the first 15 years of implementation.

As a result of the listing of Northern California steelhead under the ESA, the California Department of Forestry (CDF) imposed stricter guidelines to protect and restore watersheds with threatened or impaired values (T&I Rules) beginning on July 1, 2000. The T&I Rules minimize impacts to salmonid habitat resulting from timber harvest by requiring special management actions in planning watersheds where populations of anadromous salmonids listed as threatened, endangered, or candidate under the state or federal ESA currently preside or are restorable. Timber harvest has been trending downwards in recent decades.

Effects from timber harvest are expected to continue for the duration of the action and for years following the action, but with the effects slightly decreasing through time. The effects of timber harvesting to the VSP parameters of the interior Klamath population units may vary from neutral to negative impacts that impede the diversity and spatial structure of populations over the duration of the action.

5. Fish harvest

Coho salmon have been harvested in the past in both coho- and Chinook-directed ocean fisheries off the coasts of California and Oregon. More stringent management measures that began to be introduced in the late 1980s have reduced coho salmon harvest substantially. Initial restrictions in ocean harvest were due to changes in the allocation of Klamath River fall-run Chinook salmon (KRFC) between tribal and non-tribal fisheries. These restrictions focused on the Klamath Management Zone where the highest KRFC impacts were observed (Good *et al.* 2005). Coho salmon retention was expanded to include all California waters in 1995 (Good *et al.* 2005). With the exception of some authorized harvest by the Yurok, Hoopa Valley and Karuk tribes for subsistence, ceremonial and commercial purposes[7], the retention of coho salmon is also prohibited in California river fisheries. In order to comply with the SONCC coho salmon conservation objective, projected exploitation rates on Rogue/Klamath River hatchery coho salmon stocks are calculated during the preseason planning process using the coho salmon Fishery Regulation Assessment Model (FRAM, Kope 2005). Season options are then crafted that satisfy the 13 percent maximum ocean exploitation rate. In recent years,

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[7] Good *et al.* (2005) reported that coho salmon harvest by the Yurok tribe, which were the only tribal harvest data available, ranged from 42 to 135 fish between 1997 and 2000 and increased to 895 fish in 2001. The majority of this catch (63-86 percent) was comprised of hatchery fish.

these rates have been well below 13 percent with five of the last eight years at or below 6 percent and no year exceeding 9.6 percent. Due to the predicted low abundance of Sacramento River Basin fall-run Chinook salmon, severe ocean salmon fishing closures were adopted for 2008. Ocean exploitation rates are anticipated to be negligible in 2008. Post-season estimates are not performed due to a lack of information necessary to generate accurate expansions of in river coded wire tag (CWT) recoveries (Kope 2005). Tribal and other harvest effects are expected to continue during the eight year action and for several years thereafter.

While NMFS does not expect that these effects will be decreasing over the course of the eight year action, we are unaware if these effects will remain consistent or increase over time. The effects of fish harvesting to the VSP parameters of the interior Klamath population units may vary from neutral to negative over the duration of the action. The main impact to the VSP parameters is a reduction in the population abundance level. However, by selecting for certain size classes, runs, or certain ages of individuals, harvesting can also impact genetic diversity. By reducing the number of adults returning to a stream or river, fish harvesting can in turn reduce the amount of marine derived nutrients, which can impact summer and winter juvenile rearing areas by limiting the amount of food available to juveniles as invertebrate production may suffer.

6. Climate change

Climate change is postulated to have a negative impact on salmonids throughout the Pacific Northwest due to large reductions in available freshwater habitat (Battin *et al.* 2007). The hydrologic characteristics of the Klamath River main stem and its major tributaries are dominated by seasonal melt of snowpack (NRC 2004). Van Kirk and Naman (2008) found statistically significant declines in April 1 Snow Water Equivalent (SWE) since the 1950s at several snow measurement stations throughout the Klamath Basin, particularly those at lower elevations (<6000 ft.). Mayer (2008) found declines in winter precipitation in the upper-Klamath Basin. The overall warming trend that has been ubiquitous throughout the western united states (Groisman et al. 2004), particularly in winter temperatures over the last 50 years (Feng and Hu 2007; Barnett *et al.* 2008) has caused a decrease in the proportion of precipitation falling as snow (Feng and Hu 2007). Basins below approximately 1800-2500 m in elevation appear to be the most impacted by reductions in snowpack (Knowles and Cayan 2004; Mote 2006; Regonda *et al*. 2005). Some of the largest declines in snowpack over the Western U.S. have been in the Cascade Mountains and Northern California (Mote *et al.* 2005; Mote 2006). These declines in snowpack are expected to continue in the Klamath Basin and increase the demand for water by humans (Döll 2002, Hayhoe *et al.* 2004) and decrease water availability for salmonids (Battin *et al.* 2007). These decreases in water supply and increases in irrigation demand are likely to negatively impact coho salmon in the Klamath Basin.

Bartholow (2005) found that the Klamath River is increasing in water temperature by 0.5°C/decade, which may be related to warming trends in the region (Bartholow 2005) and/or alterations of the hydrologic regime resulting from the Project, logging, and water utilization in Klamath River tributary basins. Particularly, changes in the timing of peak spring discharge, and decreases in water quantity in the spring and summer may affect salmonids of the Klamath River. Most life history traits (*e.g.* adult run timing, juvenile migration timing) in Pacific salmon have a genetic basis (Quinn *et al.* 2000; Quinn 2005) that has evolved in response to watershed characteristics (e.g. hydrograph) as reflected in the timing of their key life-history features (Taylor 1991; NRC 2004). In their natural state, anadromous salmonids become adapted to the specific conditions of their natal river like water temperature and hydrologic regime (Taylor 1991; NRC 2004). Therefore, the extent, and speed of changes in water temperatures and hydrologic regimes of the Klamath River and associated tributaries will determine whether or not coho salmon of the Klamath River are capable of adapting to changing river conditions.

Climate change may at best complicate recovery of coho salmon, or at worst hinder their persistence (Beechie *et al.* 2006; Van Kirk and Naman 2008). By negatively affecting freshwater habitat for Pacific salmonids (Mote *et al.* 2003; Battin *et al.* 2007), climate change is expected to negatively impact one or more of the VSP criteria for the interior Klamath population units. Climate change can reduce the spatial structure by shrinking the amount of freshwater habitat available to coho salmon. Diversity could also be impacted if one specific life history strategy is disproportionately affected by climate change. Population abundance can also be reduced if fewer juveniles survive to adulthood. Climate change affects critical habitat by decreasing water quantity and quality, and limiting the amount of space available for summer juvenile rearing.

7. Hatcheries

Two fish hatcheries operate within the Klamath River basin, Trinity River Hatchery (TRH) near the town of Lewiston and IGH on the mainstem Klamath River near Hornbrook, California. Both hatcheries mitigate for anadromous fish habitat lost as a result of the construction of dams on the mainstem Klamath and Trinity Rivers, and production focuses on Chinook and coho salmon, and steelhead. Trinity River Hatchery releases roughly 4.3 million Chinook salmon, 0.5 million coho salmon and 0.8 million steelhead annually. IGH releases approximately 6.0 million Chinook salmon, 75,000 coho salmon and 200,000 steelhead annually, for a total of roughly 11,875,000 hatchery salmonids released into the Klamath Basin annually. IGH releases Chinook salmon from the middle of May, to the end of June, a time when discharge from IGD is in steep decline and water temperatures are rapidly rising, which may create competition between hatchery and natural fish for food and limited resources, especially limited space and resources in thermal refugia.

Hatchery operations may have a suppressive effect on coho salmon through predation and competition, and it should not be assumed that hatchery operations are beneficial to salmonids or to coho salmon in particular (NRC 2004). When released into the freshwater, hatchery fish may compete with naturally produced fish for food and habitat (McMichael *et al.* 1997; Fleming *et al.* 2000; Kostow *et al.* 2003; Kostow and Zhou 2006). The exact effects on juvenile coho salmon from competition and displacement in the Klamath River from the annual release of 5,000,000 hatchery-reared Chinook salmon smolts from IGH are not known. However, Chinook salmon are released from IGH at virtually the same time that coho salmon peak emigration occurs in the Klamath River, near the middle of May (Figure 7), the same period that the hydrograph is in sharp decline. In a review of 270 references on ecological effects of hatchery salmonids on natural salmonids, Flagg *et al.* (2000) found that, except in situations of low wild fish density, increasing release numbers of hatchery fish can negatively impact naturally produced fish. It was also evident from the review that competition of hatchery fish with naturally produced fish almost always has the potential to displace wild fish from portions of their habitat (Flagg *et al.* 2000). The substantial increase in density of juvenile salmonids, combined with the reduction in instream habitat resulting from decreased flows in May resulting from hydrologic alteration of the Klamath River (see Hydrologic Alteration section above), could have negative impacts on coho salmon juveniles. During May, and into the summer, sometimes hundreds or even thousands of juvenile salmonids can be forced by water temperatures into small areas with cold water influence (Sutton *et al.* 2007). The NRC (2004) recommended altering the number of fish released at IGH and TRH in order to gain a better understanding of the extent to which hatchery fish impact natural production.

Another important consideration in regards to SONCC coho salmon diversity, spatial structure, and productivity is how smaller coho salmon populations from tributaries such as the Scott and Shasta Rivers, which are important components of the ESU viability, are affected by straying of hatchery fish. Pearse *et al.* (2007) found that hatchery steelhead adults sampled from IGH in 2001 clustered strongly [genetically] with smolts sampled by screw trap in the Shasta and Scott Rivers, suggesting that significant gene flow has occurred between IGH and these nearby tributaries, presumably due to 'straying' of returning hatchery adults. Outmigrating hatchery smolts are known to utilize the Shasta River, so it is likely that some may return to spawn there as well (Pearse *et al.* 2007). Although it is possible that the screw trap samples represent mixtures of smolts originating from multiple, distinct, upstream populations, the pairwise F_{ST} (Fixation index, a measure of population differentiation values) between IGH and the screw trap samples were among the lowest significant values observed (0.004–0.009), supporting the hypothesis of high gene flow between the hatchery and these populations (Pearse *et al.* 2007). CDFG (2002b) found that 29 percent of coho salmon carcasses recovered at the Shasta River fish counting facility (SRFCF) had left maxillary clips in 2001, indicating that they were progeny from IGH. The average percentage of hatchery coho salmon carcasses recovered at the SRFCF from 2001, 2003, and 2004 was 16 percent (Ackerman and Cramer 2006). These data indicate that substantial straying of IGH fish occurs into important tributaries of the Klamath River, like the Shasta River, which has the potential to reduce the reproductive success of the natural population (Mclean *et al.* 2003; Chilcote 2003; Araki *et al.* 2007) and negatively affect the diversity of the interior Klamath populations via outbreeding depression (Reisenbichler and Rubin 1999; HSRG 2004).

The effects due to hatcheries are expected to continue throughout the eight year action and for the foreseeable future thereafter, potentially increasing over time due to climate change. For example, freshwater habitat availability for juvenile coho salmon rearing and migration is expected to decrease in the future due to climate warming (Mote *et al.* 2003; Battin *et al.* 2007); therefore, competition for limited thermal refuge areas will increase. Bartholow (2005) found a warming trend of 0.5°C/decade in the Klamath River and a decrease in average length of river with temperatures below 15°C (8.2 km/decade), underscoring the importance of thermal refugia areas. However, hatchery releases are expected to remain constant during this period of shrinking freshwater habitat availability, which makes the detrimental impact from density-dependent mechanisms in the freshwater environment to naturally produced coho salmon populations increase through time under a climate warming scenario. In this way, hatcheries impact the critical habitat of coho salmon by limiting the amount of space available to rearing juveniles.

Behrenfeld *et al.* (2006) found that ocean productivity is closely coupled to climate variability. A transition to a warmer climate state and sea surface warming may be accompanied by reductions in ocean productivity which affect fisheries (Beamish and Mahnken 2001; Ware and Thomson 2005; Behrenfeld et al 2006). The link between total mortality and climate could be operating via the availability of nutrients regulating the food supply and hence competition for food (i.e. bottom–up regulation) in the ocean (Beamish and Mahnken 2001; Ware and Thomson 2005). Hatchery releases may exacerbate the effect of reductions in ocean productivity on naturally produced salmonids through density-dependent mechanisms, which have their strongest effect during the first year of salmonid life in the ocean (Beamish and Mahnken 2001), because hatchery releases are rarely reduced during years of poor ocean productivity (Beamish *et al.* 1997a; Levin *et al.* 2001; Sweeting *et al.* 2003). These competitive effects may negatively affect the population abundance and productivity of the interior Klamath populations.

8. Restoration

There are various restoration and recovery actions underway in the Klamath Basin aimed at improving habitat and water quality conditions for anadromous salmonids. Congress authorized $1.0 M annually from 1986 through 2006 to implement the Klamath River Basin Conservation Area Restoration Program. The Klamath River Basin Fisheries Task Force (Task Force) was established by the Klamath River Basin Fishery Resources Restoration Act of 1986 (Klamath Act) to provide recommendations to the Secretary of the Interior on the formulation, establishment, and implementation of a 20-year program to restore anadromous fish populations in the Klamath River Basin to optimal levels. The 16-member Task Force included representatives from the fishing community, county, state and federal agencies, and tribes. A Technical Work Group of the Task Force provided technical and scientific input. In 1991, the Task Force developed the Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program to help direct fishery restoration programs and projects throughout the Klamath River.

In addition to creating a fishery restoration plan for the river basin restoration program, the Task Force also encouraged local watershed groups to develop restoration plans for each of the five sub-basins of the lower Klamath River Basin. These groups included the

Shasta River Coordinated Resource Management Planning Group (Shasta sub-basin), Scott River Watershed Council (Scott sub-basin), Salmon River Restoration Council (Salmon sub-basin), Karuk Tribe and Mid-Klamath Watershed Council (mid-Klamath sub-basin), and the Yurok Tribe (lower-Klamath sub-basin). Since 1991, over $1.3 M has been given to these groups to develop the sub-basin plans and conduct restoration activities. Funds from the Klamath Act are often leveraged to develop broader restoration programs and projects in conjunction with other funding sources, including CDFG restoration grants. As an example, nearly $1.9 M of CDFG restoration funding was spent on a variety of Klamath River Basin restoration projects during the 2002-2006 period alone. While the Klamath River Basin Conservation Area Restoration Program ended in 2006, federal funds were authorized for fiscal year 2007, and the FWS continues to administer funds in the near term consistent with the goals of the program.

The Trinity River Restoration Program (TRRP) was created as part of the 1984 Trinity River Basin Fish and Wildlife Management Act authorizing the Secretary of the Interior to develop and implement a management program to restore fish and wildlife populations in the Trinity River Basin to levels which existed prior to construction of the Trinity and Lewiston Dams. The program is focused on improving habitat conditions for salmonid fry by increasing channel complexity and restoring river-floodplain connectivity

In August, 2004, the California State Fish and Game Commission listed coho salmon north of San Francisco Bay under the California Endangered Species Act (CESA). CDFG created both a multi-stakeholder Coho Recovery Team to address rangewide recovery issues, and a sub-working group [Shasta –Scott Recovery Team (SSRT)] to develop coho salmon recovery strategies associated specifically with agricultural management within the Scott and Shasta Rivers to return coho salmon to a level of viability so that they can be delisted. The SSRT continues to work cooperatively with CDFG on the Shasta and Scott River Watershed-wide Permitting Program (Permitting Program) being developed by CDFG in consultation with the Siskiyou RCD, Shasta Valley RCD, and agricultural operators within the Scott and Shasta River watersheds. The Permitting Program will implement key coho salmon recovery tasks while facilitating compliance with CESA and Fish and Game Code section 1602 because both agricultural water diversions and agricultural land practices may adversely affect coho salmon and its habitat.

In 2002, NMFS began ESA recovery planning for the SONCC and Oregon Coast coho salmon ESUs through a scientific technical team created and chaired by the Northwest and Southwest Regional Fishery Science Centers, referred to as the Oregon and Northern California Coast coho salmon technical recovery team (TRT). As a part of the larger TRT, a SONCC working group is focusing on coho salmon populations within the SONCC coho salmon ESU, which includes all populations within the Klamath River basin. The final phase of recovery planning for the SONCC coho salmon ESU is underway (September 11, 2006, 71 FR 53421).

NOAA administers several grant programs to further restoration efforts in the Klamath River Basin. Since 2000, NMFS has issued grants to the States of California and Oregon, and Klamath River Basin tribes (Yurok, Karuk, Hoopa Valley and Klamath) through the Pacific Coast Salmon Restoration Fund (PCSRF) for the purposes of restoring coastal salmonid habitat. California integrates the PCSRF funds with their salmon restoration funds and issues grants for habitat restoration, watershed planning, salmon enhancement, research and monitoring, and outreach and education. Screening has reduced entrainment mortality and increased abundance.

Restoration activities are expected to benefit coho salmon and their critical habitat. These effects are expected continue throughout the duration of the action, possibly increasing during that time period. Passage improvements have reintroduced critical habitat. Restoration activities are expected to improve upon on or more of the VSP parameters for the interior Klamath populations.

9. Mining

Mining activities within the Klamath River Basin began prior to 1900. Many of the communities in the Klamath River Basin originated with the gold mining boom of the 1800s. Water was diverted and pumped for use in sluicing and hydraulic mining operations. This resulted in dramatic increases in turbidity levels altering stream morphology. The negative impacts of stream sedimentation on fish abundance were observed as early as the 1930s. Mining operations adversely affected spawning gravels, which resulted in increased poaching activity, decreased survival of fish eggs and juveniles, decreased benthic invertebrate abundance, adverse affects to water quality, and impacts stream banks and channels. Since the 1970s, large-scale commercial mining operations have been eliminated due to stricter environmental regulations. All California instream suction dredge mining has been suspended following the Governor's signature on a new state law. The ban will be in effect until CDFG completes a court-ordered environmental review of its permitting program, expected in late summer 2011 (CDFG 2010). The moratorium on instream suction dredge mining took effect immediately as an urgency measure, prohibiting the use of vacuum or other suction dredging equipment for instream mining in reliance on any permit previously issued by CDFG (CDFG 2010). The moratorium does not apply to suction dredging operations performed for the regular maintenance of energy or water supply management infrastructure, flood control, or navigational purposes.

10. Road maintenance and culvert replacement

Limit Number 10 of the ESA section 4(d) rule pertains to take of threatened salmon and steelhead arising from routine road maintenance. Specifically, the limit does not prohibit take resulting from routine road maintenance conducted by the employees or agents of a state, county, city, or port under a program that complies substantially with the "Transportation Maintenance Management System Water Quality and Habitat Guide [Oregon Department of Transportation (ODOT) 1999]. To qualify their road programs under Limit 10, Humboldt, Del Norte, Trinity, Siskiyou and Mendocino Counties (Five Counties) collaboratively developed the "Water Quality and Stream Habitat Protection Manual for County Road Maintenance in Northwestern California Watersheds" (Five

Counties Salmon Conservation Program 2002) which is based largely on ODOT (1999). In November 1999, the California Resources Agency convened a group of interested state, local and federal agencies, fisheries conservation groups, researchers, restoration contractors, and others to discuss ways to restore and recover anadromous salmonid populations by improving fish passage at fabricated barriers. Now recognized as the Fish Passage Forum, this diverse group meets on a quarterly basis to promote the protection and restoration of listed anadromous salmonid species in California, primarily by encouraging collaboration among public and private sectors for fish passage improvement projects and programs. Road maintenance and culvert replacement will likely benefit coho salmon in the action area.

These effects are expected to continue throughout the duration of the action, and beyond. Road maintenance and culvert activities may have a neutral or, in many cases, a positive effect upon all of the VSP parameters for the interior Klamath populations. For instance, reestablishing historical habitat associated with opening new spawning areas is likely to increase the spatial structure of SONCC coho salmon.

11. Fish Disease

Pathogens associated with diseased fish in the Klamath River include bacteria (*Flavobacterium columnare* and motile aeromonid bacteria), a digenetictrematode (presumptive *Nanophyetus salmincola*), myxozoan parasites (*Parvicapsula minibicornis* and *Ceratomyxa shasta*) and external parasites (Walker and Foott 1993; 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 is not fully understood. However, individuals with dual infections of *C. shasta* and *P. minibicornis* would likely have low survival rates (Nichols and Foott 2005).

C. shasta and *P. minibicornis* are myxosporean parasites found in a number of Pacific Northwest watersheds (Hoffmaster *et al.* 1988; Bartholomew *et al.* 1989; Jones *et al.* 2004; Bartholomew *et al.* 2006). These parasites occur in a number of Pacific Northwest watersheds and both parasite life cycles include the polychaete, *Manayunkia speciosa*, as an alternate host (Hoffmaster *et al.* 1988, Jones *et al.* 2004, Bartholomew *et al.* 2006). The actinospore, a stage that is infectious to salmon, is released from infected polychaetes into the water column, and infections by *C. shasta* can occur from spring through fall at water temperatures > 7°C (Ching and Munday 1984, Hendrickson *et al.* 1989). Myxospores develop within infected salmonids (particularly migratory adults infected during declining water temperature periods), and it is this stage that, once shed from fish, can infect polychaetes to complete the life cycle (Bartholomew *et al.* 1997; Figure 13). Studies conducted in 2004 and 2005 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 2005; Bartholomew *et al.* In Press).

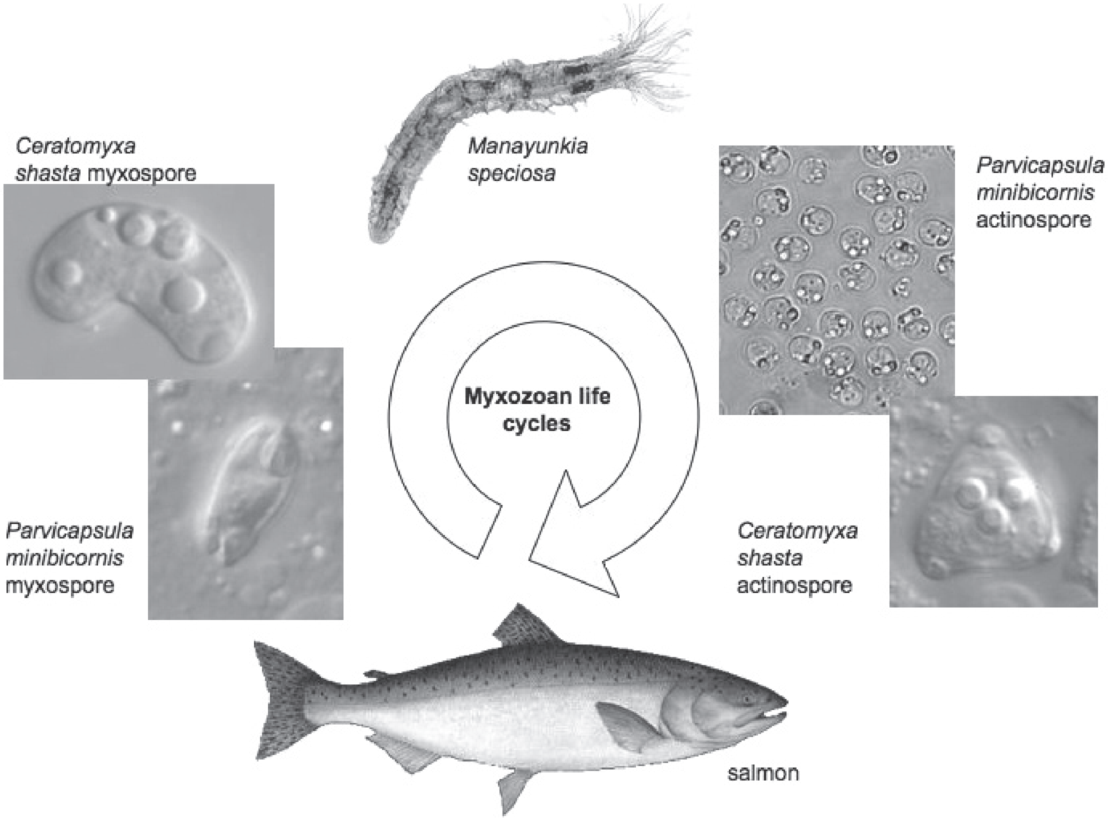

Figure 13**.** Life cycle of *C. shasta* and *P. minibicornis*, showing release of actinospore stages of both parasites from the polychaete, infection of the salmon, and release of myxospore stages that infect the polychaete. (Figure courtesy of J. Bartholomew, Oregon State University)

Researchers believe modifications to the river's historical hydrologic regime have likely created instream conditions that favor disease proliferation and fish infection (Stocking and Bartholomew 2007). Less frequent fall pulse-flows may affect disease transmission from adult salmon carcasses to the intermediate polychaete host. Under an unaltered hydrologic regime, fall and winter freshets help distribute salmon carcasses downstream into lower sections of the watershed, effectively dispersing nutrients, as well as infective spores that enter the aquatic environment as the carcass decomposes. The current flow regime does not effectively redistribute carcasses within the IGD to Shasta River reach, resulting in high densities of decomposing fish downstream of popular spawning areas, specifically the areas directly below IGH and the confluence of Bogus Creek and the Klamath River mainstem. Compounding the issue is the large number of returning adult salmon that congregate and spawn in areas adjacent to the hatchery, thus increasing carcass concentrations in the IGH to Shasta River reach above natural levels. The high carcass densities have helped create areas where high spore loads from decomposing carcasses combine with an unchecked polychaete population. Researchers theorize that these areas represent a zone of disease nidus where the rate and efficiency at which disease pathogens are transmitted from polychaete host to juvenile salmonids dramatically increase (Stocking and Bartholomew 2007).

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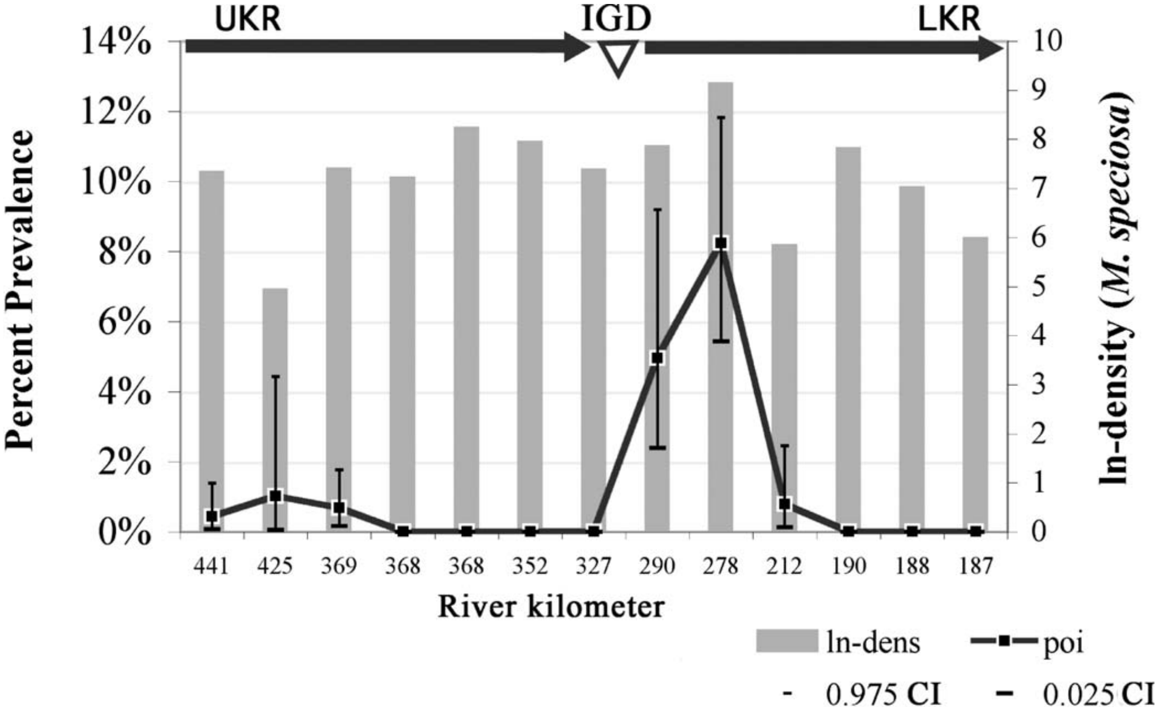

Figure 14. Estimates of *C. shasta* prevalence of infection (poi) and associated CIs within selected populations of *M. speciosa* collected from the Klamath River. Figure from Stocking and Bartholomew (2007).

High winter and spring flows of 2006 were considered to provide a “natural experimental flow.” IGD flows exceeded 10,000 cfs in April of 2006 and sustained high flows lasted through the spring (Figure 14). This period of high flows was anticipated to have an effect on disease infection rates through the disruption or destruction of polychaetes, reduced actinospore concentrations, or juvenile salmonid exposure timing (*e.g.,* Stocking and Bartholomew 2007). The results of the FWS spring 2006 monitoring study indicated the prevalence of both *C. shasta* and *P. minibicornis* during May and June was lower in 2006 compared to previous studies in 2004 and 2005. The higher flows appeared to delay the peak of infection for both parasites, but peak prevalence of infection was still similar in magnitude to previous monitoring studies (FWS 2007). The delayed infection rates in 2006 may have resulted from one or more of the following: (1) A reduction in the polychaete host involved in the life cycle of these parasites due to scouring associated with high flows, (2) A dilution effect on the actinospore (infectious to fish) stage of the parasites; (3) A reduced transmission/infection efficiency of the parasites due to environmental conditions (temperature, turbidity, velocity).

Results from the 2007 monitoring study indicate 37 percent of coho salmon juveniles tested positive for *C. shasta* and 66 percent of coho salmon juveniles tested positive for *P. minibicornis.* Disease prevalence rates were highest in the Upper Klamath River reach in mid-May when flows at IGD ranged from 1400 to 1700 cfs.

High water temperatures can stress adult salmon and slow upstream migration rates, facilitating the transmission of bacterial pathogens (*e.g., Ichthyopthirius multifilis* and *Flavobacterium columnares*) between healthy and sick fish as they crowd into the few cold water refugial areas of the Klamath River (FWS 2003). High water temperature was one of several factors that likely contributed to a massive die-off of Klamath River salmon in 2002 – other factors include run timing, run size, habitat availability, and meteorological conditions (FWS 2003). Of the over 34,000 fish estimated to have died during the event, approximately 344 were coho salmon (CDFG 2004).

The effects to coho salmon due to disease are expected to continue throughout the action period and into the foreseeable future. Disease effects are likely to negatively impact all of the VSP parameters of the Interior-Klamath population units because both adults and juveniles can be affected. In terms of critical habitat, disease impacts adult and juvenile migration corridors, and juvenile summer rearing areas.

12. Pinniped Predation

Pinniped predation on adult salmon can significantly affect escapement numbers within the Klamath River basin. Hillemeier (1999) assessed pinniped predation rates within the Klamath River estuary during August, September, and October, 1997, and estimated that a total of 223 adult coho salmon were consumed by seals and sea-lions during the entire study period. Fall-run Chinook salmon were the main fish consumed (an estimated 8,809 during the entire study period), which may be primarily due to the fall-run Chinook salmon migration peaking during the study period (the peak of the coho salmon run is typically October through mid-November). Hillemeier (1999) cautioned that the predation results may represent unnaturally high predation rates, since ocean productivity was comparatively poor during the El Niño year of 1997. The Marine Mammal Protection Act of 1972 protected seals and sea lions from human harvest or take, and as a result, populations are now likely at historical highs (Low 1991). Pinniped predation has its biggest effect on the population abundance of coho salmon. Similarly to harvesting, reductions in the amount of marine derived nutrients in a stream can result from predation, which reduces the amount of food available to winter and summer rearing juveniles.

D. Water Quality Conditions in the Action Area

1. Below IGD

a. Temperature

The diversity of the Klamath River basin's geographic region is the predominant influence on the basin's water temperature regime. The Klamath River basin is sometimes referred to as being an "upside down" system, given that the system's low gradient, dry upper watershed and steep, high rainfall lower portion are inverted with regard to classic watershed structure. As a result, the maritime climate and cool tributary inflow emanating from heavily forested tributaries can moderate water temperatures in the Lower Klamath River section, often leaving water temperatures slightly cooler (although still warm) than those further upstream. However, meteorological conditions can be severe throughout the basin for extended periods from June through September, and water temperatures will rise appreciably with ambient air temperatures. Ambient air temperatures tend to be highest upstream of the Trinity River confluence, which, when combined with limited tributary accretion throughout much of the Middle Klamath section, can produce critically high water temperatures during summer months (Fadness 2007).

b. Dissolved oxygen (DO)

DO concentrations vary considerably both spatially and temporally within the Klamath River mainstem, and are influenced primarily by high nutrient levels emanating from the upper basin (PacifiCorp 2006). Pacificorp's reservoirs appear to be a net sink on an annual basis, but can act as both a source and sink for these nutrients, based largely upon the time of year and the cycling mechanisms occurring at that time (Kann and Asarian 2007). Highly enriched water also likely arises from mainstem tributaries that support large agricultural operations. Currently (and perhaps historically), the Klamath River mainstem supports a significant benthic algae community as a result of the warm water, abundant solar input, and highly nutrified water chemistry. As the large aquatic plant community undergoes complex diel cycles of photosynthesis and respiration during summer months, instream DO concentrations can fall to levels stressful to coho salmon adults and juveniles.

c. pH

Given that the Klamath River below IGD remains in a weakly buffered state, pH levels throughout the river can experience wide diel fluctuations as a result of high primary production (*i.e.,* algae and benthic macrophyte growth) during summer months. Photosynthesis and associated uptake of carbon dioxide by aquatic plants result in high pH (*i.e.,* basic) conditions during the day, whereas plant and fish respiration at night decreases pH to more neutral conditions.

Ammonia toxicity can be a concern in aquatic environments, like the Klamath River, where high nutrient concentrations coincide with elevated pH and water temperature. Ammonia toxicity is more of a concern within upstream reaches [*e.g.,* IGD to Seiad Valley (rm 128)] where temperatures and pH, as well as macrophyte and algae concentrations, are appreciably higher than those common to the lower river (PacifiCorp 2006).

E. Critical Habitat of Klamath Population Units

Designated critical habitat for SONCC coho salmon in the mainstem Klamath River downstream of IGD is vital to the species' conservation. Within the action area, the essential habitat types of SONCC coho salmon designated critical habitat are: (1) Juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) adult migration corridors; and (4) spawning areas. Areas for growth and development to adulthood are not covered in this critical habitat section because these areas are restricted to the marine environment for coho salmon, which is not in the action area. Within the essential habitat types, essential features of coho salmon critical habitat include adequate; (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions (May 5, 1999, 64 FR 24049).

Juvenile summer and winter rearing areas should contain adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, and space. These essential features are necessary to provide sufficient growth and reasonable likelihood of survival to smoltification. Juvenile migration corridors need to have sufficient water quality, water quantity, water temperature, water velocity, and safe passage conditions in order for coho salmon juveniles and smolts to emigrate to estuaries and the ocean, or to redistribute into non-natal rearing zones. Adequate juvenile migration corridors need to be maintained throughout the year because smolts emigrate to estuaries and the ocean from the early spring through the late summer, while juveniles may redistribute themselves at any time in response to fall freshets or while seeking better habitat and rearing conditions. Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover/shelter and safe passage conditions in order for adults to reach spawning areas. Adults generally migrate in the fall or winter months to spawning areas. Spawning areas for SONCC coho salmon must include adequate substrate, water quality, water quantity, water temperature, and water velocity to ensure successful redd building, egg deposition and egg to fry survival. Coho salmon spawn in smaller tributary streams from November through January in the ESU.

The Klamath River Basin (including the Trinity River) provides habitat for two entire Diversity Strata (out of seven) as well as one population unit in a third stratum in the SONCC coho salmon ESU. Coho salmon that inhabit the Klamath River Basin occupy temperate coastal regions as well as arid inland areas stretching from IGD to the north, all the way to South Fork Trinity River, roughly 100 miles to the south. The geographic distribution of coho salmon in the Klamath Basin covers approximately 38 percent of the entire ESU. Thus, the conservation value of the designated critical habitat in the action area is extremely important for the species. Without the Klamath River and associated tributaries, a vast area of the SONCC coho salmon ESU would no longer support the species, fragmenting populations to the north and south, thereby increasing the risk of local extirpations within the ESU as well as increasing the extinction risk for the species.

The Lower Klamath River is not discussed here in the critical habitat section because it falls within the boundaries of the Yurok Tribe Reservation, and tribal lands are excluded from critical habitat designation. Critical habitat in the Shasta, Scott, and Trinity Rivers are also not covered below because they are out of the action area.

1. Upper Klamath River

The Upper Klamath River reach begins at the mouth of Portuguese Creek (rm 128) and extends upstream to IGD at rm 190 (Appendix 1, Figures D, E). Water quality and quantity conditions reduce the functionality of essential habitat types in this reach and diminish the ability of the habitat types to establish essential features. IGD flow releases typically have a proportionally larger affect on the flow regime in this reach than in downstream reaches, because tributary accretions boost discharge farther downstream.

a. Juvenile Summer and Winter Rearing Areas

For the Upper Klamath River Population Unit, juvenile summer rearing areas have been compromised by low flow conditions, high water temperatures, insufficient dissolved oxygen levels, excessive nutrient loads, habitat loss, disease effects, pH fluctuations, non-recruitment of large woody debris, and loss of geomorphological processes that create habitat complexity. Water released from IGD during summer months is already at a temperature stressful to juvenile coho salmon, and solar warming can increase temperatures even higher (up to 26ºC) as flows travel downstream (NRC 2004). Nocturnal DO levels directly below IGD are likely below 7.0 mg/L and highly stressful to coho salmon juveniles during much of the late summer and early fall. Between IGD and Seiad Valley, daily maximum pH values in excess of 9.0 have been documented, as high primary production within the weakly buffered Klamath River basin causes wide diurnal pH fluctuations (PacifiCorp 2006). Riparian recruitment within the first several miles below IGD is likely impaired by the typically fast recession of the spring hydrograph, since the roots of newly established vegetation are unlikely to keep up with the rapidly lowering water table (FERC 2006). This can limit the amount of cover available to rearing coho salmon. Dams also impair gravel and fine sediment recruitment downstream of Pacificorp's Project reservoirs, which result in poorly functioning floodplains that fail to support healthy riparian recruitment. Winter rearing areas suffer from non-recruitment of large woody debris and stream habitat simplification.

b. Juvenile Migration Corridor

In the Upper Klamath River reach, juvenile migration corridors suffer from low flow conditions, disease effects, high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution. The unnatural and steep decline of the hydrograph in the spring may slow the emigration of coho salmon smolts, speed the proliferation of fish diseases, and increase water temperatures more quickly than would occur otherwise. Disease effects, particularly in areas such as the Trees of Heaven site, likely have a substantial impact on the survival of juvenile coho salmon in this stretch of river. Thus, the conservation role of the juvenile migration corridor of the Upper Klamath River reach is not properly functioning.

c. Adult Migration Corridor

The current physical and hydrologic conditions of the adult migration corridor in the Upper Klamath River reach likely functions in a manner that supports its intended conservation role. Water quality is suitable for upstream adult migration, and flow volume is above the threshold at which physical barriers may form.

d. Spawning Areas.

Coho salmon are typically tributary spawners. However, low numbers of adult coho salmon do spawn in the Upper Klamath River reach annually. Upstream dams block the transport of sediment into this reach of river. The lack of clean and loose gravel diminishes the amount and quality of salmonid spawning habitat downstream of dams. This condition is especially critical below IGD (FERC 2006). Water temperatures and water velocities are generally sufficient in this reach for successful adult coho salmon spawning.

2. <u>Middle Klamath River</u>

The Middle Klamath River section begins above the Trinity River confluence and extends upstream 85 miles to the mouth of Portuguese Creek (rm 128). It is substantially different from the Klamath River upstream and downstream and adjacent sub-basins (Salmon and Scott Rivers), particularly in precipitation and flow patterns (Williams *et al.* 2006, Appendix 1, Figures B-D). Water quality and quantity conditions impede the proper function of this river reach. IGD flow releases typically have a proportionally larger affect on the flow regime in this reach than the lower Klamath River reach, since two (Salmon and Trinity Rivers) of the four major Klamath River tributaries enter near the lower end of this section.

a. Juvenile Summer and Winter Rearing Areas

Juvenile summer rearing areas in this stretch of river have been compromised relative to the historic state. A few tributaries within the Middle Klamath River Population Unit (*e.g.,* Boise, Red Cap and Indian Creeks) support populations of coho salmon (NMFS 2007a), and offer critical cool water refugia within their lower reaches when mainstem temperatures and water quality approach uninhabitable levels. Mean weekly water temperatures near Cade Creek (rm 110), exceeded 29ºC when monitored in 1992 (Fadness 2007). Perhaps more importantly, minimum nighttime water temperatures in the Middle Klamath River reach are consistently above 20ºC in the summer. pH values downstream of the Middle Klamath River reach at Weitchpec tend to rise throughout the monitoring season toward peak values in late August and serve as a surrogate for the lower portion of the Middle Klamath River reach. Daily maximum values were greater than 8.5 for most of the summer, but attenuated when adult fish would likely be migrating through the area in early October. High pH, in combination with high water temperatures, can precipitate high ammonia levels during summer months (FERC 2006). Highly fluctuating DO concentrations, such as those measured during summer 2004 at the Weitchpec site, are common throughout the mainstem, resulting from high primary productivity fueled by naturally elevated water temperatures and the enriched outflow from IGD. DO levels at Weitchpec during 2004 peaked above 10 mg/L for several days in mid-October, but were generally above 7 mg/L for most of the summer (Yurok Tribe 2005). The exception was several days in both late August and early September, when DO levels as low as 5.5 mg/L were measured. Generally, the conservation role of juvenile summer and winter rearing areas of the Middle Upper Klamath River reach is impaired and functioning at a low level during summer months.

b. Juvenile Migration Corridor

Disease effects in this stretch of river can limit the survival of juvenile coho salmon as they emigrate downstream. Low flows can slow the emigration of juvenile coho salmon, which can in turn lead to longer exposure times for disease, and greater risks due to predation.

c. Adult Migration Corridor

Most migrating adult coho salmon are likely unaffected by elevated summer water temperatures characteristic of the Middle Klamath River section. By late September when adult coho salmon migration begins, water temperatures are usually close to 19ºC throughout the Middle Klamath River section, although one gauging site [Klamath River at Oak Flat Creek (rm 100)] registered water temperatures in excess of 23ºC during late September 1992 (Fadness 2007). Based upon comparative analysis with historical Klamath flow records, CDFG (2004) could not conclusively demonstrate that water depth impeded upstream migration during the 2002 fish die-off, although anecdotal evidence (*i.e.,* field observations, gage height data) suggest some fish migration may have been impeded.

d. Spawning Areas.

There is some evidence that limited spawning of coho salmon occurs in the Middle Klamath River reach (Magneson and Gough 2006). However, the quality and amount of spawning habitat in the Middle Klamath River reach is naturally limited due to the geomorphology and the prevalence of bedrock in this stretch of river. Coho salmon are typically tributary and headwater stream spawners, so it's unclear if there was historically very much mainstem spawning in this reach.

F. Critical Habitat of Interior-Klamath Diversity Stratum

The current function of critical habitat in the Interior-Klamath Diversity Stratum is degraded relative to its unimpaired state. Sedimentation, low stream flows, poor water quality, stream habitat simplification, and habitat loss from poorly designed road crossings plague coho salmon streams in this stratum. Additionally, critical habitat in the Interior Diversity stratum often lacks the ability to establish essential features due to ongoing human activities. For example, IGD on the Klamath River, California, stops the recruitment of spawning gravels, which impacts both an essential habitat type (spawning areas) as well as an essential feature of spawning areas (substrate). Water utilization in many regions throughout the diversity stratum (*e.g.,* Shasta and Scott Rivers) reduces summer base flows, which limits the establishment of several essential features such as water quantity and water quality.

G. Risk of Extinction of Klamath Population Units

Coho salmon were once abundant in the Klamath River (see Table 6 in Snyder 1931). This section will detail the current condition of the three mainstem Klamath River population units and two tributary population units (*i.e.,* the Shasta and Scott) affected by the Project. The effects of the Proposed Action on the Salmon River population unit and the three Trinity River population units are expected to be minimal. The effects of IGD discharge downstream of the Salmon River are largely attenuated during most times of the year due to tributary accretions.

Based on precipitation and flow patterns, among other factors, Williams *et al.* (2006) identified the distribution of Upper Klamath River Population Unit as extending from Portuguese Creek to Spencer Creek (inclusive), the reported historical upstream distribution of coho salmon in the basin (Hamilton *et al.* 2005). Although it may seem intuitive to describe the *status of the species* in the *action area* separately above and below IGD, they are combined in the Upper Klamath River sections in order to maintain consistency with the historical population structure identified by Williams *et al.* (2006).

Within the California portion of the SONCC coho salmon ESU, estimating the risk of extinction of a given coho salmon population is difficult since longstanding monitoring and abundance trends are largely unavailable. Williams *et al.* (2007) proposed biological viability criteria, including population abundance thresholds as part of the ESA recovery planning process for the SONCC coho salmon ESU. The viability criteria developed by Williams *et al.* (2007) address and incorporate the underlying viability concepts (*i.e.,* abundance, productivity, diversity and spatial structure) outlined within McElhany *et al.* (2000), and are intended to provide a means by which population and ESU viability can be evaluated in the future when robust population data become available. For our purposes, comparing rough population estimates recently derived through Klamath coho salmon life-cycle modeling (Ackerman *et al.* 2006) against population viability thresholds proposed by Williams *et al.* (2007) allow NMFS to make conservative assumptions concerning the current risk of extinction of Klamath River mainstem and tributary population units.

