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Elwha River Restoration Project

Chinook and Steelhead Monitoring Plan

This document outlines a strategy to evaluate responses of listed salmon species during and following the removal of dams on the Elwha River, Washington. This is a watershed scale plan that identifies specific implementation actions for identified reaches of the Elwha River. This plan partially fulfills the requirements of the Amended Incidental Take Statement for the Elwha River and Fisheries Restoration Project Biological Opinion (NMFS 2011/03769).

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Final

For over 100 years, two dams on the Elwha River, Washington, blocked the upstream migration of anadromous salmon into Olympic National Park (ONP). Removal of the dams, as authorized by the Elwha River Ecosystem and Fisheries Restoration Act (Elwha Act), Pub. L. 102-495, 106 Stat. 3173 (Oct. 24, 1992), will restore anadromous fish passage to the Elwha River watershed and represents a major step in recovery efforts for a variety of fish stocks listed under the Endangered Species Act (ESA), including Puget Sound Chinook salmon (*Oncorhynchus tsawytscha)* (NMFS, 2007), Puget Sound steelhead (*O. mykiss*) (NMFS, 2012), and Pacific eulachon (*Thaleichthys pacificus)* (NOAA, 2011).

The Secretary of the Interior delegated his discretionary authority under the Elwha Act to mitigate for the adverse impacts of dam removal, and to restore the Elwha River ecosystem, to NPS under Secretarial Order No. 3212, as amended. NPS's mitigation activities and its efforts to restore the Elwha River are commonly referred to as "the Elwha River Restoration Project" or "Elwha Project."

Removal of both structures began in September 2011. By May 2012, demolition of the Elwha Dam was completed. Shortly afterwards, steelhead had migrated past the Elwha Dam site and were observed spawning in Little River and Indian Creek. On September 5, 2012, Chinook salmon were observed spawning in ONP for the first time since construction of Elwha Dam began in 1910. Removal of the Glines Canyon Dam is expected to be completed in the fall of 2013.

This document is the monitoring implementation plan required by paragraph 6 of the Terms and Conditions (T&Cs) and Reasonable and Prudent Measures (RPMs) sections within the July 2, 2012 National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) for the Elwha Restoration Project (Project), as amended by letter dated November 30, 2012, from NMFS to ONP (see Stelle 2012) (hereafter, "monitoring plan").[1] This monitoring plan describes the specific steps the National Park Service (NPS) intends to undertake to document dam removal impacts to listed salmon species and meet the requirements of the BiOp.

Plan Goals and Objectives

The goals outlined by NMFS in the BiOp that shape this monitoring plan are, simply stated, to:

[1] Under paragraph 6 of RPM 2.8.3, NMFS states "The NPS shall undertake or fund effective efforts to monitor salmonid abundance, distribution, productivity, stock composition, and general habitat and ecosystem conditions to allow for adaptive management and to assess the impacts associated with dam removal to ESA listed species. It is estimated that, over a ten year period beginning in 2013, such monitoring efforts will cost approximately $6.7 million." Under paragraph 6 of T&C 2.8.4, which implements the corollary RPM, NMFS states, "The NPS shall create a monitoring implementation plan by March 1, 2013, that describes how the NPS will support monitoring and adaptive management."

- enumerate adult returns and spawning abundance;
- enumerate smolt emigration;
- evaluate distribution of fish in the watershed (and potential barriers to migration);
- ensure key conditions in the watershed are sustained and that dam removal and fish restoration activities are not prohibiting recovery.

A suite of possible tools has already been identified by federal agencies (including NPS), state agencies, and the Lower Elwha Klallam Tribe (the "Tribe"), to try to meet each of these broad goals (see Tables 3 – 8). For each of the possible tools executing a goal, a lead(s) has been identified. The National Park Service will implement a sub-set of these monitoring tools that target the goals outlined by NMFS.

This monitoring plan's primary objective is to provide information in a timely manner to the resource managers of the agencies involved with the Elwha Project so that they can make better informed decisions regarding the implementation of recovery actions.

This monitoring plan is flexible and allows for the tools to be sensibly modified, based upon adaptive management. The actual tools implemented will be annually agreed to by NMFS and NPS. Some of the factors that will guide selection and implementation of any given tool, including use of a particular type of equipment, are: the river's current condition at the time of the proposed action, the weather forecast, the stability of the riverbank, the likelihood of success, the benefits of the program, any new information that has been acquired, and especially, safety of employees. Potential tools may be nullified by changing river conditions, or conversely, may present themselves over time.