Generally speaking, none of the five population units of Klamath River coho salmon affected by the Proposed Action are considered viable at this point in time. Even the most optimistic estimates from Ackerman *et al.* (2006) indicate each population falls well short of abundance thresholds for the proposed viability criteria that, if met, would suggest that the populations were at low risk of extinction for this specific criterion. In some years, populations have fallen below the high risk abundance level (such as the Shasta River population). A population is considered at low risk of extinction if all criteria are met, therefore failure to meet any one specific criterion would result in the population being at an elevated risk of extinction (*i.e.,* not viable). The adult run size estimate for 2009 was nine fish for the Shasta River, all of which were thought to be males. Similarly, the Scott River coho salmon population fell well below the high risk abundance threshold in 2009, with an estimated run size of 81 adult fish (Table 12). For both of these populations, abundance is critically low and they are likely experiencing depensation pressures. With regard to spatial structure and diversity, Williams *et al.* (2007) abundance thresholds were based upon estimated historical distribution and abundance of spawning coho salmon, and thus capture the essence of these two viability parameters. By not meeting the low risk annual abundance threshold, all Klamath River coho salmon populations are likewise failing to meet spatial structure and diversity conditions consistent with viable populations. Several of these populations have also recently failed to meet the high risk abundance thresholds, underscoring the critical nature of recent low adult returns.

Table 12. Estimated abundance of unmarked coho salmon adul returns versus various abundance thresholds for coho salmon populations in the Klamath Basin (from Williams *et al.* 2007).

Stratum	Population Unit	Approximation of run size estimates from 2001-2004 (from Ackerman *et al.* 2006)	2009 Unmarked adult returns	High Risk Annual Abundance Level[a]	Low Risk Annual Abundance Level[b]
Central Coastal Basins	Lower Klamath	0 – 2,000	NA	205	5,900
Interior - Klamath	Middle Klamath	0 – 1,500	NA	113	3,900
Interior - Klamath	Upper Klamath	100 – 4,000	NA	425	8,500
Interior - Klamath	Scott River	10 – 4,000	81[d]	441	8,800
Interior - Klamath	Shasta River	100 - 400	9[d]	531	10,600
Interior - Klamath	Salmon River	50	NA	115	4,000
Interior - Trinity	South Fork Trinity River	500-9,000[c]	567[d]	242	6,400
Interior - Trinity	Lower Trinity River			112	3,900
Interior - Trinity	Upper Trinity River			64	2,400

[a] High risk annual abundance level corresponds to a population threshold below which there exists a high risk of depensation (*i.e.,* decreasing productivity with decreasing density). Depensatory processes at low population abundance result in high extinction risks for very small populations because any decline in abundance further reduces the population's average productivity, resulting in a steep slide toward extinction (McElhany *et al.* 2000).

[b] Low risk annual abundance level represents the minimum number of spawners required for a population to be considered at low risk for spatial structure and diversity threshold.

[C] Ackerman *et al.* 2006 produced single estimates for the Trinity River from 2001-2004; they did not distinguish between the population units identified by Williams *et al.* (2007).

[d] Preliminary run size estimates for 2009 do not cite. Source: CDFG. Estimates for the Trinity River made at Willow Creek Weir, estimate does not distinguish between populations.

NMFS 2005 status review concluded the effect of hatchery programs on the spatial structure, productivity and diversity within the SONCC coho salmon ESU is uncertain (70 FR 37160). More recently, the specific viability criterion proposed by Williams *et al.* (2007) considers the influence of hatchery fish within a population. Hatchery fish can affect natural salmon populations through increased competition, disease introgression and genetic dilution (NRC 1996). To limit these effects, Williams *et al.* (2007) propose that the fraction of naturally spawning fish within a given population that are of hatchery origin not exceed 5 percent. Populations within both the Klamath River and Trinity River are influenced by hatchery fish, with native coho salmon present only in small numbers (NMFS 2004a). The high proportion of hatchery-reared coho salmon within the Trinity and Klamath Rivers would suggest the Klamath River meta-population is at least at a moderate risk of extinction with regard to its genetic diversity.

Below, the population units that may be affected by the Proposed Action are discussed in more detail. Run size approximations compiled by Ackerman *et al.* (2006) were used to gage whether or not specific population units had met the Low Risk Annual Abundance Level at any time during the period 2001 to 2004 (Table 13). The information compiled by Ackerman *et al.* (2006) represents virtually all that was known about adult coho salmon returns in the Klamath Basin at the time. Due to the relatively long distance from IGD and the effects of tributary accretions, population units of the Salmon River and the three population units in the Trinity River basin are expected to experience no or negligible effects from the Proposed Action. Likewise, the Lower Klamath River Population is also expected to experience no or negligible effects from the Proposed Action. However, the Lower Klamath Population is discussed in more detail here because it is within the action area. Population units in the Scott and Shasta rivers, while not in the action area, use the action area for various activities, including migration, rearing, and holding. Due to the relatively close proximity of these populations to IGD, releases from IGD constitute a higher proportion of flow in the river than for populations located downstream. Therefore, these two populations, while not in the action area, have the potential to be affected by the action to a greater degree than other populations located downstream.

Table 13. Approximation of run size estimates of returns of naturally produced coho to various reaches within the Klamath Basin in 2001-2004. Values represent an approximation of results for each reach and sum or reaches to reflect the generalized nature of these estimates. Table excerpted from Ackerman *et al.* (2006).

Reach	2001	2002	2003	2004
IGH	200	200	600	400
Upper Mainstem	100	100	100	100
Shasta	200	100	200	400
Scott	1,000-4,000	10-50	10-50	2,000-3,000
Up Misc Tribs	1,500	500-1,500	1,000-4,000	2,500
Mid Mainstem	0	0	0	0
Salmon	50	50	50	50
Mid Misc Tribs	300-700	0-500	300-700	1,000-1,500
Lower Mainstem	0	0	0	0
Trinity	3,000	500	4,000	9,000
Low Misc Tribs	500	0	400-800	1,000-2,000
Total	**7,000 – 10,000**	**1,500 – 3,000**	**7,000 - 11,000**	**16,000 - 19,000**

1. Upper Klamath River Population Unit

The Upper Klamath River Population Unit covers the Klamath River and tributaries from Portuguese Creek, upstream past IGD to Spencer Creek (inclusive), the historical upstream distribution of coho salmon in the Klamath Basin (Hamilton *et al.* 2005). Using a variety of methods, including data from a video weir on Bogus Creek, maps, and an Intrinsic Potential (IP) database, Ackerman *et al.* (2006) developed run size approximations for tributaries in this stretch of river. Using reports from FWS, they also assumed that spawning in the mainstem was limited to 100 fish or less. From 2001 to 2004, the number of adult spawners returning to the Upper Klamath River Population Unit fell below the Low Risk Abundance Level proposed by Williams *et al.* (2007) of 8,500 spawners (Table 12 and Table 13). In 2009, 70 coho salmon returned to IGH, of which 16 were unmarked. Of the 54 marked coho salmon that returned, 13 were from Trinity River Hatchery. Although the count of coho salmon on Bogus Creek was probably not complete in 2009, 7 coho salmon were counted. Using the information above, the Upper Klamath River Population Unit has a high risk of extinction.

2. Shasta River Population Unit

Adult coho salmon entering the Shasta River are counted at the Shasta River Fish Counting Facility (SRFCF) operated by the CDFG. The facility consists of a video camera, counting flume, and an Alaska style weir placed diagonally across the river. Ackerman *et al.* (2006) used the coho counts from this video weir combined with return timing information and the number of hatchery coho salmon carcasses recovered at the weir to develop approximations of run sizes for the Shasta River (Table 13).

Due to its proximity to IGH, the Shasta River likely has a higher hatchery coho salmon stray rate than the Scott River, probably surpassed in the Klamath River only by Bogus Creek. The average percentage of natural coho salmon carcasses recovered at the SRFCF in 2001, 2003, and 2004 was 84 percent, the remainder being hatchery origin fish. The number of adult coho salmon returning to the Shasta River falls well below the Low Risk Annual Abundance Level and below the High Risk Annual Abundance Level (Table 12). Adult coho salmon returns were 30 and 9 in 2008 and 2009. These numbers are well below the high risk abundance threshold (Table 12) At these low levels, depensation (e.g. failure to find mates), inbreeding and genetic drift, which accelerate the extinction process, become a concern. Therefore, the Shasta River Population Unit has a high risk of extinction, and has substantial genetic and other depensation risks associated with low numbers of adult spawners.

3. Scott River Population Unit

Ackerman *et al.* (2006) estimated the range of abundance for the Scott River coho salmon population and approximated the total run size as 1,000-4,000 for 2001, 10-50 for 2002 and 2003, and to 2,000-3,000 for 2004 (Table 13). Variable rates of effort and differences in survey conditions between years may have influenced these estimates of run size. Uncertainty regarding mainstem spawning of coho in the Scott River was also a source of concern (Ackerman *et al.* 2006). Recently, a video weir was erected in the Scott River, alleviating concerns about data collection methods. In 2009, 81 adult coho salmon returned to the river, well below the high risk abundance threshold (Table 12). The adult return estimates for the Scott River (Table 13) were less than the Low Risk Annual Abundance Level (Table 12) in each year from 2001 to 2004, and below High Risk Annual Abundance Level in two of the four years. Therefore, the Scott River Population Unit has a high risk of extinction.

4. Middle Klamath River Population Unit

The Middle Klamath River Population Unit covers the area from the Trinity River confluence upstream to Portuguese Creek (inclusive) and Seiad and Grider Creeks. Little data on adult coho are available for this stretch of river (Ackerman *et al.* 2006). Adult spawning surveys and snorkel surveys have been conducted by the US Forest Service and Karuk Tribe, but data from those efforts are insufficient to draw conclusions on run sizes (Ackerman *et al.* 2006). Ackerman *et al.* (2006) relied on professional judgment of local biologists to determine what run sizes would be in high, moderate, and low return years to these tributaries; therefore, the run size approximations are judgment based estimates. In each of the four years presented by Ackerman *et al.* (2006; Table 13), the run size approximations fall below the Low Risk Annual Abundance Level (Table 12). Therefore, the Middle Klamath River Population Unit has a high risk of extinction.

5. Lower Klamath River Population Unit

Using juvenile coho salmon abundance estimates and overwinter and marine survival rates, Ackerman *et al*. (2006) estimated adult returns in 2002-2006 in Klamath River tributaries below the Trinity River confluence. The estimates ranged from 14 to 1,483 adults. Incorporating the upper and lower 95% CIs from juvenile sampling yielded a range of 1 to 2,026 adults. Estimates of abundance for the 2002 return year may be biased low due to the nature of the site selection regime (Ackerman *et al*. 2006). Estimates were rounded to the nearest 100 or 1000 for estimating basin wide abundance (Table 13). The adult return estimates for the Lower Klamath Population Unit (Table 13) were less than the Low Risk Annual Abundance Level (Table 12) in each year from 2001 to 2004. Therefore, the Lower Klamath River Population Unit has a high risk of extinction.

VI. EFFECTS OF THE ACTION

In this section, NMFS will identify the probable risks that individual coho salmon and essential features of critical habitat will experience as a result of the Project. In general, NMFS will first identify the environmental “stressors” (physical, chemical, or biotic) directly or indirectly caused by the Proposed Action. Next we will assess coho salmon exposure to the stressors. Finally, NMFS will evaluate the likely response of coho salmon and essential features of critical habitat to such stressors, given their exposure to the existing and ongoing impacts of other actions and factors in the action area (the environmental baseline), to determine if the addition of the Proposed Action will affect the growth, survival or reproduction of individuals or the function and value of critical habitat features. Habitat modification by the Proposed Action represents the primary mechanism by which the Proposed Action has potential effects on individual coho salmon and critical habitat. Therefore, NMFS utilizes a habitat-based assessment in this section of this Opinion.

The following effects analysis organizes the mainstem Klamath River spatially into geographical units delineated by the three mainstem historical population units (Upper, Middle and Lower Klamath River)described by Williams *et. al* (2006). For each reach, the analysis is organized into three seasonal periods: October through February, March through June, and July through September. These seasonal periods align well with both the life stage and periodicity of Klamath River coho salmon, as well as Reclamation’s seasonal operations. We first describe the hydrological and water quality effects of the Project. The hydrological effects of the Action are organized in terms of effects to base flows and flow variability. Reclamation's predicted flows (Table 6) represent the expected base flows during the eight-year Action for the purposes of this analysis. The Project also affects flow variability and the mainstem Klamath River hydrological response to rainfall and snowmelt. After determining the hydrological and water quality effects of the Proposed Action, we then describe the hydrological and water quality effects on essential features of coho salmon critical habitat. Finally, we then consider individual life stages of coho salmon to analyze the anticipated response of individuals to the Project.

In general, NMFS found that Project impacts are greatest in the Upper Klamath River reach and diminish as tributaries contribute flow, increasing the magnitude, duration and variability of the mainstem Klamath River flow. Coho salmon of the Upper Klamath, Shasta River, Scott River, and Middle Klamath historic population units will experience the greatest magnitude and intensity of stressors on their fitness based on their proximity to IGD.

In the *Analytical Approach* section, we present the use of Reclamation's No Project flows as an analytical tool. The No Project Flows represent the predicted flows that would occur if Reclamation's Project was not implemented. All other factors currently influencing the hydrology of the Klamath River Basin would continue. Hence, the No Project flows include multiple anthropogenic factors (*e.g.,* water diversion projects upstream of UKL, Pacificorp's Hydroelectric Project, sub-basin water diversion project), and environmental factors (*e.g.,* climatological condition). We use these flows as the nearest approximation of the future baseline conditions to which we add the effects of Reclamation's Proposed Action. The difference in flows (Project vs. No Project) provides us with the magnitude and extent of the hydrological effect of the Project. We then analyze the hydrological effect in terms of effects to coho salmon and their critical habitat.

Subsequent to our 2002 biological opinion on the Project (NMFS 2002), new information on Klamath River anadromous salmonids, including coho salmon, has become available. NMFS has described much of this new information in the preceding *Environmental Baseline* section. The breadth of information available provides a number of tools from which to build lines of evidence that will form the basis for analyzing effects of the Proposed Action. Earlier in our *Analytical Approach* section, we identified a number of key assumptions for our analysis, and here we provide a more detailed description of important new information for NMFS to consider in our *Effects Analysis* section.

The Evaluation of Instream Flow Needs in the Lower Klamath River Phase II Report (Hardy et al. 2006), and NRC's Report on the Hydrology, Ecology, and Fishes of the Klamath Basin (NRC 2007).

Hardy *et al.* (2006) provides NMFS with important information on the relationship of mainstem flows and environmental conditions which anadromous salmonids rely upon to meet their life history needs. Hardy *et al.* (2006) developed habitat suitability criteria (HSC) for life history stages of anadromous salmonids in the mainstem Klamath River based on the fundamental concepts of the ecological niche theory. The 2006 report defines an ecological niche as "the set of environmental conditions (*e.g.,* temperature, depth, velocity) and resources (things that are consumed such as food) that are required by a species to exist and persist in a given location." Species and life stage specific habitat suitability criteria (HSC) used in instream flow determinations are an attempt to measure the important niche dimensions of a particular species and life stage (Gore and Nestler 1988). These criteria are then used to measure niche changes relative to changes in flow.

Empirical data on juvenile coho salmon in the mainstem Klamath River are limited. While juvenile outmigration monitoring (*e.g.,* downstream migrant traps) provides information on distribution and emigration timing on the mainstem Klamath River, there are few observations of juvenile coho salmon utilizing micro-habitat. Consequently Hardy *et al.* (2006) developed literature-based HSC to quantify habitat availability for juvenile coho salmon within the mainstem Klamath River. HSC were validated using the limited empirical observations of coho salmon fry and parr in the mainstem Klamath River.

Utilizing simulated hydrodynamic variables at intensive study sites, Hardy developed Composite Suitability Indices (CSI) for each site from the HSC data, which incorporated species and life-stage specific preferences with regard to specific microhabitat features such as flow, depth, velocity, substrate, and cover characteristics. The CSIs were later converted into a combined measure known as the Weighted Usable Area (WUA) to characterize the quality and quantity of habitat in terms of usable area per 1,000 linear feet of stream (NRC 2007). Hardy then scaled up WUA results from the individual sites to the larger reach-level scale (see Hardy *et al.* 2006 or NRC 2007 for further discussion). WUA is a measure of habitat suitability, predicting how likely a habitat patch is to be occupied or avoided by a species life stage at a given time, place, and discharge (*i.e.,* the suitability of the habitat for a specific species and life-stage of fish; NRC 2007). Within the *Effects of the Action* section, NMFS utilizes reach-level WUA curves to gauge the general change in instream habitat availability (incorporating both quantity and quality) within the mainstem Klamath River brought about by the Proposed Action, and characterizes the change as a difference in suitable habitat volume.

NMFS uses WUA curves from reach-level study sites for the Upper Klamath and Middle Klamath River reach effects analyses (Table 14). NMFS is aware of the limitations of focusing solely on WUA analysis when analyzing an individual coho salmon or coho population's response to an action (*e.g.,* NRC 2007). For example, whether or not individuals actually occupy suitable habitat is dependent on a number of factors that may preclude access, including connectivity to the location, competition with other individuals, and risks due to predation (Hardy *et al.* 2006). Like all models, the instream flow model developed by Hardy *et al.* (2006) is an imperfect representation of reality (NRC 2007), and uncertainty exists in the model. Thus, our analysis focuses not only on habitat availability, but also considers other important components of the flow regime (water quality, channel function, hydrologic behavioral cues, *etc.*), and how they affect coho salmon individual fitness.

Table 14. Hardy *et al.* (2006) reach-level study sites used by NMFS for analysis.

Klamath River Reach	Hardy *et al.* 2006 Reach Level site	Location
Upper Klamath River Reach	R-Ranch	Appendix 1, Figure E, IGD-Interstate 5
Upper Klamath River Reach	Trees of Heaven	Appendix 1 Figure E, Shasta River
Upper Klamath River Reach	Seiad Valley	Appendix 1, Figure D, Scoot River to Portuguese Creek
Middle Klamath River Reach	Rogers Creek	Appendix 1, Figure C, Rogers Creek
Middle Klamath River Reach	Orleans	Appendix 1, Figure C, Town of Orleans

In this Opinion we reference 80 percent of maximum habitat available as a value that is generally accepted to provide conservation value (*i.e.,* restorative value) to species habitat. The 80 percent of maximum habitat available is expected to provide a wide range of conditions and habitat abundance such that populations can grow and prosper. In these cases where habitat availability is 80 percent or greater under the Proposed Action, habitat is not expected to limit individual fitness or population productivity or distribution nor adversely affect the function of essential features of coho salmon critical habitat. Instream maximum available habitat of 80 percent has been used to develop minimum flow regimes for the conservation of anadromous salmonids (Tennant 1976, Clipperton *et al.* 2002, Clipperton *et al.* 2003, NMFS 2002, Simondet *et al.* 2007). In this analysis we reference a number of time periods and flow exceedences when we predict the Proposed Action will result in lower habitat availability than under a No Project flow, but habitat availability is still not expected to be limiting (*i.e.,* habitat availability under the Project would still be >80 percent).

With regard to Hardy's instream flow recommendations for the mainstem Klamath River, we note the different objectives and standards for analyses in Hardy *et al.* (2006) and this Opinion. Specifically, Hardy *et al.* (2006) uses a multi-species approach to develop flow recommendations for conserving the entire suite of anadromous salmonids inhabiting the Klamath River Basin. In contrast, NMFS focuses its jeopardy analysis upon the ESA-listed species (*i.e.,* SONCC coho salmon). Nevertheless, Hardy *et al.* (2006) instream flow recommendations provide NMFS with an important reference when analyzing expected flows under the Proposed Action. Hardy *et al.* (2006) instream flow recommendations were based on the natural flow paradigm that concludes effective instream flow prescriptions should mimic processes characteristic of the natural flow regime (Annear *et al.* 2002). These patterns and processes were described in the *Environmental Baseline* section. Therefore, the Hardy *et al.* (2006) instream flow recommendations are useful in our analysis as an indicator of how closely the expected outcomes of the Proposed Action align with the patterns and processes of a natural flow regime.

Bureau of Reclamation's Coho Life Cycle Model

Reclamation developed a coho life cycle model to predict the influence of water operations on Klamath Basin coho salmon. Essentially, the model quantifies the effects of varied environmental factors (*e.g.,* tributary conditions, mainstem flows, ocean productivity) into resultant survival rates of the different life stages of coho salmon as they move spatially through the Klamath River Basin and the marine environment (Cramer Fish Sciences 2007). The model's primary utility lies in comparing coho salmon production levels that may result from differing flow management scenarios. NMFS' Southwest Region Protected Resources Division and NOAA's Southwest Fisheries Science Center staff participated in technical meetings throughout the development of the model, and provided a series of comments for Reclamation and Cramer Fish Sciences regarding components of the coho salmon life cycle model (NMFS 2006b-d, 2007c-e). A central theme of our comments on the model is the limited expression of the critical link between the geographic structure of habitats, populations, and diverse salmon life histories and salmon resilience and productivity within the Klamath River Basin.

The model's general approach that coho salmon life history characteristics are largely uniform within the Klamath River is not consistent with information presented in this Opinion and throughout the literature, which demonstrates very complex movement and habitat use patterns. The coho life cycle model has adopted a "production" framework to allow the model to inform population performance based on mainstem flow scenarios. The outputs of the model provided in Reclamation's BA are a comparative approach of two flow alternatives to assess production, but are of limited use for describing the effects of IGD flow management alternatives on the viability of Klamath River coho populations. The model is insufficient to use in analyzing potential viability impacts resulting from the Proposed Action because it does not capture the unique stressors fish experience within the action area, nor the unique life-history strategies fish have developed to deal with these stressors, both of which are critical components influencing the future persistence of coho salmon within the Klamath River Basin. For example, the model has not adequately incorporated the relationship of fish disease, environmental conditions, and coho survival in the mainstem Klamath River (Yurok Tribe 2007). The model also places limited focus on the historic populations proximal to IGD and focuses more on the aggregate of coho salmon individuals (Huntington 2007).

Given the concerns raised regarding the ability of the model to incorporate the relationship of fish disease, environmental conditions, and coho survival in the mainstem Klamath River (Yurok Tribe 2007), NMFS uses the model in this analysis solely to predict the relationship of flows on coho salmon smolt survivability from IGD to the estuary.

Analysis of Project Effects

In the *Environmental Baseline* section, we described the current environmental condition Klamath River coho salmon are exposed to under Phase III flows. Below, we first describe the hydrological effects of Project operations between 2008 and 2018, using No

Project flows as a gauge to determine the magnitude and extent of hydrological effects. Next, we describe the amount and extent of hydrological effects on essential features of Klamath River coho salmon critical habitat. Last, we describe the response of coho salmon individuals to these anticipated environmental conditions.

A. Upper Klamath Population Reach (IGD to Portuguese Creek)

1. October through February

a. Hydrologic Effects of the Project

(1) Base Flows. Reclamation has proposed a minimum base flow of 1,300 cfs at IGD for the October through February time period. Reclamation's WRIMS model outputs predict flows at IGD will generally be at the minimum flow of 1,300 cfs with incremental increase to base flows predicted to occur by December in wetter than average water year exceedences (<50 percent). Reclamation's action of storing water in UKL during this period reduces the incremental increase in base flows that would otherwise occur during this time period, as evidenced by No Project flows in Appendix 2, Figures A-E.

(2) Flow Variability. Reclamation's Proposed Action evaluates climatological and hydrological information in an effort to create opportunity for flow variability in a more real-time response to existing environmental conditions. However, based on the operational priority to meet refill targets, flow variability in the fall and early winter is likely to be minimal, as predicted in Appendix 2, Figures A-C. For example, predicted flows for a 60 percent flow exceedence remain at the minimum 1,300 cfs from October through December.

Although there is uncertainty in climate trends over the next 10 years, NMFS presented information in our *Climate Change* section indicating earlier onsets of springtime snowmelt and peak streamflow across western North America (Hamlet and Lettenmaier 1999; Regonda *et al.* 2005; Stewart *et al.* 2005). Data indicate precipitation is more likely to fall as rain than snow, resulting in a greater likelihood of rainfall-driven high pulse flows in winter months. These climatological forecasts suggest winter flow variability may increase as surface flow in winter increases and snowpack decreases. Reclamation's Proposed Action of prioritizing water storage in the time period temper the magnitude and duration of pulse flows if UKL is not near flood control thresholds or capacity.

The likelihood of experiencing large infrequent overbank flows (*e.g.,* December 2006) is not likely to be affected by the Proposed Action. Hardy *et al.* (2006) concluded that the combined effect of Reclamation's Project, the network of Klamath River reservoirs, and limited storage capacities in the Upper Klamath Basin maintained the likelihood of experiencing over bank flows that provide riverine restorative function as would be expected under unimpaired conditions. In their Proposed Action, Reclamation does not propose substantive changes to the approach to storing water described by Hardy *et al.*

(2006) such that we would expect changes to the frequency of overbank flow occurrence in the eight-year action period.

(3) Hydrologic Effects from Ramp-down Rates. When flows at IGD exceed 3,000 cfs, Reclamation proposes ramp-down rates at IGD that follow the rate of decline of inflows into UKL, combined with accretions between Keno Dam and IGD. When the flow at IGD is equal to or less than 3,000 cfs, ramp down rates at IGD will achieve the following rates: (1) decreases in flows of 300 cfs or less per 24-hour period and no more than 125 cfs per 4-hour period when IGD flows are above 1,750 cfs, or (2) decreases in flows of 150 cfs or less per 24-hour period and no more than 50 cfs per two-hour period when IGD flows are 1,750 cfs or less.

Ramp-down rates are intended to mimic the natural hydrology of the Basin above IGD when flows are above 3,000 cfs. Ramp-down rates below 3,000 cfs are artificially set to minimize risks of stranding juvenile coho salmon. Daily and hourly ramp-down rate requirements are set to meter out the reduction in flow volume and avoid dramatic reductions that could harm coho salmon.

b. Effects to Critical Habitat

The Project has the potential to impact the following four essential habitat types during the October through February period: fall/winter juvenile rearing habitat, juvenile and adult migration corridors, and spawning habitat.

(1) Fall/winter juvenile rearing habitat. During the fall months (*i.e.,* October and November), coho salmon parr migrate through mainstem habitat as they redistribute from thermally suitable, summer habitat into winter rearing habitat characterized by complex habitat structure and low water velocities (Lestelle 2006). In the upper portion of the Upper Klamath River reach, characterized by the R-Ranch reach level study site, the volume of juvenile habitat is generally similar under Project and No Project modeled flow volumes, except in the most extreme wet exceedences (*i.e.,* 5-10 percent) in January and February (
Figure **15**). NMFS does not consider the 5-10 percent exceedence as likely occur in the eight-year action period and therefore does not analyze these effects of the Proposed Action. In the middle and lower portions of the Upper Klamath River reach, characterized respectively by the Trees of Heaven and Seiad Valley reach-level study sites, the volume of juvenile habitat under Project flow volumes is appreciably less than under a No Project flow volume in January in wet water exceedences (Figure 16; Figure 17). In other months and in drier exceedences, habitat availability is generally the same for both modeled flows. The results suggest the Project reduces the quantity of rearing habitat availability for coho salmon parr redistributing and overwintering within a large portion (Trees of Heaven to Seiad Valley) of the Upper Klamath River Reach during a select time period and condition (*i.e.,* January in wet exceedences). Otherwise, the addition of the Proposed Action appears to have little effect on the baseline conditions of the fall/winter rearing habitat type.

Average monthly flow-habitat estimates do not provide information on the potential short-term (*i.e.,* transitory) habitat that becomes available during pulse flow events. The Proposed Action reduces fall flow variability, thereby reducing the amount of transitory habitat that would be available to juvenile coho salmon under a higher pulse flow. These effects are likely to be evident from IGD to the Scott River, at which point Scott River flows ameliorate the reduction in flow variability caused by the Proposed Action.

(2) Juvenile and adult migration corridors. Both coho salmon adults and juveniles utilize the mainstem Klamath River as a migration corridor (Leidy and Leidy 1984; FWS 1998). Flow-habitat analyses determining the suitability of mainstem Klamath River habitat to meet the life history needs of migratory adult coho salmon are currently unavailable for the Klamath River mainstem. However, the Project flow regime will likely affect water depth and velocity within the mainstem channel, which are the two fluvial aspects controlled by the Project that affect fish passage dynamics. The Project will lower flows during much of November and December, whereas Project flows in September and October are generally higher than No Project conditions (Appendix 2, Figures 1, 12). Average monthly Proposed Action flows are predicted to be up to 800 cfs lower during the period of upstream migration. Fall-run adult coho and Chinook salmon adult escapement monitoring activities have confirmed successful passage at IGD releases of 1,300 cfs in the fall period (*e.g.,* FWS mainstem redd/carcass surveys, CDFG Shasta and Bogus Creek video weir studies, IGH returns). Therefore, no hindrances to the adult migration corridor of the Upper Klamath River reach are expected under the Proposed Action. Adequate depth and velocity for migration are expected to result when flows at IGD are 1,300 cfs as evidenced by the successful return of adult salmon to IGH when flow releases at IGD have been 1,300 cfs.

Likewise, the juvenile migration corridor in the Upper Klamath River reach is also expected to be suitable at flows at or above 1,300 cfs. Navigating shallow channel sections is inherently less troublesome for juvenile than adult fish due to their difference in size. Juvenile coho salmon have also been observed migrating from the mainstem Klamath River into tributaries at times when IGD flows have been appreciably less than 1,300 cfs and tributary base flows are at summer low levels (Soto *et al.* 2008).

(3) Spawning habitat. Coho salmon are predominately tributary spawners and limited coho salmon spawning occurs in the Upper Klamath River reach, primarily in side-channels and margins of the mainstem Klamath River. Where spawning habitat exists, gravel quality and fluvial characteristics are likely suitable for successful spawning and egg incubation. As part of a study investigating mainstem coho salmon spawning within the Klamath River, Magneson and Gough (2006) noted that the dominant substrate within sampled redds was either gravel or cobble, while a geomorphic and sediment evaluation of the Klamath River performed by Ayres Associates (1999) concluded that little fine sediment was embedded within river bed and bar gravel deposits. Redd dewatering is not expected to occur based on the predicted base flows. Base flows are predicted to be 1,300 cfs and incrementally increase through the fall/winter period and not decrease.

High flow pulses provide important ecological function. In the *Environmental Baseline* section we describe the hydrological mechanisms associated with the prevalent disease pathogens affecting coho salmon populations. High flow pulses flush fine sediment and provide restorative function and channel maintenance through scouring. Fish health researchers (*e.g.,* Stocking and Bartholomew 2007) have hypothesized high flow pulses in the fall and winter could have the added benefit of re-distributing salmonid carcasses concentrated in the mainstem below IGD, since adult salmon carry the myxospore life history stage of *C. shasta* and *P. minibicornis*. In the Upper Klamath River reach, the reduction of these geo-fluvial processes combine with the network of dams upstream to create highly eutrophic, static flow conditions for extended periods of time. These conditions favor the proliferation of Cladophora, *M. speciosa*, and ultimately *C. shasta* and *P. minibicornis* (Stocking and Bartholomew 2007). Multiple years of reduced flow variability likely have a compounding effect, likely resulting in higher risks of disease to juvenile coho salmon. An increase in flow variability added to the current baseline could reduce disease outbreaks in the Upper Klamath River reach, however NMFS expects Project effects of reduced flow variability may result in increased risk of fish disease to juvenile coho salmon.

(4) Habitat Effects of Ramp-down Rates. NMFS expects the proposed ramp-down rates when flows at IGD are greater than 3,000 cfs will generally reflect natural flow variation. We expect habitat effects, such as disconnection of off-channel habitats from the mainstem Klamath River as flows recede, to be representative of conditions that would be observed under flow conditions without Project influence. NMFS concluded in our 2002 biological opinion that the proposed ramp-down rates below 3,000 cfs minimize adverse effects to essential features of coho salmon habitat (*e.g.,* rearing, spawning habitat features). Hardy *et al.* (2006) concurred with NMFS' conclusion that decreases in flows of 150 cfs or less per 24-hour period and no more than 50 cfs per two-hour period when IGD flows are 1,750 cfs or less are not likely to adversely affect juvenile coho salmon critical habitat.

c. Effects on Individuals

(1) Effects to juvenile coho salmon rearing. Coho salmon parr and pre-smolts are expected to rear in the Upper Klamath River reach through the fall/winter period. In the *Habitat Effects of Proposed Flows* section, NMFS determined the Project will reduce juvenile coho salmon rearing habitat in the month of January in wetter exceedence conditions. In this window of time when Project effects are anticipated to reduce habitat availability, NMFS generally expects, due to the low abundance of juvenile coho salmon present in this time period, habitat reductions will not result in adverse effects to individuals.

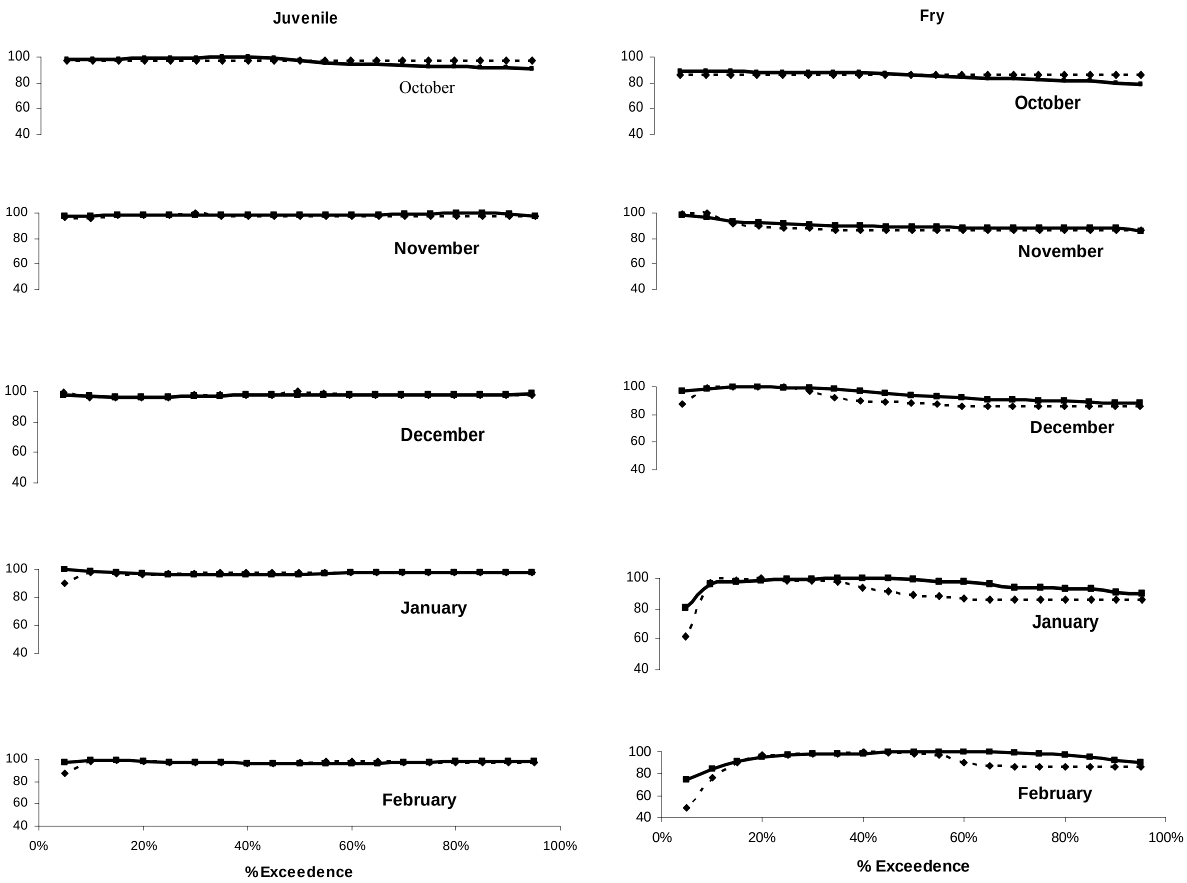

Figure 15. Percent maximum WUA at R-Ranch for both juvenile and fry coho salmon during the months October through February. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action. Analysis was based upon WUA curves from Hardy *et al.* (2006).

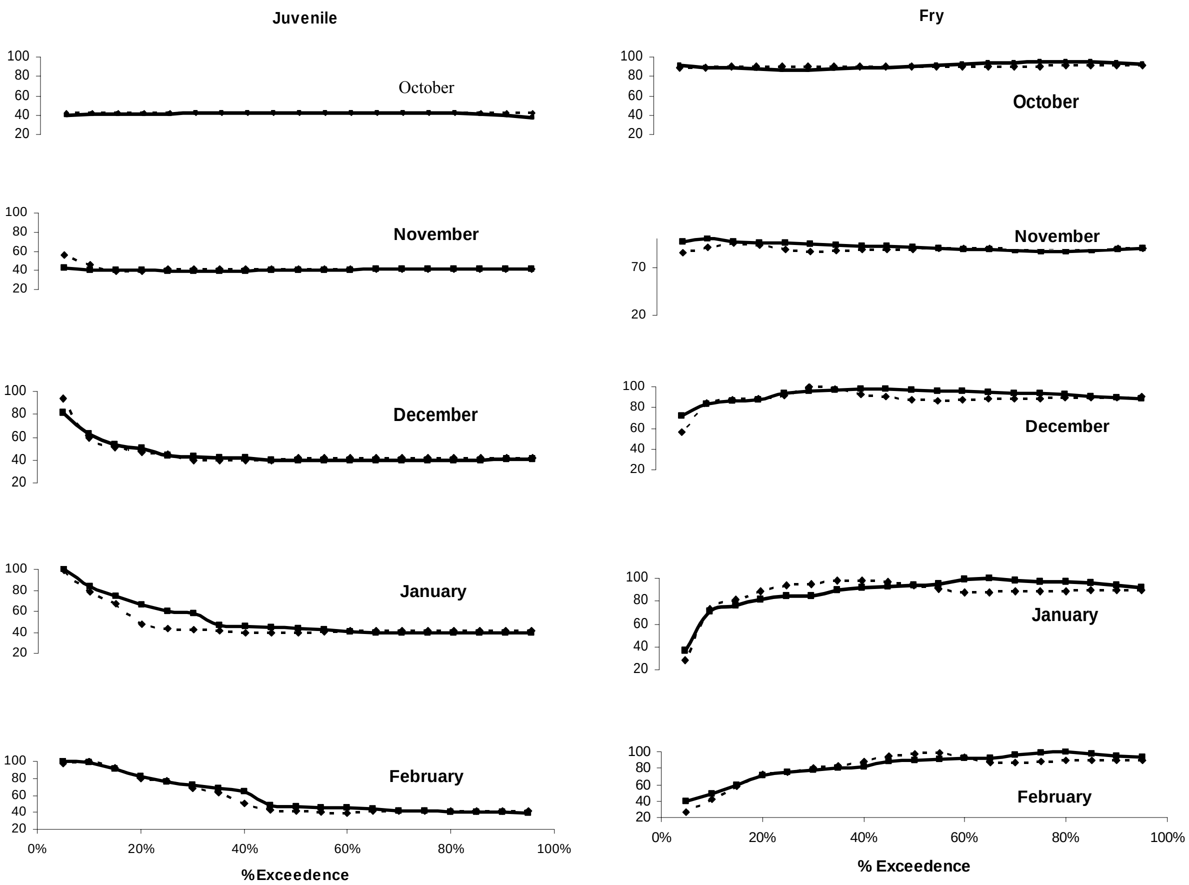

Figure 16. Percent maximum WUA at Trees of Heaven for both juvenile and fry coho salmon during the months October through February. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action. Analysis was based upon WUA curves from Hardy *et al.* (2006).

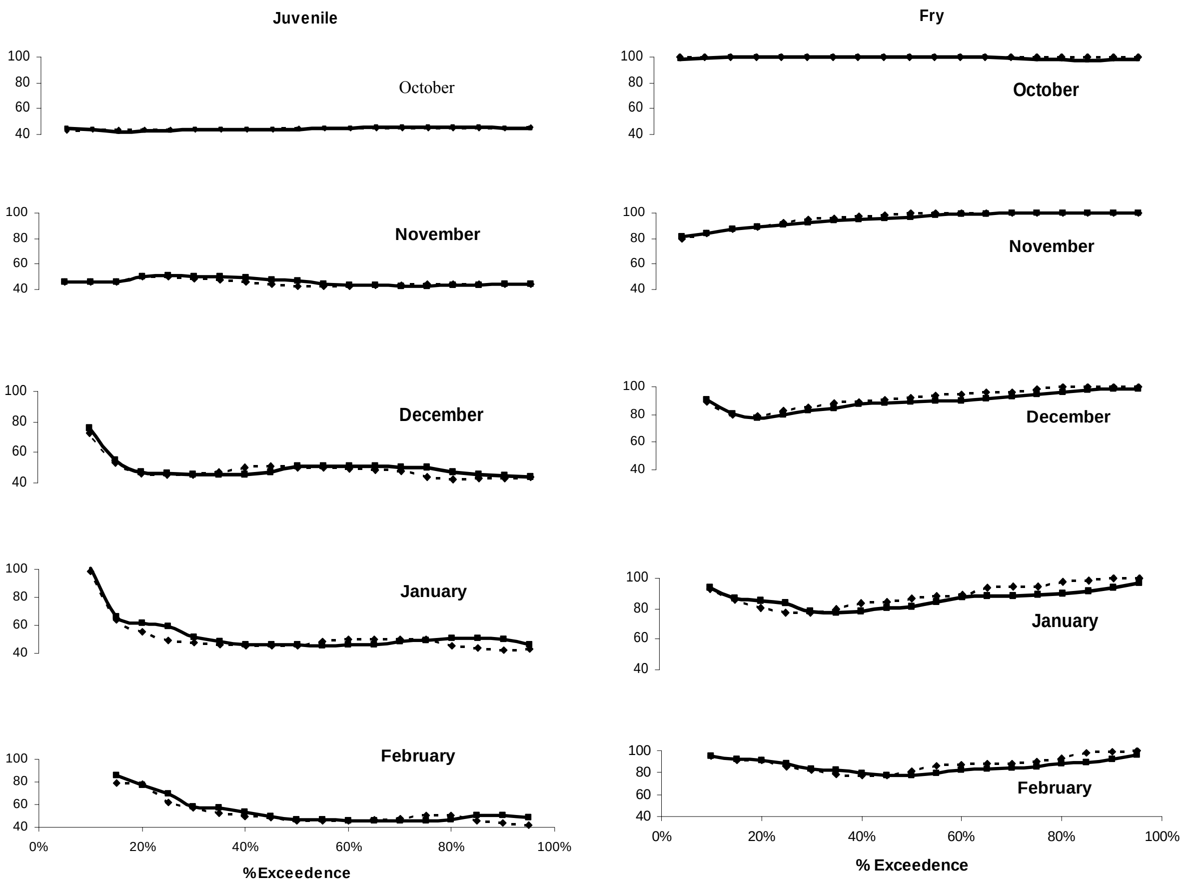

Figure 17. Percent maximum WUA at Seiad Valley for both juvenile and fry coho salmon during the months October through February. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action. Analysis was based upon WUA curves from Hardy *et al.* (2006).

(2) Effects to migration. Coho salmon in the Upper Klamath River reach require sufficient base flows to provide for movement across their landscape, including access to and from lower reaches and tributaries of the mainstem Klamath River. Through the fall (*i.e.,* October, November), ambient air and water temperatures generally decrease, rainfall events occur at greater frequency, and parr coho salmon movement from natal tributaries into the mainstem Klamath River increases.

Juvenile coho salmon have been observed successfully accessing tributaries during summer months when IGD base flows have been 1,000 cfs and tributary discharge has been generally lower than the fall through winter period (Soto *et al.* 2008). NMFS expects juvenile coho salmon will be provided adequate flows to access tributaries when base minimum flows are 1,300 cfs or above. As described in the ***Juvenile and adult migration corridors*** portion of this section, no hindrances to adult and juvenile coho salmon are expected as a result of flows under the Proposed Action in the October through February time period. Therefore, NMFS expects adult and juvenile coho salmon will experience no adverse effects of the Proposed Action during migration in October through February.

A loss of flow variability will likely reduce the environmental cues that coho salmon would experience. Increased flow variability that better reflects the natural flow regime would likely improve the fitness of these individuals through short term gains in habitat and important ecological functions. During fall and winter freshets, individuals in this reach will likely experience environmental cues other than flow, such as changes to ambient temperature and barometric pressure, although the effectiveness of the cues will be tempered by the Project's effect of reducing flow variability. The effects will be most pronounced in fall and early winter, and diminish as spill conditions are realized. Parr coho salmon utilizing the Upper Klamath River reach in October and November are most likely to be adversely affected. These individuals will likely experience a reduction in environmental cues to redistribute and are less likely to find suitable overwintering habitat that exists in downstream reaches. As a result, some individuals will likely experience a reduction in fitness, including lower overwintering survival rates.

(3) Effects to Spawning. As we describe in our *Environmental Baseline* section, the diversity of life history strategies of coho salmon include utilizing the mainstem Klamath River for spawning. A small but consistent number of adult coho salmon spawn in mainstem habitat in the Upper Klamath River reach, primarily using side channels and margin habitat. Coho salmon have been observed to successfully spawn in the mainstem Klamath River when base flows at IGD ranged between 900 cfs and 1350 cfs (Magneson and Gough 2006). Thirty-eight confirmed coho redds were observed in the five year span from 2001 to 2005, with the highest count occurring in 2001 (n=13). Physical habitat modeling specific to adult coho salmon spawning in the Klamath River has not occurred. Yet, model results presented in Hardy *et al.* (2006) for Chinook salmon spawning habitat indicated that spawning habitat is maximized at approximately 1,300 cfs in the IGD to Shasta River reach and this information serves as a general index of the abundance of spawning habitat for all adult salmonids. Based on the information presented herein, NMFS expects there is an abundance of suitable coho salmon spawning habitat available when IGD releases are 1,300 cfs, such that in the event of future increases to the abundance of the Upper Klamath Population unit, spawning habitat is anticipated to be sufficient.

(4) Effects to in-gravel incubation. In-gravel incubation survival can be affected, for example, when base flows decrease appreciably and redds become de-watered or intra-gravel flow is disrupted. Reclamation has proposed a minimum base flow of 1,300 cfs or more throughout the coho salmon spawning and incubation period. Since base flows are predicted to remain stable throughout the incubation period or increase, no redd dewatering or disruptions to intra-gravel flow are anticipated.

(5) Effects of ramp-down rates on individuals. Ramp-down rates can strand juvenile coho salmon if flow reductions accelerate the dewatering of lateral habitats. Stranded juvenile coho salmon disconnected from the main channel are more likely to experience fitness risks, becoming more susceptible to predators and poor water quality. Death from desiccation may also occur as a result of excessive ramp-down rates that dry up disconnected habitats. While stranding of juvenile salmonid can occur under a natural flow regime, artificially excessive ramp-down rates exacerbate stranding risks. Salmonid fry are generally at the most risk from stranding than any salmonid life stage due to their swimming limitations and their propensity to use margins of the channel. NMFS expects the proposed modifications to ramp-down rates when flows at IGD are greater than 3,000 cfs will generally reflect natural flow variation. We expect any stranding that may occur at these higher flows to be consistent with rates that would be observed under natural conditions. We concluded in our 2002 biological opinion that the proposed ramp-down rates below 3,000 cfs adequately reduce the risk of stranding juvenile coho salmon. Hardy *et al.* (2006) concurred with NMFS' conclusion that decreases in flow when IGD flows are 1,750 cfs or less provide adequate protection to salmonids from stranding. NMFS concludes Reclamation's proposed ramp-down rates are not likely to adversely affect juvenile coho salmon and therefore does not analyze this part of the Proposed Action further in this Opinion.

2. March through June

The March through June time period is critical within the life history of Klamath River coho salmon. Coho salmon smolts in the Klamath Basin use the mainstem as their migratory corridor to the sea in this time period. The size of the fish, flow conditions, water temperature, dissolved oxygen levels, day length, and food availability all tend to affect the time of migration (Shapovalov and Taft 1954). Also, coho salmon fry and parr utilize the mainstem Klamath River for rearing in this time period. Juvenile coho salmon must also contend with the compounding effects of changing climatological conditions that reduce the quantity and quality of spring flows, and the adverse effects of hatchery releases.

a. Hydrologic Effects of the Project

(1) Base Flows. Reclamation proposes to meet minimum flows and provide surplus water through the IM process when available. Reclamation has prioritized the March through June time period for seasonal distribution of IM water, and their modeling predicts flows at IGD will either be at minimum flows or above as a result of IM flow augmentation or spill. Spill events are expected to occur in most years, as Reclamation has prioritized filling UKL by April 1, while also considering impending snowmelt. Reclamation's WRIMS modeling predicts spill events will most likely occur in March and April although climatological forecasting suggests spills may occur earlier in the future. The degree that Reclamation can control spill events is dependent on a number of factors, including meteorological and climatological conditions, and storage availability. Based on climatological forecasts, water availability in late spring is expected to be limited in the eight-year action period, suggesting a greater likelihood of dry hydrological conditions (*i.e.,* dry flow exceedences) in the late spring period. For the purpose of analyzing the effect of predicted flows under the implementation of the Proposed Action on coho salmon, we consider spill and IM water together.

Reclamation's predicted flows under the Proposed Action result in spring hydrographs that generally perpetuate and exacerbate the truncated late spring flows evident under current baseline conditions (Appendix 3). The magnitude, duration and timing of base flows through the March through June period are affected by the Project. As we described in the *Environmental Baseline*, anthropogenic and climatological factors have caused a shift in the timing of the annual peak flow from April to March, in part as a result of Reclamation's past and present operations to accelerate water storage in UKL until capacity is reached. Model results indicate this shift in the timing of the annual peak flow will perpetuate into the future under the Proposed Action.

The Project consumes water and reduces water availability downstream of IGD throughout the March through June, and WRIMS modeling predicts the Project will reduce spring base flows under most flow exceedences (Appendix 2, Figures F-I). These effects are most evident in late spring (May, June) when agriculture and refuges are expected to require the greatest volume of water in this time period

(2) Flow Variability. The early spring period of March and April is generally a period of high flow variability. Water storage in UKL and PacifiCorp hydroelectric reservoirs generally peaks in these months. Rainfall events and sudden increases in snowmelt can result in variable flows at IGD as Reclamation and PacifiCorp treat hydrological fluctuations as run-of-the-river. However, in recent years (*e.g.,* 2001-2005) during dry winter and spring conditions, minimum "flat-line' flows have been implemented and flow variability has been reduced at IGD even during March and April. Under the Proposed Action, flow variability will likely only occur in May and June during substantial rainfall events. Large rain-on-snow events in May will likely result in substantial flow variability, even in relatively drier water years (*e.g.,* May 2005).

Reduced flow variability resulting from Project Operations will be greatest proximal to IGD and diminish longitudinally, as tributary accretions contribute to the volume of water and impart flow variability. By early April, contributions from the Shasta River are expected to be reduced from water diversion projects, and tributary contributions are minimal until the Scott River. By mid-June, as Scott River flows decrease substantially from lack of snowmelt and water diversions, the loss of flow variability at IGD will be evident throughout the Upper Klamath River reach. With a strong likelihood that current climatological trends in warm spring conditions continue over the eight-year action period, we anticipate early peak flows and reduced late spring accretions from the snowmelt driven Scott River watershed.

b. Effects to Critical Habitat

The Project has the potential to impact the following essential habitat types during the March through June period: (1) coho salmon fry and juvenile rearing habitat, and (2) juvenile migration corridors. The Project may also affect water quality conditions.

(1) Coho salmon fry habitat. In the *Environmental Baseline*, we describe how coho salmon fry are present throughout the entire Upper Klamath River reach of the mainstem throughout this time period. Generally, an abundance of coho salmon fry habitat is predicted throughout the entire Upper Klamath River reach under the Proposed Action (Figures 18-20). In months and flow exceedence combinations where habitat availability is not anticipated to be abundant (*i.e.,* less than 80 percent), the Proposed Action generally results in either similar volumes or greater volumes of coho salmon fry habitat than would occur under a No Project flow (Figures 18-20).

Information specific to coho salmon fry, and habitat availability in this reach and time period is limited. Williamson (2005) observed poor survival of coho salmon fry in the Bogus Creek to Interstate 5 reach in March and April, 2005, when flows at IGD were lower than proposed by Reclamation and varied between 800 and 1000 cfs. However, Reclamation has proposed minimum monthly flows at IGD in the March through June period range between 1,400 and 1,500 cfs, and we conclude the Project is not likely to adversely affect coho salmon fry critical habitat in the Upper Klamath River reach in the March through June period.

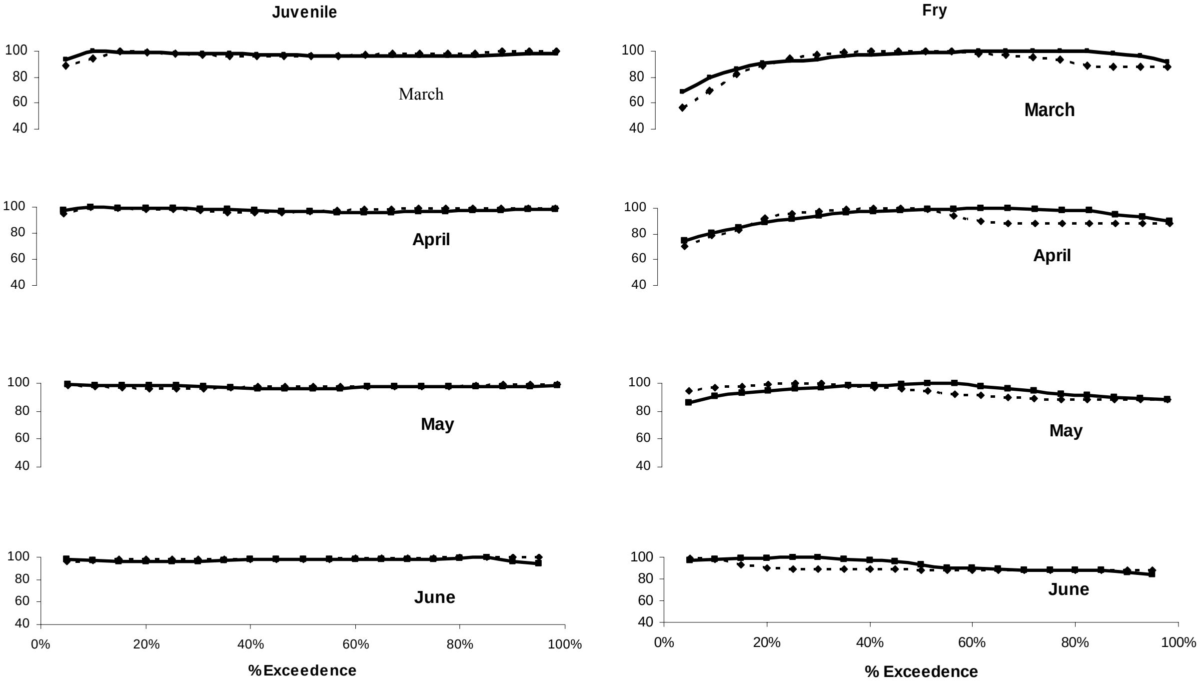

Figure 18. Percent maximum WUA at R-Ranch for both juvenile and fry coho salmon during the months March through June. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action.

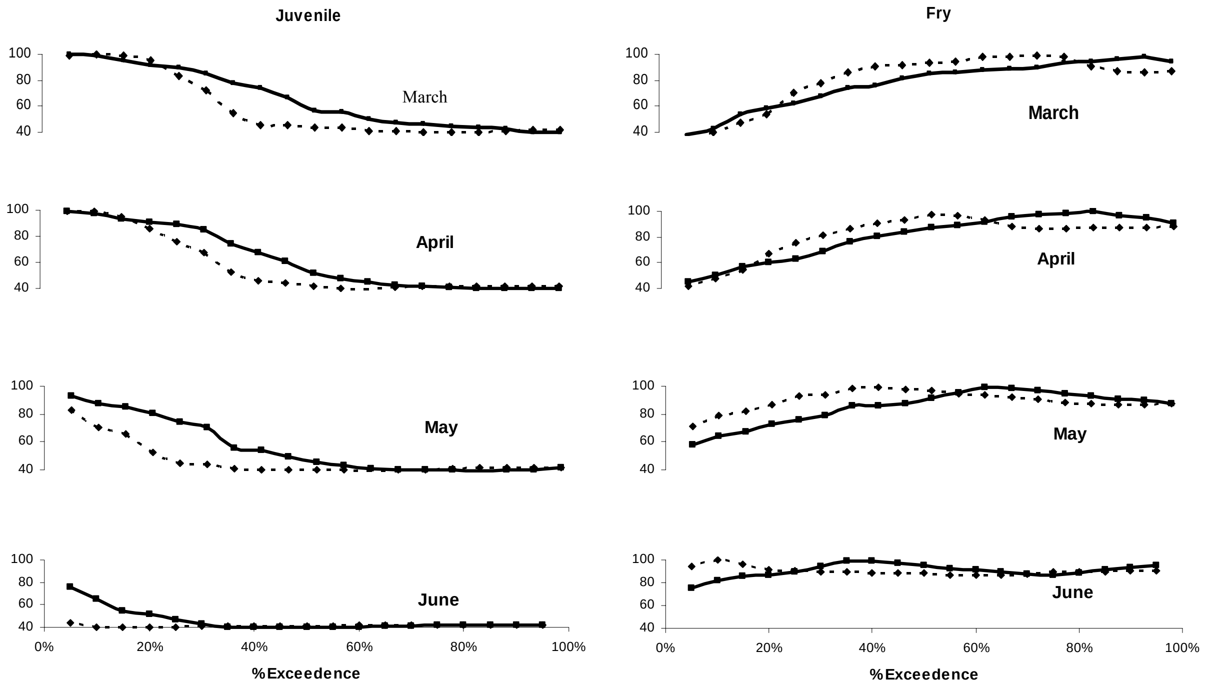

Figure 19. Percent maximum WUA at Trees of Heaven for both juvenile and fry coho salmon during the months March through June. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action.

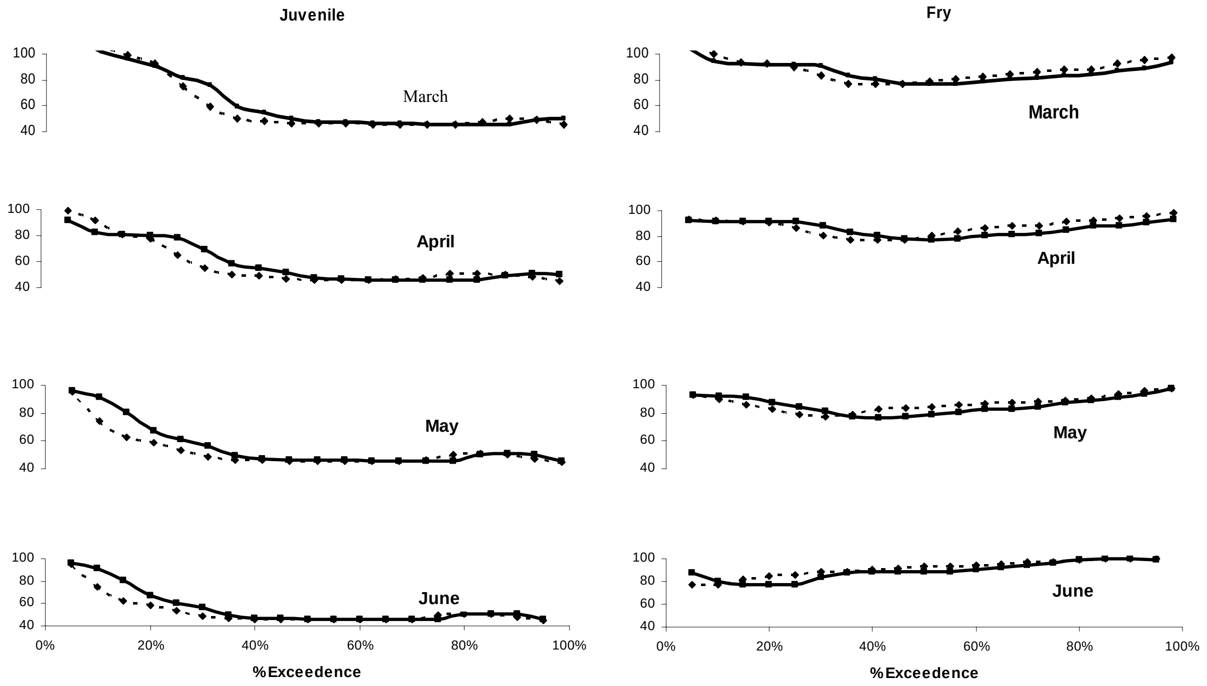

Figure 20. Percent maximum WUA at Seiad Valley for both juvenile and fry coho salmon during the months March through June. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action.

(2) Coho salmon juvenile (parr, pre-smolt, and smolt) rearing habitat. Based on monitoring information, coho salmon parr are expected to be present in the Upper Klamath River reach beginning in mid-April. In the *Environmental Baseline*, we described that as coho salmon fry grow to approximately 50 to 60 mm, they transform into parr, and their habitat preferences change. Coho salmon juveniles show preference to use complex habitat features, and we expect these individuals will seek available locations in the mainstem Klamath River that contains adequate depths, velocities and associated cover as they rear.

In the upper portion of the Upper Klamath River reach, represented by the R-Ranch reach level study site, an abundance of juvenile coho salmon critical habitat under all predicted flow exceedences from March through June period is anticipated (Figure 18).

In the middle portion of the Upper Klamath River reach, represented by the Trees of Heaven reach-level study site, the Proposed Action results in generally similar volumes of available habitat as would occur under a No Project flow in the dry through below average flow exceedences (*i.e.,* 95 to 65 percent). Habitat modeling predicts appreciable reductions in the amount of critical habitat for juvenile coho salmon rearing, specifically in average and wetter flow exceedence conditions. For example, in the four month period of March through June, and in flow exceedences ranging from 25 percent to 55 percent (7 5-percent increments), the Proposed Action results in habitat reductions greater than 10 percent in 16 of the 28 possible flow exceedence/time period combinations (mean reduction 16 percent, maximum reduction 30 percent).

In the lower portion of the Upper Klamath River reach, represented by the Seiad Valley reach-level study site, the Proposed Action results in generally similar volumes of available habitat as would occur under a No Project flow in the dry through above average flow exceedences (*i.e.,* 95 to 35 percent). Habitat modeling predicts appreciable reductions in the amount of suitable habitat for juvenile coho salmon, specifically in wetter flow exceedence conditions (30 to 5 percent).

(3) Migration corridors. Based on the information provided on the effects of the Proposed Action on juvenile migration corridors in the fall, and given that flows are generally predicted as higher in the spring than the fall, NMFS anticipates the March through June predicted flows will be sufficient to provide adequate depth and volume to maintain connectivity with tributaries and downstream reaches of the mainstem Klamath River

(4) Water Quality. Long-standing hydrological alterations resulting from anthropogenic factors, including past and current Project effects, have had a pronounced effect on water quality (see the *Environmental Baseline* section). In the March through June time period, large shifts in water quality conditions can occur when spring storms result in high flow pulses. Large, snow melt driven high flow pulses can result in decreases to water temperature that have ecological bearing and benefits to juvenile coho salmon survival.

The influence of flow releases at IGD on downstream water temperature has been studied using the USGS Systems Impact Assessment Model (SIAM). The decision support system includes a water quantity/water quality component that allows a user to evaluate the influence of water management alternatives, including hypothetical water releases at IGD, on water temperature. Water temperature is an important variable influencing disease infection rates among anadromous salmonids in the Klamath River. Recently, USGS conducted a model run, evaluating a range of flow alternatives at IGD under the current baseline condition (Campbell 2008). Their results on the effect of IGD release on mean monthly water temperature for the March through June period include: (1) Discharge at IGD accounted for up to 2^{o}C of the variation in temperature, (whereas ambient meteorology accounted for up to 6^{o}C of the variation in temperature); and (2) Increasing IGD flows generally had no discernable effect (March-April) or slight increases (May-June) to mean or maximum monthly water temperature. The modeling indicates that as the Upper Klamath Basin begins to experience a warming trend, IGD releases are generally warmer, and flow increases tend to result in slight increases to mean and maximum water temperatures. This information suggests the linkage between the Project's effect on water temperature in this time period are minor given the overriding effect of environmental baseline conditions, principally the network of reservoirs upstream of IGD. However, these data do suggest the Project may reduce water temperatures slightly in May and June.

Beginning in April and lasting through September, run-off and drain water entering the Klamath River from the Klamath Straits Drain is likely to contain nutrients, organics, and sediment. Return flow from the Klamath Straits Drain contains low DO, especially in summer months but may occur as early as June (Figure 21).

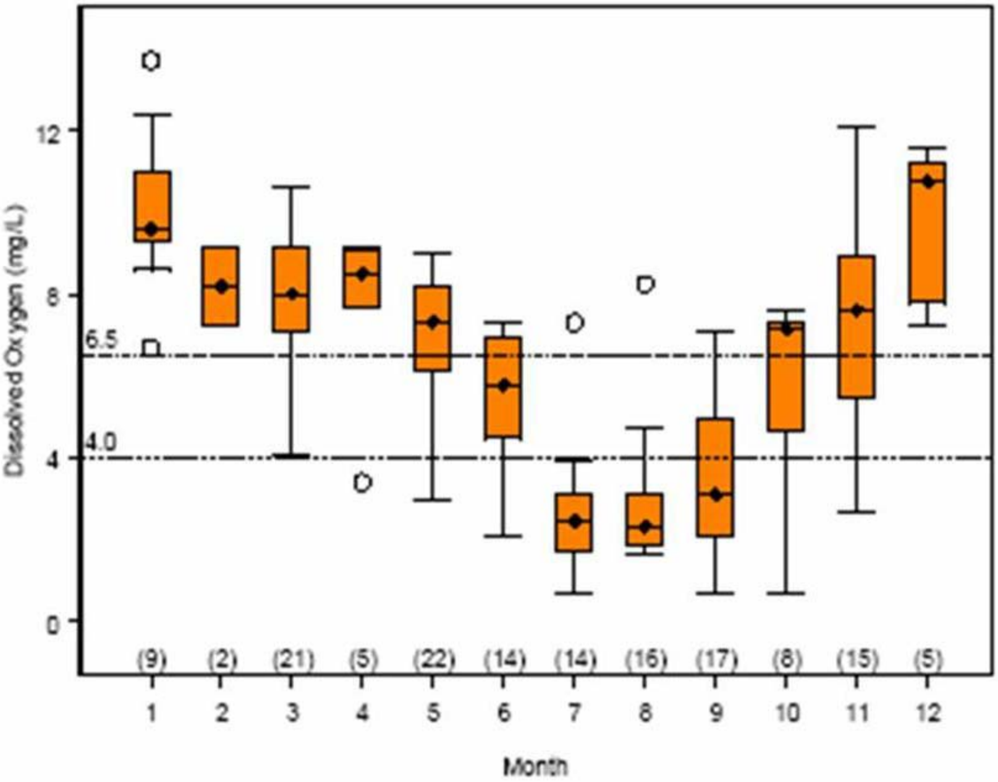

Figure 21. Monthly variation in DO levels in the Straits Drain (from EPA 2007). The dashed lines at DO levels of 6.5 and 4 mg/l represent the upper and lower range for Oregon's DO standards.

The highly eutrophic outflow from UKL upstream of Klamath Straits Drain confounds the ability to separate water quality effects of the Project from other factors. Water quality in Keno Reservoir is strongly influenced by the amount of organic matter (primarily in the form of blue-green algae) originating from UKL and exceeding the assimilative capacity of the reservoir, resulting in a considerable oxygen-demanding load on the system during the summer (Deas *et al.* 2006; FERC 2007). High pH and un-ionized ammonia are also associated with the heavy transfer of blue-green algae from UKL (Deas *et al.* 2006). Isolating the nutrient loading and effect of the Proposed Action on water quality in Keno Reservoir and downstream at IGD from municipal, industrial, and other non-Project sources has yet to be completed; however, TMDL analyses currently underway in Oregon will identify these loads.

Low DO concentrations are primarily observed in the Upper Klamath River reach in summer and early fall, however low DO concentrations can occur in June. Low DO concentrations in the Upper Klamath River reach are largely driven by the effects of the PacifiCorp Hydroelectric Project (NMFS 2007b), and the influence of the Proposed Action on DO concentrations is likely to be negligible.

c. *Effects to Individual Fish*

(1) Rearing Habitat. Based on information presented in the *Critical Habitat Effects* portion of this section, NMFS expects coho salmon fry will likely experience adequate volumes of suitable rearing habitat in the Upper Klamath River reach to support their life history needs under the Proposed Action (Figures 18-20). NMFS does not expect the Proposed Action to have adverse effects on the coho fry salmon life history stage as a result of the Project's effect on fry rearing habitat in the Upper Klamath River reach.

Wild coho salmon smolts and parr will be competing for available habitat with hatchery-released salmon and steelhead from March through June. Competition likely peaks during May and early June, when the highest numbers of wild coho salmon smolts and parr overlap with the approximately 5 million Chinook salmon smolts released from IGH. The lower juvenile habitat volume caused by the Proposed Action is likely to result in a number of adverse effects to individuals, including increased risks of predation and reduced bioenergetics and growth, making individuals more susceptible to disease and ultimately increasing their risk of mortality.

In the upper portion of the Upper Klamath River reach, juvenile coho salmon are expected to be provided an abundance of available habitat at all flow exceedences predicted under the Proposed Action (Figure 18). NMFS does not expect the Project will have adverse effects on coho salmon juveniles as a result of the Project's effect on juvenile rearing habitat in the upper portion of the Upper Klamath River reach.

In the *Critical Habitat Effects* portion of this section, we describe the Project's effect of appreciably reducing the volume of coho salmon juvenile available habitat in the middle and lower portion of the Upper Klamath River reach during average and wetter late spring conditions. These Project effects are compounded by other anthropogenic and environmental factors. For example, this effect occurs coincident to the peak in juvenile salmonid density in the upper Klamath River reach. Also, based on climatological forecasts, described in the preceding *Climate Change* sections of this Opinion, NMFS expects over the eight-year action period, a reduced probability of average and wetter hydrological conditions in late spring, and limited opportunities for coho salmon to experience beneficial late spring conditions. In those limited opportunities in the future, when late spring flows are more representative of the Klamath River's natural flow regime, NMFS would expect juvenile coho salmon to experience benefits to their fitness, improving survival. The Project's effect of reducing available rearing habitat in average and wetter conditions to a volume that is more representative of drier flow exceedences over a large portion of the Upper Klamath River reach (*i.e.,* Trees of Heaven through Seiad Valley) will likely reduce the fitness and survival of some juvenile coho salmon.

Shasta River coho salmon may be most susceptible to the Project's effects on juvenile coho salmon rearing habitat. Based on CDFG outmigrant data (Chesney *et al.* 2007), coho salmon parr from the Shasta River outmigrate in mid-May. These parr face myriad risks to survival including density-dependent risks resulting from habitat limitations (*e.g.,* increased risk of predation), and density-independent risks as described below in the *fish disease* analysis. Kostow and Zhou (2006) found that large releases of hatchery smolts contributed to a decrease in wild salmonid productivity. In the Upper Klamath River reach, colonies of piscivorous mergansers are common, and coho parr salmon that are not closely associated to cover would likely experience increased risks from predation. Cover habitat in the Upper Klamath River reach is primarily composed of vegetation in lateral portions of the channel. Based on Chinook salmon fry WUA curves in the Upper Klamath River reach (Hardy *et al.* 2006), cover habitat is rapidly reduced when flows at IGD are less than 2,000 cfs. Habitat limitations can also displace fish and force them to seek out suitable habitat.

(2) Effects on Fish Disease. The likelihood that an individual juvenile coho salmon in the Upper Klamath River reach may contract disease is a function of a number of variables, including flow. In the *Environmental Baseline* section, and earlier in this *Effects Analysis* section, we described how the magnitude, duration and frequency of flow can affect the life cycle of the disease pathogens, *C. shasta* and *P. minibicornis* and their hosts. As described earlier, water quality studies of *C. shasta* actinospore concentration loads indicate high concentrations in the Upper Klamath River reach (Hallett and Bartholomew 2006; Stocking *et al.* 2006), suggesting a disease nidus exists in the vicinity of the Trees of Heaven study site (Stocking and Bartholomew 2007).

Large magnitude flows are hypothesized to disrupt the life cycle of *M. speciosa*, thereby lowering disease infection rates (Stocking and Bartholomew 2007). The 2006 study results reported in the *Environmental Baseline* section suggest the high peak (>10,000 cfs) and sustained spring flows resulted in a general reduction in seasonal disease rates and a delay in the peak infection rates among juvenile anadromous salmonids. Flows at IGD in the spring of 2006 may have influenced disease infection rates by: (1) reducing the abundance of *M. speciosa* colonies due to the scouring of slack water habitats and cladophora beds, (2) diluting *C. shasta* and *P. minibicornis* actinospore concentrations; and/or (3) reducing the transmission/infection efficiency of the parasites due to environmental conditions (temperature, turbidity, velocity). While the Project reduces base flows and flow variability, it does not appear to affect the likelihood of future large overbank flows resulting from Upper Klamath Basin spill, and similar in magnitude to the high flows of 2006.

Disease rates are generally lower in March and April than May and June, when water temperatures begin to increase, flows generally diminish, and actinospore concentrations increase. The Project’s effect of accelerating the reduction in the base flow hydrograph in May and June will likely have adverse effects on infection rates of juvenile coho salmon. However, the body of information available to NMFS does not illustrate a clear linkage between incremental changes in flow and disease rates. Rather, the information available to us indicates the effect of flow on disease rates is interwoven throughout the life cycle of the disease pathogens, their hosts and their habitats. Despite the limitations in our ability to parse out effects of flow on disease, Klamath River disease monitoring and research provides us with important empirical data to consider as we analyze the effects of reduced base flows and flow variability on disease risks to coho salmon.

The May 2005 flows and concurrent fish disease sampling exemplify the complex interaction described above. A rain-on-snow event raised IGD flows from 1,370 cfs to a peak of 5,520 cfs and sustained high flows for approximately 3 weeks. Mean daily water temperatures fluctuated by approximately 2°C throughout the Upper Klamath River reach (Figure 22). Prior to the pulse flow event, *P. minibicornis* infection rates of sampled juvenile Chinook salmon in the Upper Klamath River reach was 100 percent and *C. shasta* infection rates were approximately 75 percent (Figure 23). During the descending limb of the hydrograph, *C. shasta* disease rates decreased, culminating with a low of 32 percent in sampled fish by June 13 when IGD flows were approximately 1,200 cfs. *P. minibicornis infection rates* remained high throughout May and June 2005.. Stocking and Bartholomew (2007) reported a colony of *M. speciosa* located in fine sediment near the Trees of Heaven study site was displaced following the high flow event, while other colonies located in cladophora beds were less affected. Surprisingly, actinospore concentrations in the Klamath River did not appear to be reduced by the high flow event (Foott *et al.* 2006). This information underscores the lack of a clear causal relationship between base flows and disease rates.

Under the Proposed Action, reduced base flow will limit habitat availability and either increase stressors to the individual through density dependent effects, or displace individuals. Juvenile coho salmon outmigrating from the Shasta River enter a zone of high infection near the Trees of Heaven study site and additional stressors to the individual could make them more susceptible to infection.

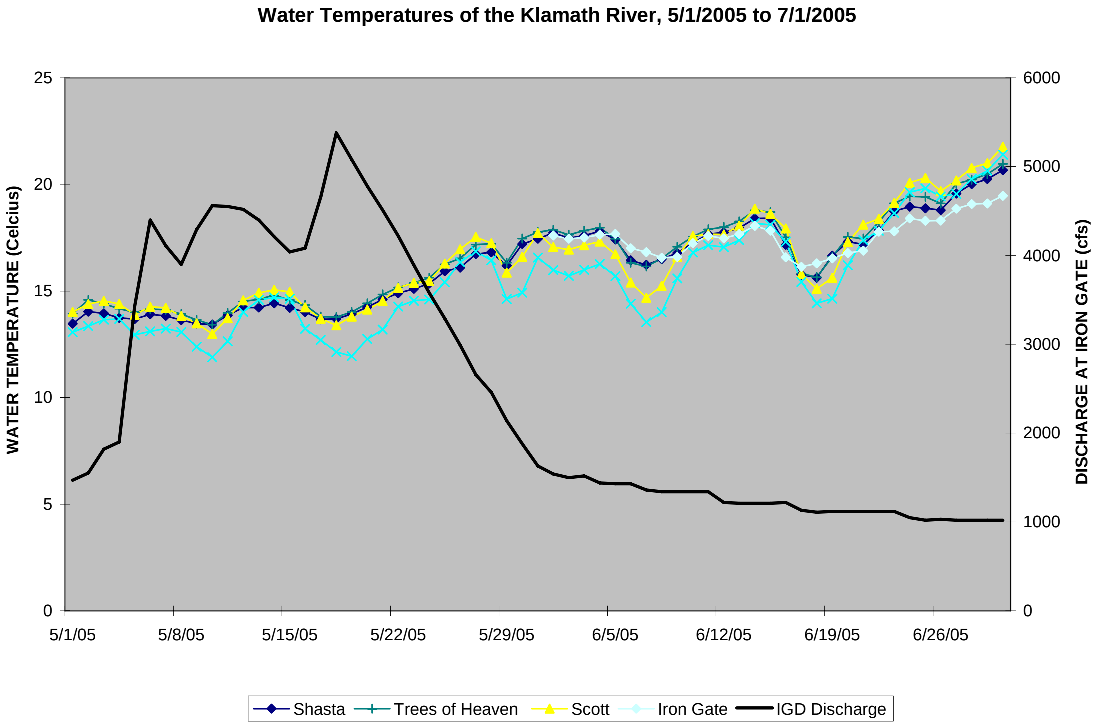

Figure 22. Mean daily water temperatures at four mainstem Klamath River sites, May 1 to July 1, 2005 (FWS-AFWO data).

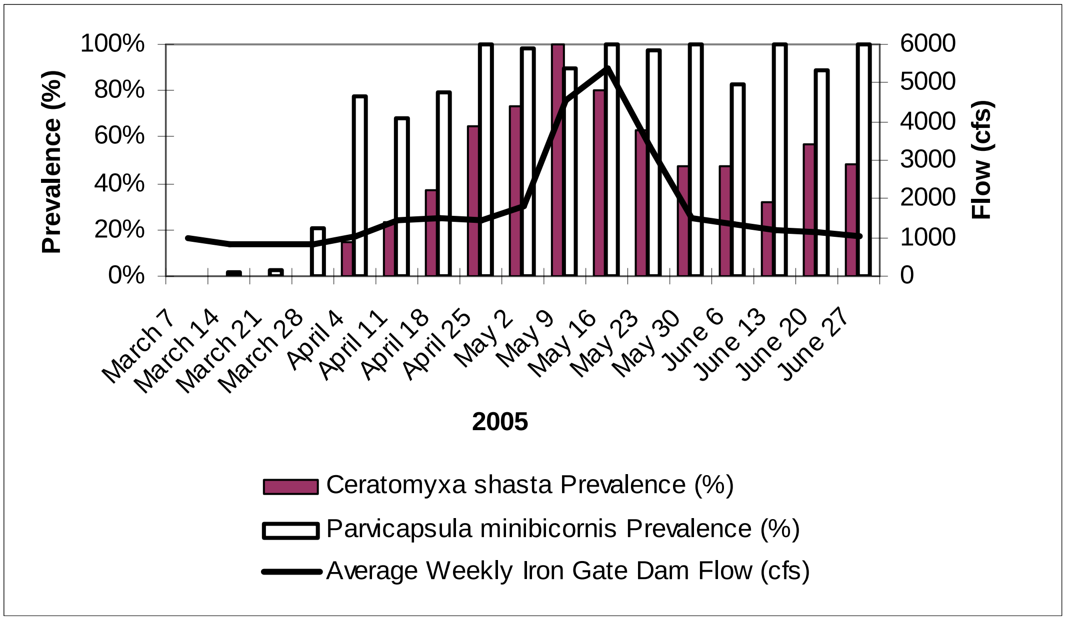

Figure 23. Weekly prevalence of *C. shasta* and *P. minibicornis* in juvenile Klamath River Chinook salmon collected in the Shasta to Scott River reach, March 7 through July 2, 2005 (Nichols *et al.* 2005).

High over bank flow events that are most likely to disrupt the life cycle of *C. shasta* and *P. minibicornis* are likely to occur independent of the Project. While we have described the general regional climatological trend as one of dry, warm conditions, climatological information also suggests we will continue to experience increased climatological variability (Pagano and Garen 2005), and periods of persistent wet or dry conditions may occur over the next 10 years. Disease monitoring from spring 2006 indicates, however, that under current baseline conditions, the magnitude of disease rates can still be high following over bank flows.

The information available to us indicates the varying and generally high rates of disease infection from *C. shasta* and *P. minibicornis* observed in juvenile coho salmon in the upper Klamath River reach are likely to perpetuate into the future under the Proposed Action. However, the influences of the Project on fish disease are difficult to discern. While Reclamation has discretion to release higher flows in the spring than are currently projected, the influence of incrementally higher flows in the spring on infection rates of juvenile coho salmon is difficult to predict. The information available suggests that concentrations of actinospores are excessively high during periods of high infection, and we currently lack information to indicate if increases in base flow can dilute actinospore concentrations to a level that infection rates lower in a corresponding fashion. However, NMFS assumes disease rates would be lower under a “no project” flow regime than under the Proposed Action since a no project flow regime better represents the natural hydrograph with higher winter and spring base flows and increased flow variability. Disease infection rates likely elevate when the watershed experiences multiple years of low base flows. The information available suggests disease rates are exacerbated by multiple years of low base flows. In the 10 year action period, multiple years of dry climatological conditions would likely result in extended periods of steady state flows at IGD, resulting in high rates of disease infection. By reducing spring flows, the Proposed Action trends hydrological conditions towards drier flow exceedences. Therefore NMFS concludes the Proposed Action increases disease risks to juvenile coho salmon.

(3) Effects on smolt outmigration. Migrating wild smolts are usually present in the Upper Klamath River reach between February and the middle of June, with April and May representing the peak migration months (FWS 1998). Wild coho salmon smolts, upon entering the Klamath River from their natal tributary, generally tend to begin their downstream movement quickly, and movement rates accelerate as fish move through the Upper Klamath River reach (Stutzer et al 2006). However, Stutzer *et al.* (2006) found at least 11 percent of the wild coho salmon smolts radio-tagged and released in the Upper Klamath River reach exhibited rearing-type behavior during their downstream migration.

The relationship of flow on smolt transit time has been studied primarily to determine the effect of reservoirs and water budgets on transit times. In the Columbia River, variables including flow, and travel time have been studied, and results generally indicated an inverse relationship between flow and transit time (Berggren and Filardo 1993). In the *Environmental Baseline* section we presented the results of recent Klamath River studies that investigated the survival rates of coho salmon smolts in the Upper Klamath River reach. Constraints of these studies included: (1) the lack of opportunity to regulate flow for experimental purposes; (2) wild coho salmon smolts were available for only one year of study; and (3) hatchery coho salmon appear to differentiate from wild coho smolt salmon by exhibiting a migration delay after release, therefore the use of hatchery-reared fish as a surrogate for wild fish behavior is not prudent.

Spring flows in the Upper Klamath River reach varied considerably in 2006 and 2007 (Figure 24). Overall survival in 2006 (68 percent) and 2007 (70 percent) were comparable, and in 2007, poor survival in the IGD to Scott River reach was observed. The USGS and FWS 2007 radio-tracking study indicates survival of hatchery coho salmon smolts was disproportionately reduced when fish were released in the Trees of Heaven zone of the Klamath River. As reported above, the Trees of Heaven is a zone of disease nidus. Given the affinity of hatchery-raised coho to delay migration upon entering the Klamath River, survival is likely to be poor as a result of disease.

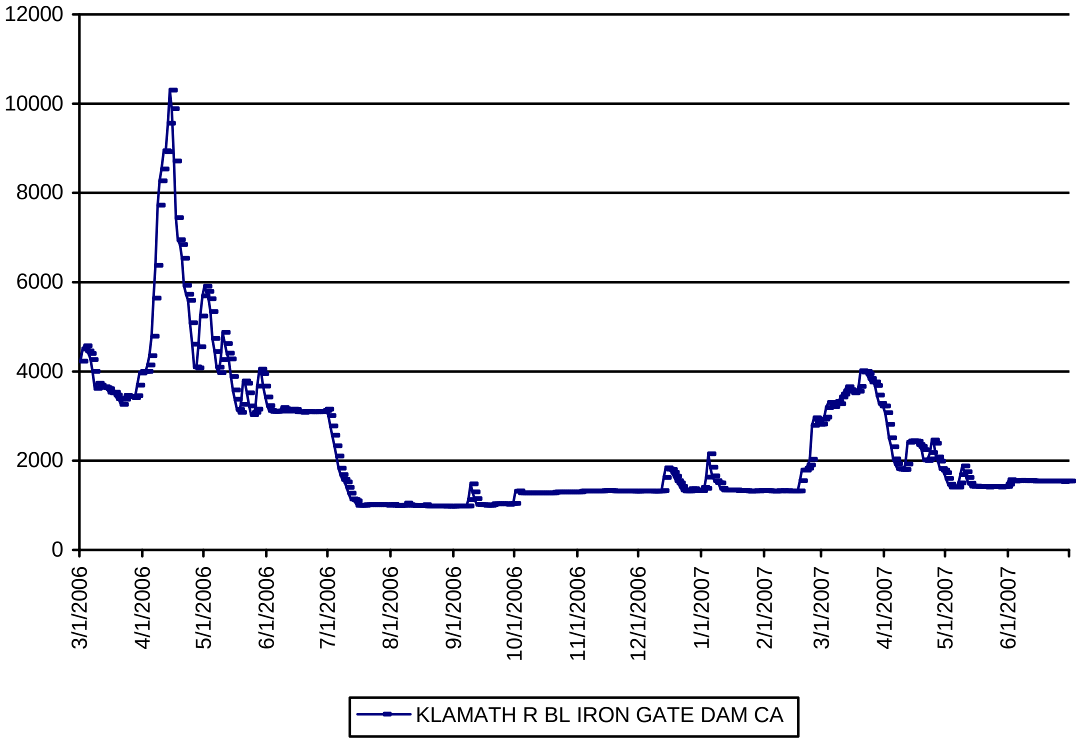

Figure 24. Mean daily flows (cfs) at IGD, March 1, 2006, to June 30, 2007 (USGS data).

Smolt outmigration timing and smolt size appear to respond to small-scale habitat variability (Weitkamp *et. al* 1995). Flow variability is an important environmental cue, and when combined with other environmental (photoperiod, temperature) and physiological (gill ATPase) factors, influence smolt outmigration. Reclamation proposes ramp-down rates that will result in variable flow reduction. However, variable flow increases will be reduced under the Proposed Action. The lack of hydrological response to storm events and the degree that this loss influences coho smolt outmigration is difficult to discern, but we expect some coho smolts will experience delayed migration resulting from lower base flows and reduced flow variability.

Cramer Fish Science's coho salmon life cycle model investigates effects of IGD releases on smolt survivability. In an analysis of IGD flow alternatives including Reclamation's Proposed Action and predicted No Project flows for select flow exceedences (25, 50, 75 percents) flow at IGD explained a much greater proportion of the variation in survival than exceedence types for reaches closest to IGD. As fish move downstream, the influence of tributary inputs begins to outweigh the effects of flow released at IGD. Based on some simple ANOVA models using the Proposed Action flow scenarios, flows at IGD explained approximately 81 percent of the variation in survival of fish emigrating from reach 1 (IGD to Shasta River), while differences in water year type (*e.g.,* 25, 50, 75 percents) explained only 19 percent. For Shasta River emigrants, flow at IGD explained about 62 percent of the variation in survival, while water year type accounted for about 38 percent. For fish originating in the Scott River to Portuguese Creek reach, flow at

IGD explained approximately 16 percent of the variation in survival while water year type accounted for approximately 84 percent (Table 15).

Table 15. Predicted annual survival rates for juvenile coho salmon smolts migrating from their reach of origin in the Klamath River to the ocean for nine different IGD flow release scenarios. Survival estimates were generated using the Klamath Coho Life-Cycle Model V1.3 developed by Cramer Fish Sciences using the "cohort" migration survival option. Each flow scenario is defined by the percent exceedence at IGD (*e.g.*, 75% = low flow), and the tributary and meteorological conditions downstream of IGD (*e.g.*, 2001 Dry = dry water year).

	Proposed Action			No Project		
Reach of Origin	75% 2001 Dry	50% 2004 Avg	25% 2006 Wet	75% 2001 Dry	50% 2004 Avg	25% 2006 Wet
IGH	28.5%	40.8%	53.8%	36.6%	48.5%	58.0%
Mainstem Reach 1 IGD to Shasta	33.5%	45.6%	56.8%	40.7%	52.1%	60.4%
Shasta River Age 1	38.5%	50.5%	61.0%	44.4%	55.0%	64.0%
Shasta River Age 0	37.2%	43.7%	53.0%	39.8%	48.4%	59.8%
Mainstem Reach 2 Shasta to Scott	48.3%	58.6%	66.9%	52.5%	61.9%	69.1%
Scott River	59.2%	68.1%	73.0%	61.7%	69.8%	74.0%
Mainstem Reach 3 Scott R. to Portuguese Cr.	62.3%	70.3%	75.2%	64.5%	71.8%	76.1%

IGH coho salmon smolts are generally released in mid-March. IGD releases and water quality conditions are generally conducive for smolt outmigration in March. Since the hatchery release of coho salmon precedes both the hatchery release of Chinook salmon and the peak of wild juvenile salmonid outmigration, hatchery coho salmon that pause to rear in the upper portion of the Upper Klamath River reach are not likely to experience a lack of available habitat. NMFS does not anticipate the Proposed Action will have adverse effects on hatchery coho salmon smolts.

While we still lack information to suggest a causal relationship between ranges of flow and transit time through the Upper Klamath River reach, new information presented in this biological opinion and our understanding of the current literature generally supports our 2002 conclusion that additional flow at IGD would reduce transit rates of smolt outmigration and result in benefits to coho smolt survivability. We conclude Project Operations will result in a small delay in coho smolt outmigration, and in the latter portion of the coho smolt outmigration run (May and June). These delays will likely increase risks of disease described above.

3. <u>July through September</u>

a. Hydrologic Effects

Reclamation has proposed to maintain a 1,000 cfs minimum base flow at IGD for the July through September period. The July through September period is a relatively dry period of the year with little or no flow variability. Historically, under a natural flow regime, sustained base flows from the Upper Klamath River Basin supported higher base flows through August than proposed by Reclamation

b. Effects on Critical Habitat

The Proposed Action has the potential to affect the following essential habitat features of coho critical habitat: thermal refugia, migration corridors and water quality.

(1) Thermal refugia. In the *Environmental Baseline* section we described the current state of information on refugial habitat and the influence of mainstem flow on refugial habitat availability. Through investigations, we have more information to suggest juvenile salmonids, including coho salmon, utilize refugial habitat in both the mainstem Klamath River and non-natal tributaries as refuge from critically high mainstem Klamath River water temperatures (*e.g.,* Sutton *et al*. 2007, Soto *et al*. 2008).