Another significant factor that will guide selection of any given tool is compliance with the National Environmental Policy Act, Wilderness Act, and NPS Management Policies, which require, among other things, a minimum requirement analysis and no-impairment determination. Since approximately sixty percent of the mainstem Elwha River channel and tributary habitat are within designated wilderness, further compliance steps are likely to be needed before actions proposed within Olympic National Park and wilderness can occur. NPS anticipates that many of the monitoring activities that will occur above Glines Canyon Dam will be by foot, limiting the types of activities that can take place.

Recovery Phases

The fish restoration period has been described in the Elwha River Hatchery and Genetic Management Plans (HGMPs) recently approved by NMFS on December 10, 2012, (WDFW, 2012; LEKT, 2012) as four discrete phases: Preservation, Re-colonization, Local Adaptation, and Self-Sustaining exploitable population. These phases have been generally defined for this document as follows:

> **Preservation** – the period during dam removal when elevated suspended sediment concentrations are expected, at times, to be lethal to all fish in the river, resulting in a high probability for complete loss of native fish populations and their associated genetic and life history diversity if no protective measures are taken. Beginning with the start of

dam removal in 2011, this phase is currently in progress. ***The goal*** of the Preservation Phase is to protect the existing genetic and life history diversity of native salmonid populations until fish passage is restored and water turbidity is determined to be non-lethal to fish in the river.

Re-colonization – the period after the dams are removed, passage is restored, and fish have access to refugia away from lethal suspended sediment concentrations, or suspended sediment concentrations no longer reach lethal levels that negatively impact fish populations. ***The goal*** of the Re-colonization Phase is to ensure that salmonids are continually accessing habitats above the old dam sites with some fish spawning successfully and producing smolts capable of surviving in the Elwha River.

Local Adaptation – the period during which: (1) sufficient numbers of spawning adults (e.g., meeting or exceeding minimum VSP criteria) are accessing and using newly accessible habitats above the old dam sites, and; (2) fish are successfully spawning at a rate that allows for population growth. ***The goal*** of the Local Adaptation Phase is to maintain or increase life history diversity of natural spawning populations through local adaptation to the Elwha River ecosystem until minimum levels of spawner abundance, productivity, and distribution are met.

Self-sustaining Exploitable Population – the period when all aspects of the previous stages are met, and viable, self-sustaining populations exist that can sustain exploitation by fisheries. ***The goal*** of the Self-sustaining Exploitable Population Phase is to ensure that viable, self-sustaining and exploitable population levels continue once desired values for all VSP and habitat parameters have been met and hatchery programs are no longer needed to provide for protection, recovery, or exploitation.

During the Preservation and Re-colonization Phases, it is anticipated that hatchery production will contribute significantly to the naturally spawning population to reduce the threat of extirpation. During the Local Adaptation Phase, the goal is to reduce the contribution of hatchery fish to the natural spawning population to zero, such that the hatchery programs could be phased out without risk to maintaining salmon populations at abundance levels necessary for sustainable harvests.

Action Strategy

This monitoring plan addresses the first two fish restoration periods—the Preservation and Re-colonization Phases.

As a governmental agency, NPS is subject to the Anti-Deficiency Act, 31 U.S.C. § 1341. Therefore, nothing contained in this monitoring plan is to be construed as binding the NPS to expend in any one fiscal year any sum in excess of appropriations made by Congress and available for purposes of this monitoring plan for that fiscal year, or as implying that Congress will at a later date appropriate funds for this monitoring plan.

Subject to the Anti-Deficiency Act, the availability of funds, and NPS's need to comply with other mandates, the NPS will implement a sub-set of the monitoring tools identified in Tables 1 and 2. These tools were selected by NPS to best meet the requirements of the BiOp as well as to

aid understanding of the impacts of dam removal, and therefore, management of the Elwha Project. A cost estimate has been provided for each tool. Annual inflation has been factored in. A description and justification for each task follows. It should be recognized, however, that over time it may be found that some tools are more or less effective at providing the information required for adaptive management purposes, so may be discarded or modified to meet the BiOp and Elwha Project needs. The tools are anticipated to cost approximately $6,688,000. However, this figure may fluctuate lower, if different tools are used or certain tools are excluded, based upon adaptive management. Therefore, while the annual costs identified in Tables 1 and 2 are assumed to be relatively fixed for the tools that have been identified at this time for implementation, the actual tools that are ultimately implemented will be annually agreed to by NMFS and NPS, which may impact the costs actually incurred by NPS.