IGD flows can influence both the amount and extent of refugial habitat in the mainstem Klamath River as well as influence the connectivity between tributary and the mainstem. However, refugial zones in the Upper Klamath River reach are limited. Tributaries that historically provided cold water accretions to the mainstem Klamath River produce appreciably less water to the mainstem Klamath River due to off channel diversions and provide less non-natal rearing habitat (*e.g.,* Shasta and Scott River), therefore reducing the amount of available refugia. Based on thermal refugia studies (Sutton *et al.* 2004, Sutton *et al.* 2007), IGD releases of 1,000 cfs through the summer provide adequate flows to maintain the integrity of the limited refugial zones in the Upper Klamath River reach.

(2) Migration corridors. Based on the limited research of the effects of mainstem Klamath River flows on thermal refugia that have observed diurnal movement of juveniles from the mainstem into tributaries (Sutton *et al.* 2007), the 1,000 cfs base flow is expected to provide sufficient flow to maintain connectivity to tributaries to allow for non-natal rearing of juvenile coho salmon.

(3) Water Quality. The relationship between Project operations, water temperature and quality of IGD releases, and conditions that exacerbate fish disease mechanisms is complicated and not fully understood. For example, the water temperature modeling component of SIAM indicates that, over the course of the summer, water temperatures in the mainstem are likely affected most by environmental conditions and the influence of the PacifiCorp owned network of reservoirs upstream of IGD. Results from the water temperature model as applied in dry water years (when ambient temperatures are higher) suggest that in general, the mean daily temperature of IGD releases are higher during the summer directly below IGD under relatively high IGD flows. The same modeled scenarios also suggest that at Seiad Valley this relationship is reversed and mean daily water temperatures are expected to be relatively lower under relatively high IGD flows.

In both locations, maximum daily water temperatures predicted by the companion regression model are expected to be closer to the mean water temperatures with higher IGD flows in the summer. Water temperature modeling applied by Deas and Orlob (1999) indicates that the magnitude of diurnal water temperature fluctuations differ from IGD to Seiad Valley, this model also indicates that temperatures increases more in this mainstem reach under relatively low flows, and less under higher flows. This supports the general expectation that diurnal temperature fluctuations in the mainstem are higher under lower summer flows.

c. Effects on Individuals

(1) Effects to Thermal Refugia on Individuals. Juvenile coho salmon will be afforded limited habitat opportunities to inhabit the mainstem Klamath River once water quality conditions become inhospitable in the summer. The Proposed Action generally provides sufficient flows to maintain the integrity of the limited areas of thermal refugia. Hence juvenile coho salmon are not expected to be adversely affected by the effects of the Proposed Action on mainstem thermal refugia.

(2) Effects to Migration Corridors on Individuals. The Proposed Action is expected to keep migration corridors intact through the summer to allow juvenile coho salmon to access non-natal tributaries during summer months. Hence juvenile coho salmon are not expected to be adversely affected by the effects of the Proposed Action on migration corridors.

(3) Effects to Water Quality on Individuals. Water temperatures and quality contribute to a hostile environment for juvenile salmon during the summer in the mainstem Klamath River. Temperatures are typically above the preferred range of coho salmon, and sometimes exceed the lethal limit of 25.5° C reported by Bell (1991), although coho salmon have been observed in the Klamath River at temperatures greater than 25.5 ° C (FWS, unpublished data). IGD releases of 1,000 cfs are expected to slightly increase water temperatures in the upper portion of the Upper Klamath River reach, and slightly decrease water temperatures in the lower (Seiad Valley) reach, generally striking a balance on effects to individuals across populations exposed to the Upper Klamath River reach.

4. Summary of Effects

a. October through February

The Proposed Action is expected to provide sufficient mainstem Klamath River flow to provide adequate adult coho salmon spawning habitat and migration corridors for coho salmon adult and juveniles. The Proposed Action will also provide rearing habitat for juvenile coho salmon representative of low flow volumes that would occur under a natural flow regime in fall. However, the project reduces the amount of rearing habitat in winter that would otherwise occur with higher flows. Due to the anticipated low number of overwintering coho salmon expected in this reach, NMFS does not expect adverse effects to individuals as a result of this habitat reduction.

By reducing flow variability in the fall and early winter, the project will likely reduce the effectiveness of environmental cues for juvenile coho salmon to redistribute in the Upper Klamath River reach. Reductions in flow variability are also expected to have adverse effects on riparian function through loss of scouring and will likely increase disease risks by maintaining steady state flows through extended periods that favor *M. speciosa, P. minibicornis, and C. shasta*. Less common overbank flows are likely to occur under the Proposed Action. These large-scale flow events will provide benefits to channel maintenance , however they are not anticipated to occur frequently over the eight-year action period.

b. March through June

The Proposed Action is expected to provide sufficient abundance of essential features of coho salmon fry critical habitat such that coho salmon fry individuals are not likely to be adversely affected by the Project in the eight-year action period.

The Project's effect on habitat availability for juvenile coho salmon in the spring period will vary temporally and spatially. In the R-Ranch study site vicinity (IGD to Interstate 5) habitat availability is expected to be abundant and provide benefits to survival. The abundance of habitat availability is expected to be sufficient to support the life history needs of a future, more abundant Upper Klamath coho salmon population. Through the middle and lower portions of the Upper Klamath River reach, appreciable habitat reductions resulting from the Project are expected in average and wetter conditions while in drier conditions Project effects on habitat availability are minimal. NMFS expects the habitat reductions anticipated in average and wetter conditions will have adverse effects on the fitness of rearing coho salmon parr, smolts and pre-smolts that would otherwise experience beneficial habitat conditions and improved survival. The Project effects will be greatest in May and June when the Proposed Action will reduce the amount of available habitat by up to 31 percent. These effects are anticipated to occur during the peak of hatchery releases when density dependent effects are most pronounced. Reductions to fitness caused by these habitat reductions are expected to increase risks from disease and lower survival rates of some individuals, and NMFS expects the Shasta River population will be most susceptible to these adverse effects.

The Project's effect of reducing spring base flows and flow variability are expected to increase the risk of disease to coho salmon fry, parr and smolts. These adverse effects are anticipated to be exacerbated in periods of extended inter-annual dry flow conditions.

The Proposed Action is expected to delay smolt outmigration, and as a result, some individuals are anticipated to experience increased risks from disease.

c. July through September

In summary, juvenile coho salmon in the Klamath River during this period are expected to encounter marginal to lethal water quality conditions. However, Reclamation's Proposed Action appears to have a negligible additional effect on these inhospitable environmental conditions.

B. Middle Klamath River reach (IGD to Portuguese Creek)

The following analysis utilizes reach-level WUA curves at Rogers Creek and Orleans (from Hardy *et al.* 2006) to gauge the effect of the Proposed Action on instream habitat availability (incorporating both quantity and quality) within the mainstem Klamath River. The analysis also considers other important components of the flow regime (water quality, channel function, hydrologic behavioral cues, *etc.*) that are not explicitly captured within the WUA analysis, but are nonetheless critical attributes influencing overall fish population response.

1. <u>October through February</u>

a. Hydrologic Effects of the Project

Flow variability in response to small storm events will diminish during much of the fall and early winter period due to the fixed flow schedule and a general lack of fall IM augmentation at IGD. The effect is most pronounced upstream of the Scott River and likely diminishes steadily with increasing distance from the Upper Klamath River reach. Examining a recent fall freshet within the basin illustrates the impact steady-state discharges out of IGD have on the river's hydrologic response. In November 2006, a small fall freshet occurred within the lower Klamath River. During the freshet, flows within Salmon River, Scott River, and Indian Creek, representing largely unregulated (*i.e.,* devoid of dams or other flow regulating structures/operations) Klamath tributaries, rose between approximately 880% and 2,100% from base to peak flow over the course of the storm (Figure 25). The unaltered Klamath River mainstem (*i.e.,* unimpaired) likely responded in a similar fashion to fall freshets, although the response (both flow timing and magnitude) would be comparatively muted due to the vast watershed area that feeds mainstem flows. In comparison, flows below IGD did not vary during the same time frame. Hydrologic response was also muted at Seiad Valley (47% increase from baseflow), even after considering substantial accretion from the Scott River 15 miles upstream. Hydrologic variability was largely restored by the time storm flows passed Orleans at rm 59 (~400% rise from baseflow to storm peak), which was not unexpected since several large, unregulated tributaries enter the mainstem between Seiad Valley and Orleans. Thus, NMFS suspects fall hydrologic variability is reduced within the Middle Klamath River reach by Project operations at IGD, but the effect is likely small. The effect is most pronounced within the upper section of the river reach, likely upstream of the town of Happy Camp where two large, unregulated tributaries (Indian Creek and Elk Creek) join the mainstem Klamath River.

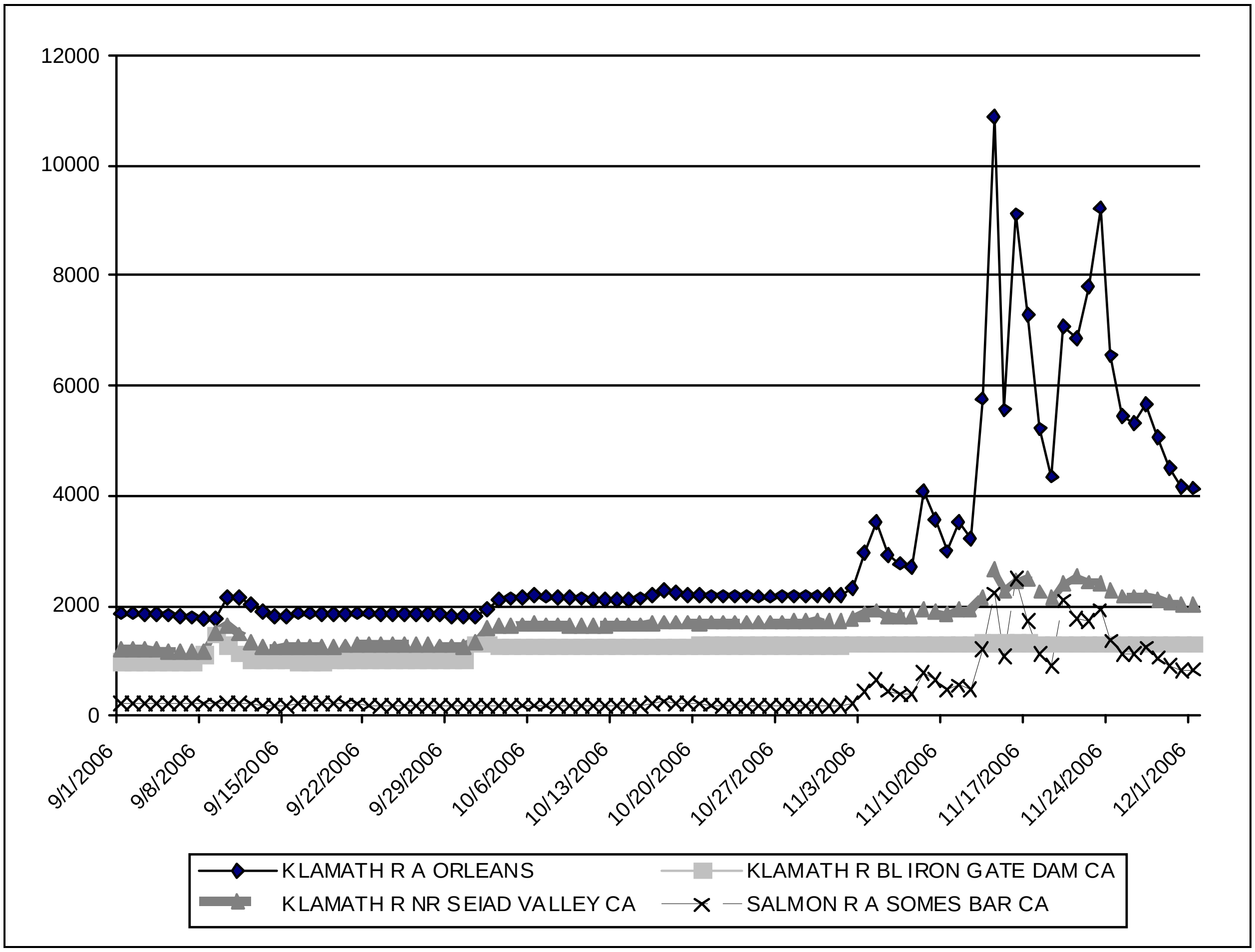

Figure 25. Example of hydrologic variability at various stations within the Klamath River during a 2002 fall freshet.

Due to the limited storage capacity of UKL and the hydropower reservoirs, large winter storm events often cause uncontrolled spill. These spill events, in combination with heavy accretions from upstream tributaries, likely create over-bank flows at approximately the same frequency and magnitude as those that occurred under the natural flow regime (Hardy *et al.* 2006). As described earlier, over-bank flows are critical in creating and maintaining in-channel and riparian habitat.

b. Effects on Critical Habitat

The Project has the potential to impact the following four essential habitat types during the October through February period: winter rearing habitat, juvenile migration corridors, adult migration corridors, and spawning habitat. As illustrated in Figure 26 and Figure 27, the volume of suitable juvenile habitat is generally similar under Project and No Project modeled flow volumes throughout the Middle Klamath River reach, as represented by reach-level WUA curves at Rogers Creek (covering the Scott River to Salmon River reach) and Orleans (Salmon to Trinity reach). The volume of suitable juvenile habitat in the Rogers Creek reach decreases slightly during most January and

February estimates as a result of the Proposed Action. Below the Salmon River, Project flows slightly improve the volume of suitable juvenile rearing habitat, as evidenced within the Orleans reach-specific data.

The Proposed Action will lower flows during much of November and December, whereas river flows in September and October are generally higher than No Project conditions. Although Project flows can be up to 800 cfs lower during the period of upstream migration, the overall effect of lower Project flows is not anticipated to adversely affect fish passage conditions because adequate water depth and velocity are expected to result when IGD releases are 1300 cfs or greater. Recent observations of successful fish migration at critical passage areas within the Middle Klamath River reach support the conclusion that IGD flows at or above 1300 cfs provide unimpaired upstream access to migrating adult coho salmon (Soto 2008). Likewise, juvenile coho salmon redistributing through the mainstem river during the fall are likely to encounter suitable passage conditions at flows at or above 1300 cfs, given that navigating shallow channel sections is inherently less troublesome for juvenile than adult fish due to their difference in size.

Coho spawning habitat is naturally limited within the Middle Klamath River reach, due largely to the incised, bedrock dominated characteristics common through much of the reach (Ayres and Associates 1999). Where spawning habitat exists, gravel quality and fluvial characteristics are likely suitable for successful spawning and egg incubation. Magneson and Gough (2006) noted that the dominant substrate within sampled redds were either gravel or cobble, and Ayres and Associates (1999) determined the level of fine sediment was not impairing redd function. Both references suggest spawning gravel composition is not limiting redd function within the mainstem Klamath River. In areas where fine sediment is the dominant substrate, the reduced discharge from IGD that occurs under the Project could theoretically reduce the frequency and efficiency with which sediment is flushed from spawning gravel. However, due to substantial winter accretion from several large tributaries upstream of Happy Camp (rm 110), NMFS believes the small decrease in flow experienced at IGD would likely have an insignificant effect on the frequency or efficiency of flushing flows experienced within the Middle Klamath River reach. Redd dewatering is not expected to occur under the Proposed Action due to the conservative ramp-down rates Reclamation has proposed for IGD releases (NMFS 2002).

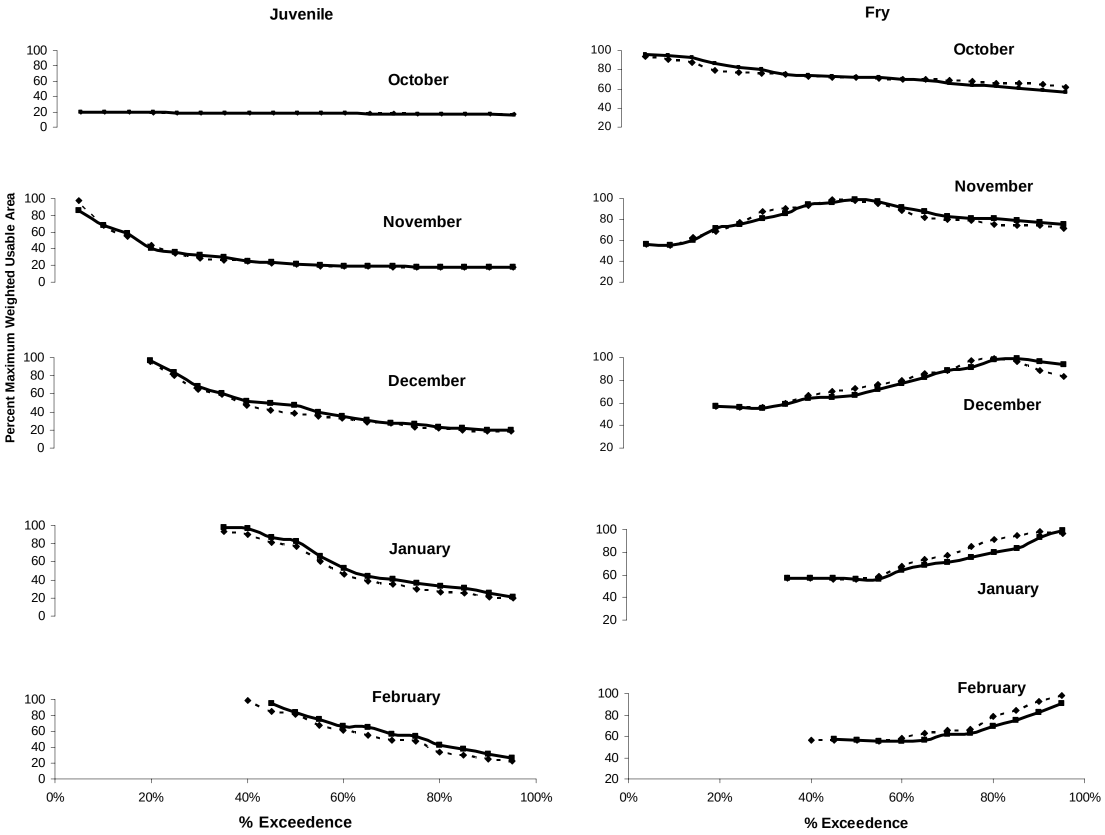

Figure 26. Percent maximum WUA at Rogers Creek (reach-specific analysis) for both juvenile and fry coho salmon during the months October through February. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action. Analysis was based upon reach-level WUA curves from Hardy *et al.* (2006). Curves for December, January and February do not capture the full range of exceedences since some modeled flows fall outside the flow range analyzed by Hardy *et al.* (2006). Absent site-specific information that would suggest otherwise, NMFS assumes that observed habitat trends would generally extend into the range of flows outside those considered by Hardy.

c. Effects to individual fish

NMFS does not expect the slight loss of suitable juvenile habitat during October and November that results from the Proposed Action to lower survival rates as coho salmon parr migrate through the Middle Klamath River reach.

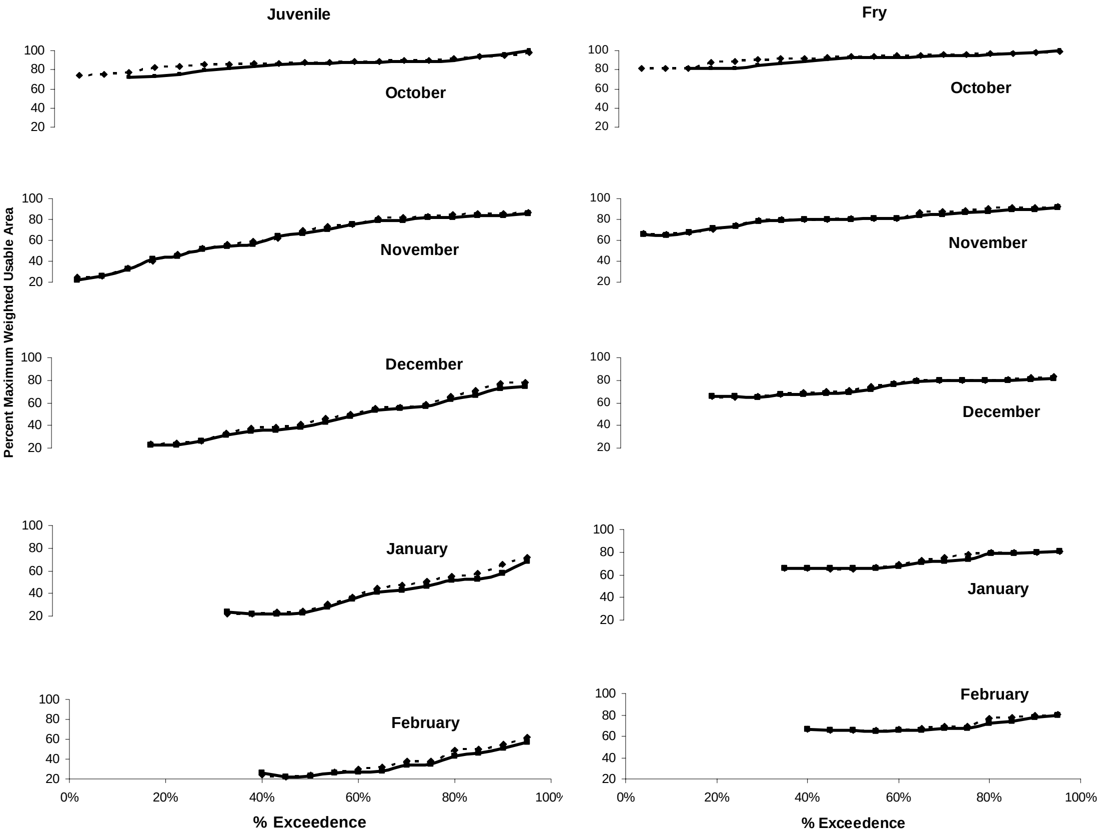

Figure 27. Percent maximum WUA at Orleans for both juvenile and fry coho salmon during the months October through February. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action. Analysis was based upon WUA curves from Hardy *et al.* (2006). Curves for December, January and February do not capture the full range of exceedences since some modeled flows fall outside the flow range analyzed by Hardy *et al.* (2006). Absent site-specific information that would suggest otherwise, NMFS assumes that observed habitat trends would generally extend into the range of flows outside those considered by Hardy.

The volume of suitable juvenile habitat available during November can be especially low when compared to maximum levels (*e.g.,* ~20% maximum WUA for most water-year types at Rogers Creek in November). However, juvenile coho salmon habitat within the Middle Klamath River reach was likely limited, although likely higher, even under a natural flow regime on account of the incised, bedrock dominated geomorphic nature of the reach. The habitat volumes realized under the Proposed Action are largely similar to No Project values, and are likely sufficient to meet the species needs given the relatively small number of coho salmon parr (assumed 3-11% of summer population) likely redistributing from tributary habitat into the mainstem (Ackerman and Cramer 2006). Thus, NMFS believes the population of redistributing coho salmon parr entering the Middle Klamath River reach mainstem will be afforded a level of suitable juvenile habitat that will not appreciably diminish their overall survival during this important life-history phase. Given that early fall flows, and hence juvenile habitat volumes, were likely similar or lower under historic conditions, NMFS expects that the current habitat volumes will support higher numbers of fish in the future as populations recover.

The abundance of juvenile habitat availability is generally lower under the Proposed Action during most of January and February within the Rogers Creek reach. Alternatively, juvenile habitat suitability is largely the same, or at times slightly greater, during most winter estimates within the Orleans reach. In general, the volume of winter habitat preferred by coho salmon juveniles (*i.e.,* off channel or slack-water habitat) is limited within the Middle Klamath River reach, and recent field investigations have documented few coho salmon juveniles rearing within the reach (Soto 2008). Throughout the reach, winter flows realized under the Proposed Action are expected to inundate and create winter rearing within the limited area it currently exists, given that side-channel habitat was effectively inundated under similar flows in the past (Shaw 2008). NMFS expects the volume and suitability of juvenile coho salmon habitat will currently meet the needs of the species given the low numbers of overwintering fish observed within the Middle Klamath River reach and the likely suitable condition of the small volume of available overwintering habitat (Soto 2008). As the Klamath River coho salmon population grows, the level of mainstem juvenile habitat realized under the Proposed Action will likely be sufficient to support higher fish populations in the future, since winter flows, and consequently winter juvenile habitat volume, are expected to increase as climatic changes trend the basin to warmer winters characterized by more rainfall and less snowfall.

Adult coho salmon migrate through the Middle Klamath River reach primarily during October and November, when proposed flows from IGD will be 1300 cfs or higher. Exceedingly low discharge in the Action Area has been theorized as a potential factor impeding upstream migration of adult salmonids whether by creating shallow river sections that physically block passage or by contributing to degraded water quality conditions that force fish to hold within pockets of suitable water (CDFG 2004). Furthermore, low mainstem flows are often insufficient in either volume or variability to trigger upstream adult migration (FWS 2003). Both of these factors were suspected during September, 2002, when a large fish die-off occurred within the Lower Klamath River. However, at the time of the fish kill IGD discharge was approximately 750 cfs, and several other factors, such as high fish density and above average air temperature confounded the effect. Ambient air temperature is typically cooling throughout the basin during October, resulting in river temperatures largely below 18°C that are conducive to upstream adult migration. Given past observations of successful upstream migration through the Middle Klamath River reach under a 1300 cfs flow release, NMFS does not anticipate any delay in migration to occur under the proposed flow regime.

Adult coho salmon spawn within the Middle Klamath, but to a lesser degree than areas farther upstream. Magneson and Gough (2006) recently noted a small but consistent group of coho salmon spawning between IGD and Indian Creek (rm 109) during annual redd surveys. Their results indicate the majority of coho redds observed were in close proximity to IGH (just downstream of IGD), with fewer redds observed toward the bottom of the study reach. Below Portuguese Creek, the Klamath River channel transitions to a more confined configuration characterized by more bedrock pool habitat and less shallow, alluvial habitat, which may explain the scarcity of coho spawning observations in the Middle Klamath River reach. Given the low number of coho salmon likely to spawn within the Middle Klamath River reach, NMFS anticipates the volume of suitable spawning habitat realized under the Project will not limit the current and future population's reproductive success.

Water quality under the Project will likely be sufficient during winter months to support coho salmon spawning, egg development, and early rearing survival. Water temperatures are expected to be less than 12°C between January and March, and DO concentrations are largely above 8 mg/L throughout the river (Fadness 2007).

2. March through June

a. Hydrological Effects of the Project

The timing, magnitude and duration of the spring peak flow event has been substantially altered by water management activities throughout the basin (*see* Appendix I for decadal plots depicting No-Project and Project flow regimes). However, spring mainstem flows within this reach are augmented through tributary accretions from the Scott River, Salmon River and several other large tributaries, such that the effect of the Project on limiting and shifting the Klamath's annual spring peak flow is somewhat muted when compared to points farther upstream. Nevertheless, mainstem flows without the Project operating would be more representative of the natural hydrograph under which coho salmon have evolved and persisted.

Similarly, the effect on spring flow variability is muted due to the influence of tributary inflow throughout the Middle Klamath River reach. The resultant rise and fall in mainstem flow brought about by spring rainfall and snowmelt would likely be realized under the Proposed Action, since the influence of tributary accretions tends to override the steady state flow regime emanating from IGD. During dry years the effect of the Project's fixed discharge is likely more pronounced as lower tributary accretions affect mainstem flow variability to a smaller degree.

b. Effects on Critical Habitat

The Project has the potential to impact the following two essential habitat types during the March through June period: rearing habitat and juvenile migration corridors.

(1). Fry Habitat. The majority of coho salmon mainstem spawning occurs upstream of the Scott River, thus coho salmon fry are likely less common within the Middle Klamath River reach than the Upper Klamath River reach. Since little coho salmon spawning actually occurs within the Middle Klamath River reach, a large proportion of the limited coho salmon fry inhabiting the reach likely disperse from upstream sources (*e.g.,* the Upper Klamath River reach or lower sections of productive tributaries).

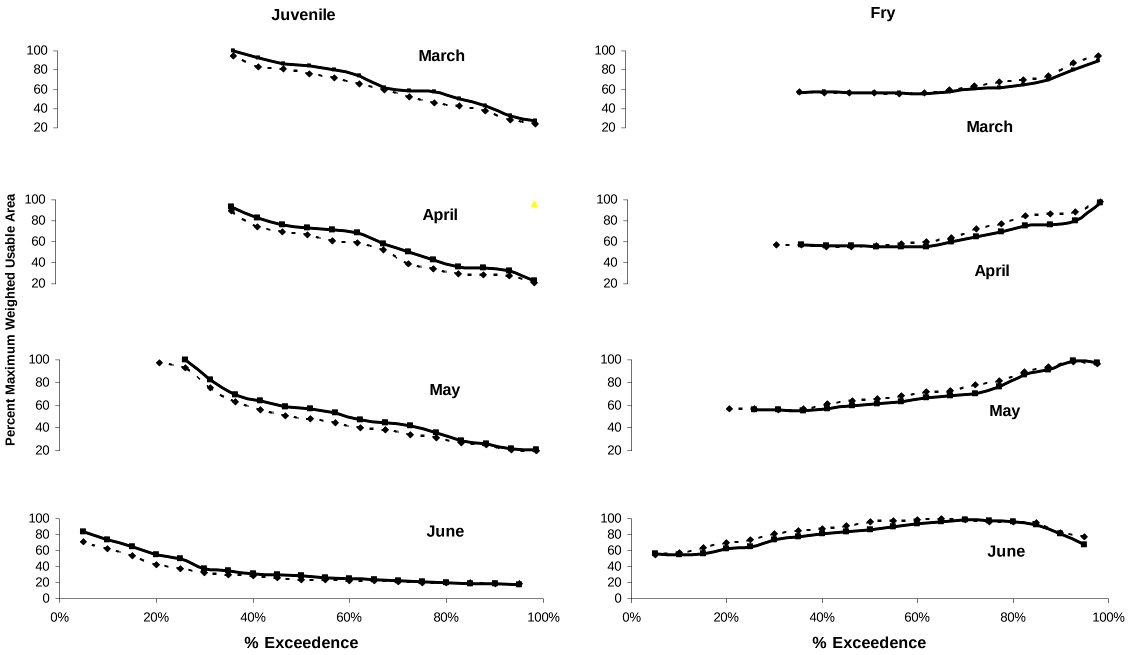

Figure 28. Percent maximum WUA at Rogers Creek for both juvenile and fry coho salmon during the months March through June. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action. Analysis was based upon WUA curves from Hardy *et al.* (2006). Curves for March, April and May do not capture the full range of exceedences since some modeled flows fall outside the range analyzed by Hardy *et al.* (2006). Absent site-specific information that would suggest otherwise, NMFS assumes that observed habitat trends would generally extend into the range of flows outside those considered by Hardy.

As can be seen in Figure 28, most flows realized under the Proposed Action actually result in greater WUA values than those realized under a No Project flow regime within the Rogers Creek reach (*i.e.,* section of mainstem between Salmon River and Portuguese Creek). The improvement in fry habitat is most apparent during dryer conditions (*i.e.,* between approximately 70-95% exceedence flows) in March and April, which correspond to the time period most critical to fry survival (see fry periodicity, Figure 7). Most coho salmon fry within the Klamath River system have matured to parr by the end of May.

Near Orleans, the lower flows realized under the Proposed Action also favor coho salmon fry (Figure 29), since fry habitat is greatest at a flow of approximately 1600 cfs, and decreases steadily as flows rise from that level (Appendix I, Hardy *et al.* 2006). Within the Orleans reach, the amount of habitat available to fry under Project flows will range from 65 to 80 percent of maximum available habitat for the critical months of March and April. Since mainstem coho salmon spawning is uncommon within the Middle Klamath River reach and overall fry numbers are likely low, the amount of fry habitat resulting from Project operations is likely supportive of coho salmon fry survival within the Middle Klamath River reach.

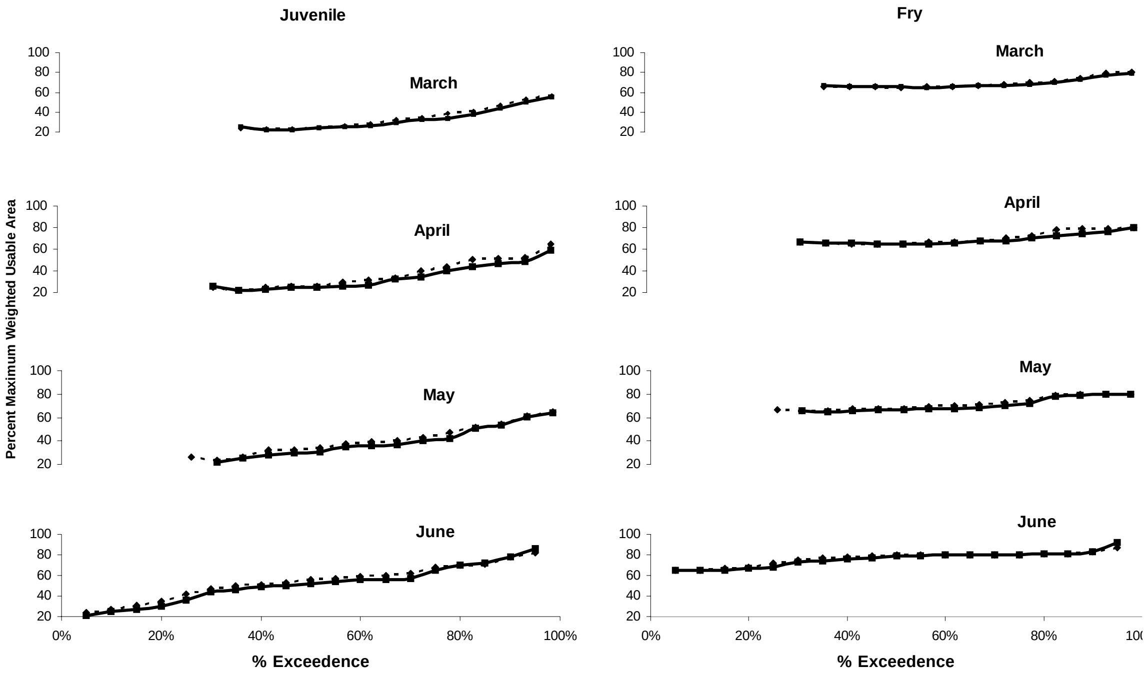

Figure 29. Percent maximum WUA at Orleans for both juvenile and fry coho salmon during the months March through June. Solid lines represent No Project modeled flows, whereas the dashed lines represent modeled flows anticipated under the Proposed Action. Analysis was based upon WUA curves from Hardy *et al.* (2006). Curves for March, April and May do not capture the full range of exceedences since some modeled flows fall outside the range analyzed by Hardy *et al.* (2006). Absent site-specific information that would suggest otherwise, NMFS assumes that observed habitat trends would generally extend into the range of flows outside those considered by Hardy.

(2) Juvenile Habitat. Both parr and smolts utilize similar habitat during the spring months and likely overlap spatially and temporally within the Middle Klamath River reach. Yet, smolt usage is likely more sporadic and demonstrates less fidelity to a particular patch of habitat since they are actively migrating downstream toward the ocean environment. When discussing effects to coho salmon smolts, the following analysis is primarily focused on wild (*i.e.,* naturally produced) fish, instead of hatchery-produced fish. Hatchery coho salmon smolts are typically released from IGD during mid-March, and a large proportion have likely migrated out of the river by early May.

The amount of juvenile rearing habitat exhibits a negative relationship with flow at Rogers Creek. Juvenile coho salmon rearing habitat under the Proposed Action would range from approximately 20 percent to close to 100 percent of maximum WUA under both Project and No Project scenarios (Figure 28). The flow regime resulting from the Proposed Action generally lowers the amount of available juvenile coho salmon habitat during March through June period within the Scott River to Salmon River reach (*i.e.,* the Rogers Creek reach). The loss of juvenile habitat is greatest during average and drier exceedence flows in April and May, when the difference in the percent of maximum WUA can vary by as much as 12 percent. Similar reductions occur during wetter hydrologic conditions in June.

Within the reach between the Salmon and Trinity rivers (Orleans reach-level data), an inverse relationship exists between flow and juvenile habitat volume (Figure 29) that illustrates juvenile habitat volume increasing as flows decrease. These incongruous results can possibly be explained by the channel morphology present within the lower portion of the Middle Klamath River reach. The Orleans reach is more confined and bedrock influenced, thus lacking the same floodplain dynamic as the upstream reach (Ayres and Associates 1999). Thus, higher flows do not inundate floodplain habitat, and the suitability of coho salmon juvenile habitat appears to decrease as flows increase. Therefore, the Proposed Action is unlikely to adversely affect juvenile coho salmon habitat within the Orleans reach, since the quantity of habitat should largely increase on account of the Proposed Action.

Earlier in this effects analysis, fall flow levels were found sufficient for juvenile migration through the Middle Klamath River reach, as well as between mainstem and tributary habitat. Because spring flow levels will be considerably higher than the fall flows previously analyzed, NMFS believes mainstem flows realized under the Proposed Action will provide adequate water depth and volume necessary to maintain connectivity with tributaries and downstream reaches of the mainstem Klamath River.

(3) Water quality effects. Project operations are likely to have a discountable effect on water quality in the Middle Klamath River reach during the March through June period. Water quality downstream of IGD is largely driven by two variables: Pacificorp's Hydroelectric reservoir network, and ambient meteorological conditions. Since any contribution to water quality arising from IGD releases largely dissipates by the time flows reach Seiad Valley (Pacificorp 2006), ambient weather conditions likely have the most impact on water quality conditions within the Middle Klamath River reach. Thus, Project flows are not expected to appreciably influence water quality conditions within the Middle Klamath River reach.

c. Effects to Individual Fish

Coho salmon utilize mainstem Klamath River habitat most of the year, but the period between March and June is likely the most critical since it coincides with peak smolt migration and spring redistribution of fry/parr. The amount of rearing habitat realized within the mainstem channel is directly influenced by discharge, and adequate habitat is critical to the survival of migrating smolts and relocating juvenile coho salmon. River discharge also affects disease parameters within the river, likely influencing spore concentrations as well as the rate of smolt migration, which in turn can minimize the time fish are exposed to pathogens. Each of these effects will be further explained below.

(1) Habitat limitation. Wild coho salmon smolts and parr will be competing for available habitat with hatchery-released salmon and steelhead beginning in May (CDFG and NMFS 2001). Competition for available instream habitat likely peaks during May and early June, when the highest numbers of wild coho salmon smolts and parr overlap with the approximately 5 million Chinook salmon smolts released from IGH. The upper portion of the Middle Klamath River reach (*i.e.,* upstream of the Salmon River) contains more rearing habitat at a given flow than areas farther downstream (Appendix I *in* Hardy *et al* 2006), and thus is probably more important as a rearing area for juvenile fish. Nevertheless, within both sections of the reach, the lower volume of suitable juvenile habitat resulting from the Proposed Action will likely force some juvenile coho salmon into less favorable habitat, which would consequently lower individual survival rates.

(2) Disease effects. The dynamics influencing disease infection rates and resultant salmon mortality within the Klamath River are numerous and varied. Water temperatures greater than 10°C are believed to be a critical threshold for the production and release of the infective stage of the *C. shasta* within the Klamath River (Stocking *et al.* 2006), with higher temperatures accelerating infectivity rates up to 18°C. Temperatures above 18°C are thought to reduce actinospore viability and lower infection rates (Foott *et al.* 2006). Yet, recent modeling suggests the thermal lag caused by upstream reservoirs limits the ability of higher IGD flows to cool downstream water temperatures (Campbell 2008). Also, highly nutrified source-water originating from the upper reaches of the Klamath basin has fueled the proliferation of aquatic vegetation below IGD, creating optimal habitat for the polychaete host of both *C. shasta* and *P. minibicornis* (Stocking and Bartholomew 2007). While mainstem temperature and water quality dynamics are largely unaffected by the Project operations, flow volume is the one parameter controlled by Project operations that theoretically could impact disease infection dynamics within the Middle Klamath River reach.

River discharge can influence smolt migration rates and disease spore concentration, both of which can influence infection incidence and severity. Higher flows likely increase the speed at which smolts migrate downriver (Giorgi *et al.* 2002), intuitively decreasing the time fish are exposed to in-river pathogens. Yet, a recent study by Foott *et al.* (2007) showed substantial infection and mortality of juvenile Chinook salmon following only 6 hours of Klamath River exposure and 10 hours post-exposure in the lab, which suggests the benefit expected to result from shorter exposure times may not be realized in an environment where excessive spore concentrations exist. Extremely high spore concentrations can occur during late spring within the Klamath River mainstem (Foott *et al.* 2003).

River discharge likely influences instantaneous spore concentrations (*i.e.,* higher flows lead to lower concentrations), which would theoretically lower the probability of an individual fish encountering an infective actinospore and, in turn, lead to lower infection rates. For instance, disease infection and mortality rates of juvenile Chinook salmon were lower during June of 2005 following a high flow event in May (Nichols *et al.* 2007). The lower observed disease rate occurred against the typical backdrop of lower flows and higher water temperatures that usually coincide with high infection and mortality, suggesting that high flows may have reduced spore counts and concomitantly reduced disease transmission rates. Yet, other confounding variables besides flow volume can influence spore concentration. One such variable is the relative density of *M. speciosa* before and during the peak infection months of April and May. Stocking and Bartholomew (2007) documented the scouring and removal of a large *M. speciosa* colony at the Trees of Heaven site (rm 170) following a high flow event from May to June, 2005. Less *M. speciosa* present within the river would likely result in lower spore concentrations during late spring, and could confound the relationship diluted spore concentrations and disease dynamics seen in 2005. Furthermore, the influx of fresh smolt and parr from upstream tributaries may bias the perceived rate of disease infectivity, since mainstem residence time for some of these fish may be insufficient to contract the disease or display clinical signs of infection (Nichols *et al.* 2007). Despite these uncertainties, NMFS believes the high incidence of disease noted within the mainstem Klamath River results largely from the dramatic shift in hydrologic timing and magnitude from the natural hydrologic regime under which the fish evolved. Summer baseflow conditions now materialize much earlier than historically, with spring flows now receding precipitously in May and June, whereas the spring snow-melt pulse historically receded much more slowly into August or September. Thus, coho salmon smolts migrating downstream in May and June under current conditions experience reduced survival due to heightened disease dynamics brought about by this hydrologic shift.

(3) Effects to smolt outmigration. Since coho salmon smolts utilize the mainstem as a migratory corridor to the ocean, fish will be passing through the entire Middle Klamath River reach from February through June, with a peak in April and May for wild fish (hatchery smolts are released in mid-March). Both wild and hatchery coho salmon smolts move relatively quickly through the Middle Klamath River reach, as compared to the slower migration rates observed with hatchery fish in the Upper Klamath River reach (Stutzer *et. al.* 2006). Median travel time of wild coho salmon smolt between the Scott and Trinity Rivers (165 km) observed during the study was 3.3 days (median migration rate of 50 km/day). Research has generally concluded a positive correlation between river discharge and the downstream migration rate of salmonids (Bergren and Filardo 1993, Giorgi *et al.* 2002). Yet, little evidence exists linking discharge with the survival rate of juvenile salmon migrating downstream. For example, Smith *et al.* (2002) did not find a strong or consistent relationship between discharge and survival of juvenile Chinook salmon migrating through the lower Snake River. However, the Klamath and Snake River systems likely differ to a significant degree with regard to flow pattern, aquatic condition, and fish migration patterns. The Klamath River mainstem typically transforms into a hostile environment during May and June, when water quality deteriorates (FERC 2006), disease pathogens proliferate (Nichols and True 2007), and competition with hatchery smolts likely intensifies. NMFS believes lower flows are likely to exacerbate these effects by slowing migration rates, which would increase potential interaction between migrating juvenile coho salmon and the stressors alluded to above. However, due to significant tributary accretions above and within the Middle Klamath River reach (*e.g.,* Scott River and Indian Creek), the effect of IGD releases on smolt outmigration delay is likely ameliorated.

3. <u>July through September</u>

Reclamation proposes to discharge flows of 1000 cfs, or slightly higher, during the July through September period. During this period, coho salmon found within the mainstem are largely rearing parr, since most coho salmon smolts have left the system by early

July. Much research and monitoring has been conducted recently investigating coho salmon use of the mainstem Klamath River, with most focusing on how coho salmon utilize cold-water refugia to survive the inhospitable water temperatures common during summer months. Coho salmon parr are thought to utilize mainstem rearing habitat within the Klamath River throughout the entire summer, but their numbers are greatly reduced after July (Hardy *et al.* 2006) when water temperatures exceed their thermal preference (NAS 2004). Some of these fish likely perish due to inter- and intra-specific competition for limited instream habitat, but recent data suggest many fish are utilizing thermal refugia at tributary mouths and within lower tributary habitat during summer, where water temperatures are often several degrees cooler than the mainstem river.

The proposed summer flow regime of approximately 1000 cfs from IGD is unlikely to produce discernable effects within the Middle Klamath River reach for several reasons. First, flow volume at IGD can alter the diurnal pattern of water temperatures within the Klamath River, but the effect is most pronounced upstream of the Shasta River and is significantly reduced by the time flows reach Seiad Valley (Pacificorp 2006). Second, the combined volume of Iron Gate flow and tributary accretion realized within the Middle Klamath River reach is likely sufficient to ensure unimpeded coho salmon parr migration between tributary and mainstem habitat. Finally, the majority of coho salmon observed rearing within the mainstem Klamath River occur within the Upper Klamath River reach. NMFS considers coho salmon parr utilization of thermal refugial habitat within the Middle and Lower Klamath River reaches to be uncommon, since no fish have been observed in these areas during past thermal refugial studies (Sutton *et al.* 2004). For these reasons, NMFS anticipates the July through September flow regime of approximately 1000 to 1100 cfs at IGD is not likely to significantly impact coho salmon parr located within the Middle Klamath River reach.

4. Summary of Effects

The Proposed Action will reduce fall hydrologic variability below IGD during fall months, and this effect will spread downstream into the upper reaches of the Middle Klamath River reach. As a result, important hydrologic cues that stimulate fish migration will likely be compromised. During the spring, the volume of suitable juvenile habitat within the Middle Klamath River reach will decrease as a result of the Proposed Action, which will likely increase inter- and intra-specific competition and correspondingly lower the survival rate of coho salmon parr and smolt. The volume of fry habitat is not expected to appreciably change due to the Proposed Action, and in some instances actually improves as a result of the action. The low flows realized within the mainstem Klamath River in April, May and June will also lower smolt outmigration rates, which in turn will likely increase disease infection rates within wild coho salmon smolts.

C. Lower Klamath River Population Unit

The Lower Klamath Population Unit encompasses the mainstem reach between the Trinity Reach confluence and the Pacific Ocean. Because tribal land borders both banks of the Klamath River downstream of the Trinity River confluence, SONCC coho salmon critical habitat is not designated within the Lower Klamath River reach. The effect of the Proposed Action on instream habitat is therefore discussed in a more general manner (*i.e.,* without WUA comparisons) within the following analysis.

1. Hydrologic Effect of the Project

Irrigation withdrawal from the upper basin (and to a smaller extent, the Shasta and Scott basins) has effectively shifted the Klamath River hydrograph to where spring peak flow that historically occurred in April now occurs approximately a month earlier in March (NAS 2004). One effect of the shifted hydrograph is that coho salmon smolts, parr and fry utilizing the mainstem river encounter summer base flow conditions a month or two earlier (and at a lower magnitude) than those realized under historic conditions (NAS 2004), although the effect within the Lower Klamath River reach is buffered to a large degree through accretions from upstream tributaries.

Current flow releases from IGD during late summer and early fall are substantially higher (*i.e.,* 33 percent greater; 1000 cfs versus 750 cfs) than those during the fall 2002 fish die-off within the lower Klamath River, when low flows were considered one of several possible factors inhibiting upstream fish movement (CDFG 2004). Hardy *et al.* (2006) recommends summer and early fall discharge at IGD not fall below 1000 cfs to ensure an adequate temperature regime for migrating salmonids within the lower river. Proposed flow releases from the Project are at or above 1000 cfs throughout the adult coho salmon migration period, and will likely be sufficient to preclude temperature and river depth impacts to upstream migrating adult fish. Furthermore, adult coho salmon migrate through the Lower Klamath River reach from early September through mid-December (peak around late October), which historically has been a time of year when ambient air temperatures, and consequently river temperatures, are cooling. Past water quality monitoring indicates the average weekly maximum temperature of the Klamath River below the Trinity River confluence is approximately 18ºC during late October (Fadness 2007), which is suitable for successful upstream migration. The small number of coho salmon migrating during early September will generally experience stressful water quality, but water temperatures will most likely fall short of the 22ºC threshold that has been documented as halting upstream migration in Klamath River Chinook salmon (Strange 2007).

2. Habitat Effects

The predominant mechanisms affecting mainstem water quality below IGD (*i.e.,* within the Upper Klamath River reach) are the high level of nutrients emanating from the upper basin, which Project return flows influence to a small degree, and ambient meteorological conditions. However, the quality of water discharged at IGD has little impact on water quality condition in the Lower Klamath River reach, given that ambient meteorological conditions dominate water quality dynamics by the time flows reach Seiad Valley (Pacificorp 2006).

3. Effects to Individual Fish

Disease infection rates are likely very low in the Lower Klamath River reach. Monitoring in the Lower Klamath River reach by FWS during 2002 and 2006 documented very low infection rates in Trinity River Hatchery Chinook salmon (1 percent and 19 percent, respectively), as compared to infection rates over 50 percent within Chinook salmon released from IGH (Nichols and True 2007). Since *C. shasta* distribution is believed to be restricted to the mainstem river (Hendrickson *et al.* 1989), these results suggest infection rates resulting from exposure while in the lower Klamath River (*i.e.,* below the Trinity River confluence) are very low compared to areas farther upstream.

4. Summary of Effects

The Proposed Action will likely have a muted effect on water quality within the Lower Klamath River reach, given the distance of the reach from IGD. Similarly, flow releases from the Project have a limited effect on instream habitat volume and quality, since IGD flows make up a small proportion of the total river volume during much of the year. The one exception is during fall months, when tributary accretions can be low during dry water years. However, the proposed fall flow of 1300 cfs will likely provide suitable water quality and depth for adult coho salmon migrating through the Lower Klamath River reach.

VII. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the Proposed Action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

NMFS conducted a search for non-Federal activities, and requested information from the state of California and Klamath Basin tribes (NMFS 2008c). NMFS has determined that with the completion of the mainstem Klamath River TMDL in California and in the next few years, private, municipal, and industrial entities contributing to the degradation of water quality will be required to develop and implement water quality management plans that reduce nutrient loading and aid in the improvement of water quality in the mainstem Klamath River.NMFS is also aware that the completion of the water adjudication process for the Klamath Basin in Oregon is expected in 2010. The adjudication process may provide for more efficient water management in the Klamath River Basin, and result in increased water availability for resource and Project needs.

Bartholow (2005) simulated the effects of climate change on the spatial and temporal water temperature patterns within the mainstem Klamath River from 1962 to 2001 using existing data and statistical software. Although there were large degrees of uncertainty in the simulation, including the short thermograph records, large data gaps in thermograph records, and ordinary intra-annual variability that resulted in few statistically significant trend estimates, Bartholow (2005) determined that the average trend in mainstem water temperatures has been an increase of 0.5ºC/decade. Bartholow (2005) suggests trends of (1) cumulative exposure to stressful temperatures that have been increasing in both number and duration; (2) the length of the annual period of potentially stressful temperatures that 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. As discussed, above, water temperatures in the lower mainstem Klamath River are currently marginal for anadromous salmonids. If water temperature trends of the magnitude found for the mainstem Klamath River continue into future decades, some populations may decline to levels insufficient to ensure population survival (Bartholow 2005).

VIII. INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of the proposed operations of the Project between 2008 and 2018. In this section, NMFS performs two evaluations: whether it is reasonable to expect the Proposed Action is not likely to (1) reduce the likelihood of both survival and recovery of the species in the wild (as captured by increases in the species' risk of extinction) and (2) result in the destruction or adverse modification of designated critical habitat (as determined by whether the critical habitat will remain functional to serve the intended conservation role for SONCC coho salmon ESU or retain its current ability to establish those features and functions essential to the conservation of the species). The *Analytical Approach* section described the analyses and tools we have used to complete this analysis.

A. Impacts on Species

In our *Status of the Species* section, NMFS summarized the current risk of extinction of SONCC coho salmon. We described the factors that have led to the current listing of SONCC coho salmon as a threatened species under the ESA across the range of the ESU. These factors include past and ongoing human activities and climatological trends and ocean conditions that have been identified as influential to the viability of all populations of the SONCC coho salmon ESU. Beyond the continuation of the human activities affecting the species, we also expect that ocean condition cycles and climatic shifts will continue to have both positive and negative effects on the species' ability to survive and recover. The criteria recommended for SONCC coho salmon viability are intended to represent a species and populations that are able to respond to these types of environmental changes and withstand adverse environmental conditions. Thus, when our assessments indicate that a species or population has a high or moderate risk of extinction, we also understand that future adverse environmental changes could have significant consequences on the ability of the species to survive and recover. Also, it is important to note that an assessment of a species having a moderate or high risk of extinction does not mean that the species has little or no potential to become viable or recover, but that the species faces moderate to high risks from internal and external processes that can drive a species to extinction. With this understanding of both the current risk of extinction of the species and the potential future consequences for species survival and recovery, NMFS will analyze whether the added effects of the Proposed Action are likely to in some way increase the extinction risk the species faces.

Our assessment of the best available information indicates that the SONCC coho salmon ESU generally has a high risk of extinction. All four VSP criteria values for the species are indicative of a species facing moderate to high risks of extinction from a variety of threats. As noted previously, in order for the species to be viable, all of the diversity strata that comprise the species must be viable. In order for each diversity stratum to be viable, each stratum must meet certain criteria of population representation, abundance, and diversity. Current information indicates that the species is presently vulnerable to further impacts to its abundance and productivity (Good *et al.* 2005). Known or estimated abundance of the species across the ESU and the seven diversity strata is generally well below the 50 percent thresholds determined for viable independent populations. Diversity of the species has declined and is influenced by the large proportion of hatchery fish present in the ESU. Population growth rates appear to be declining in many areas and spatial distribution of the species has declined. Population growth rates, abundance, diversity, and spatial distribution have been affected by both anthropogenic activities and environmental variation in climate and the ocean, and future adverse conditions are likely to further reduce their values. The species' habit of relying on productive ocean environments, wetter climatological conditions and a diversity of riverine habitats to bolster or buffer populations against adverse conditions may fail if those conditions occur less frequently or intensely (as is predicted) or if human activities interfere.

In this biological opinion NMFS has described the most recent environmental conditions that influence the survival and recovery of Klamath River coho salmon populations. Poor ocean survivorship for the 2007 adult cohort was observed (MacFarlane *et al.* 2008). In 2008, those conditions improved (see *Status of the Species* section). However, the strong negative PDO began to weaken in June 2009 and abruptly turned positive in August; signaling a change from the very productive ocean conditions of the past two years to poor ocean conditions (NOAA 2010). After June 2009, the ocean began to warm significantly, leading to detrimental changes in the pelagic food web and likely high mortality of juvenile salmonids. As a result, expectations for returns of coho in 2010 are considerably lower due to warm sea–surface conditions throughout August 2009 (NOAA 2010). In the immediate future, poor ocean survival is expected for coho salmon in the Klamath Basin. Over the course of the action, a range of ocean conditions could be expected, but uncertainty exists in the trends of ocean survival for coho salmon during the period of the Proposed Action. Climate information indicates that over the eight-year action, the Klamath River Basin is likely to experience a wide variation in conditions (Pagano and Garen 2005), with continued warm spring periods as experienced in the last decade (Van Kirk and Naman 2008). In the future, during warm spring periods, Project and off-Project water demands will likely continue to be high as represented in the most recent record.

The Proposed Action predominantly affects the Interior Klamath Basin diversity stratum. This stratum is comprised of 5 populations, all of which are designated as either functionally or potentially independent. Williams (2006) suggests that the populations within the Klamath stratum developed into separate populations as a result of substantial environmental variability. NMFS has determined that the populations within this stratum have a high risk of extinction due to the nature and severity of the risks facing each population from the condition of some or all of their VSP factors. Minimal information is available on the condition of each VSP factor, however available information on natural and anthropogenic threats and estimates of population abundance implicate the condition of the other three VSP factors. Abundance information and estimates indicate that all of the populations within the stratum fall below the levels needed to result in a low risk of extinction due to spatial structure and diversity concerns. Ranges provided for the abundance estimates for all stratum populations also fall within the levels of high extinction risks due to depensatory processes. Large proportions of hatchery coho influence diversity and productivity of the wild species. Large releases of hatchery Chinook smolts compete with coho for available space and resources.

Five coho salmon historical populations will be affected by the Project -- the three mainstem Klamath populations, as well as the Shasta River and Scott River populations. Although the Shasta River and Scott River populations spawn in watersheds that lie outside the action area of the Project, poor habitat and water quality conditions in these sub-basins disperse larger numbers of coho salmon fry and parr out of the Shasta and Scott basins and into the mainstem Klamath River each spring than would otherwise occur if these tributaries met the ecological needs of coho salmon (Chesney and Yokel 2003; Chesney 2006). While not restricted to the Shasta and Scott Rivers, this response to anthropogenic factors nevertheless appears to impact these two populations to a greater degree than other tributary-based populations within the Klamath River Basin (NAS 2004).

1. Upper Klamath Population Unit

a. Population Overview

The boundaries of the Upper Klamath Population unit currently comprise mainstem habitat and tributaries between Portuguese Creek and IGD, excluding the Shasta and Scott Rivers. IGH effects are significant because IGH origin coho salmon comprise a substantial proportion of the adult spawners in this population due to straying. For example, among tributaries in the Upper Klamath population, Bogus Creek is currently the largest producer of coho salmon, and hatchery origin adult coho salmon comprised approximately 35 percent of the observed carcasses in the winter 2008 carcass surveys. These data indicate the diversity parameter of this population may be reduced from outbreeding depression as described in Reisenbichler and Rubin (1999) and HSRG (2004). Habitat conditions of tributaries and mainstem have been degraded through a number of anthropogenic factors including water withdrawals, the network of roads and other land management activities that have reduced the quality and quantity of instream habitat. These factors, combined with the loss of historical habitat above IGD and environmental factors, including climate change, have contributed to the high risk of extinction of this population.

In the eight-year action period, beneficial effects to the Upper Klamath River Population unit are expected through the PacifiCorp interim measures (see *Environmental Baseline* section. For example, habitat restoration actions and water quality improvements downstream of IGD are currently taking place. Despite these improvements, NMFS considers the risk of extinction of the Upper Klamath Population unit to remain high in the foreseeable future. As described in the *Environmental Baseline* section, recent estimates of adult coho salmon abundance have reported the number of adult spawners returning to the Upper Klamath River Population Unit fell far short of the Low Risk Abundance Level proposed by Williams *et al.* (2007) of 8,500 spawners (Table 12).

b. Project Effects on Population Extinction Risk

(1) Individual Effects. During the fall/winter time period, the Proposed Action is expected to provide favorable conditions to some life stages of coho salmon of the Upper Klamath Population unit. Mainstem Klamath River flows and habitat conditions during the October through February time period are expected to provide adult coho salmon opportunity to successfully spawn in the mainstem Klamath River. In-gravel larvae of mainstem spawners of the Upper Klamath Population unit are expected to receive sufficient intra-gravel flow and low risks of desiccation under the Proposed Action. These beneficial conditions are expected to extend through the eight-year action period and sufficiently meet the needs of the Upper Klamath Population unit in the event that population abundance increases over the eight-year action period.

Adverse effects to the Upper Klamath Population unit resulting from the Project are also expected in the fall/winter time period. Juvenile coho salmon utilizing the mainstem Klamath River will generally experience a low volume of rearing habitat availability. The Proposed Action of storing water in UKL during winter periods is expected to reduce the amount of rearing habitat that would otherwise be available in wet exceedence flow conditions, reducing the beneficial conditions and potentially reducing the overwintering survival of some individuals. By reducing flow variability in the fall and early winter, the project may reduce the effectiveness of environmental cues for juvenile coho salmon to redistribute in the Upper Klamath River reach, and result in individuals using less favorable habitat conditions through the winter period. Reductions in fall and winter flow variability resulting from the Project are also expected to have adverse effects on riparian function and will likely increase disease risks to juvenile coho salmon of the Upper Klamath population unit by maintaining steady state flows through extended periods that favor the proliferation of *P. minibicornis, and C. shasta*.

In the March through June time period, the Proposed Action is expected to provide sufficient abundance of essential features of coho salmon fry critical habitat such that coho salmon fry individuals of the Upper Klamath Population unit are not likely to be adversely affected by the Project in the eight-year action period. The Proposed Action's effect on juvenile coho salmon life history stages in the spring period will vary temporally and spatially. In the R-Ranch study site vicinity (IGD to Interstate 5) the Project's effect on habitat availability is expected to result in benefits to survival and growth by providing an abundance of rearing habitat. The abundance of habitat availability in the upper portion of the Upper Klamath River reach is expected to be sufficient to support the life history needs of a future, more abundant Upper Klamath coho salmon population.

Through the middle and lower portions of the Upper Klamath River reach, appreciable habitat reductions resulting from the Project are expected in average and wetter conditions while in drier conditions Project effects on habitat availability are minimal. NMFS expects the habitat reductions anticipated in average and wetter conditions will have adverse effects on the survival of rearing coho salmon parr, pre-smolts, and smolts that would otherwise experience beneficial habitat conditions and improved survival in wetter exceedences. The Project effects will be greatest in May and June in average and wetter flow exceedences when the Proposed Action will inhibit the amount of available habitat by up to 31 percent and these effects are overlaid on top of the peak of IGH releases. Low survival rates of individuals are expected in these conditions through mechanisms such as disease, predation and reduced bioenergetics. While low survival rates of juvenile coho salmon are expected in May and June in drier flow exceedences, the Proposed Action is expected to extend these low survival rates into average and wetter flow exceedences.

The effect of the Proposed Action on reducing spring base flows and flow variability are expected to increase the risk of disease to coho salmon fry, parr and smolts. Reductions in spring base flows and flow variability are also expected to delay smolt outmigration, and as a result, some individuals will likely experience increased risks to fitness, including increased likelihood of disease infection. The Project's effect on fish disease incidence will be most pronounced in the Trees of Heaven vicinity, located approximately in the middle of the Upper Klamath River reach. Since most of the spawning within the Upper Klamath Population unit occurs upstream of the Trees of Heaven site, most juveniles will be subject to these potential adverse effects. These adverse effects are anticipated to be exacerbated in periods of extended inter-annual dry flow conditions. Decadal plots since 1960 suggest inter-annual periods of dry conditions have occurred in recent decades (Appendix 3). Considering the climatological patterns of the recent period of record and climatological forecasts for the Klamath River Basin, NMFS anticipates a high likelihood of experiencing an extended period of dry conditions at some point during the eight-year action period.

During the summer period, and as a result of environmental and anthropogenic factors described in the baseline, coho salmon of the Upper Klamath Population unit are expected to encounter marginal to lethal water quality conditions in the mainstem Klamath River. Individuals will be limited to areas of or near thermal refugia and NMFS anticipates Reclamation's Proposed Action will have a negligible effect on these areas. NMFS also expects the Proposed Action to provide sufficient flows for coho salmon to migrate and access non-natal tributaries during this time period.

(2) Consequences of fitness impacts on population viability parameters. The above described effects of the Project are here considered over the eight-year action period. Baseline conditions extending into the future eight years indicate warm spring and summer climatological conditions will persist and potentially increase, resulting in high ambient and water temperatures. These environmental conditions suggest disease infection rates of juvenile coho salmon are likely to be high over the eight-year period. Short term improvements to water quality in the Upper Klamath River reach are expected through the PacifiCorp interim measures (*e.g.*, turbine venting in 2009), however their role in reducing fish disease effects is likely to be minor.

The current status of the Upper Klamath Population unit of coho salmon is that it is persisting at an extremely low level, supported by hatchery strays. Freshwater survival of juvenile coho salmon in the Upper Klamath Population unit is likely low due to myriad risks and habitat degradation described in the baseline. NMFS has determined the Proposed Action will lower survival of juvenile coho salmon individuals of the Upper Klamath Population unit through (1) loss of rearing habitat in the spring period in average and wetter conditions, and (2) increased risks of disease. By reducing flows and habitat availability in average and wetter flow exceedences to levels that are more representative of drier flow exceedences, the Proposed Action is expected to lower the survival rates of affected juvenile coho salmon in average and wetter flow exceedences to levels that are more representative of drier flow exceedences. During wetter exceedences, NMFS would expect populations to rely on increased habitat availability and flow for improvements to abundance. Hence, the Proposed Action is expected to inhibit the ability of the Upper Klamath Population unit to benefit from higher survival rates under improved freshwater conditions. NMFS concludes the Proposed Action will therefore lower the overall population abundance of the Upper Klamath Population unit over the course of the eight-year proposed action.

Reduction in available spring rearing habitat is expected to lower the abundance of Upper Klamath Population unit juvenile coho salmon, resulting in lowered abundance to cohorts as they enter the marine environment. Lower abundances of returning adults will over time reduce the productive capacity of the Upper Klamath River Population unit. Hence, over the eight-year action period, the Proposed Action will impact the intrinsic productivity (*i.e.,* population growth) of the Upper Klamath Population unit.

Reduced flow variability resulting from the Project is expected to reduce the effectiveness of environmental cues. Individual fish make localized movements in response to changes in environmental conditions at temporal scales of hours to months. The loss of flow variability in the IGD to Scott River portion of the Upper Klamath River reach resulting from the Proposed Action is expected to reduce these environmental cues and constrain the ability of individuals to track short-term environmental change. This Project effect will therefore reduce the likelihood of juveniles redistributing from marginal overwintering habitat in the Upper Klamath River reach to more suitable habitat downstream, finally impacting the population's spatial structure.

Diversity in habitat conditions and the ability of fish/populations/ESUs to track changes in environmental conditions allows for the expression of life history diversity. The Proposed Action truncates the descending limb of the spring hydrograph throughout a large portion of the Upper Klamath River reach, resulting in dry flow conditions in average and wetter water year types (see Appendix 3). The Proposed Action reduces the diversity of habitat conditions available to the species over the eight-year period which in turn limits the diversity of life history strategies to the Upper Klamath Population unit.

2. <u>Shasta River Population Unit</u>

a. Population Overview

The current status of the Shasta River Population unit of coho salmon is that it is persisting at a high risk level (see *Environmental Baseline* section). Based on three years of adult returns (2001, 2003, 2004), hatchery strays comprise approximately 16 percent of the total abundance. Freshwater survival of juvenile coho salmon in the Shasta River Population unit is likely low due to myriad risks and habitat degradation described in this Opinion. The Shasta River Population Unit has a high risk of extinction, with substantial genetic and other depensation risks associated with low numbers of adult spawners and a high hatchery stray component in the population.

Continued water diversion activities, combined with other anthropogenic and environmental factors are expected to continue into the future eight-year action period and continue to adversely affect population survival and recovery. Large proportions of Shasta River coho salmon fry and parr will continue to be forced to outmigrate from the Shasta River Basin to the mainstem Klamath River in spring. These fish will face increased risks of disease infection as they acclimate to the mainstem Klamath River in the Trees of Heaven vicinity.

Restorative actions in the Shasta River sub-basin are expected to result in improvements to coho salmon habitat in the near future and may improve the overall viability of these populations. The Shasta RCD is removing several irrigation dams along the mainstem Shasta River. Removing these fish passage impediments will improve water quality conditions and increase habitat availability. NMFS does not expect these restorative actions to offset the impacts currently facing Shasta River coho salmon, however they are expected to improve the spatial structure of the Shasta River Population unit. In summary, coho salmon are expected to experience continued degraded water quality conditions and low flow conditions in the Shasta River in the foreseeable future. A substantial proportion of the annual coho salmon fry and parr leave the Shasta River and enter the Upper Klamath River reach of the mainstem Klamath River near the Trees of Heaven study site during the months of April and May as irrigation diversions commence (Chesney and Yokel 2003, Chesney 2006). Climatological trends suggest the Shasta River sub-basins will continue to experience warm spring conditions. Thus, the reliance of Shasta River Population unit coho salmon on the Klamath River mainstem and associated non-natal tributaries for rearing will continue to be an important component of the life history strategies expressed by this population.

b. Project Effects to Population Extinction Risk

(1) Individual Effects. NMFS finds that the magnitude and extent of effects from Reclamation's Proposed Action on Shasta River Population coho salmon are similar to those of the Upper Klamath Population unit. However, Shasta River coho salmon do not spawn in the mainstem Klamath River and therefore the effects of the Project on adult spawning through egg incubation coho salmon life stages are not expected. However, Shasta River Population coho salmon juveniles are reliant on the mainstem Klamath River for rearing and migration, and adult coho salmon utilize the mainstem as a migratory corridor.

Shasta River Population juvenile coho salmon enter the mainstem Klamath River in the vicinity of the Trees of Heaven study site (Appendix 1, Figure E). During the fall/winter time period, Shasta River Population coho salmon parr that redistribute into the mainstem Klamath River will experience a low volume of rearing habitat availability. The Proposed Action of storing water in UKL during winter periods is expected to reduce the amount of rearing habitat that would otherwise be available in wet exceedence flow conditions, reducing the beneficial conditions and potentially reducing the overwintering survival of some individuals. By reducing flow variability in the fall, the project will likely reduce the effectiveness of environmental cues for juvenile coho salmon to redistribute in the Upper Klamath River reach, and result in individuals using less favorable habitat conditions through the winter period.

In the March through June time period, the Proposed Action is expected to provide sufficient abundance of essential features of coho salmon fry critical habitat such that coho salmon fry individuals leaving the Shasta River are not likely to be adversely affected by the Project in the eight-year action period. The Proposed Action will affect the juvenile coho salmon life history stages of the Shasta River Population unit. Through the middle and lower portions of the Upper Klamath River reach, at and downstream of the terminus of the Shasta River, appreciable habitat reductions resulting from the Project are expected in average and wetter conditions while in drier conditions Project effects on habitat availability are minimal. NMFS expects the habitat reductions anticipated in average and wetter conditions will have adverse effects on the survival of rearing coho salmon parr, pre-smolts, and smolts that would otherwise experience beneficial habitat conditions and improved survival in wetter exceedences. The Project effects will be greatest in May and June in average and wetter flow exceedences when the Proposed Action will inhibit the amount of available habitat by up to 31 percent and these effects are overlaid on top of the peak of IGH fish releases. Low survival rates of individuals are expected in these conditions through mechanisms such as disease, predation and reduced bioenergetics. While low survival rates of juvenile coho salmon are expected in May and June in drier flow exceedences, the Proposed Action is expected to extend these low survival rates into average and wetter flow exceedences.

The Proposed Action's effect of reducing spring base flows and flow variability are expected to increase the risk of disease to coho salmon fry, parr and smolts. Reductions in spring base flows and flow variability are also expected to delay smolt outmigration, and as a result, some individuals will likely experience reductions in fitness, including increased likelihood of disease infection. The Project's effect on fish disease incidence will be most pronounced in the Trees of Heaven vicinity, located directly downstream of the Shasta River terminus. These adverse effects are expected to be greatest during extended inter-annual dry flow conditions.

During the summer period, and as a result of environmental and anthropogenic factors described in the baseline, juvenile coho salmon of the Shasta River Population unit are expected to encounter marginal to lethal water quality conditions in the mainstem Klamath River. Individuals will be limited to areas of or near thermal refugia and NMFS anticipates Reclamation's Proposed Action will have a negligible effect on these areas. NMFS also expects the Proposed Action to provide sufficient flows for coho salmon to migrate and access non-natal tributaries during this time period.

(2) Consequences of fitness impacts on population viability parameters. Juvenile outmigrant trap data indicates a large proportion of juvenile coho salmon utilizing the Upper Klamath River reach in spring are from the Shasta River Population unit. NMFS has determined the Proposed Action will lower survival of juvenile coho salmon individuals in the Upper Klamath River reach through (1) loss of rearing habitat, primarily in the spring period in average and wetter conditions, and secondarily in the winter period in wet conditions, and (2) increased risks of disease infection. These effects of the Proposed Action occur within the Upper Klamath River reach and downstream of the Shasta River confluence, therefore Shasta River outmigrants are exposed to these survival risks. By reducing flows and habitat availability in average and wetter flow exceedences to levels that are more representative of drier flow exceedences, the Proposed Action is expected to lower the survival rates of affected juvenile coho salmon in average and wetter flow exceedences to levels that are more representative of drier flow exceedences. NMFS would expect populations to rely on increased habitat availability and flow during wetter exceedences for improvements to abundance. Hence, the Proposed Action is expected to inhibit the ability of the Shasta River Population unit to benefit from higher survival rates under improved freshwater conditions. NMFS concludes the Proposed Action will therefore lower the overall population abundance of the Shasta River Population unit over the course of the eight-year proposed action.

Reduction in available habitat for rearing and over wintering as described in this Opinion is expected to lower the abundance of Shasta River Population unit juvenile coho salmon, resulting in lowered abundance to cohorts as they enter the marine environment. Lower abundances of returning adults will, over time, reduce the productive capacity of the Shasta River Population unit. Over the eight-year action period, the Proposed Action will impact the intrinsic productivity (*i.e.,* population growth) of the Shasta River Population unit.

Reduced flow variability resulting from the Project is expected to reduce the effectiveness of environmental cues. Individual fish make localized movements in response to changes in environmental conditions at temporal scales of hours to months, and the loss of flow variability in the Shasta River to Scott River portion of the Upper Klamath River reach resulting from the Proposed Action is expected to constrain the ability of Shasta River juvenile coho salmon to track environmental change. This Project effect will therefore reduce the likelihood of juveniles redistributing from marginal overwintering habitat in the Upper Klamath River reach to more suitable habitat downstream, impacting the Shasta River Population's spatial structure.

Diversity in habitat conditions and the ability of fish/populations/ESUs to track changes in environmental conditions allows for the expression of life history diversity. The Proposed Action truncates the descending limb of the spring hydrograph throughout a large portion of the Upper Klamath River reach such that dry flow conditions are likely to be realized in average and wetter water year types (Appendix 3). The Proposed Action reduces the diversity of habitat conditions available to the species over the eight-year action period which in turns limits the diversity of life history strategies in the Shasta River Population unit.

3. Scott River Population Unit

a. Population Overview

The current status of the Scott River Population unit of coho salmon is that it is persisting at an extremely low level. The adult return estimates for the Scott River (Table 13) were less than the Low Risk Annual Abundance Level (Table 12) in each year from 2001 to 2004, and below High Risk Annual Abundance Level in two of the four years and 2009. Therefore, the Scott River Population Unit has a high risk of extinction, with substantial genetic and other depensation risks associated with low numbers of adult spawners.

Excessive sediment loads and elevated water temperatures have impaired habitat conditions of the Scott River and its tributaries. Summer temperature conditions do not support suitable salmonid rearing habitat in the mainstem of the Scott River and many tributaries. Riparian vegetation has also been removed, or cannot grow due to the lowered water table, which exacerbates solar heating and water temperature. Agricultural operations, including surface water diversion and groundwater pumping, have contributed significantly to reductions in summer base flow of the Scott River (Van Kirk and Naman 2008) such that the river can become a series of disconnected and stagnant pools in the summer and fall. These conditions are not suitable for juvenile coho salmon rearing during these months, and also limit the effectiveness of cold water seeps and other thermal refugia. Low flows in the Scott River have been cited as a factor limiting the recovery of coho salmon (CDFG 2002a; NRC 2003).

Restorative actions in the Scott River sub-basin are ongoing. For example in the Scott River watershed, a water trust will provide future funding for farming interests to forego water use and to improve summer base flow. However, coho salmon are expected to experience continued degraded water quality conditions and low flow conditions in the Scott River in the foreseeable future. Like the Shasta River, a substantial proportion of the annual coho salmon fry and parr leave the Scott River and enter the Upper Klamath

River reach of the mainstem Klamath River in the spring as irrigation diversions commence and sub-basin conditions become inhospitable (Chesney and Yokel 2003, Chesney 2006). Climatological trends suggest the Scott River sub-basins will continue to experience warm spring conditions, reduced snowpack and low summer and late fall base flows. Thus, the reliance of Scott River Population unit coho salmon on the Klamath River mainstem and associated non-natal tributaries for rearing will continue to be an important component of the life history strategies expressed by this population.

b. Project Effects to Population Extinction Risk

(1) Individual Effects. Scott River Population coho salmon juveniles are reliant on the mainstem Klamath River for rearing and migration, and adult coho salmon utilize the mainstem as a migratory corridor. Instream habitat conditions in the mainstem Klamath River are generally improved from the contributions of the Scott River Basin. The functions of geo-fluvial processes are aided by the appreciable volume of Scott River accretions, and the resulting habitat and water quality conditions below the Scott River confluence are generally more suitable for juvenile coho rearing. Disease incidence rates are also generally lower below the Scott River than upstream.

Scott River Population juvenile coho salmon enter the mainstem Klamath River upstream of Seiad Valley (Appendix 1 Figure D). During the fall/winter time period, Scott River Population coho salmon parr that redistribute into the mainstem Klamath River will experience low volumes of rearing habitat availability as evidenced in Figure 17. The Proposed Action generally provides volumes of rearing habitat representative of the hydrological conditions, although a small adverse effect of the Proposed Action is anticipated in the month of January in wet flow exceedences. The risks of these adverse effects are anticipated to be low due to the relatively small window of occurrence.

In the March through June time period, the Proposed Action is expected to provide sufficient abundance of essential features of coho salmon fry critical habitat such that coho salmon fry individuals leaving the Scott River are not likely to be adversely affected by the Project in the eight-year action period. The Proposed Action is anticipated to affect the juvenile coho salmon life history stages of the Scott River Population unit by reducing the amount of available rearing habitat in wet flow exceedences.

NMFS expects the habitat reductions anticipated in wet conditions will have some adverse effects on the survival of rearing coho salmon parr, pre-smolts, and smolts that would otherwise experience additional habitat abundance. The Project effects will be greatest in the wettest flow exceedences when the Proposed Action will inhibit the amount of available habitat by up to 17 percent and these effects are overlaid on top of the peak of IGH releases. The effects of the Project are anticipated to be ameliorated by the contributions of Scott River flows which provide substantial flow to the mainstem Klamath River in wet exceedence conditions throughout the spring period. The contributions of the Scott River are expected to also improve water quality conditions such that stressors to Scott River population juvenile coho salmon will be reduced in periods when the Project is expected to reduce habitat availability. Improved water quality conditions below the Scott River confluence are expected to counter the effects of the Proposed Action on disease infection. Reductions in spring base flows and flow variability will likely delay Scott River coho smolt outmigration, although again, the effects will likely be lower than reaches upstream of the Scott River confluence due to the ameliorating effects of Scott River accretions.

During the summer period, and as a result of environmental and anthropogenic factors described in the baseline, juvenile coho salmon of the Scott River Population unit are expected to encounter marginal to lethal water quality conditions in the mainstem Klamath River. Individuals will be limited to areas of or near thermal refugia and NMFS anticipates Reclamation's Proposed Action will have a negligible effect on these areas. NMFS also expects the Proposed Action to provide sufficient flows for coho salmon to migrate and access non-natal tributaries during this time period.

***(2) Consequences of fitness impacts on population viability parameters*.** Juvenile outmigrant trap data indicates a large proportion of juvenile coho salmon utilizing the lower portion of the Upper Klamath River reach, from the Scott River confluence through Seiad Valley in spring are from the Scott River Population unit. NMFS has determined the Proposed Action will lower available rearing habitat in the Seiad Valley vicinity in wet flow exceedences. These Project effects to habitat are anticipated to pose minor risks to the Scott River Population unit, and not rise to levels anticipated in the Upper Klamath and Shasta River Population units, primarily because the magnitude and extent of habitat reductions are less, and habitat conditions below the Scott River confluence are improved as a result of flow contributions from the Scott River Basin. The Proposed Action is expected to have a minor adverse effect on population abundance.

Abundances of Scott River Population unit returning adults are anticipated to be slightly reduced by the Proposed Action, and over time, the productive capacity of the Scott River Population unit is expected to be affected by the Project. Over the eight-year action period, the Proposed Action will have an adverse effect on the intrinsic productivity (*i.e.,* population growth) of the Scott River Population unit.

The Project's effect of reducing flow variability as described in the preceding viability analyses is anticipated to be ameliorated by Scott River contributions. Scott River Population juvenile coho salmon are expected to experience environmental cues sufficient to trigger fall redistribution and other movement patterns to allow individuals to access overwintering habitat downstream. NMFS expects the Proposed Action will have a minor effect on the Scott River Population's spatial structure.

Diversity in habitat conditions and the ability of fish/populations/ESUs to track changes in environmental conditions allows for the expression of life history diversity. The project's effect of truncating the descending limb of the spring hydrograph is ameliorated but not negated by Scott River contributions. Habitat conditions, below the Scott River confluence are generally improved as a result of the Scott River flow contributions, and flow variability and augmentation from the Scott River are expected to ameliorate the Proposed Action's effect on the diversity of habitat conditions available to the Scott

River Population unit. NMFS does not expect the Proposed Action's effect to rise to a level that will limit the diversity of life history strategies available to the Scott River Population unit.

4. Middle Klamath River Population Unit

a. Population Overview

Little data on coho salmon abundance in this population exists, however the limited data indicates abundances fall below the Low Risk Annual Abundance Level (Table 12). Therefore, NMFS concludes the Middle Klamath River Population Unit is persisting at a low level and has a high risk of extinction, with substantial genetic and other depensation risks associated with low numbers of adult spawners.

Tributaries within the Middle Klamath River Population Unit (*e.g.,* Boise, Red Cap and Indian Creeks) support populations of coho salmon (NMFS 2007a), and offer critical cool water refugia within their lower reaches when mainstem temperatures and water quality approach uninhabitable levels. However, several anthropogenic factors limit the function and accessibility of refugia habitat in the area including land management activities associated with timber harvest and road construction. Elevated water temperatures during summer months limit summer rearing for coho salmon in the Middle Klamath River reach to the limited areas of thermal refugia.

b. Project Effects to Population Extinction Risk

(1) Individual Effects. Effects of the Proposed Action on Middle Klamath Population unit coho salmon are lessened as a result of tributary contributions between IGD and Portuguese Creek. The Proposed Action reduces fall hydrologic variability, and these effects are anticipated to be measurable into the upper portion of the Middle Klamath River reach, although much less than anticipated in the Upper Klamath River reach. These effects are likely to be negligible throughout the middle and lower portions of the Middle Klamath River reach.

In the March through June time period, the Proposed Action is expected to provide sufficient abundance of essential features of coho salmon fry critical habitat such that coho salmon fry individuals of the Middle Klamath River Population unit are not likely to be adversely affected by the Project in the eight-year action period. The Proposed Action reduces the amount of available habitat for coho salmon juveniles in the Rogers Creek vicinity. The loss of juvenile habitat is greatest during average and drier exceedence flows in April and May, when the reduction in the percent of maximum WUA can be as high as 12 percent. Similar reductions occur during wetter hydrologic conditions in June. Further downstream, and throughout the majority of the Middle Klamath River reach, the Proposed Action has no discernable effect on coho salmon juvenile habitat. NMFS expects low numbers of juvenile coho salmon will be exposed to the habitat reduction due to the low abundance of this population and the narrow spatial extent of the effect.

NMFS also expects the biological ramifications of the habitat reduction to be ameliorated by tributary contributions to flow and water quality.

During the summer period, juvenile coho salmon of the Middle Klamath River Population unit are expected to encounter marginal to lethal water quality conditions in the mainstem Klamath River. Individuals will be limited to areas of or near thermal refugia and NMFS anticipates Reclamation's Proposed Action will have a negligible effect on these areas. NMFS also expects the Proposed Action to provide sufficient flows for coho salmon to migrate and access non-natal tributaries during this time period.

(2) Consequences of fitness impacts on population viability parameters. Due to the low abundance of this population, and the generally favorable over-summering habitat of tributaries within this population unit, low numbers of Middle Klamath River Population juvenile coho salmon are expected to rear in the Middle Klamath River reach. The Proposed Action is anticipated to reduce rearing habitat availability in the upper portion of the Middle Klamath River reach, but have no discernible effect through most of the reach. Reduced habitat availability resulting from the Project is anticipated to pose a minor risk to the Middle Klamath River Population unit. Tributary contributions from the Scott River and other tributaries of the Middle Klamath River reduce the Project's effect on reduced base flow and reductions to habitat availability. The Proposed Action is expected to have a negligible effect on the population abundance of the Middle Klamath River Population unit.

Abundances of Middle Klamath River Population unit returning adults are not anticipated to be affected by the Proposed Action, and over time, the productive capacity of the Middle Klamath Population unit is not anticipated to be affected by the Project. Over the eight-year action period, the Proposed Action will have a neutral effect on the intrinsic productivity (*i.e.,* population growth) of the Middle Klamath River Population unit.

The Project's effect of reducing flow variability as described in the preceding viability analyses is anticipated to be ameliorated by Scott River and Middle Klamath tributary contributions. Middle Klamath River Population juvenile coho salmon are expected to experience environmental cues sufficient to trigger fall redistribution and other movement patterns to allow individuals to access overwintering habitat downstream. NMFS expects the Proposed Action will have a negligible effect on the Middle Klamath River Population's spatial structure.

Diversity in habitat conditions and the ability of fish/populations/ESUs to track changes in environmental conditions allows for the expression of life history diversity. The project's effect of truncating the descending limb of the spring hydrograph is ameliorated but not negated by Scott River contributions. Habitat conditions, below the Scott River confluence are generally improved as a result of the Scott River flow contributions, and flow variability and augmentation from the Scott River and other tributaries of the Middle Klamath River reach are expected to ameliorate the Proposed Action's effect on the diversity of habitat conditions available to the Middle Klamath River Population unit.

NMFS does not expect the Proposed Action's effect to rise to a level that will limit the diversity of life history strategies available to the Middle Klamath River Population unit.

5. Lower Klamath River Population Unit

In the Effects Analysis section of this Opinion, NMFS concluded the Proposed Action will likely have a negligible effect on habitat availability and water quality within the Lower Klamath River reach. NMFS also determined coho salmon will experience sufficient flows to meet their life history needs while in this reach. Therefore NMFS anticipates no adverse effects to the Lower Klamath River Population unit of coho salmon as a result of the Proposed Action.

6. Impacts to the Interior Klamath Diversity Stratum

As described in the above section, NMFS expects that the proposed operation of the Project over the next eight years is likely to negatively affect the viability parameters of three of the five populations within the Interior Klamath Diversity Stratum, thereby increasing the population's risk of extinction. This increase in risk is primarily as a result of the reduced abundance of coho salmon due to reduced juvenile survival and growth in the upper mainstem, particularly in above average and wetter years. Reductions in abundance of the populations also further exacerbate existing concerns for the productivity, diversity, and spatial structure of the populations. This is particularly of concern in the Shasta River population where estimates of abundance indicate that the population faces high risks of extinction due to depensatory processes. Regardless of the intended role any of the populations is expected to play in the recovery of the species, the combination of baseline conditions and the added effects of eight years of operations are expected to move the affected populations further away from the conditions needed to support a viable stratum and a recovered species. Therefore, NMFS reasons that the proposed operations will further reduce the stratum's likelihood of supporting a viable species through increases in the extinction risk of stratum populations posed by reductions in abundance, productivity, diversity, and spatial structure of three of the five populations. Given that we expect the Proposed Action will increase the risk of extinction of several of the affected populations and reduce the stratum's likelihood of supporting a viable species, we then also expect that the species' risk of extinction will be increased, and therefore the likelihood of both survival and recovery of the species will be reduced as well.

B. Critical Habitat

In designating critical habitat, NMFS considers the following requirements of the species: (1) Space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing offspring; and, generally, (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of this species (see 50 CFR 424.12(b)). In addition to these factors, NMFS also focuses on the known physical and biological features (essential features) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

Within the range of the SONCC coho salmon ESU, the life cycle of the species can be separated into five essential habitat types: (1) Juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) areas for growth and development to adulthood; (4) adult migration corridors; and (5) spawning areas. Within these areas, essential features of coho salmon critical habitat include adequate; (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions (May 5, 1999, 64 FR 24049). Within the Environmental Baseline and Effects of the Action sections, NMFS has presented evidence detailing the mainstem rearing life-history strategy common to coho salmon within the Klamath River, and that mainstem rearing occurs not just in summer and winter, but in fact year-round. Accordingly, NMFS will not restrict its analysis only to juvenile summer and winter rearing areas, but will instead consider impacts to juvenile rearing habitat occurring throughout the year.

When evaluating critical habitat within the action area, the analysis will be restricted to the Upper and Middle Klamath River reaches. Critical habitat within the mainstem action area is not currently designated below the Trinity River (tribal land) or above IGD (impassable barrier).

1. Condition of Critical Habitat at the ESU Scale

The condition of habitat throughout the range of SONCC coho salmon is degraded, relative to historical conditions. While some relatively unimpaired streams exist within the ESU, decades of intensive timber harvesting, mining, agriculture, channelization, and urbanization have altered coho salmon critical habitat, sometimes to the extent that it is no longer able to support one or more of the life stages of coho salmon. Below, the condition of the essential habitat types necessary to support the life cycle of the species (May 5, 1999, 64 FR 24049) is summarized in more detail.

a. Juvenile Summer and Winter Rearing Areas

Juvenile summer and winter rearing areas should contain adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, and space. These essential features are necessary to provide sufficient growth and reasonable likelihood of survival to smoltification.

In the SONCC ESU, juvenile summer rearing areas have been compromised by low flow conditions, high water temperatures, insufficient dissolved oxygen levels, excessive nutrient loads, invasive species, habitat loss, disease effects, pH fluctuations, sedimentation, removal or non-recruitment of large woody debris, stream habitat simplification, and loss of riparian vegetation. Winter rearing areas suffer from high water velocities due to excessive surface runoff during storm events, suspended sediment in the water column, removal or non-recruitment of large woody debris and stream habitat simplification. The morphology and hydraulic function of most stream channels within the ESU has been compromised to some degree, which has limited the amount of invertebrate production in streams and, in turn, limited the amount of food available to rearing juveniles. The majority of the waterways in the ESU fail to provide sufficient juvenile summer and winter rearing area, although some streams in the ESU remain somewhat intact relative to their historical condition.

b. Juvenile Migration Corridors

Juvenile migration corridors need to have sufficient water quality, water quantity, water temperature, water velocity, and safe passage conditions in order for coho salmon juveniles and smolts to emigrate to estuaries and the ocean, or to redistribute into non-natal rearing zones. Adequate juvenile migration corridors need to be maintained throughout the year because smolts emigrate to estuaries and the ocean during spring months, while juveniles may redistribute themselves at any time in response to fall freshets or while seeking better habitat and rearing conditions.

Within the ESU, juvenile migration corridors suffer from low flow conditions, disease effects, high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution. Low dissolved oxygen levels, excessive nutrient loads, insufficient pH levels and other water quality factors also afflict juvenile migration corridors.

c. Adult Migration Corridors

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover/shelter and safe passage conditions in order for adults to reach spawning areas. Adults generally migrate in the fall or winter months to spawning areas.