Table 1
Elwha Project Monitoring Program
2013 - 2017

Task	Tool	2013	2014	2015	2016	2017
Adult Abundance	SONAR	$280,000	206,000	212,180	218,545	225,102
Adult Abundance/ Distribution	Ground-based surveys	$100,000	154,500	159,135	163,909	168,826
Adult Abundance/ Stock Composition	Adult Capture Weir	$100,000	103,000	106,090	109,273	112,551
Juvenile Abundance	Smolt Trap	$60,000	61,800	63,654	65,564	67,531
Distribution	Tagging/ Radio Telemetry	$75,000	77,250	79,568	81,955	84,413
Distribution/Adult Abundance	Aerial Surveys	$5,000	5,150	5,305	5,464	5,628
Distribution	Fish Relocation	$30,000	30,900	31,827	32,782	33,765
Watershed Condition	Fish Pathology	$20,000	20,600	21,218	21,855	22,510
Watershed Condition	Habitat/Passage/ Ecosystem Monitoring	$75,000	77,250	79,568	81,955	84,413
YEARLY TOTAL		$745,000	736,450	758,544	781,300	804,739
5-YEAR TOTAL						**$3,826,033**

Table 2
Elwha Project Monitoring Program
2018-2022

Task	Tool	2018	2019	2020	2021	2022
Adult Abundance	SONAR	$116,000	119,480	123,064	126,756	130,559
Adult Abundance/ Distribution	Ground-based surveys	$173,891	179,108	184,481	190,016	195,716
Adult Abundance/ Stock Composition	Adult Capture Weir	$0	0	0	0	0
Juvenile Abundance	Smolt Trap	$69,556	71,643	73,792	76,006	78,286
Distribution	Tagging/ Radio Telemetry	$86,946	89,554	92,241	95,008	97,858
Distribution/Adult Abundance	Aerial Surveys	$5,796	5,970	6,149	6,334	6,524
Distribution	Fish Relocation	$0	0	0	0	0
Watershed Condition	Fish Pathology	$0	0	0	0	0
Watershed Condition	Habitat/Passage/ Ecosystem Monitoring	$86,946	89,554	92,241	95,008	97,858
YEARLY TOTAL		$539,135	555,309	571,968	589,127	606,801
5-YEAR TOTAL						**$2,862,340**
GRAND 10-YEAR TOTAL						**$6,688,373**

Adult Abundance

SONAR

At this time, SONAR will be a key tool for estimating the abundance of adult salmonids entering the river as visibility below the Glines Canyon dam site is expected to be extremely poor during the entry time for both Chinook salmon and steelhead. A minimum of two DIDSON or similar units will be deployed as near to the river mouth as feasible during the first five years following dam removal when visibility is anticipated to be the most limiting. Site locations are not specified here, but will be selected to ensure the best possible enumeration of returning adults using methods described by Denton and Liermann (2011).

Operation of the SONAR units will strive to provide abundance estimates with a maximum CV of 15%. Other data sources in the watershed (e.g., adult capture weir, ground based surveys, or other methods) will be used to inform species composition of SONAR data. If necessary, periodic sampling at the SONAR location utilizing gillnets or seines will also be employed.

Changing conditions in the river, particularly during the Preservation Phase, may limit function of the SONAR units or the duration of time that the units may be operated. When such situations arise, the types and degree of uncertainty will be clearly described.

Cost estimates for 2013 in Table X include the purchase of one DIDSON or similar SONAR unit as well as the operation of two DIDSON SONAR units during the Chinook and steelhead entry timing. Years 2014 to 2017 only cover the annual operation costs. During the period from 2018 to 2022, it is assumed that visibility will improve, allowing a reduction in the time and numbers of SONAR units that will be needed.