Removal or non-recruitment of woody debris has simplified instream habitat complexity within many river drainages, effectively reducing available shelter needed for adults to rest during high flow events. The low river flows that result from upstream diversion and water storage (*i.e.,* reservoirs) are common throughout the ESU, and can physically hinder adult migration, especially if fall rain storms are late or insufficient to raise water levels enough to ensure adequate passage. Poorly designed culverts and other road crossings have truncated adult migration corridors and cut off hundreds of miles of stream habitat throughout the SONCC coho salmon ESU.

d. Spawning Areas

Spawning areas for SONCC coho salmon must include adequate substrate, water quality, water quantity, water temperature, and water velocity to ensure successful redd building, egg deposition and egg to fry survival. Coho salmon spawn in smaller tributary streams from November through January in the ESU.

A widespread problem throughout the ESU is the high rate of sediment entering the aquatic environment, which can embed spawning gravels with fine sediment and decreases egg-to-fry survival. Excessive runoff from storms, which causes redd scouring, is another issue that plagues adult spawning areas. Spawning gravel recruitment is frequently impaired within river systems blocked by dams and reservoirs, which can limit the amount of available spawning habitat.

e. SONCC Coho Salmon Critical Habitat Summary

The current function of critical habitat in the SONCC coho salmon has been degraded relative to its unimpaired state. Although exceptions exist, the majority of streams and rivers in the ESU suffer from some combination of habitat degradation that limits the habitat's ability to adequately support one or more lifestages of coho salmon. Additionally, critical habitat in the ESU often lacks the ability to establish essential features due to ongoing human activities. For instance, water diversions reduce summer base flows in many of the larger river systems throughout the ESU. The resulting lower flow volumes degrade several essential habitat features critical to juvenile coho salmon survival, such as water quality and water quantity.

2. Condition of Critical Habitat of the Interior-Klamath Diversity Stratum

The current function of critical habitat in the Interior-Klamath Diversity Stratum is degraded relative to its unimpaired state. Sedimentation, low stream flows, poor water quality, stream habitat simplification, and habitat loss from poorly designed road crossings plague coho salmon streams in this stratum. Several streams and rivers in the diversity stratum do not support one more life stages of coho salmon during certain periods of the year, such as the Shasta River (NCRWQCB 2006). Additionally, critical habitat in the ESU often lacks the ability to establish essential features due to ongoing human activities. For example, IGD on the Klamath River, California, stops the recruitment of spawning gravels, which impacts both an essential habitat type (spawning areas) as well as an essential feature of spawning areas (substrate). Water utilization in many regions throughout the diversity stratum (*e.g.,* Scott River) reduces summer base flows, which limits the establishment of several essential features such as water quantity and water quality.

3. Critical Habitat Condition Within the Action Area

a. Current Condition and Function of Critical Habitat in the Upper Klamath River Reach

Water quality and quantity conditions reduce the functionality of essential habitat types in this reach and diminish the ability of the habitat type to establish essential features. IGD flow releases typically have a proportionally larger effect on the flow regime in this reach than in downstream reaches, because tributary accretions boost discharge further downstream.

(1) Juvenile Summer and Winter Rearing Areas. For the Upper Klamath River Population Unit, juvenile summer rearing areas have been compromised by low flow conditions, high water temperatures, insufficient dissolved oxygen levels, excessive nutrient loads, habitat loss, disease effects, pH fluctuations, non-recruitment of large woody debris, and loss of geomorphological processes that create habitat complexity. Winter rearing areas are limited by compromised large woody debris input and stream habitat simplification.

(2) Juvenile Migration Corridor. Juvenile migration corridors within the Upper Klamath River reach suffer from low flow conditions, disease effects, high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution. The unnatural and steep decline of the hydrograph in the spring may slow the immigration of coho salmon smolts, speed the fish disease proliferation, and degrade water quality more quickly than would occur naturally. Disease effects, particularly in hot spot areas such as the Trees of Heaven site, likely have a substantial impact on the survival of juvenile coho salmon in this stretch of river.

(3) Adult Migration Corridor. The current physical and hydrologic condition of the adult migration corridor within the mainstem Upper Klamath River reach likely functions in a manner that supports its intended conservation role. Water quality is generally suitable for upstream adult migration, and flow volume is likely above the threshold at which migration barriers may form.

(4) Adult Spawning. Low or non-recruitment of spawning gravels is a problem in the Upper Klamath River Reach. The lack of clean and loose gravel diminishes the amount and quality of salmonid spawning habitat downstream of dams. This condition is especially critical below IGD (FERC 2006). Water temperature, depth and velocity are generally sufficient in this reach for successful adult coho salmon spawning.

b. *Effects of the Action by Essential Habitat Type and Feature in the Upper Klamath River Reach*

The Project has the potential to impact the following four essential habitat types within the Upper Klamath River reach: juvenile rearing habitat, juvenile and adult migration corridors, and spawning habitat.

(1) Juvenile rearing habitat. The Proposed Action reduces the volume of suitable rearing habitat (*i.e.,* weighted usable area or WUA) available to redistributing (fall) and overwintering coho salmon parr throughout a large portion of the Upper Klamath River Reach, primarily during wetter exceedences in January. Similarly, habitat modeling predicts appreciable reductions in WUA for juvenile parr and smolt rearing during most spring months, again generally occurring within average and wetter flow exceedence conditions. During summer months, WUA for rearing coho salmon parr would also likely be lower under the Proposed Action during average and wetter exceedence conditions.

The following essential features influence the overall quality of juvenile rearing habitat, as well as inform the likelihood the habitat will provide its intended conservation role (*i.e.,* function in a manner that supports the lifestage that requires that habitat type). For juvenile rearing habitat, the essential features of concern are water quantity, water quality, water velocity, cover/shelter, food, and space. Unfortunately, site-specific determinations of the Proposed Action's effect on each of these essential features are unavailable. However, NMFS will utilize the WUA data as a surrogate, since WUA is a measure of habitat suitability that is informed by species and life-stage specific preferences, and incorporates microhabitat features such as flow, depth, velocity, substrate and cover. Thus, as juvenile rearing WUA is reduced, NMFS expects that all, or some combination, of these microhabitat attributes (essential features) are in turn compromised by the Proposed Action.

Generally, an abundance of coho salmon fry habitat is predicted throughout the entire Upper Klamath River reach under the Proposed Action. During spring months and flow exceedence combinations where habitat availability is not anticipated to be abundant (*i.e.,* less than 80 percent), the Proposed Action generally results in either similar volumes or greater volumes of coho salmon fry habitat than would occur under a No Project flow.

(2) Adult and juvenile migration corridors. Both coho salmon adults and juveniles utilize the mainstem Klamath River as a migration corridor during the fall, with adults traveling upstream to natal spawning tributaries and coho salmon parr moving both upstream and downstream as they redistribute into winter habitat. The proposed flow regime will affect water volume and velocity within the mainstem channel, which are the two essential habitat features influenced by the Project that affect fish passage dynamics downstream of IGD. The Proposed Action also restrains hydrologic variability downstream of IGD during the fall and winter months, which likely impairs the flow-related cues that stimulate migratory behavior in juvenile and adult fish.

The Proposed Action will decrease water depth and velocity during March, April, May and June during most exceedence types. Water velocity is a critical factor likely influencing the speed at which coho salmon smolts move through the mainstem channel, and lower velocities likely lower the conservation value of the mainstem Klamath River migration corridor. Water depth will also be lower under the Proposed Action. While low water depths can impair juvenile fish migration between mainstem and tributary habitat, the extent of this effect within the Klamath mainstem is uncertain at this time. Alternatively, higher flows and greater depths have been theorized as potentially degrading the function and formation of slow, "dead zones" within the channel that can harbor disease pathogens (Hardy *et al.* 2006).

Little migration occurs within the coho salmon population during the months of July, August and September. The one exception is the observed migration between mainstem habitat and thermal refugia located near tributary confluences and within the lower sections of some creeks. Water depth is an essential feature of migratory habitat at this time of year, with greater depths generally allowing easier access into tributary habitat. The Proposed Action generally results in greater water depths during drier exceedence types during the summer, whereas water volumes within the mainstem Klamath River (and therefore water depths) are largely lower during wetter exceedence types as a result of the Proposed Action.

(3) Spawning habitat. The essential features that influence coho salmon spawning habitat are substrate, water quality and water quantity. During the coho spawning period of November through January, the Proposed Action has little, if any, effect on substrate condition or water quality. Water velocities resulting from the Proposed Action will support high egg survival within mainstem redds.

a.   Current condition and Function of Critical Habitat in the Middle Klamath River Reach

(1) Juvenile Summer and Winter Rearing Areas. Juvenile summer rearing areas in this stretch of river have been compromised relative to the historic state. A few tributaries within the Middle Klamath River Population Unit (*e.g.,* Boise, Red Cap and Indian Creeks) support populations of coho salmon (NMFS 2007a), and offer critical cool water refugia within their lower reaches when mainstem temperatures and water quality approach uninhabitable levels. High tributary sediment loads have caused chronically high sediment concentrations within most tributaries. Mainstem water quality can limit coho juvenile survival during summer months, when water temperature, DO concentration and pH levels can approach lethal levels.

(2) Juvenile Migration Corridor. Disease effects in this stretch of river can limit the survival of juvenile coho salmon as they emigrate downstream. Low flows can slow the emigration of juvenile coho salmon, which can in turn lead to longer exposure times for disease, and greater risks due to predation.

(3) Adult Migration Corridor. Most migrating adult coho salmon are likely unaffected by elevated summer water temperatures characteristic of the Middle Klamath River section, since water temperatures are largely suitable during the October through December period. Water depth and velocity are currently suitable throughout the Middle Klamath River during the fall and winter migration period.

(4) Spawning Areas. The amount of spawning habitat within the Middle Klamath River reach is limited due the geomorphology and the prevalence of bedrock in this stretch of river. However, the quality of available habitat is likely high (*i.e.,* adequately supports successful spawning), and the overall volume is likely sufficient to support the small number of coho salmon spawning within Middle Klamath mainstem habitat.

b.   Effects of the Action by Essential Habitat Type and Feature in the Middle Klamath River Reach

The Project has the potential to impact the following four essential habitat types within the Middle Klamath River reach: juvenile rearing habitat, juvenile and adult migration corridors, and spawning habitat.

(1) Juvenile rearing habitat. Juvenile rearing habitat within the Middle Klamath River reach is affected in much the same way as habitat within the Upper Klamath River reach, except the overall magnitude of effect is generally diminished because a higher percentage of the flow volume within the Middle Klamath River reach originates from tributaries and not IGD. Nevertheless, the Proposed Action will lower the flow volume reaching the Middle Klamath River reach during most months of the year and water exceedences. However, modeling results show that juvenile coho salmon (*i.e.,* parr) WUA does not change appreciably during the fall/winter despite the lower flow volume, suggesting the Proposed Action is not compromising the conservation role of available juvenile rearing habitat within the Middle Klamath River reach during this time period.

The flow regime resulting from the Proposed Action generally lowers the amount of available juvenile coho salmon (parr and smolt) habitat during the March through June period within the Scott River to Salmon River reach (*i.e.,* the Rogers Creek reach). The loss of juvenile habitat is greatest during average and drier exceedence flows in April and May, when the difference in the percent of maximum WUA can be large (*e.g.,* 12 percent WUA difference in a 70 percent exceedence type). WUA is similarly reduced during wetter hydrologic conditions in June. The essential habitat features of juvenile rearing habitat most likely impaired by the Proposed Action are water quality, water quantity, and cover/shelter. The Proposed Action generally results in greater fry habitat (*i.e.,* higher WUA values) within the Middle Klamath River reach.

(2) Adult and juvenile migration corridors. As a result of the Proposed Action, flow volume is lower within the Middle Klamath River reach under most exceedence types during the March through June period. Lower flow volumes are expected to generally result in shallower water depth and slower water velocities. These conditions likely compromise the essential features of coho salmon smolt migratory habitat and impair the ability of the habitat to support rearing coho salmon.

Water depth is an essential feature of migratory habitat during summer months also, with greater depths generally allowing coho salmon parr easier access into tributary habitat. The Proposed Action generally results in deeper river depths during below average and drier exceedence types during the summer. However, summer water volume within the mainstem Klamath River (and therefore water depths) is largely lower during wetter exceedence types as a result of the Proposed Action.

(3) Spawning habitat. Mainstem coho salmon spawning is likely limited within most of the Middle Klamath River reach, the exception being a small number of coho salmon redds observed downstream of Indian Creek within the upper portion of the reach. During the coho spawning period of November through January, the Proposed Action has little, if any, effect on substrate condition or water quality. The Proposed Action will lower flow volumes and water velocity during most of the egg incubation period. Yet, the water velocities created by the Proposed Action are expected to create optimal redd conditions and are unlikely to impair egg development.

4. Consequences of action area effects on critical habitat function

The Proposed Action is likely to destroy or modify the following essential habitat types within the mainstem action area: juvenile rearing habitat during the fall, winter and spring; and juvenile migration corridors during the fall, winter and spring.

The loss of fall/winter juvenile rearing habitat is restricted to the Upper Klamath River reach; juvenile habitat is generally unaffected by the Proposed Action within the Middle Klamath. The loss of fall juvenile habitat is likely small and insignificant given the limited proportion of the basin's juvenile coho salmon population occupying the mainstem at that time. Competition for available habitat is not likely to be limiting fitness and survival of coho salmon within the mainstem at this time, unlike during spring when competition with hatchery fish becomes severe. Thus, given the current condition and availability of fall/winter juvenile rearing habitat and its predicted use by juvenile coho salmon, the habitat's ability to support juvenile coho salmon rearing (*i.e.,* provide adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, and space) will not be impaired during the eight-year duration of the Proposed Action. However, lost hydrologic variability caused by the Proposed Action within the Upper Klamath River reach is likely impairing migratory behavior and reducing the ability of available habitat to support and maintain successful upstream and downstream migration.

Much like the fall/winter period, juvenile coho salmon habitat is also degraded and lost as a result of the Proposed Action during the March through June period. However, the loss of juvenile habitat during the spring likely has a greater consequence to the Klamath River coho salmon population than fall habitat loss described above, since other confounding stressors (*i.e.,* fish disease and poor water quality) will magnify the effect of lower habitat volume. Furthermore, the volume of suitable habitat lost during the spring is substantially greater than that lost in the fall. As a result, the aquatic habitat condition of low habitat volume, poor water quality and high disease incidence significantly limits the function of coho salmon parr and smolt rearing habitat, as well as the habitat's ability to establish features essential to support rearing coho salmon (*i.e.,* contain adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, and space). These limitations occur during most years within both the Upper and Middle Klamath River reach.

Spring flow volume and water velocity influence coho salmon smolt migration speed through the mainstem river. The lower water volume (and hence reduced water velocity) provided by the Proposed Action will likely slow the speed at which coho salmon smolts leave the system and compromise the ability of the habitat to support a functioning juvenile migratory corridor. A functional migratory corridor is essential to minimize exposure to the poor water quality and high disease pathogen concentrations common to the Klamath River mainstem during late spring.

To summarize, the Proposed Action is anticipated to destroy or adversely modify spring juvenile rearing habitat and juvenile migratory habitat during the fall and spring. The potential of the habitat to fulfill its intended conservation role will likely be impaired, such that the ability of coho salmon to successfully rear and migrate within the Middle and Upper Klamath River reaches will suffer under the Proposed Action.

5. Critical Habitat response at the diversity stratum and ESU level

NMFS considers the substantial adverse effect the Proposed Action has on juvenile rearing critical habitat and juvenile migration critical habitat at the mainstem reach level (*e.g.*, up to 30 percent reduction in spring juvenile WUA) is of a large enough magnitude and extent as to effectively impair the function and ability of migration and rearing habitat at the Interior Klamath River diversity strata. Because the habitat effects are manifest within the Klamath River mainstem environment, the lost functionality of juvenile and adult migratory habitat will affect not only fish produced and residing year-round within the mainstem, but also fish from tributary populations that utilize the mainstem migratory habitat. Thus, population effect and ultimate response resulting from the loss or adverse modification of mainstem migratory habitat caused by Proposed Action affects the conservation of several populations within the interior Klamath diversity strata. Because interior diversity strata within the range of SONCC coho salmon are crucial to the recovery of the species, the effects resulting from the adverse modification of critical habitat within the stratum is unlikely to support the conservation of the species.

IX. CONCLUSION

After reviewing the current status of SONCC coho salmon and its critical habitat, the environmental baseline for the action area, the effects of the Project and the cumulative effects, it is NMFS' biological opinion that the action, as proposed, is likely to jeopardize the continued existence of SONCC coho salmon, and is likely to destroy or adversely modify SONCC coho salmon designated critical habitat.

X. REASONABLE AND PRUDENT ALTERNATIVE

Regulations (50 CFR 402.02) implementing Section 7 of the Endangered Species Act define reasonable and prudent alternatives (RPA) as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) would, NMFS believes, avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat. NMFS believes the following RPA is necessary and appropriate to avoid the likelihood of jeopardizing the continued existence of the Southern Oregon/Northern California Coast (SONCC) coho salmon ESU and to avoid the destruction or adverse modification of critical habitat:

This RPA has two elements that must be implemented to avoid jeopardizing the continued existence of the SONCC coho salmon ESU, and to avoid destroying or adversely modifying their critical habitat. The presentation of the two elements is followed by a discussion of how the RPA is expected to avoid jeopardizing the continued existence of the Federally threatened SONCC coho salmon ESU, and to avoid destroying or adversely modifying their critical habitat. Below, the two elements of this RPA, (A) increased fall and winter flow variability and (B) increased spring discharge in select average and wetter exceedences are described in detail.

A. Increased Fall and Winter Flow Variability

1. Fall and Winter Flow Variability Program Description

In this Opinion, NMFS determined that as a result of the Project, the loss of fall and winter flow variability is expected to reduce the effectiveness of environmental cues for juvenile coho salmon in the Upper Klamath River reach to redistribute, resulting in individuals using less favorable habitat throughout the winter. In addition, in this Opinion, NMFS determined reductions in fall and winter flow variability resulting from the Project are expected to (1) have adverse effects on the health and function of the riparian zone of the mainstem Klamath River function and (2) increase disease risks to juvenile coho salmon of the Upper Klamath population unit by maintaining steady state flows through extended periods that favor the proliferation of *P. minibicornis, and C. shasta*.

In coordination with NMFS, NOAA Weather Service (NWS), USFWS, USGS, CDFG, the Karuk, Hoopa Valley and Yurok Tribes, and Pacificorp, Reclamation shall implement a flow variability program (Program). The purpose of the Program will be to enhance flow variability to mimic the natural hydrologic response that would naturally occur at the point of IGD release due to precipitation. To implement the Program, NMFS requires the development of a flow variability team (Team), comprised of technical staff from the aforementioned agencies, tribes and stakeholders.

The Team will be charged with making recommendations to Reclamation to enhance flow variability between September 1, and March 1. Team recommendations may include all components of the hydrological response, including the ascending and descending limb of the hydrograph and sustained peak flows resulting from precipitation. The Team may also recommend higher sustained base flows following extended periods of precipitation to reflect the natural ascension of the hydrologic base flow as evidenced in Figure 5. The maximum volume of water available for the Team's combined annual (September 1 through March 1) recommendations will be 18,600 acre-feet which is equal to the volume of water conserved as a result of flow modifications described below in RPA element B. Recommendations to enhance flow variability at other times of the year may be implemented, based on water availability.

The Team will meet and develop IGD flow recommendations on a regular basis (approximately bi-weekly) and provide these recommendations to Reclamation. The Team will base their recommendations on hydrological and climatological information, including data from tributaries within the PacifiCorp Hydroelectric Project reach (Keno Dam to IGD). Flow recommendations will be required to be consistent with ramp-down rates described in the *Proposed Action* section of this Opinion, unless otherwise evaluated and determined to not result in additional adverse effects to coho salmon as described in this Opinion. Reclamation, in coordination with PacifiCorp, will implement the Team's recommendations for the September 1 through March 1 time period unless: (1) operational constraints prohibit implementation; or (2) the implementation of the recommendation will result in a risk to human safety or property. In the event that (1) or (2) prohibit the implementation of the Team's recommendation, the Team will have the opportunity to modify its recommendation.

To supplement flow variability, Reclamation shall modify their proposed minimum flow schedule. NMFS has determined that Reclamation has proposed higher minimum flows in the month of October than would be expected to occur under the No Project flow regime in dry and below average flow exceedences (Appendix 2, Figure A). Given the constraints of water availability, NMFS considers a reduction in October minimum flows at IGD to 1,000 cfs in support of enhanced flow variability to be a prudent approach to flow management. In section 4 of this RPA element, NMFS describes the anticipated effects of reducing October minimum base flows at IGD to 1,000 cfs on coho salmon and their critical habitat.

2. Anticipated Effects of Increasing Fall and Winter Flow Variability on Species' Likelihood of Survival and Recovery

NMFS anticipates increased fall and winter flow variability through the implementation of this RPA will reduce Project-related incidental take of juvenile coho salmon over an extended range of the mainstem Klamath River (IGD to Seiad Valley). As outlined in the *Environmental Baseline* section, fall redistribution is an integral life history strategy of coho salmon. Fall redistribution is triggered through environmental cues, including flow variability resulting from precipitation. NMFS expects juvenile coho salmon will be afforded environmental cues under this alternative, and likely redistribute downstream to abundant overwintering habitat in the Lower Klamath River reach and downstream non-natal tributaries.

Implementation of this RPA is expected to provide environmental conditions necessary to trigger fall redistribution, thereby reducing the effects of the Proposed Action on the phenotypic diversity and spatial structure of affected coho population units (Upper Klamath, Shasta, and Scott population units). NMFS anticipates enhanced fall flow variability through this RPA will provide transitory habitat in side-channels and margins preferred by juvenile coho salmon. This habitat is expected to provide suitable cover from predators, and ideal feeding locations.

NMFS also anticipates enhanced flow variability through the fall and winter will help disrupt the fine sediment habitat of *M. speciosa* and increase the redistribution of adult salmon carcasses in the mainstem Klamath River, thereby reducing actinospore concentrations of *C. shasta and P. minibicornis* the following spring; ultimately reducing disease rates amongst juvenile salmonids in the mainstem Klamath River.

3. Anticipated Effects of Increasing Fall and Winter Flow Variability on SONCC Coho Salmon Designated Critical Habitat.

NMFS anticipates increased flow variability will reduce Project related effects to essential features of SONCC coho salmon designated critical habitat over an extended range of the mainstem Klamath River (IGD to Seiad Valley). Fall flow variability below IGD in response to climatological events will improve water quality conditions, increase the amount of complex and transitory habitat, and flush sediment from low velocity areas of the channel. Fall and winter flow variability are intended to mimic elements of the Klamath River natural flow regime. For example, flow recommendations may include ascension of the base flows through November, resulting in an expansion of side channel habitat preferred by adult coho salmon for spawning.

4. Anticipated Effects of Reducing October Minimum Base Flows from 1,300 cfs to 1,000 cfs.

Through this alternative, October base minimum flows at IGD will be reduced to 1,000 cfs. While NMFS has determined that at the onset of October, a 1,000 cfs minimum base flow is prudent, NMFS expects, through the implementation of the Fall Flow Variability Program, IGD releases will more closely reflect the mainstem Klamath River natural flow regime through response to fall precipitation. Therefore NMFS expects IGD releases during the month of October may include pulse flows and ascension of the base flows. The extent of these flow increases will reflect the natural hydrological and climatological condition.

Prior to fall precipitation, when IGD releases in October may be as low as 1,000 cfs, NMFS anticipates the following effects to coho salmon individuals and their critical habitat:

Juvenile coho salmon and their critical habitat- During the fall months, coho salmon parr migrate through mainstem habitat as they redistribute from thermally suitable, summer habitat into winter rearing habitat characterized by complex habitat structure and low water velocities (Lestelle 2006). In the Upper Klamath River reach, characterized by the R-Ranch, Trees of Heaven and Seiad Valley reach level study sites, the volume of juvenile coho salmon habitat under a 1,000 cfs IGD release is generally similar as predicted under a 1,300 cfs IGD release. That is, habitat availability is not sensitive to the 300 cfs flow reduction. Consistent with our findings in the October through February portion of the *Effects of the Action* section, NMFS expects juvenile coho salmon will experience sufficient habitat availability under a 1,000 cfs base flow during the month of October, given their current and future abundance over the period of this action.

Adult coho salmon and their critical habitat- During October, adult coho salmon use the mainstem Klamath River as a migration corridor. Adult coho salmon escapement monitoring in the past decade have confirmed successful passage during IGD releases of 1,000 cfs in the fall period (*e.g.,* FWS mainstem redd/carcass surveys, CDFG Shasta and Bogus Creek video weir studies, IGH returns). NMFS anticipates no hindrances to adult coho salmon migration through the mainstem Klamath River reach in October when flows may be as low as 1,000 cfs. Further, adult movement is often precipitated by flow variability, and NMFS expects the RPA to enhance adult coho salmon movement through the affected reach (IGD to Seiad Valley).

No adverse effects to adult coho salmon spawning are anticipated as a result of this alternative. Mainstem coho salmon spawning has not been observed prior to November 15 (Magneson and Gough 2006). NMFS anticipates flow variability through fall and winter months when coho do spawn is likely to enhance mainstem salmon spawning habitat by expanding spawning habitat under periods of higher flow.

B. Increased Spring Discharge in Select Average and Wetter Exceedences

1. Increased Spring Discharge Description.

NMFS concluded the Proposed Action would result in appreciable habitat reductions for juvenile coho salmon through portions of the Upper and Middle Klamath River reaches (Trees of Heaven, Seiad Valley, Rogers Creek reaches) during spring in average and wetter flow exceedences. Reclamation shall modify Project operations described in Table 18 to increase spring flows in average and wetter exceedences. In the *Analytical Approach* section of the Opinion, we described Reclamation's anticipation that the implementation of the operational rules should not result in flows per time period that deviate between the next higher or lower exceedence value (*i.e.,* between the flow immediately higher or lower flow as represented in Table 18), and the average flow per time period meets or exceeds the target flow. In addition, NMFS analyzed the 95 percent exceedence flows as minimum instantaneous flows, and NMFS requires, unless otherwise described in this RPA and Incidental Take Statement, that the 95 percent exceedence flows are minimum instantaneous flows.

In the Opinion, NMFS used the flow habitat relationships of Hardy *et al.* (2006) to analyze the effects of Reclamation's proposed action on critical habitat. This information was also used to evaluate the effects of other ecological factors (*e.g.,* disease, competition, and predation). NMFS determined Hardy *et al.* (2006) provides the best available scientific information for analyzing the hydrological effect of the Project on coho salmon in the mainstem Klamath River. As a result of the rigorous technical review process undertaken in the development of Hardy *et al.* (2006), and the independent peer review process conducted by the NRC (2008), NMFS considers the flow habitat relationship data to support the habitat based flow requirements of this RPA.

NMFS concluded the Proposed Action would result in appreciable habitat reductions for juvenile coho salmon through portions of the Upper and Middle Klamath River reaches (Trees of Heaven, Seiad Valley, Rogers Creek reaches) during spring in average and wetter flow exceedences. These habitat reductions will reduce the fitness of rearing coho salmon parr, pre-smolts and smolts that would otherwise experience beneficial habitat conditions and improved survival. In light of the current and future climate conditions expected in the Klamath River Basin over the action period (see section 6, *Environmental Baseline*), NMFS considers the habitat and fluvial conditions of average and wetter flow exceedences to be essential to improve the viability of affected coho salmon populations. The effect of the Project is anticipated to be greatest in May and June when the proposed action would potentially reduce the amount of available habitat of juvenile coho salmon by as much as 30 percent (see *Effects of the Action* section). In the *Integration and Synthesis* section of the Opinion, NMFS concluded the effect of the Project on coho salmon survival and essential features of designated critical habitat will reduce the viability of three independent populations of SONCC coho salmon and adversely modify essential features of coho salmon critical habitat in the Upper Klamath River Reach.

2. Reference Point for RPA Flow Development.

In the Opinion, NMFS determined that the majority of the effects of the Project on essential features of designated critical habitat of SONCC coho salmon were likely to occur in the Upper Klamath River reach of the mainstem Klamath River. Additionally, NMFS found that the Project was likely to affect the Upper Klamath, Shasta River, and Scott River population units. The Upper Klamath River reach contains three reach level sites. Of these sites, Trees of Heaven (TOH) was selected by NMFS for setting RPA guideline flows for the following reasons:

a. Greatest effects at TOH

The greatest adverse effects of the Project on essential features of juvenile coho salmon habitat and disease infection rates were identified in the TOH reach. In *the Integration and Synthesis* section, NMFS concluded the Project would reduce the likelihood of the Upper Klamath, Shasta River and Scott River population units of becoming viable. Both the Shasta River and Upper Klamath River population units are exposed to Project induced stressors within the TOH reach.

b. Beneficial effects at other sites

Increases in habitat availability at TOH resulting from the implementation of the RPA will result in increases in habitat availability in other reaches where appreciable habitat reductions under the Proposed Action were determined to occur (i.e., Seiad Valley, Rogers Creek). RPA flows developed using TOH flow habitat relationships will increase habitat availability for juvenile coho salmon in these downstream reaches where Upper Klamath, Shasta River and Scott River population units will be exposed to Project effects.

c. Consistency with other evaluations

The use of TOH as a reference point for developing flow requirements downstream of IGD is consistent with past efforts. NMFS (2002) previously concluded that the Shasta River to the Scott River reach (i.e., TOH reach) was the logical reference point to develop long term recommended flows at IGD, due to the importance of this reach to juvenile coho salmon in the mainstem Klamath River and the heightened effect of the Project in this reach.

3. Method for Developing RPA Spring Flows.

NMFS concluded that the Project will appreciably reduce the amount of available rearing habitat for coho salmon juveniles in the spring period (March through June) in select flow exceedences. To minimize the effect of the Project on habitat availability such that the Project avoids the likelihood of jeopardizing the continued existence of SONCC coho salmon, NMFS developed RPA flows that result in proportional reductions to available juvenile coho salmon habitat levels of no greater than ten percent of maximum available habitat under No Project flows. Given the level of modeling resolution and gauging error inherent among hydrological records, NMFS believes that ten percent reductions in habitat availability are not likely to result in appreciable effects to coho salmon or their designated critical habitat.

NMFS calculated IGD flows required to reduce the effect of the Project on habitat availability such that the Project does not reduce the volume of juvenile coho salmon habitat at the Trees of Heaven site by more than 10 percent of what would be available under a No Project flow. NMFS used the following steps:

a. Using interpolation between flow habitat reference points in Hardy *et al.* (2006) Appendix I, Table I-9, calculate flow habitat relationships within the range of potential flows.
b. Determine the percent maximum habitat for juvenile coho salmon required to result in Project effects that proportionally reduce habitat availability by 10 percent (*i.e.,* No Project Habitat Availability multiplied by 0.9).
c. Determine the flow at TOH that results in required habitat value based on step 1.
d. Determine the flow at IGD (RPA flow) that produces required habitat value (*i.e.,* TOH flow – Shasta River monthly average accretion, computed for the period of record).
e. Compare the resulting flow requirements to Hardy *et al.* (2006) final integrated monthly instream flow recommendations below IGD (Table L-5 in Hardy *et al.* 2006). NMFS expects that Hardy *et al.* (2006) instream recommended flows sufficiently provide hydrological conditions for the life history needs of coho salmon such that implementing the flows would avoid jeopardizing coho salmon or destroying or adversely modifying its designated critical habitat. Therefore, in instances where resulting RPA flows are *higher* than the Hardy *et al.* (2006) flow recommendations, NMFS modified the RPA flow by adopting Hardy *et al.* (2006) flows for that select monthly flow exceedence.

4. Anticipated Effects of Implementing RPA Spring Flows on Species Likelihood of Survival and Recovery.

NMFS has determined that modifying the predicted hydrological regime will not appreciably reduce the likelihood of survival and recovery of SONCC coho salmon. The RPA flows (Table 18) result in Project-related habitat reductions that do not exceed a proportional 10 percent of maximum available habitat for juvenile coho salmon during the March through June period under the No Project flow (Table 17).

NMFS anticipates that the amount of available rearing habitat that is proportionally within 10 percent of maximum available habitat under a No-Project scenario will minimize Project-related stressors on juvenile coho salmon to a level such that the impacts of the Project are largely ameliorated. Under the Proposed Action, NMFS found that juvenile coho salmon survival was likely to be impeded in average and wetter water exceedences and would not be higher than survival rates during drier exceedences, therefore limiting the benefits to coho salmon populations of average and wetter than average water year type conditions.

RPA flows are anticipated to provide hydrological conditions that will enhance survival and ultimately improve the viability of affected coho salmon populations. Due to the current and foreseeable stressors affecting coho salmon populations as described in this Opinion, NMFS believes the required hydrological conditions in the spring period are essential to ensure the likelihood of coho salmon populations becoming viable is not further reduced as a result of Reclamation's Project Operations. RPA flows are also expected to increase smolt survival in the Upper and Middle Klamath River reaches by decreasing smolt transit rates; thereby, reducing disease risks associated with *C. shasta* and *P. minibicornis*.

NMFS has considered the concepts of the natural flow regime while developing this RPA and concluded the RPA flows shift the hydrology of IGD releases towards a more natural flow regime by enhancing spring flows through the month of June in average and wetter flow exceedences (Table 16). Diversity and abundance in habitat conditions and the ability of fish/populations/ESUs to track changes in environmental conditions allows for the expression of a multitude of life history strategies. RPA flows are expected to support a greater abundance of life history strategies than under the Proposed Action, resulting in increases to the diversity of affected populations. Diversity of life history strategies is an important factor that may help protect coho salmon in the Klamath Basin, and the SONCC coho salmon ESU, from extirpation.

NMFS expects coho salmon parr, pre-smolt and smolt (*i.e.*, juvenile) individuals of the Upper Klamath, Shasta, and Scott River population units to experience fitness benefits as a result of the implantation of the RPA flows. These fitness benefits are likely to include increased growth, lower risks of disease infection from *C. shasta* and *P. minibicornis*, reduced competition with hatchery-reared salmonids, and lower risks of predation. Through enhanced fitness, juvenile coho salmon will experience higher freshwater survival rates resulting in increased abundance. Coho salmon smolts are also anticipated to experience reduced exposure to disease and other instream risks to survival (*e.g.,* predation) under the RPA flows as a result of shorter transit times through the Upper Klamath River reach.

Increased abundance of returning adults will, over time, increase the productivity of affected populations. Hence, over the action period, the implementation of the RPA flows should improve the productivity (*i.e.,* population growth) of the Upper Klamath Population unit.

5. Anticipated Effects of Implementing RPA Spring Flows on SONCC Coho Salmon Designated Critical Habitat.

For juvenile rearing habitat, the essential features of concern are water quantity, water quality, water velocity, cover/shelter, food, and space. RPA flows that increase Project flow requirements at IGD will provide essential features of critical habitat and hydrological conditions representative of average and wetter exceedences. RPA flows ensure that reductions in WUA for juvenile parr and smolt rearing is within 10 percent of maximum available habitat under a No Project flow for a given flow exceedence and time period (Table 17). NMFS anticipates, under the RPA flows, the essential features of SONCC coho critical habitat will provide their intended conservation role (*i.e.,* function in a manner that supports the lifestage that requires that habitat type). Using WUA as a surrogate for these essential features, NMFS anticipates the amount and diversity of microhabitat features such as flow, depth, velocity, substrate and cover will be sufficiently representative of average and wetter flow exceedences under the RPA flows.

RPA flows are also expected to provide sufficient water depths and velocities to allow for successful coho salmon smolt outmigration through the Upper Klamath River reach. NMFS anticipates the RPA flows will reduce transit time through areas of high disease infectivity as a result of the RPA flows. Additionally, higher velocities resulting from the RPA flows are also expected to degrade the function and formation of slow "dead zones" within the channel that can harbor disease pathogens (Hardy et al. 2006), thereby reducing the overall impact of disease infection on coho salmon.

6. Modifications to other Proposed Action Flows.

NMFS is aware that the implementation of the RPA flows is likely to create limitations to other Project water needs, including UKL levels that affect federal listed suckers and Project water users. NMFS has coordinated the development of this alternative with USFWS and Reclamation in an attempt to create more flexibility in water availability. Through these coordinated efforts, NMFS has modified additional IGD flows proposed by Reclamation and described in Table 16 during select months and select flow exceedences.

NMFS has determined that Reclamation has proposed flows higher than Hardy et al. (2006) Phase II flow recommendations for IGD releases in select months and exceedences. In the *Effects Analysis* section of this Opinion, NMFS concluded that the implementation of Hardy Phase II flow recommendations at IGD will sufficiently provide fluvial conditions necessary for the conservation of coho salmon. Further, the conservation standard utilized in Hardy Phase II is a higher conservation standard than the jeopardy standard utilized by NMFS for this section 7(a)(2) analysis. As such, NMFS believes the adoption of select flows to reflect Hardy Phase II flows is both a reasonable and prudent approach to formulating this RPA and consistent with the standards of avoiding jeopardy of SONCC coho salmon or resulting in the destruction or adverse modification of critical habitat. Therefore, as part of this alternative, NMFS has modified select flows proposed by Reclamation to reflect Hardy Phase II flows as described in 3(e) of this RPA element.

To reduce the likelihood of adult salmonid die-off events from occurring in the Lower Klamath River reach, NMFS has maintained Reclamation's proposed 1,000 cfs minimum flow release at IGD from August 16 to August 31 time period for consistency with CDFG's recommendations, as described in their 2004 Report on the 2002 die-off event (CDFG 2004).

Table 16. Adjusted spring flow requirements at IGD (cfs) for select exceedences.

Exceedence	March	April	May	June
95%				
90%				
85%				
80%				
75%				
70%				
65%	2629			
60%	2890	2590		
55%	3150	2723		
50%	3177	3030	2642	
45%	3466	3245	2815	
40%	3685	3485	2960	
35%	3767	3705	3115	
30%	3940	3930	3225	
25%		4065	3390	2727
20%			3480	2850
15%			3615	2975
10%			3710	3055
5%				3185

Table 17. Juvenile coho salmon percent maximum available habitat in the Trees of Heaven Reach for RPA Flows and No Project Flows.

	March			**April**			**May**			**June**		
Exceedence	RPA	No Project	% diff.	RPA	No Project	% diff.	RPA	No Project	% diff.	RPA	No Project	% diff.
95%												
90%												
85%												
80%												
75%												
70%												
65%	42	47	-10									
60%	45	50	-10	41	45	-10						
55%	50	55	-10	42	47	-10						
50%	51	57	-10	47	52	-10	41	45	-10			
45%	60	67	-10	55	61	-10	45	50	-10			
40%	67	74	-10	61	68	-10	49	54	-10			
35%	70	78	-10	67	74	-10	50	56	-10			
30%	77	86	-10	76	85	-10	63	70	-10			
25%				80	89	-10	67	75	-10	42	47	-10
20%							72	80	-10	47	52	-10
15%							77	86	-10	49	54	-10
10%							79	88	-10	58	65	-10
5%										68	76	-10

Table 18. NMFS modified RPA flows. Flow requirements are for IGD releases in cfs. Modified RPA flows include (1) discharge increases in spring described in section 1 of this RPA component (bolded); (2) discharge decreases described in section 5 of this RPA component (italicized); (3) discharge decreases from 1300 cfs to 1000 cfs in October, described in RPA component A. All other flows are consistent with flows estimated to occur under Reclamation's Proposed Action (Table 6).

	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Jul	Aug 1-15	Aug 16-31	Sep
95%	1000	1300	*1260*	*1130*	1300	*1275*	*1325*	*1175*	*1025*	*805*	*880*	1000	1000
90%	1000	1300	1300	*1245*	1300	*1410*	1500	*1220*	*1080*	*840*	*895*	1000	1000
85%	1000	1300	1300	1300	1300	1450	1500	*1415*	*1160*	*905*	*910*	1001	1000
80%	1000	1300	1300	1300	1300	1683	1500	1603	*1320*	*945*	*935*	1005	1006
75%	1000	1300	1300	1300	1300	*2050*	1500	1668	1455	1016	*975*	1008	1013
70%	1000	1300	1300	1300	1300	*2350*	1500	1803	1498	1029	*1005*	1014	1024
65%	1000	1300	1300	1300	1323	**2629**	1589	1876	1520	1035	1017	1017	1030
60%	1000	1300	1300	1309	1880	**2890**	**2590**	2029	1569	1050	1024	1024	1041
55%	1000	1300	1345	1656	2473	**3150**	**2723**	2115	1594	1056	1028	1028	1048
50%	1000	1300	1410	1751	2577	**3177**	**3030**	**2642**	1639	1070	1035	1035	1060
45%	1000	1300	1733	2018	2728	**3466**	**3245**	**2815**	1669	1077	1038	1038	1066
40%	1000	1300	1837	2242	3105	**3685**	**3485**	**2960**	1682	1082	1041	1041	1071
35%	1000	1300	2079	2549	3505	**3767**	**3705**	**3115**	1699	1100	1050	1050	1085
30%	1000	1434	2471	2578	3632	**3940**	**3930**	**3225**	1743	1118	1053	1053	1089
25%	1000	1590	2908	2627	3822	*3990*	**4065**	**3390**	**2727**	1137	1058	1058	1097
20%	1000	1831	2997	2908	3960	*4160*	*4230*	**3480**	**2850**	1152	1066	1066	1135
15%	1000	2040	3078	3498	*4210*	*4285*	*4425*	**3615**	**2975**	1223	1093	1093	1162
10%	1000	*2415*	*3280*	*3835*	*4285*	*4355*	*4585*	**3710**	**3055**	1370	1126	1126	1246
5%	1000	*2460*	*3385*	*3990*	*4475*	*4460*	*4790*	3845	**3185**	1430	1147	1147	1281

C. ESA Requirements for RPAs

RPAs are alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) would, NMFS believes, avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.

The elements of the RPA can be implemented in a manner consistent with the intended purpose of the action. Reclamation proposes to operate the authorized features and facilities of the Project, to March 31, 2018, to store, divert, and manage flows of the Klamath and Lost Rivers, and NMFS has developed this RPA consistent with Reclamation's intended purpose. Reclamation has proposed an Interactive Management (IM) process to manage the distribution of stored water and the flows of the Klamath and Lost Rivers. NMFS expects this RPA to require modified operational defaults of the IM process to ensure RPA flows are met, primarily increasing the proportion of surplus water released downstream. Other elements of the IM process will remain. For example, Reclamation has proposed under the IM process, bi-weekly coordination with agencies, tribes and stakeholders to evaluate hydrological conditions and forecasting. This level of coordination will be necessary under the RPA.

The elements of the RPA can be implemented consistent with the scope of Reclamation's legal authority and jurisdiction. As described in the *Proposed Action* section, Reclamation's legal responsibilities and obligations within the Klamath River Basin include: Tribal trust resources, ESA, senior water rights, project water users' contractual rights, National Wildlife Refuges, and other requirements mandated by law and within the authority of the Secretary of the Interior. NMFS has determined the implementation of the RPA flows and the implementation of an enhanced fall flow variability program are necessary for Reclamation to avoid jeopardizing SONCC coho salmon and to avoid resulting in the destruction or adverse modification of their designated critical habitat. Given the information available, NMFS concludes the RPA is consistent with the scope of Reclamation's legal requirements under ESA. NMFS is also aware that RPA flows increase flow requirements at IGD and may affect Reclamation's ability to meet other responsibilities and obligations, including: ESA prescribed lake level requirements in UKL to meet the needs of Federal listed suckers and Project water delivery needs. NMFS anticipates, following the release of this Opinion, that the USFWS and Reclamation will evaluate the anticipated effects of this RPA on listed suckers to determine if the RPA results in the need for Reclamation to re-consult with USFWS on effects of this RPA on listed suckers.

In regards to effects of the RPA on Project water deliveries, NMFS is not aware of any information to indicate Project water delivery supersedes Reclamation's requirements under the ESA. NMFS anticipates that the RPA will result in shortages to Project water deliveries during the eight-year action, and water balance modeling predicts shortages the amount and extent of delivery shortages to the Klamath Project are likely to be similar as under current Operations, described in Reclamation's biological assessment (Reclamation 2008b).

The elements of the RPA are expected to be economically and technically feasible. Reclamation has the expertise to implement this RPA within the scope of their proposed IM process. Water releases are often undertaken at dams for the protection and conservation of fish species, and NMFS does not anticipate the RPA will require any additional infrastructure or improvements other than meeting the RPA flows and implementing the fall and winter flow variability program in coordination with PacifiCorp. NMFS has developed spring augmentation RPA flows that are less than No Project flows. As described in the Opinion, No Project flows represent the flows that would be available if the Klamath Project ceased to operate. Therefore NMFS is ensured spring augmentation RPA flows can be met. NMFS has also reduced Reclamation's proposed flows in select months and exceedences thereby, in part, reducing downstream water releases in select months and exceedences.

In this RPA, NMFS has described how the implementation of this RPA will avoid the likelihood of jeopardizing the continued existence of listed SONCC coho salmon and avoid the destruction or adverse modification of its designated critical habitat. To summarize, the elements of this RPA are expected to promote an increase in the natural hydrologic function of the mainstem Klamath River and result in essential features of critical habitat for juvenile coho salmon that will improve the fitness of juvenile coho salmon individuals. The RPA ensures juvenile coho salmon will benefit from higher spring flows and increased fall flow variability that will result in improvements to the overall viability of three Klamath River Basin coho salmon population units. The RPA also creates water efficiencies by reducing flows during periods when NMFS has determined the Proposed Action would result in negligible benefits.

Because the Biological Opinion has determined the proposed action is likely to jeopardize the continued existence of the threatened SONCC coho salmon ESU, and is likely to destroy or adversely modify critical habitat for this species, Reclamation is required to notify NMFS of its final decision on the implementation of the RPA.

XI. INCIDENTAL TAKE STATEMENT

Section 9(a)(1) of the ESA prohibits the take of endangered species without a specific permit or exemption. Protective regulations adopted pursuant to section 4(d) extend this prohibition to threatened species. Take is defined as to harass, harm, pursue, hunt, wound, kill, capture or collect, or to attempt to engage in any such conduct [ESA section 3(19)]. Harm is further defined by NMFS as an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering (50 CFR 222.102). Incidental take refers to takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(o)(2) exempts any taking from the take prohibition that meets the terms and conditions of a written incidental take statement (ITS).

The measures described below are non-discretionary, and must be implemented by Reclamation so that they become binding conditions of any grant or permit issued to the permittee, as appropriate, in order for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity covered by this ITS. If Reclamation fails to assume and implement the terms and conditions, the exemption provided in section 7(o)(2) may not apply. In order to monitor the impact of incidental take, Reclamation must report the progress of the action and its impact on the species to NMFS as specified in the ITS [50 CFR 402.14(i)(3)]. NMFS developed this ITS based on the premise that the reasonable and prudent alternative (RPA) presented within the Opinion will be implemented.

A. Amount or Extent of Take

NMFS anticipates the implementation of this RPA will result in take in the form of harm to coho salmon individuals. Quantifying Project take below Iron Gate Dam is difficult, since the Project's primary mechanism for affecting coho salmon is through hydrologic changes to Klamath River discharge emanating from IGD. Translating the hydrologic effect into definitive numbers of fish taken cannot be done at this time, since finding dead or impaired specimens is unlikely because of the dynamic nature of riverine systems. To address this issue, NMFS will instead use habitat-based surrogates to address the five stressors that NMFS identified in the Opinion as likely resulting in take: loss of available instream habitat, increased predation risk, competition for food and habitat, elevated disease infection rates, and slower smolt migration rates.

The physical and biological mechanisms influencing predation rates, competitive interactions, and disease dynamics within the Klamath River are myriad and complex. For instance, predation rates within the Klamath River are likely influenced by water quantity, water quality (*e.g.,* turbidity), and available instream habitat, as well as the critical relationship between predator and prey abundance and their spatial overlap between the two. Thus, estimating the amount or extent of these three stressors (*i.e.,* disease, competition, and predation) expected to remain following implementation of the RPA is difficult. However, the higher flow and habitat quantity required through the RPA are expected to directly address and lower predation rates, competition and disease incidence within the Klamath River juvenile coho salmon population. Therefore, NMFS has quantified the amount or extent of take of coho salmon through the use of flow habitat indicators that have a direct effect on these primary sources of incidental take (disease, competition, and predation).

1. Habitat Downstream of Iron Gate Dam

In the *Effects of the Action* section, NMFS determined that habitat loss during the March through June period caused by the proposed action would likely lower the survival of juvenile coho salmon in the Upper and Middle Klamath River reaches. To address these effects, NMFS' RPA improves habitat availability (via higher IGD flow releases) during select average and wetter hydrologic periods during the spring, utilizing the Trees of Heaven reach as a proxy to address instream conditions throughout the river. Although the RPA increases habitat quantity at the Trees of Heaven reach, Project operations will continue to lower habitat quantities when compared to the No Project scenario. NMFS estimates the proportional loss of habitat (*i.e.,* relative to No Project habitat volumes) at the Trees of Heaven reach that remains under the RPA in Table 19 below. The percent difference in habitat availability between the RPA and No Project actions serve as the take surrogate.

2. Smolt Outmigration Rates

When compared to a No Project scenario, RPA flows during the March through June period are expected to slow coho salmon smolt outmigration rates during many exceedence periods (Table 20). Despite recent research on the topic (e.g., Stutzer et al. 2006), the complex relationship between coho salmon smolt migration rates and the various environmental conditions that ultimately influence outmigration survival remains unclear within the Klamath River basin. Thus, given the general assumption established with the Effects of the Action section that smolt transit times are generally correlated with river discharge, NMFS will be utilizing water transit rates between IGD and the Scott River as a surrogate for estimating the slower smolt migration rate expected under the RPA. Table 20 presents the estimated amount of time (in hours) for water to travel from IGD to the Scott River during the months of March through June for the RPA and No Project flow regimes, as well as the time difference between the two. The difference between the two travel times represents the RPA's remaining effect with regard to slowing flow transit rates and serves as the take surrogate. The effect of the RPA flow regime on river flow rate is greatest during drier exceedences in March and April, when flow rates can be as much as 6.5 hours slower than No Project as a result of the RPA. NMFS chose to evaluate travel rates downstream to the Scott River because the majority of competition, predation and disease stressors occur upstream of the Scott River confluence. Also, discharge (and by extension smolt travel rates) are expected to improve below the Scott River confluence due to increased tributary accretion. Modeling by Deas and Orlob (1999) does not consider the effect of tributary accretions on flow rates below IGD, thus the flow/travel rate analysis is likely more accurate if restricted to the reach upstream of the Scott River.

Table 19. Juvenile coho habitat values (in percent of maximum Weighted Usable Area) and anticipated proportional loss of habitat due to implementation of the RPA. Habitat values were derived at the Trees of Heaven Reach of the Klamath River utilizing flow/habitat data.

		March			April			May			June	
exceedence	RPA	No Project	% diff.	RPA	No Project	% diff.	RPA	No Project	% diff.	RPA	No Project	% diff.
95%	42	40	6	42	40	4	42	41	2	37	42	-11
90%	42	40	5	42	40	5	42	40	4	39	42	-7
85%	41	42	-2	42	40	5	42	40	4	42	42	-1
80%	40	44	-8	42	40	4	41	40	4	42	42	0
75%	40	44	-10	42	41	2	41	40	4	42	42	1
70%	40	46	-14	42	42	0	40	40	1	42	41	1
65%	42	47	-10	41	43	-4	40	40	0	42	41	3
60%	45	50	-10	41	45	-10	40	40	-2	42	40	4
55%	50	55	-10	42	47	-10	40	43	-8	41	40	4
50%	51	57	-10	47	52	-10	41	45	-10	41	40	3
45%	60	67	-10	55	61	-10	45	50	-10	41	40	3
40%	67	74	-10	61	68	-10	49	54	-10	41	40	2
35%	70	78	-10	67	74	-10	50	56	-10	41	40	2
30%	77	86	-10	76	85	-10	63	70	-10	41	43	-6
25%	78	89	-13	80	89	-10	67	75	-10	42	47	-10
20%	84	92	-9	83	91	-9	72	80	-10	47	52	-10
15%	86	95	-10	86	93	-8	77	86	-10	49	54	-10
10%	89	99	-11	67	97	-31	79	88	-10	58	65	-10
5%	92	100	-8	72	99	-27	49	93	-47	68	76	-10

Table 20. Estimated travel time in hours (Deas and Orlob 1999) between Iron Gate Dam and the Scott River for flow rates expected under the Reasonable and Prudent Alternative and No Project flow regimes. An asterix (*) denotes an exceedence where one or both flow values fell outside the range evaluated in Deas and Orlob (1999).

	March					**April**					**May**					**June**				
Exceedence	**RPA2 Flows**	**Travel Time**	**No Project Flows**	**Travel Time**	**Travel time difference**	**RPA2 Flows**	**Travel Time**	**No Project Flows**	**Travel Time**	**Travel time difference**	**RPA2 Flows**	**Travel Time**	**No Project Flows**	**Travel Time**	**Travel time difference**	**RPA2 Flows**	**Travel Time**	**No Project Flows**	**Travel Time**	**Travel time difference**
95%	1275	34.2	2043	28.5	**5.7**	1325	34.1	1831	29.8	**4.3**	1175	35.4	1635	31.0	**4.4**	1025	37.1	1181	35.3	**1.8**
90%	1410	32.8	2383	27.1	**5.7**	1500	32.0	2151	27.9	**4.1**	1220	34.8	1801	29.9	**4.9**	1080	36.2	1262	34.4	**1.8**
85%	1450	32.5	2625	26.0	**6.5**	1500	32.0	2320	27.2	**4.8**	1415	32.8	1834	29.7	**3.1**	1160	35.5	1375	33.1	**2.4**
80%	1683	30.5	2830	25.2	**5.3**	1500	32.0	2570	26.2	**5.8**	1603	31.3	1998	28.8	**2.5**	1320	34.2	1487	32.1	**2.1**
75%	2050	28.5	2858	25.1	**3.4**	1500	32.0	2618	26.0	**6.0**	1668	30.6	2084	28.4	**2.2**	1455	32.4	1582	31.4	**1.0**
70%	2350	27.1	3055	24.5	**2.6**	1500	32.0	2717	25.5	**6.5**	1803	29.9	2279	25.4	**4.5**	1498	32.0	1629	31.1	**0.9**
65%	2629	26.0	3096	24.4	**1.6**	1589	31.5	2770	25.4	**6.1**	1876	29.5	2397	26.9	**2.6**	1520	31.8	1781	30.0	**1.8**
60%	2890	25.0	3153	24.3	**0.7**	2590	26.1	3051	24.5	**1.6**	2029	28.6	2546	26.3	**2.3**	1569	31.5	1862	29.8	**1.7**
55%	3150	24.3	3307	23.8	**0.5**	2723	25.5	3172	24.2	**1.3**	2115	28.1	2836	25.2	**2.9**	1594	31.3	1928	29.2	**2.1**
50%	3177	24.2	3381	23.7	**0.5**	3030	24.6	3306	23.8	**0.8**	2642	25.9	3041	24.6	**1.3**	1639	30.9	2181	28.0	**2.9**
45%	3466	23.3	3629	23.1	**0.2**	3245	23.9	3565	23.2	**0.7**	2815	25.3	3255	23.9	**1.4**	1669	30.6	2358	27.0	**3.6**
40%	3685	23.0	3815	22.7	**0.3**	3485	23.2	3667	23.1	**0.1**	2960	24.8	3359	23.8	**1.0**	1682	30.5	2466	26.8	**3.7**
35%	3767	22.5	4055	*	*	3705	22.9	4098	*	*	3115	24.4	3447	23.3	**1.1**	1699	30.4	2518	26.4	**4.0**
30%	3940	22.3	4417	*	*	3930	22.3	4307	*	*	3225	24.0	3876	22.4	**1.6**	1743	30.1	2890	25.0	**5.1**
25%	3990	22.1	4475	*	*	4065	*	4621	*	*	3390	23.7	4128	*	*	2727	25.5	3172	24.2	**1.3**
20%	4920	*	4651	*	*	4521	*	4804	*	*	3480	23.2	4254	*	*	2850	25.1	3344	23.8	**1.3**
15%	5327	*	5017	*	*	5239	*	5143	*	*	3615	23.1	4417	*	*	2975	24.7	3391	23.7	**1.0**
10%	5952	*	5519	*	*	5544	*	5439	*	*	3710	22.8	4681	*	*	3055	24.5	3758	22.5	**2.0**
5%	6627	*	6010	*	*	5939	*	5751	*	*	3845	22.5	5055	*	*	3185	24.1	3947	22.3	**1.8**

B. Effect of the Take

In the RPA, NMFS determined that this level of anticipated take is not likely to jeopardize the continued existence of SONCC coho salmon.

C. Reasonable and Prudent Measures

Pursuant to section 7(b)(4) of the ESA, NMFS believes that the following reasonable and prudent measures and terms and conditions are necessary and appropriate to minimize or to monitor the incidental take of SONCC coho salmon resulting from the Reasonable and Prudent Alternative. In order to be exempt from the prohibitions of section 9 of the ESA, Reclamation must comply with all of the reasonable and prudent measures and terms and conditions set forth below.

1) Reclamation shall make efforts to reduce uncertainties associated with the implementation of Klamath Project Operations.

2) Reclamation shall make efforts to optimize the use of available water to improve conditions for critical life history stages of SONCC coho salmon.

3) Reclamation shall ensure that a monitoring and reporting program is implemented to confirm that the operations of the Klamath Project are adhering to the requirements of this biological opinion.

D. Terms and Conditions

The following terms and conditions implement reasonable and prudent measure #1.

1A) To reduce uncertainties associated with estimating water availability within the Upper Klamath River Basin, Reclamation shall, within three months of the finalization of this Biological Opinion, convene and fund technical forums within the fields of hydrology, climatology, and hydro-geology. Through these technical forums, Reclamation will facilitate evaluation of alternative methodologies used to forecast water supply. Forum members will be tasked with reviewing existing water supply forecasting tools, the hydrologic period of record, and consumptive water use and develop a “needs list” and recommendations to improve confidence (*e.g.*, better predict) in water supply forecasting and water year exceedence determinations. Forums will include key federal and state agencies, tribes, and stakeholders affected by water supply in the Klamath River Basin[8]. Reclamation shall continue to fund and convene the technical forums as needed to ensure the goals and objectives are met.

Reclamation shall incorporate all practical recommendations into subsequent procedures used to estimate water supply for Project Operations at the earliest time practicable. Reclamation shall

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[8] Participants may include representatives from the following federal and state agencies and tribes: U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, Natural Resources Conservation Service, National Marine Fisheries Service, NOAA Weather Service, State of Oregon, State of California, Hoopa Valley Tribe, Karuk Tribe, Klamath Tribes of Oregon, and Yurok Tribe.

also compile a report to capture fundamental components resulting from the efforts of the technical forum.

1B) Reclamation shall, in coordination with the NMFS and USFWS, codify written operational procedures for coordinating and implementing the Klamath Project Operations as it applies to Upper Klamath Lake levels and Klamath River flows. Through this term and condition, Reclamation shall, in coordination with NMFS and USFWS, develop and implement a protocol for coordinating their Operations (including those elements of the IM process that still apply to the RPA) with the Services and other key agencies, tribes and stakeholders. Reclamation shall complete the document by July 15, 2010.

1C) To reduce potential Klamath Project water consumption errors, Reclamation shall, within one year of finalization of this Biological Opinion, conduct a program review of the current Klamath Irrigation Project water use accounting, and develop and implement a plan for improving the accuracy of measuring Project water consumption.

1D) Reclamation shall publish all major diversion and return flows at least monthly, in a publicly accessible data portal.

1E) To reduce uncertainties associated with the effects of mainstem Klamath River flows on coho salmon and their critical habitat, Reclamation shall fund and convene a scientific advisory group composed of federal, state and tribal biologists. The purpose of the group shall be to prioritize future coho salmon research in the mainstem Klamath River. NMFS and Reclamation shall determine panel members to ensure that the membership and the results of the effort are scientifically sound and objective. Within eighteen months of the finalization of this Opinion, Reclamation shall fund research and monitoring activities that have been prioritized by the science panel at a minimum cost of $500,000. Reclamation shall continue to fund prioritized research and monitoring activities at a minimum cost of $500,000, annually over the eight-year action.

2A) Reclamation shall convene a technical workgroup of representatives of Reclamation, NMFS, USFWS, CDFG, the Yurok Tribe, the Klamath Tribes of Oregon, the Hoopa Valley Tribe, and the Karuk Tribe to evaluate the benefits and risks of reducing flows from November through February for the purpose of accelerating the refill of UKL, and ultimately enhancing IGD flows the following spring. NMFS will review work products resulting from this technical workgroup and determine if implementing flow reductions from November through February result in greater effects to coho salmon and their designated critical habitat than are otherwise described in this Opinion.

3A) Reclamation shall prepare and provide to NMFS by February 1 of each year an annual report on the operations of the Klamath Project. The report will cover the prior October through September time period. The annual report will include, at a minimum, the following:

> a) An annual description of Klamath Project Operations, including average daily and monthly flows at IGD and Keno Reservoir, monthly minimum and maximum daily flows,

and a review of Klamath Basin water balancing, including inflow and outflow data for all key components of the system (*e.g.,* UKL, Link River, Project, Keno, IGD)

b) An annual status of Reclamation's implementation of terms and conditions.

XII. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Conservation recommendations are discretionary measures suggested to minimize or avoid adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, to help implement recovery plans, or to develop additional information.

1. As stated in this Opinion, NMFS relied on probabilities expressed in an exceedence table for its analysis, and any deviation from these expected probabilities could create greater than expected adverse effects. Basing the probability of eight years of future conditions on 46 years of historic data means that there is a possibility that the flow conditions over the next eight years could vary from those represented in the RPA. Additionally, the predicted effect of climate change suggests low SWE in the Klamath River Basin in the future that may not be adequately represented in the modeling results. Further, wetter and drier hydrologic conditions may not be evenly or randomly distributed over time. Wetter and drier conditions may occur in groups such that a dry year may be more likely followed by another dry year rather than by a wet year. Therefore, Reclamation should investigate the development of a "Safety Matrix" approach to minimize take of SONCC coho salmon due to unexpected poor conditions, and provide a way to meaningfully address climate change. The objective of the safety matrix may include protective measures to minimize impacts on consecutive cohorts (years 1-4-7-; 2-5-8; 3-6).

2. In an effort to reduce disease rates of coho salmon, NMFS recommends Reclamation implement winter and spring pulse flow events at IGD.

In order for NMFS to be kept informed of actions that minimize or avoid adverse effects or benefit listed species or their habitats, we request notification of the implementation of the conservation recommendations.

XIII. REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR 402.16, reinitiation of formal consultation is required when discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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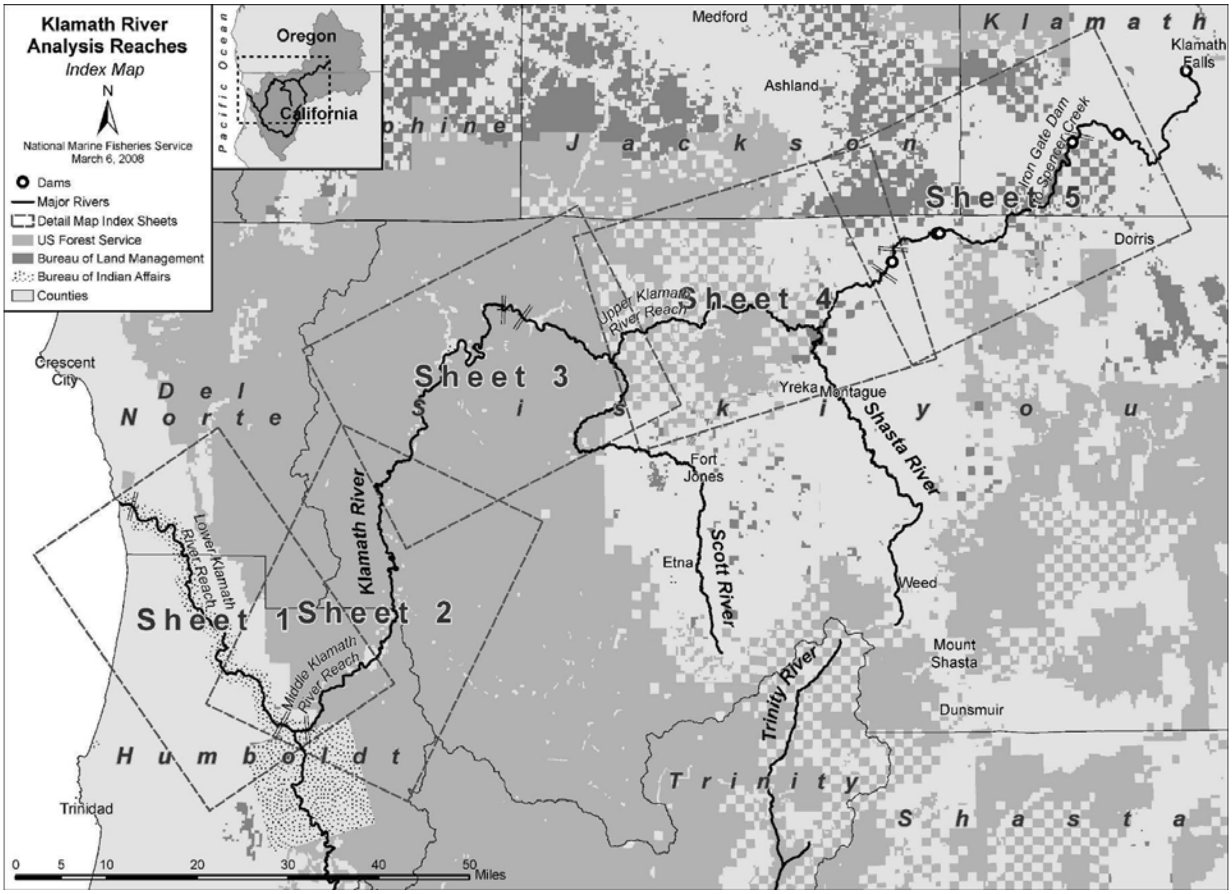
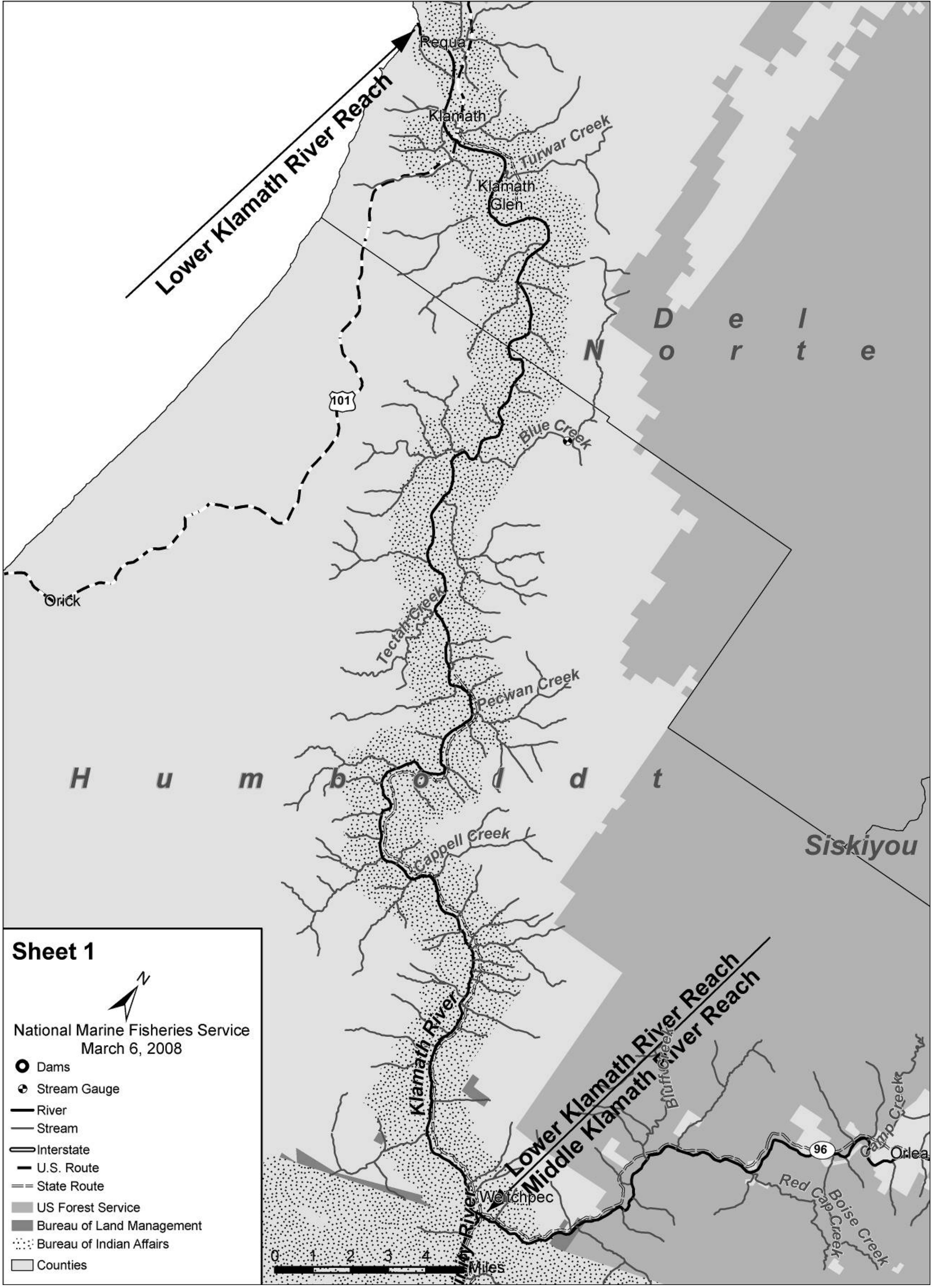
XV. APPENDICIES

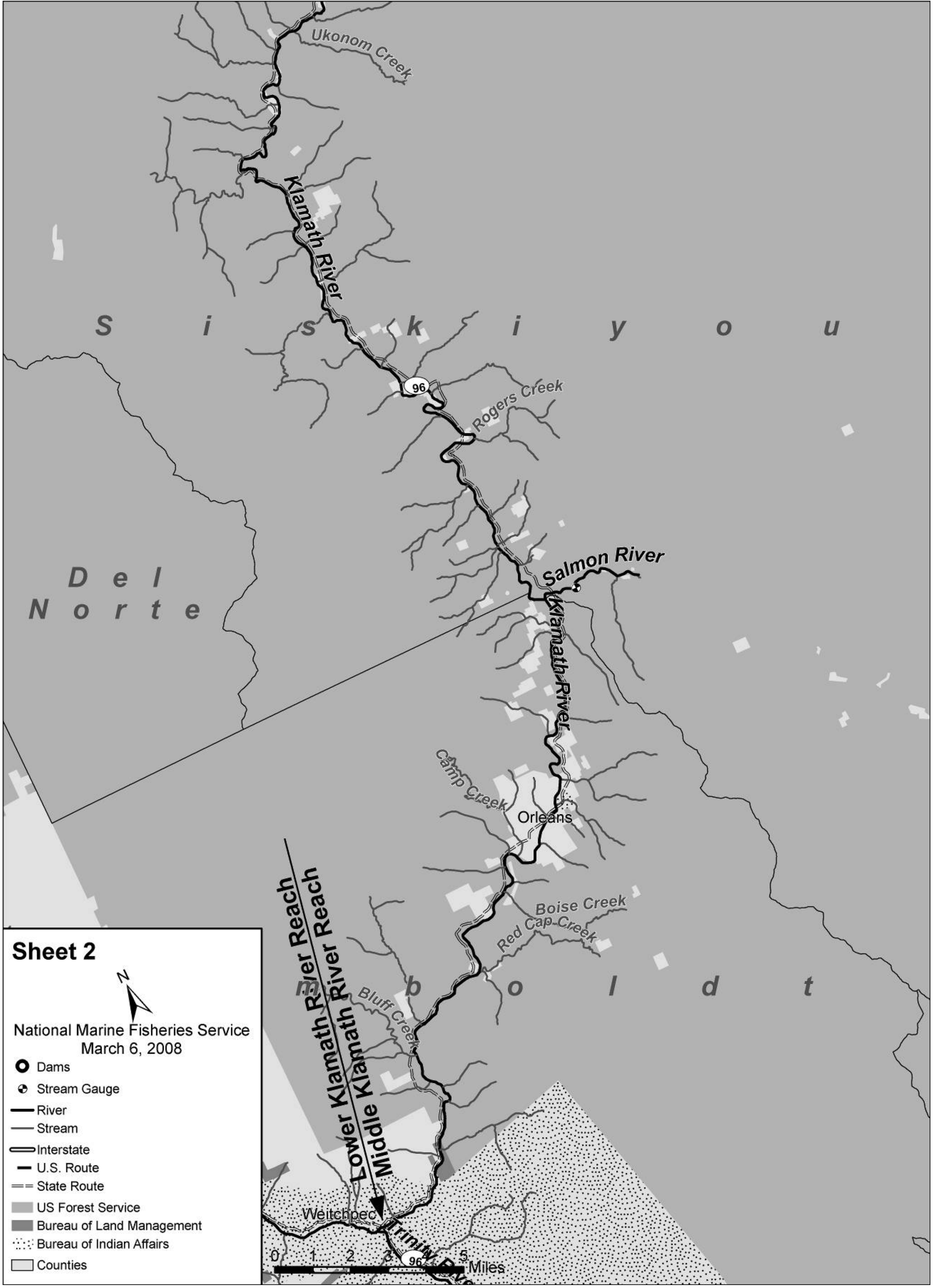
Appendix 1, Figure A. Overview of Klamath River Reaches



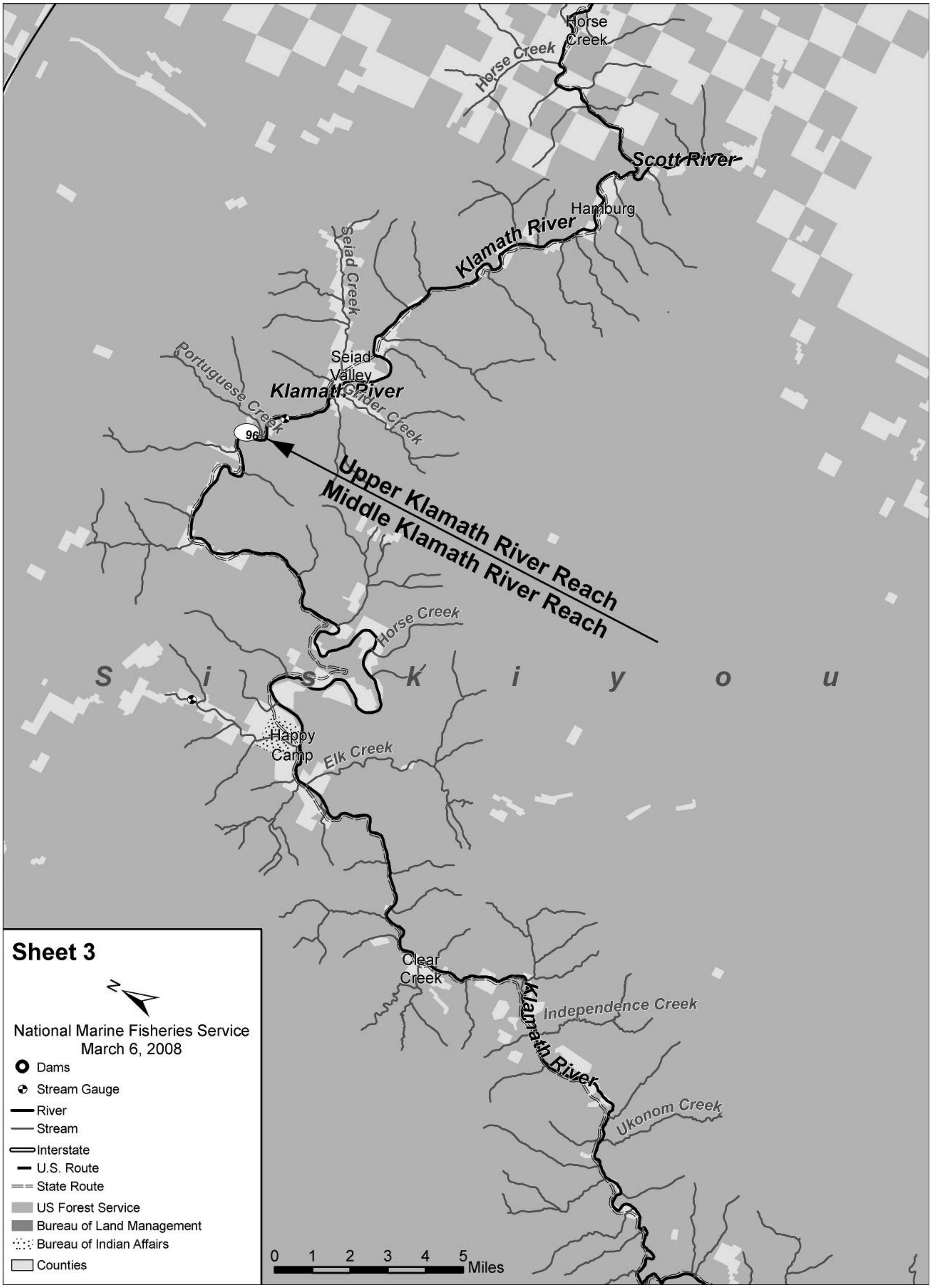
Appendix 1, Figure B. Lower Klamath River Reach.



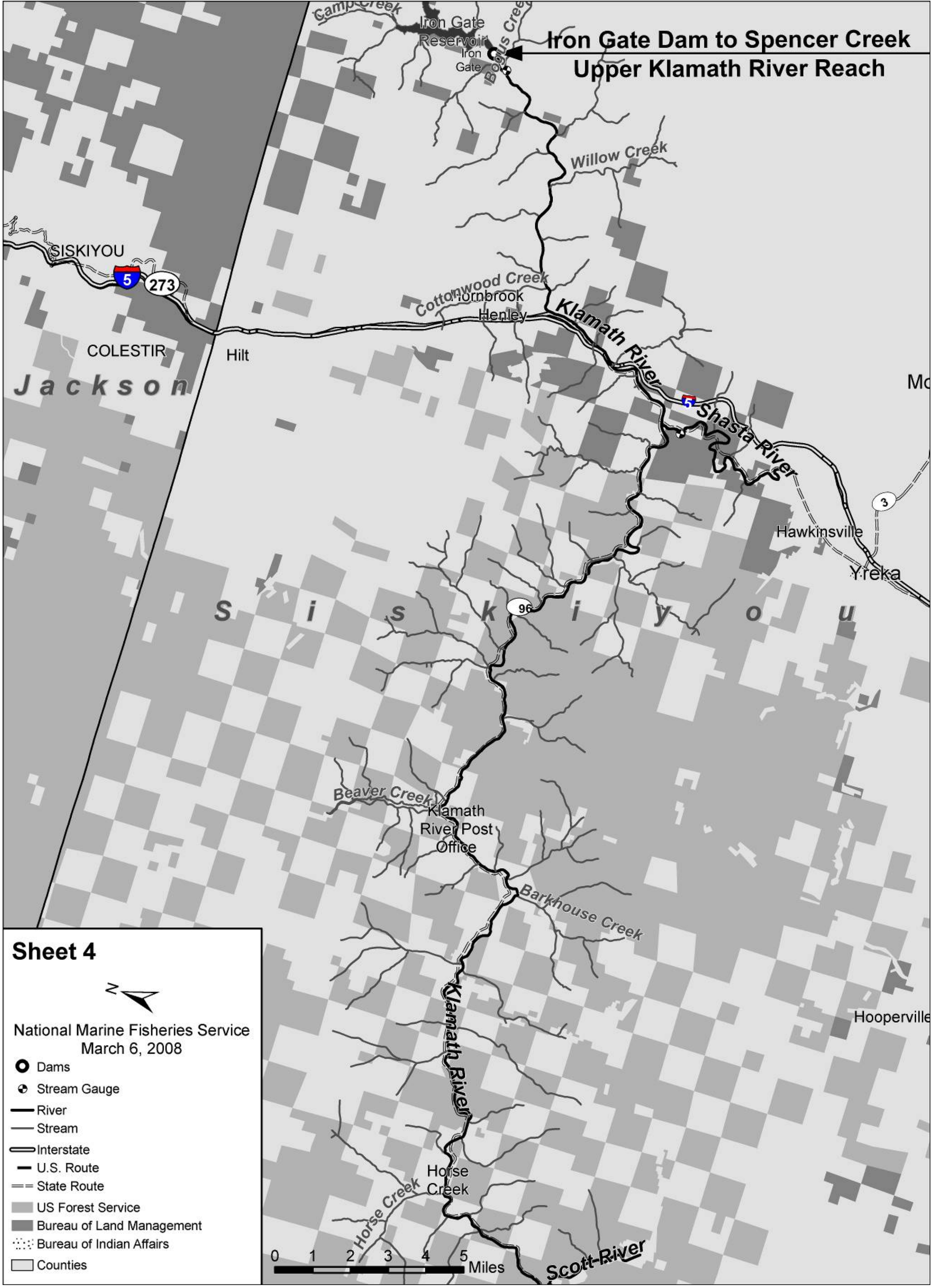
Appendix 1, Figure C. Middle Klamath River Reach Part One.



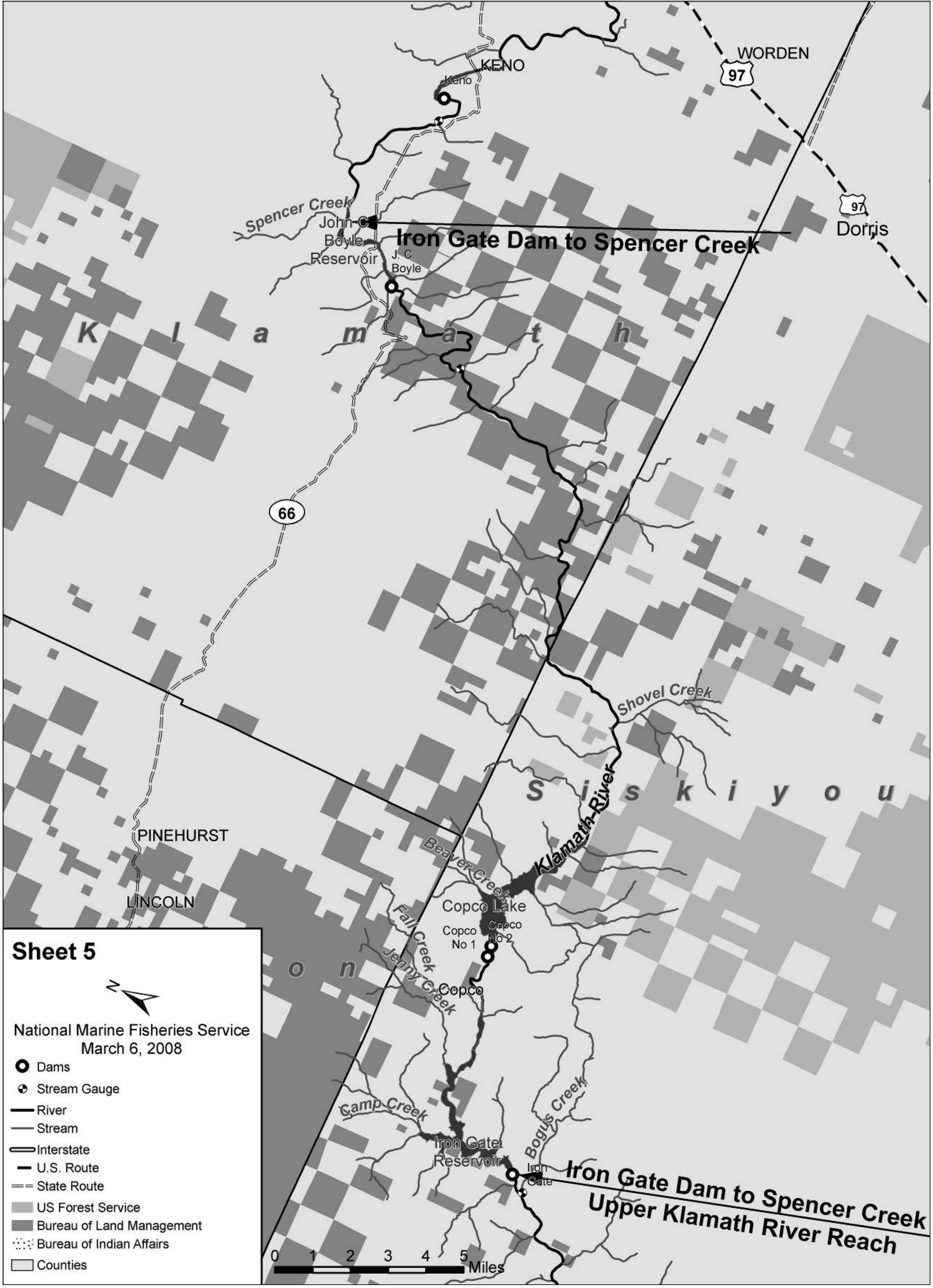
Appendix 1, Figure D. Middle Klamath River Reach Pt. Two, Upper Klamath River Reach Part One.



Appendix 1, Figure E. Upper Klamath River Reach Part Two.



Appendix 1. Figure F. Upper Klamath River Reach Part Three.



Appendix 2. Monthly average modeled flows at IGD (cfs) for two flow management scenarios: No Project and Proposed Action (IM); displayed in 5 percent exceedences intervals (Reclamation WRIMS Modeling data 2008).

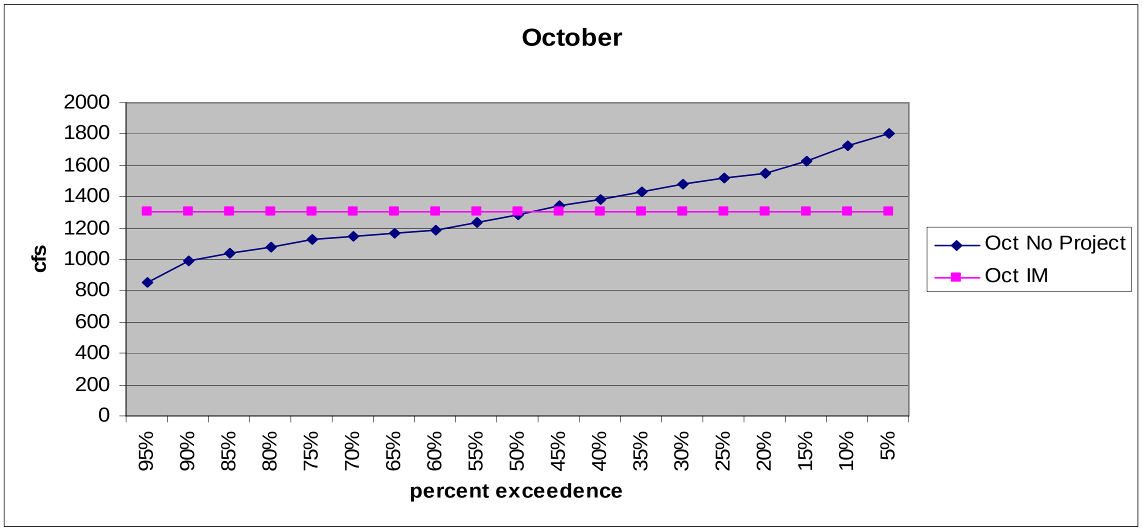


Figure A. Average October flows at IGD.

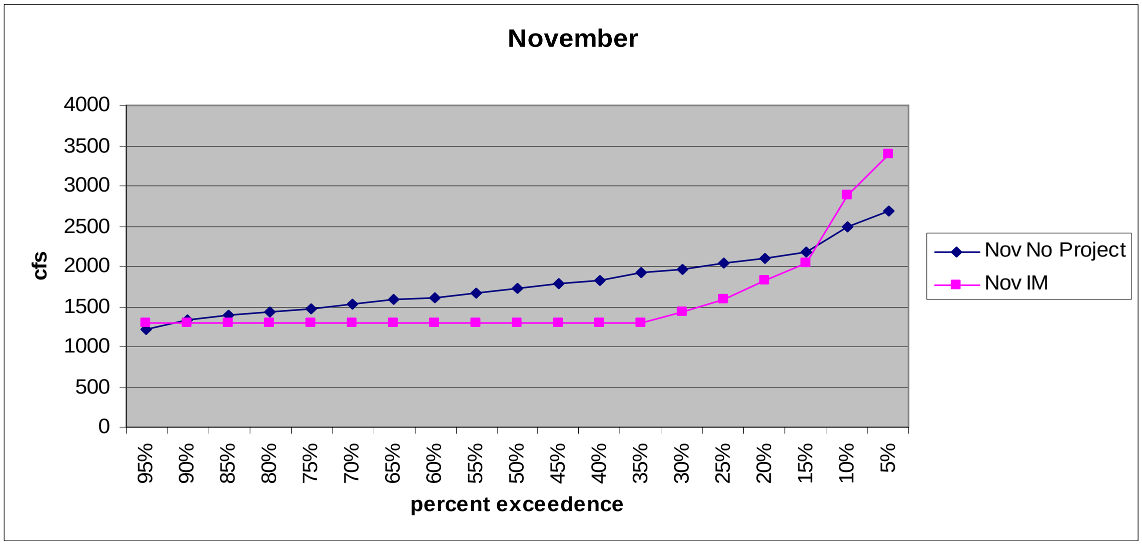


Figure B. Average November flows at IGD.

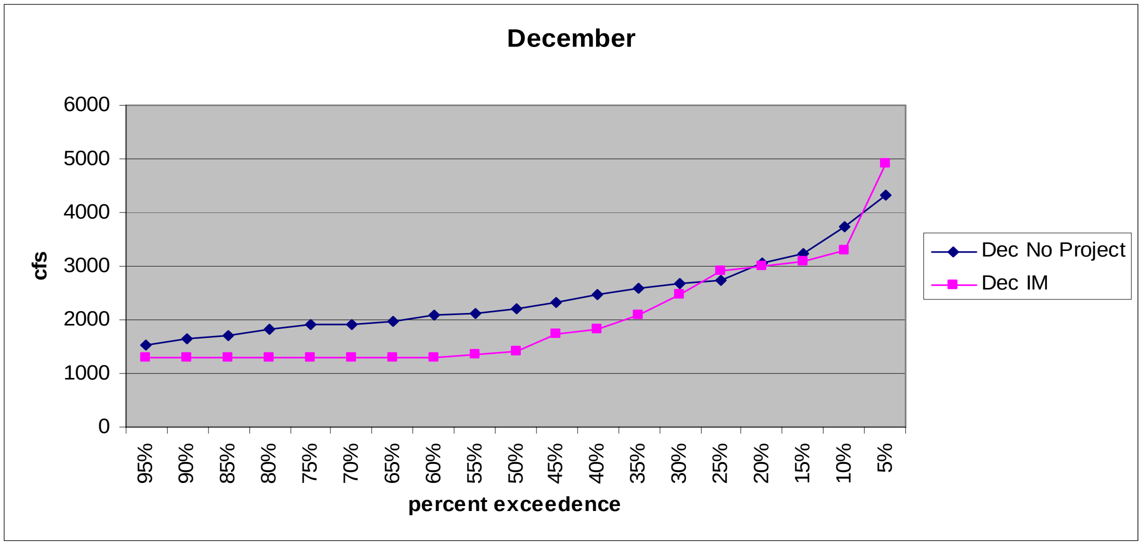


Figure C. Average December flows at IGD.