At this time, NPS plans to purchase the SONAR equipment and may fund the Tribe to perform SONAR surveying.[2]

Ground-based surveys

Adult population estimates developed through the use of SONAR will provide a robust estimate of total adult returns to the river (and hence, marine survival rates), but may not accurately represent spawning success and certainly do not provide information of spawning distribution throughout the watershed. Pre-spawning mortality of Elwha River Chinook salmon was routinely on the order of 20% during the summer droughts experienced during the late 1980s and early 1990s. In 1992, when water temperatures exceeded 18^{o} C, nearly 70% of the return was lost prior to spawning (PNPTC and WDFW 2006). Due to the potential for pre-spawning mortality and the need to understand spawning distribution, it will be necessary to also conduct ground-based surveys consisting of redd counts, adult live/dead counts, and snorkel surveys.

Ground-based surveys (redd counts and/or snorkel surveys) will be conducted every 7- 10 days during the Chinook salmon spawning season (late-August to early-October), bull trout spawning season (late-September to early-November), and native steelhead spawning season (mid-March to early-July). Redd surveys will be conducted using methods widely applied in the Pacific Northwest and similar to those described for other projects (Nelle and Moberg 2008). Survey reaches will be identified each year in cooperation with staff from NMFS, Washington Department of Fish and Wildlife (WDFW), Lower Elwha Klallam Tribe (Tribe), and U. S. Fish and Wildlife Service (USFWS). Selection of survey reaches will be informed by existing habitat and biological information for the watershed (for example, McHenry and Pess, 2008; Pess et al, 2008; Brenkman et al (2), 2008). The intent of the surveys will be to establish index reaches that can be repeated annually to provide information on fish distribution, abundance, and pre-spawning mortality.

Snorkel surveys will be conducted using methods described in Brenkman and Connelly (2008). Generally, snorkel surveys are most effective for enumerating adult bull trout in the Elwha River, but may also be applicable for Chinook salmon. Visibility during the spring will limit the applicability of this tool for steelhead.

At this time, NPS intends for its staff to conduct ground-based surveys.

[2] NPS has preliminarily identified, at this time, possible future partners and funding recipients. However, NPS may later elect to have a different partner, or its own staff, carry out a given activity.

Aerial Surveys

Aerial surveys during lower flow periods can be an effective method for counting salmon redds and estimating distribution of adult fish in remote terrain, particularly if conducted at low elevations using a helicopter. However, the use of this tool will be limited in ONP by the requirements of the National Environmental Policy Act (NEPA), the Wilderness Act, or restrictions on the use of helicopters imposed under the ESA to protect the marbled murrelet and spotted owl. To the extent this may be allowed after NEPA, Wilderness Act, and ESA compliance has occurred, aerial surveys will be used to estimate the upper extent of Chinook salmon and steelhead spawning distribution and relative abundance of Chinook salmon and steelhead throughout the watershed. Data from aerial surveys will also be compared to concurrent foot and/or boat surveys in the middle and lower river reaches to allow the sampling efficiency of the aerial surveys to be assessed. Multiple passes may be completed in some reaches during both foot and aerial surveys to evaluate observer efficiency.

At this time, NPS envisions its staff may conduct aerial surveys, after further legal compliance has occurred, as described above.

Adult Capture Weir

Adult capture weirs, when feasible to operate, provide a nearly complete census of upstream migrating adult salmonids. As each fish is passed above the weir, important biological information can be gathered from captured fish (length, weight, species, sex, etc.), tissue samples for genetic analysis may be collected, and marks or tags may be assessed to determine origin (hatchery or wild). In addition, weir operation provides an opportunity to implant passive integrated transponder (PIT) tags or radio tags which can then be used to track fish migration and distribution.

The WDFW, with assistance from the U.S. Geological Survey (USGS), ONP, and other agencies has operated a resistance board weir on the Elwha River since August 2010. Although originally envisioned to function through most of the year, operation has been limited to the mid-summer/early fall and early spring time frames due to complications associated with high flows. Though limited in scope, the periods when operation can occur overlap significantly with Chinook salmon, pink salmon, and native steelhead run timing. Therefore, the weir is a useful tool for collecting information on run size, along with the other metrics noted above, and may be useful for estimating species composition that is needed for the proposed SONAR operation. Additionally, the weir can be used to collect adult brood stock for the hatchery Chinook salmon program, an integral component of the protection strategy for the population.

Other problems have arisen with the weir, so this tool must be reassessed regarding its continued as a part of this plan. Preliminary evidence from the weir operation has not produced favorable results for Chinook salmon. Each year, a significant proportion of the Chinook run had passed the weir site prior to flows dropping to levels that allowed the weir to be installed. Additionally, few Chinook were collected in the adult traps. Adaptations to the design have been made and will be evaluated during the summer of 2013.