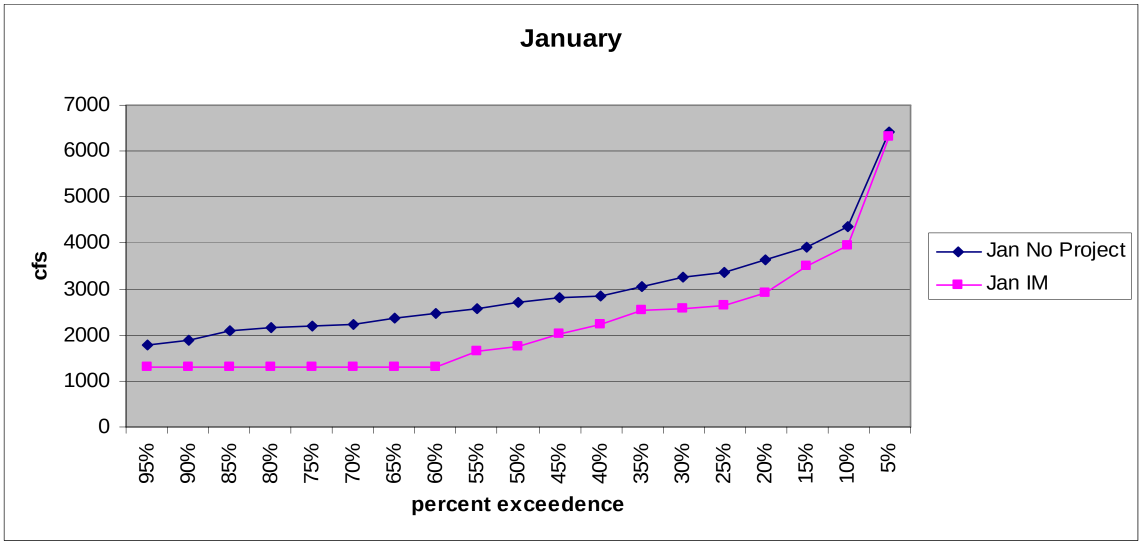


Figure D. Average January flows at IGD.

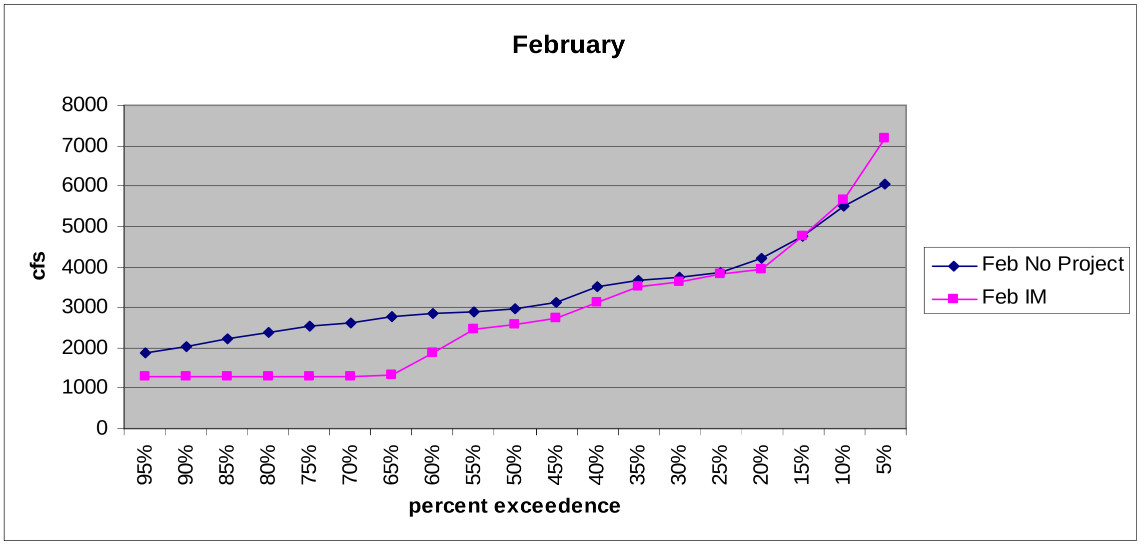


Figure E. Average February flows at IGD.

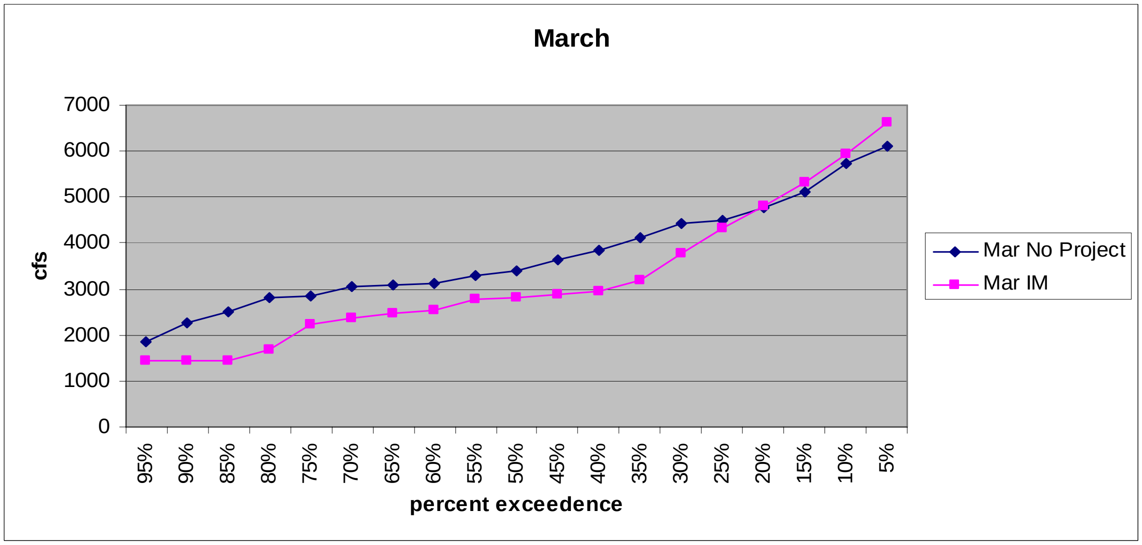


Figure F. Average March flows at IGD.

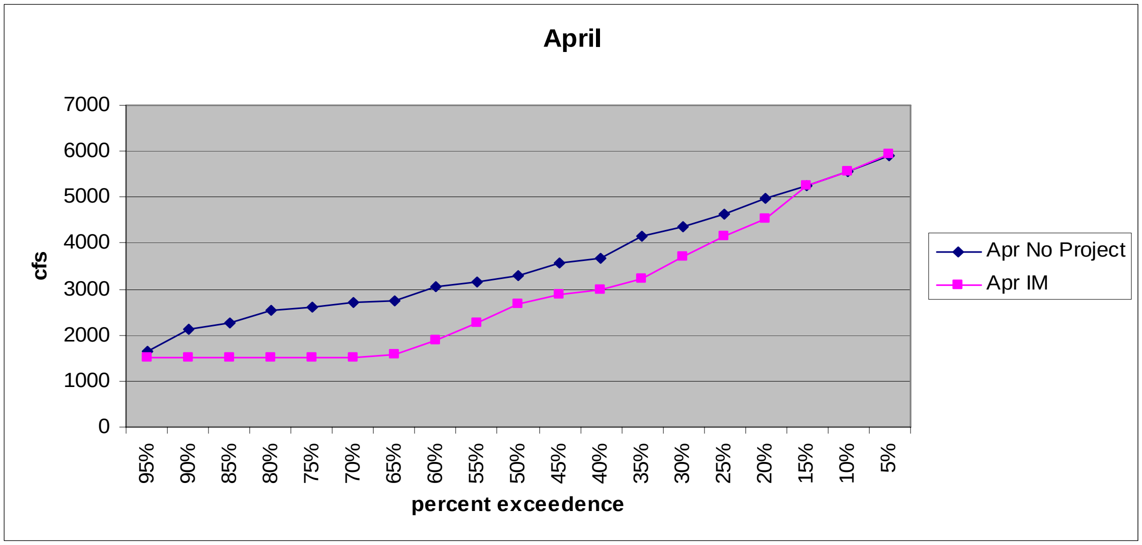


Figure G. Average April flows at IGD.

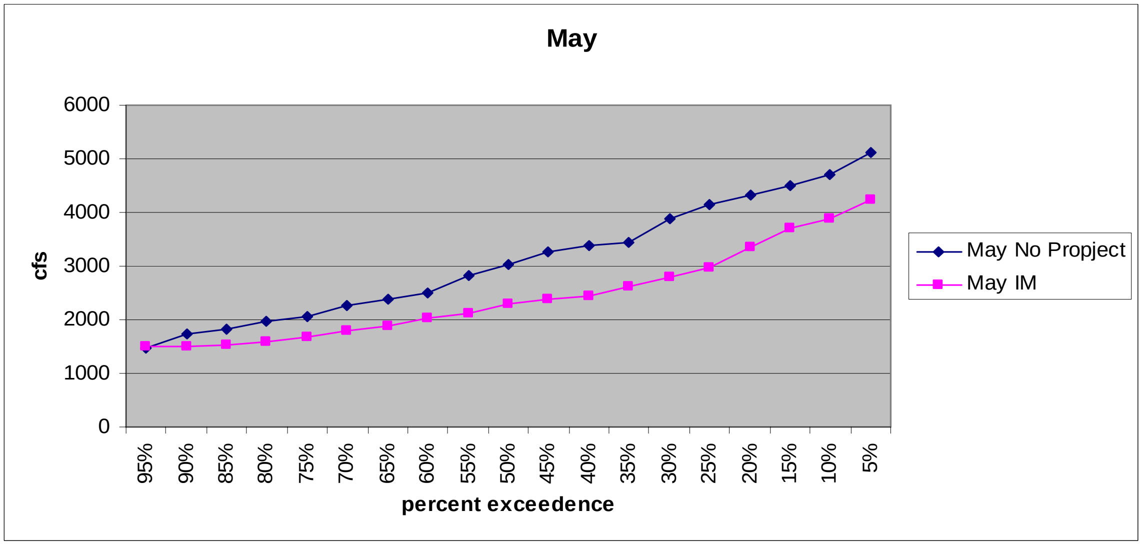


Figure H. Average May flows at IGD.

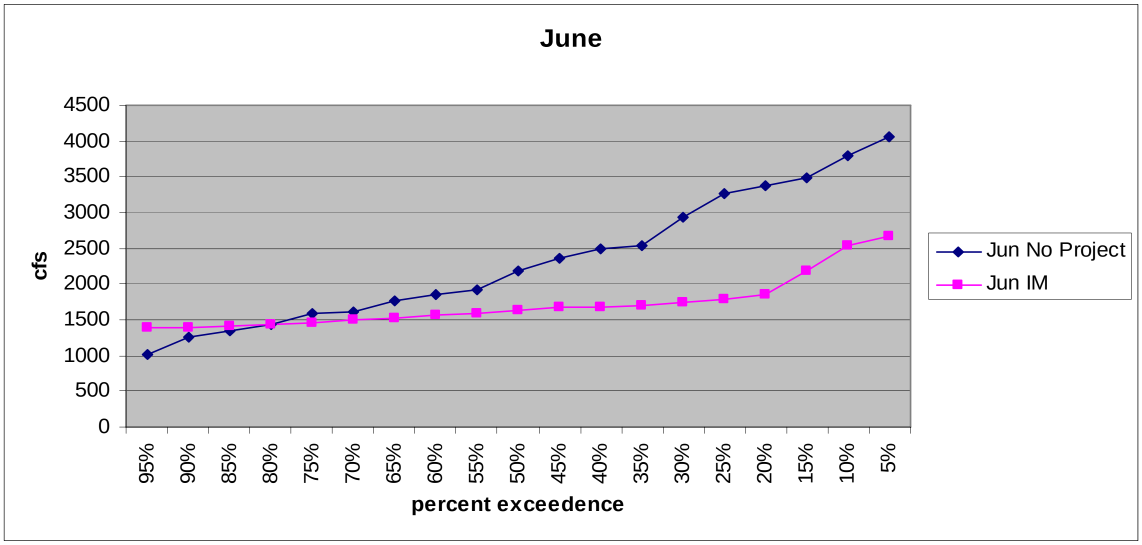


Figure I. Average June flows at IGD.

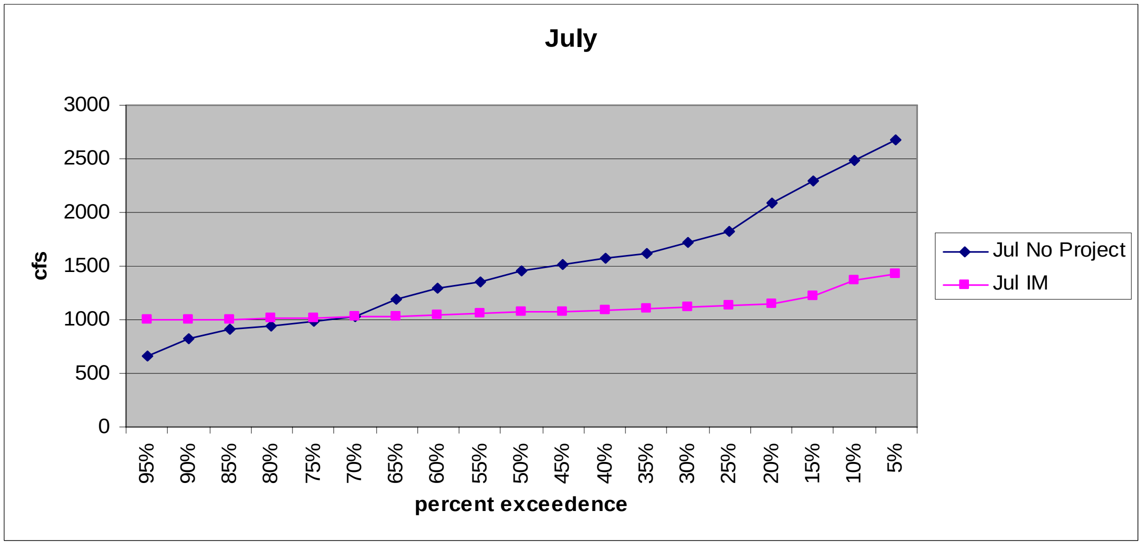


Figure J. Average July flows at IGD.

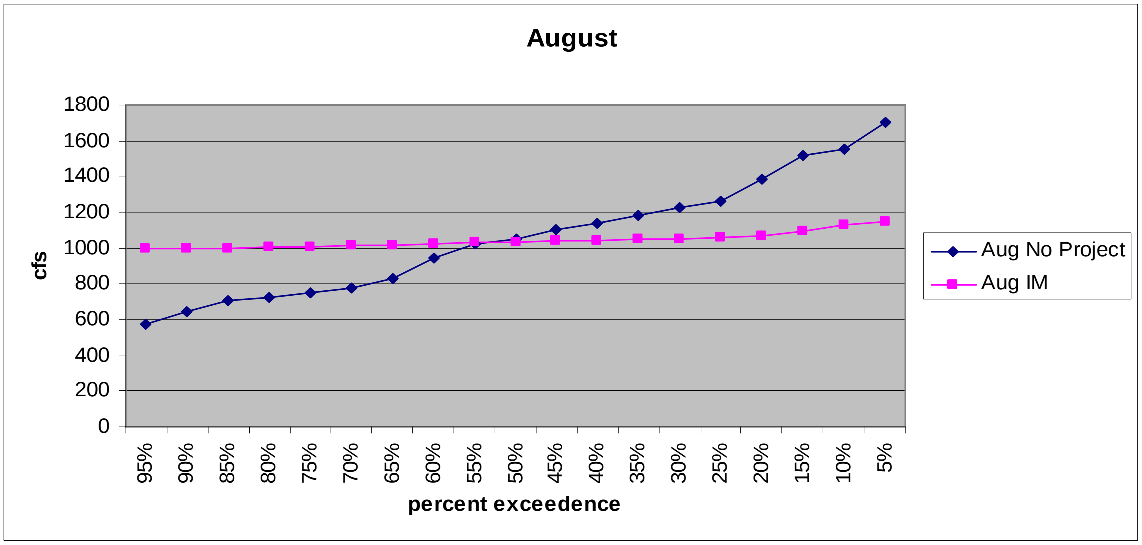


Figure K. Average August flows at IGD.

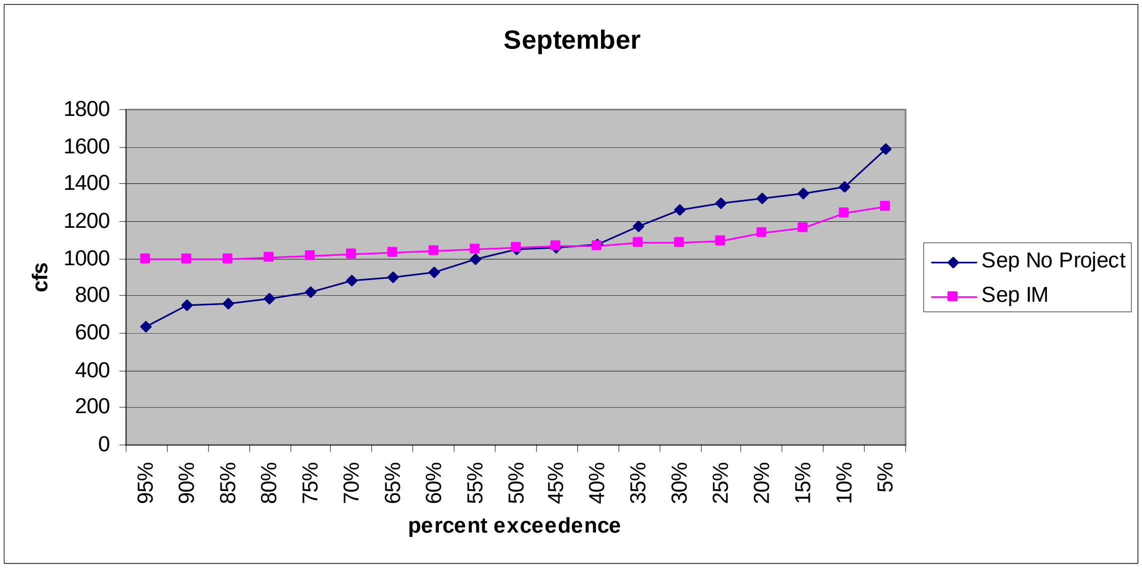
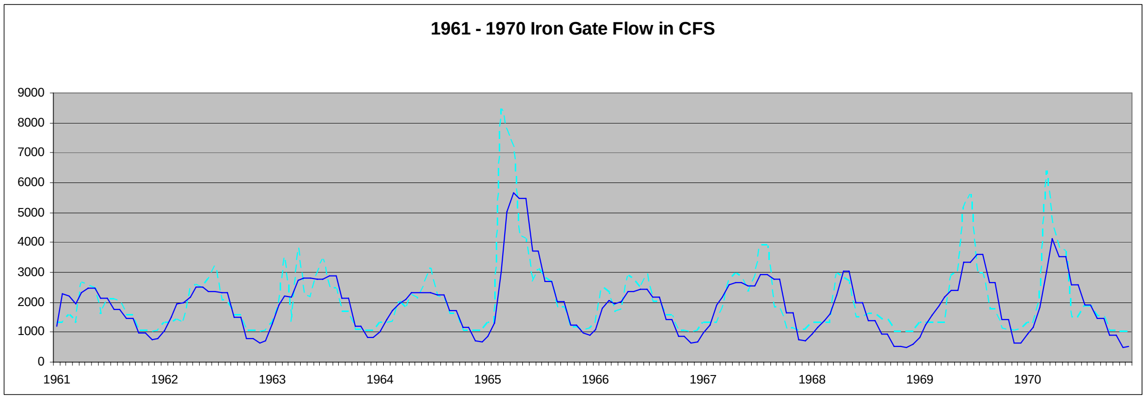
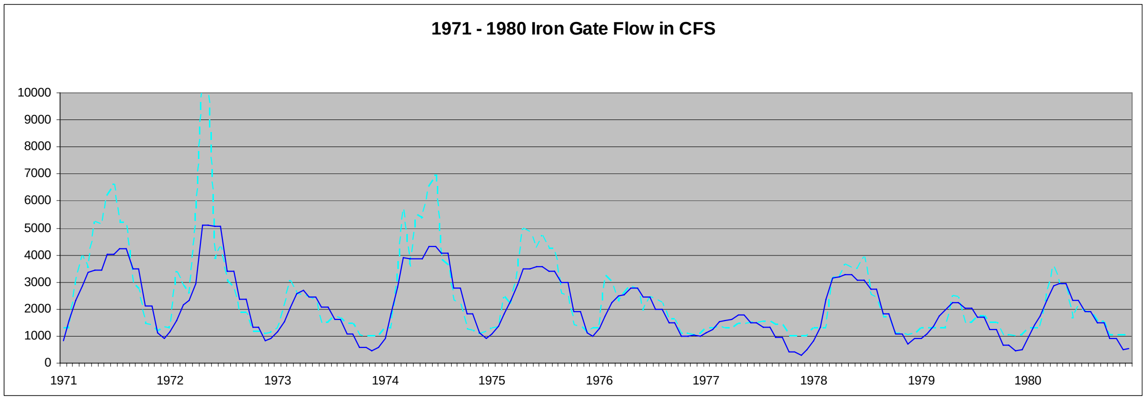
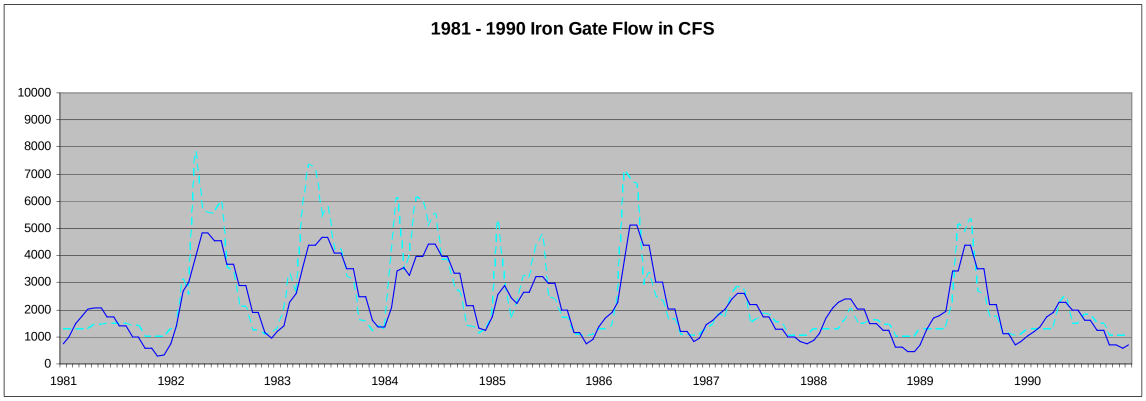


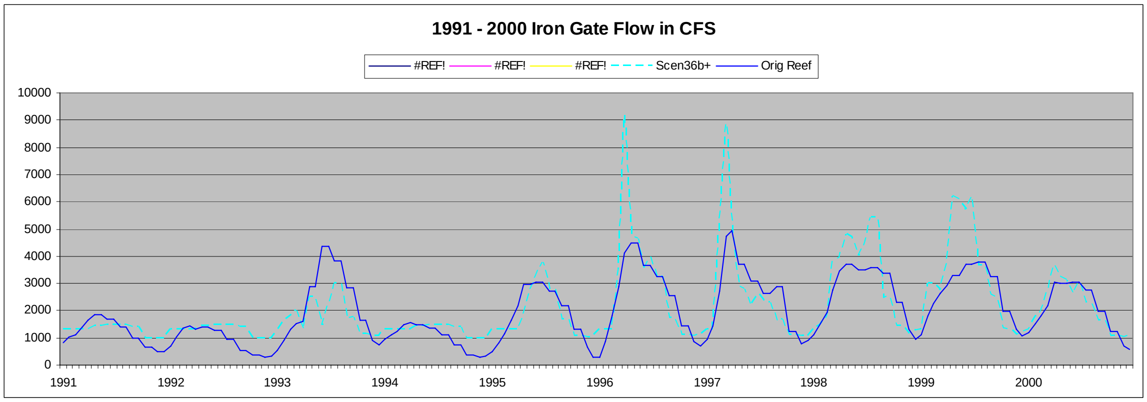
Figure L. Average September flows at IGD.

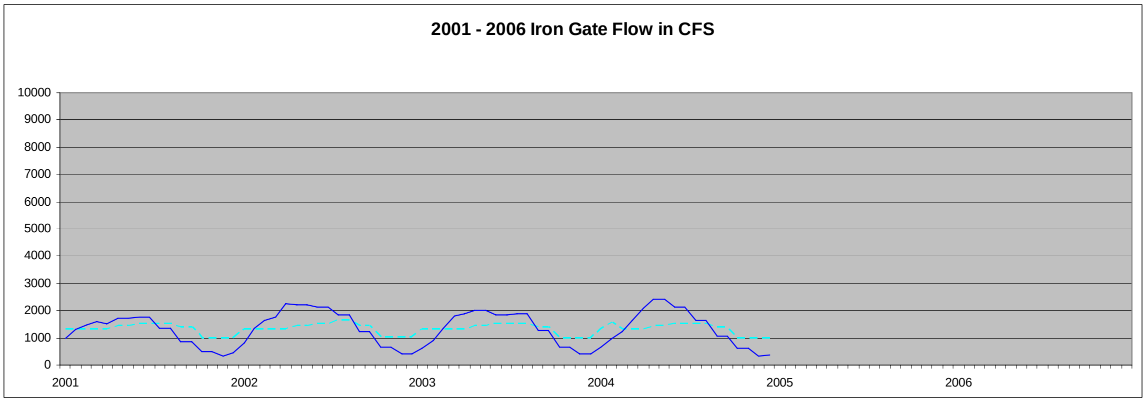
Appendix 3. Decadal Flow Plots of modeled flows at IGD (cfs) for two flow management scenarios: No Project (dashed lines) and Proposed Action (solid lines). Data provided by Reclamation (2008).








1991 - 2000 Iron Gate Flow in CFS
#REF!
#REF!
#REF!
Scen36b+
Orig Reef
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000


2001 - 2006 Iron Gate Flow in CFS
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2001
2002
2003
2004
2005
2006

		Juvenile coho									**Fry coho**								
		Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
	95%	98	98	98	98	98	100	99	99	100	86	86	86	86	86	88	88	88	88
	90%	98	98	98	98	98	100	99	99	100	86	86	86	86	86	88	88	88	88
	85%	98	98	98	98	98	100	99	99	100	86	86	86	86	86	88	88	88	88
	80%	98	98	98	98	98	98	99	98	100	86	86	86	86	86	89	88	88	88
	75%	98	98	98	98	98	98	99	98	100	86	86	86	86	86	94	88	89	88
	70%	98	98	98	98	98	98	99	98	99	86	86	86	86	86	96	88	89	88
	65%	98	98	98	98	98	98	98	98	99	86	86	86	86	87	97	88	90	88
	60%	98	98	98	98	98	97	98	98	99	86	86	86	87	90	98	90	92	88
	55%	98	98	99	98	98	96	98	98	98	86	86	87	89	97	100	94	93	88
Project	**50%**	98	98	100	98	97	96	97	98	98	86	86	88	89	98	100	99	95	88
	45%	98	98	98	98	96	96	96	98	98	86	86	89	91	99	100	100	96	89
	40%	98	98	98	98	96	96	96	98	98	86	86	90	94	100	100	100	97	89
	35%	98	98	98	97	97	96	96	97	98	86	86	92	98	98	99	99	98	89
	30%	98	100	98	97	97	97	97	96	98	86	88	97	98	98	97	98	100	89
	25%	98	98	96	97	97	98	98	96	98	86	88	100	99	97	94	96	100	89
	20%	98	98	96	96	98	99	99	96	98	86	90	100	100	97	89	92	99	90
	15%	98	98	96	97	99	100	99	97	98	86	92	100	98	90	82	83	98	93
	10%	98	96	96	98	98	95	100	98	97	86	100	99	97	76	70	79	97	98
	5%	98	96	99	90	88	89	95	98	97	86	99	88	62	49	57	70	95	99

		Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
	95%	91	97	98	98	98	98	98	98	94	79	86	88	90	90	92	90	88	84
	90%	91	99	98	98	98	98	98	98	96	80	88	89	91	92	96	93	89	86
	85%	92	100	98	98	98	97	98	98	100	81	88	89	93	95	98	95	90	88
	80%	92	100	98	98	98	96	97	98	99	82	88	90	93	97	100	98	91	88
	75%	93	99	98	98	97	96	97	98	98	83	88	90	94	98	100	98	92	88
	70%	94	99	98	98	97	96	96	98	98	83	88	90	94	99	100	99	95	88
	65%	94	98	98	98	96	96	96	98	98	84	88	91	96	100	100	100	96	89
	60%	95	98	98	98	96	96	96	97	98	84	88	92	97	100	100	100	98	90
	55%	96	98	98	97	96	96	96	96	98	85	89	93	98	100	99	100	100	90
No Project	**50%**	97	98	98	96	96	96	96	96	98	86	89	93	99	100	99	99	100	93
	45%	99	98	98	96	96	97	97	96	98	87	89	95	100	100	98	98	99	96
	40%	100	98	98	96	97	97	97	96	98	88	90	97	100	99	97	98	99	97
	35%	100	98	97	96	97	98	98	97	98	88	90	98	100	98	97	96	99	98
	30%	99	98	97	96	97	99	98	98	96	88	91	99	99	98	93	94	97	100
	25%	99	98	96	96	98	99	99	98	96	88	92	99	99	97	93	91	96	100
	20%	99	98	96	97	98	99	99	98	96	88	92	100	98	96	91	89	95	99
	15%	98	98	96	97	99	99	99	99	96	88	93	100	97	91	86	85	93	99
	10%	98	98	97	98	99	100	100	99	97	89	96	98	96	84	79	81	91	98
	5%	98	97	98	100	97	94	97	99	98	89	98	97	81	74	69	74	86	97

Appendix 4 a: Juvenile and fry WUA within the R Ranch reach by month and exceedence type (based upon Hardy *et al*. 2006).

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	95%	42	42	42	42	42	42	42	42	42	92	90	90	90	90	87	88	87	91
	90%	42	42	42	42	42	42	42	42	42	91	90	90	90	90	87	88	87	90
	85%	42	42	42	42	42	41	42	42	42	91	90	90	89	90	87	87	86	90
	80%	42	42	42	42	42	40	42	41	42	91	90	89	89	89	90	87	87	89
	75%	42	42	42	42	42	40	42	41	42	91	90	89	89	89	98	86	88	89
	70%	42	42	42	42	42	40	42	40	42	91	90	89	88	87	99	86	90	88
	65%	42	42	42	42	42	41	41	40	42	91	90	88	88	87	98	88	92	87
	60%	42	42	42	41	40	41	40	40	42	90	90	87	87	94	98	93	93	86
	55%	42	42	42	40	41	43	40	40	41	90	89	87	90	99	95	97	95	87
Project	**50%**	42	42	41	40	42	44	42	40	41	90	89	87	93	97	93	97	97	88
	45%	42	42	40	40	43	45	44	40	41	90	89	91	96	94	91	93	98	88
	40%	42	42	40	40	50	46	46	40	41	90	89	93	98	88	91	90	99	89
	35%	42	42	40	42	63	54	53	41	41	90	87	98	97	83	86	87	99	89
	30%	42	42	40	43	68	72	67	44	41	90	86	100	95	81	78	81	93	90
	25%	42	41	45	44	77	83	76	44	40	90	88	91	94	75	70	75	93	91
	20%	42	40	47	48	80	95	86	53	40	90	93	89	88	73	54	67	87	92
	15%	42	40	51	67	92	99	95	65	40	90	95	87	81	59	48	54	82	96
	10%	42	45	60	79	100	100	99	70	40	90	91	84	73	42	40	47	79	100
	5%	42	56	94	99	98	99	100	83	44	89	86	56	29	27	32	41	71	94

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	95%	38	42	41	40	40	40	40	41	42	93	90	89	92	93	95	91	87	95
	90%	40	42	41	40	40	40	40	40	42	94	89	89	94	95	99	95	90	94
	85%	41	42	40	40	40	42	40	40	42	95	88	91	96	98	96	97	91	91
	80%	42	42	40	40	40	44	40	40	42	95	87	93	97	100	94	100	93	89
	75%	42	41	40	40	41	44	41	40	42	95	87	94	97	98	93	99	94	87
	70%	42	41	40	40	42	46	42	40	41	94	88	94	97	97	89	97	97	87
	65%	42	41	40	40	45	47	43	40	41	94	89	95	100	92	89	96	98	90
	60%	42	41	40	40	45	50	45	40	40	93	89	96	99	92	88	91	99	91
	55%	42	40	40	43	46	55	47	43	40	92	90	96	95	91	86	89	95	92
No Project	**50%**	42	40	40	44	47	57	52	45	40	91	91	97	94	89	85	87	92	96
	45%	42	40	40	45	48	67	61	50	40	89	92	98	92	88	82	84	88	97
	40%	42	40	42	45	65	74	68	54	40	88	93	98	91	82	76	81	86	99
	35%	42	40	42	47	69	78	74	56	40	87	93	97	89	80	74	77	86	99
	30%	42	40	43	58	71	86	85	70	43	87	94	96	85	78	67	69	79	95
	25%	42	40	44	60	76	89	89	75	47	87	95	94	84	75	62	63	76	89
	20%	41	40	50	66	82	92	91	80	52	88	96	88	82	72	59	61	72	87
	15%	41	40	53	74	92	95	93	86	54	89	97	86	76	59	54	57	68	86
	10%	41	40	63	83	98	99	97	88	65	89	100	83	71	49	43	50	64	82
	5%	40	42	81	100	100	100	99	93	76	92	96	72	36	40	39	45	58	75

Appendix 4b: Juvenile and fry WUA within the Trees of Heaven reach by month and exceedence type (based upon Hardy *et al*. 2006).

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	95%	45	44	44	43	42	45	45	45	44	100	100	100	100	100	98	98	98	100
	90%	45	44	43	42	43	49	49	47	43	100	100	100	100	99	95	95	96	100
	85%	45	44	43	44	45	51	50	50	42	100	100	100	99	98	92	94	94	100
	80%	45	44	42	46	50	48	50	51	44	100	100	100	97	94	88	93	91	99
	75%	45	44	44	50	51	46	51	50	46	100	100	99	94	91	88	91	89	98
	70%	45	44	47	50	48	46	48	46	47	100	100	96	94	88	86	88	88	97
	65%	44	44	48	50	47	46	47	46	48	100	100	96	94	88	85	88	88	96
	60%	44	43	50	50	46	46	46	46	50	100	100	95	89	87	83	86	87	94
	55%	44	43	50	48	46	46	46	46	50	100	100	94	88	86	80	84	86	94
Project	**50%**	44	42	51	46	46	46	46	46	50	100	100	92	87	82	79	80	85	93
	45%	44	44	51	46	49	46	46	46	51	100	99	90	84	77	77	77	83	92
	40%	44	46	50	46	50	48	49	46	51	100	97	89	84	77	77	77	83	90
	35%	44	48	47	46	52	50	50	46	50	100	96	88	80	78	77	77	79	89
	30%	44	49	46	48	57	59	55	49	49	100	95	85	77	82	84	81	77	89
	25%	44	50	46	49	62	75	65	53	46	100	93	83	77	86	90	87	79	86
	20%	44	51	46	55	78	93	78	58	46	100	89	79	81	91	92	91	83	84
	15%	43	46	53	64	79	99	80	63	46	100	87	79	86	91	93	91	86	82
	10%	43	46	73	98	102	107	92	74	47	100	84	89	93	95	100	92	90	77
	5%	43	46	113	174	139	115	99	95	50	100	80	106	163	129	108	93	93	77

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	95%	44	44	44	46	48	50	50	46	45	98	100	99	97	96	94	93	97	99
	90%	45	44	45	50	50	49	51	50	44	98	100	98	94	92	89	91	94	100
	85%	46	43	45	51	50	46	49	51	42	98	100	98	91	89	87	89	91	100
	80%	46	43	47	51	47	46	46	50	43	98	100	96	90	88	85	88	89	99
	75%	46	43	50	50	46	46	46	46	47	98	100	94	89	86	84	84	88	97
	70%	45	42	50	48	46	46	46	46	50	99	100	93	88	84	82	82	85	94
	65%	45	43	51	46	46	46	46	46	51	100	99	91	88	83	80	81	83	92
	60%	45	44	51	46	46	46	46	46	51	100	99	90	88	82	78	80	83	90
	55%	44	44	51	46	46	47	46	46	50	100	98	90	84	79	77	78	80	89
No Project	**50%**	44	47	51	46	47	48	48	46	49	100	97	89	81	77	77	77	79	89
	45%	44	48	47	46	50	50	52	46	48	100	96	88	80	77	77	78	77	88
	40%	44	49	46	46	53	55	55	47	47	100	95	87	78	79	81	81	77	88
	35%	44	50	46	49	57	59	58	50	46	100	94	85	77	82	84	83	77	87
	30%	43	50	46	52	58	76	69	56	46	100	93	83	78	83	91	88	81	84
	25%	43	51	46	59	69	81	79	61	46	100	91	80	83	88	91	91	85	77
	20%	43	50	47	62	77	91	80	67	47	100	89	77	85	91	92	91	87	77
	15%	42	46	54	66	86	96	81	81	50	100	87	80	87	92	93	91	91	77
	10%	44	46	76	100	101	102	83	91	54	99	84	90	94	95	95	92	92	80
	5%	45	46	103	170	121	113	92	96	67	98	81	96	159	113	105	92	93	87

Appendix 4c: Juvenile and fry WUA within the Seiad Reach reach by month and exceedence type (based upon Hardy *et al*. 2006). Shaded areas represent extrapolated WUA values (*i.e.*, analyzed flows were outside those considered in Hardy *et al*. 2006).

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	95%	17	18	19	20	23	25	21	20	18	62	71	83	96	98	94	98	97	77
	90%	17	18	19	21	25	28	27	21	18	65	74	88	98	93	88	89	98	82
	85%	17	18	20	25	30	38	29	25	19	65	74	97	94	84	74	86	94	95
	80%	17	18	22	26	34	43	30	27	20	66	76	100	91	79	70	85	89	96
	75%	17	18	23	30	47	46	35	32	20	67	79	97	85	67	67	78	81	97
	70%	18	18	28	35	49	52	39	34	21	69	80	88	77	65	64	72	78	99
	65%	18	18	29	38	55	59	52	38	22	69	82	86	73	62	60	64	73	100
	60%	18	19	33	46	61	66	59	40	23	70	89	80	67	58	56	60	72	98
	55%	18	19	36	60	68	72	61	44	23	71	95	76	59	55	55	58	68	97
Project	**50%**	18	21	38	77	81	76	66	49	24	71	98	73	56	56	56	56	66	96
	45%	18	22	42	81	85	81	69	51	26	72	99	70	56	56	56	55	64	91
	40%	18	25	47	90	99	83	74	56	28	73	93	66	57	56	56	56	62	87
	35%	18	27	59	94	105	95	90	63	30	75	90	60	57	59	57	57	57	85
	30%	18	28	65	109	109	114	96	75	32	76	87	56	61	62	64	57	56	81
	25%	18	35	81	118	113	121	105	93	38	77	77	56	66	63	68	59	57	74
	20%	18	45	95	119	118	131	112	97	43	79	68	57	67	67	74	63	57	70
	15%	19	55	105	134	128	140	115	102	53	88	62	59	76	72	79	65	57	63
	10%	19	68	144	167	136	156	118	108	62	91	55	81	94	77	88	67	61	57
	5%	19	98	200	262	217	169	139	119	71	93	57	113	148	122	95	78	67	55

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	95%	16	18	19	21	26	27	23	21	17	57	75	94	99	91	90	97	98	68
	90%	16	18	20	25	31	33	32	22	18	59	77	96	93	82	80	80	99	81
	85%	17	18	22	31	37	43	36	26	19	61	79	99	83	75	70	76	91	92
	80%	17	18	23	32	43	50	36	28	20	63	81	98	80	70	65	76	87	96
	75%	17	18	26	36	54	57	43	36	21	64	81	91	76	63	61	69	76	98
	70%	17	19	28	41	57	58	51	42	22	65	83	89	71	61	60	65	70	99
	65%	18	19	31	44	65	62	58	45	24	68	87	83	69	56	58	60	68	96
	60%	18	19	35	52	67	74	68	47	25	70	92	77	64	56	56	55	67	93
	55%	18	21	40	66	75	80	71	53	27	72	98	72	56	56	56	55	63	91
No Project	**50%**	18	22	47	83	84	84	73	57	29	72	99	67	56	56	56	56	61	86
	45%	18	24	49	87	96	87	77	59	30	73	97	65	57	57	57	56	60	84
	40%	18	25	51	96	103	93	82	64	31	74	94	64	57	58	57	56	57	82
	35%	18	29	61	98	107	100	93	69	35	75	86	59	57	60	56	57	55	78
	30%	18	32	68	110	114	107	102	82	38	80	81	55	62	64	61	57	56	74
	25%	19	36	83	123	115	128	108	100	50	82	76	56	70	65	72	61	56	65
	20%	19	41	97	130	122	130	112	101	55	87	71	57	73	69	74	63	57	62
	15%	19	58	111	136	129	136	117	106	65	93	60	63	77	73	77	66	60	56
	10%	19	68	145	169	136	155	121	112	74	95	55	82	95	76	87	68	63	56
	5%	20	86	190	260	196	166	136	124	83	96	56	107	147	110	93	77	70	56

Appendix 4d: Juvenile and fry WUA within the Rogers Creek reach by month and exceedence type (based upon Hardy *et al.* 2006). Shaded areas represent extrapolated WUA values (*i.e.*, analyzed flows were outside those considered in Hardy *et al.* 2006).

Project

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
95%	98	87	78	72	62	57	65	65	82	99	93	84	81	80	80	80	80	87
90%	94	86	77	66	55	53	52	61	78	97	92	82	80	80	79	79	80	83
85%	94	85	71	58	50	47	52	55	71	97	91	81	80	78	74	79	79	81
80%	92	85	65	55	49	41	50	52	70	96	90	80	80	77	71	78	79	81
75%	90	83	59	51	38	39	43	47	68	96	88	80	78	69	70	72	75	80
70%	90	82	56	47	38	35	40	43	62	95	88	80	75	69	68	71	72	80
65%	89	81	55	44	32	33	33	40	60	95	87	80	73	67	67	67	71	80
60%	88	75	50	37	30	28	31	39	59	94	81	77	69	66	66	67	70	80
55%	88	73	47	30	27	27	29	38	57	94	81	74	67	66	65	66	69	80
50%	88	70	41	24	24	24	26	34	56	94	81	71	65	65	65	65	68	80
45%	87	62	39	24	22	24	25	33	53	93	80	70	65	65	65	65	67	79
40%	86	59	37	22	24	23	25	32	51	92	80	69	65	66	65	65	67	78
35%	86	56	33	22	27	23	22	26	50	91	80	67	65	67	66	65	65	77
30%	85	52	27	30	28	30	25	23	47	91	79	65	73	68	75	66	65	75
25%	83	46	24	31	30	33	29	26	42	89	74	65	77	74	80	71	67	72
20%	82	40	23	34	32	35	30	27	35	88	70	66	83	78	86	75	68	68
15%	77	34	29	37	35	38	31	29	31	82	67	71	91	87	93	76	71	67
10%	76	26	40	48	36	42	32	30	27	81	65	99	119	90	103	79	74	65
5%	74	25	54	69	56	45	36	33	24	81	66	134	171	137	110	88	82	65

No Project

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
95%	#N/A	85	74	68	57	55	59	64	86	#N/A	91	81	80	80	80	80	80	92
90%	#N/A	84	73	58	51	50	49	60	78	#N/A	90	81	80	78	77	76	80	83
85%	100	83	67	52	46	43	46	53	72	100	89	80	79	74	73	74	79	81
80%	96	82	63	52	43	38	44	51	70	98	88	80	79	72	69	73	78	81
75%	94	81	57	46	35	34	40	42	65	97	87	80	74	68	67	70	72	80
70%	90	79	55	43	34	33	35	40	57	95	85	80	72	68	67	68	71	80
65%	89	79	54	41	28	30	33	37	56	95	84	79	71	66	66	67	69	80
60%	88	76	48	35	27	26	26	35	56	94	81	76	68	66	65	65	68	80
55%	88	71	42	27	26	25	26	35	54	94	81	72	66	65	65	65	68	79
50%	87	67	38	23	23	24	25	31	52	93	80	70	65	65	65	65	67	79
45%	87	64	36	22	22	23	24	30	50	93	80	68	65	66	65	65	67	77
40%	86	57	35	21	26	22	22	28	49	92	80	68	65	67	65	65	66	76
35%	85	55	32	24	27	25	22	25	46	91	79	67	66	67	66	65	65	74
30%	83	51	26	30	29	29	26	22	44	89	78	65	74	71	71	67	65	73
25%	81	45	23	32	30	33	29	28	36	86	73	65	80	73	82	70	68	68
20%	79	42	23	36	32	35	30	29	30	84	72	66	88	79	87	75	70	67
15%	75	32	30	38	35	37	32	29	27	81	67	75	94	86	91	79	72	65
10%	73	26	41	47	37	42	33	32	25	81	65	100	117	91	104	81	78	65
5%	72	22	52	69	51	44	35	35	21	81	65	129	170	126	109	87	86	65

Appendix 4e: Juvenile and fry WUA within the Orleans reach by month and exceedence type (based upon Hardy *et al.* 2006). Shaded areas represent extrapolated WUA values (*i.e.,* analyzed flows were outside those considered in Hardy *et al.* 2006).