Similarly, capture of steelhead within the weir has been problematic. While adult steelhead do appear to enter the traps when the weir is in operation, flows during the peak of the steelhead run often exceed the design capacity of the weir. Additionally, the high sediment and debris loads associated with dam removal have overwhelmed the staff's ability to clean the structure. Following the 2013 operation season, a detailed assessment of the utility of the weir operation will be conducted. The commitment to future operation of the weir will be based upon the results of this assessment.

In the near term, NPS proposes to continue to deploy the weir during river flow conditions of 2,000 cubic feet per second (cfs) or less. When the weir is operating, it will be checked at least once a day, depending on flows, debris load, and/or numbers of fish present. Data collection for salmonids includes, but is not limited to the number of adults, species, origin, sex, fork length, scales for determining age at spawning, freshwater and ocean ages, number of repeat spawners, and DNA tissue samples.

The NPS may fund WDFW to operate the adult capture weir.

Juvenile Abundance

Smolt Trap

Estimates of juvenile abundance, and in particular the abundance of emigrating (outmigrating) smolts, provide the basis for estimating freshwater productivity. Freshwater productivity is the freshwater production (number of juvenile migrants) divided by the number of parent spawners. NPS hopes to monitor freshwater production in most years using a smolt trap (rotary screw trap) near the river mouth with a mark-recapture study design. However, high sediment loads have recently filled in pools that had previously been deep enough to allow the placement and operation of smolt traps. Other methods may be necessary if smolt traps cannot be deployed. When they can, smolt traps will operate as close to the entirety of the outmigration period as possible. Missed fishing periods during high flows or large releases of hatchery Chinook will be recorded by time period so that missed catch can be estimated and incorporated into the total estimate. Efficiency trials used to calibrate the smolt trap will be conducted on a weekly basis. A subsample of Chinook will be measured to assess freshwater growth and assign outmigrant age class. Scales will be collected to assign age class, as needed. A Petersen estimator, appropriate for a single trap design, will be used to calculate freshwater production (Volkhardt et al. 2007). Operation of the smolt trap will strive to provide abundance estimates with a maximum CV of 15%.

The NPS may fund the Tribe to perform the smolt trapping.

Fish Distribution

Tagging/Radio Telemetry

Radio-telemetry will be used to obtain more detailed information regarding the distribution of Chinook salmon and steelhead in the Elwha Basin. Up to 40 adults captured at the weir, hatchery facilities, or by other methods will be externally tagged with radio-tags and released to continue

upstream. Both Chinook salmon and steelhead will be tagged each year, and an array of up to 7 fixed stations will be located from near the mouth of the river to the upstream end of Rica Canyon. These fixed stations will allow the monitoring of broad scale movement and distribution. The fixed station data will be supplemented by ground tracking or fixed wing aerial surveys to allow for finer a scale finer scale understanding of distribution, habitat selection, and extent of migration.

Careful consideration will be given to the type of radio tag(s) to be employed. While Chinook salmon are relatively short-lived in freshwater, native steelhead may remain in the river for several months, with a significant proportion of the run migrating back downstream after spawning. It is desirable to not only investigate the upstream distribution of these fish, but also the number of fish that may return to the marine environment and ultimately contribute to subsequent spawning populations. To the extent practical, tags will be selected that achieve both of these objectives.

The NPS plans, at this time, for its biologists to carry out tagging/radio-telemetry activities.

Fish Relocation

During the stock Preservation Phase, when turbidity and sediment loads are anticipated to be fatal or otherwise harmful to fish, it may be desirable to relocate returning adults from areas of higher turbidity to more protected areas. When conditions exist that are determined to be detrimental to naturally migrating fish, NPS will collaborate with the WDFW the Tribe to relocate fish from the lower river to Little River, Indian Creek, or other areas of the watershed that may be accessible and appropriate for the species of interest. The numbers of fish moved will be dependent upon the size of the return, the needs of the hatchery program (for Chinook only), and the estimated production capacity of the receiving area.

The NPS may fund the Tribe to help with fish relocation.

Habitat/Ecosystem Monitoring

Fish Pathology

Monitoring of fish health in the Elwha River Basin will be conducted annually for five years, beginning in 2013, by the USFWS Wild Fish Health Center. Fish collection will occur in the lower, middle, and upper reaches of the Elwha River. The annual monitoring program for fish pathology is designed to test for the presence and distribution of bacteria, viruses, and for *Myxobolus cerebralis*. The primary emphasis will be on Pacific salmonids. At a minimum, samples will be collected at the 11 locations previously sampled by Brenkman et al.(1) (2008). This 5-year period is intended to cover the period expected to have the highest influence of hatchery origin spawners above the former Elwha Dam site.

Laboratory analysis will be conducted to determine presence of regulated pathogens, including infectious pancreatic necrosis virus (IPNV), infectious hematopoietic necrosis virus (IHNV), and viral hemorrhagic septicemia virus (VHSV). These analyses will also determine the presence of *Aeromonas salmonicida* (the causative agent of furunculosis), *Yersinia ruckeri* (the causative

agent of red mouth disease), *Renibacterium salmoninarum* (the causative agent of bacterial kidney disease [BKD]), and *Myxobolus cerebralis* (the causative agent of whirling disease). For more detailed information regarding the laboratory procedures, please refer to the National Wild Fish Health Survey (NWFHS) Laboratory Procedures Manual (Puzach 2006).

Independent of this monitoring plan, it is anticipated that both the WDFW and the Tribe will fully implement the Washington State Fish Health policy, which includes a detailed monitoring approach for fish pathogens in hatchery programs. The information collected from both the hatchery and basin monitoring will be compared to baseline surveys in the Elwha River to complete a risk assessment of fish pathogen distribution in the basin.

The NPS may fund USFWS or USGS to perform the fish pathology studies.

Habitat Assessments

Removal of the two Elwha River dams will mobilize millions of cubic meters of sediment and organic debris over a very short timeframe resulting in dramatic changes over time. A number of tools and methods have been developed to assess changes in habitat quantity and quality. These methods can be broadly divided into three habitat categories: spawning habitat (quantity and quality), rearing habitat (quantity and quality), and water quality. NPS intends to employ a selection of the methods to investigate habitat changes associated with dam removal. In doing so, we will collaborate with other related work ongoing in the basin to maximize the utility of the information collected. Protocols for those methods employed will be developed prior to the commencement of field activities.

Particle size distributions and residual pool depths are two indicators that may be used to measure spawning habitat quantity. The tools used to derive these indicators are generally pebble counts and main stem residual pool depth. Streambed particle composition should be quantified for “full spanning” riffles.

Rearing habitat can be characterized by six habitat types for the main stem Elwha River: pools, riffles, and glides in mid-channel; and bank edges, bar edges, and backwaters along the channel margins. The quantity of each habitat type available in the river below the dams can be derived from field measurements or from high resolution aerial photos. Cover within each habitat unit can be classified broadly as single pieces of large wood (minimum dimensions), large wood accumulations, small wood accumulations, vegetation (live aquatic and terrestrial vegetation within the water column), and rock (i.e., cobble size or greater). Each cover element will be measured for surface area.

Substrate size within each primary unit is often classified as the number of unique areas of specific size as well as percent substrate composition within the unit. Substrate sizes are usually classified as sand/silt, gravel, cobble, or boulder. Each area of unique and relatively uniform substrate size (i.e., 70%) within the habitat unit can be classified by size and measured for surface area. This information is then compiled to estimate the percentage of substrate composition for each habitat unit.

Temperature monitoring has been conducted for a number of years by the Tribe in tributary and side channel sites. It is desirable that this monitoring continue as thermal conditions in the lower river have been linked to high fish mortality in the past. Further, elevated temperatures may exacerbate the effects of elevated turbidity and suspended sediment loads on migrating adults during the stock Preservation Phase.

The USGS, in cooperation with the NPS, is monitoring turbidity levels in the Elwha River at three stream gauge locations (#12044900, Elwha River above Lake Mills; #12045500, McDonald Bridge; and #12046260, Elwha River at Diversion) using an array of on station monitoring equipment. In addition to the standard Digital Turbidity Sensor (DTS) suitable for low to moderate suspended sediment levels, there are also Acoustic Doppler Current Profiler (ADCP) and Laser In Situ Scattering and Transmissometery (LISST) instrumentation for the high concentration turbidity range. These gauges will continue to operate at least through the stock Preservation Phase as part of the Elwha Project's sediment monitoring strategy.

The NPS may fund the Tribe to conduct the habitat assessments.

Challenges to Implementation

During the period of delta erosion, turbidity has exceeded 1,000 parts per million (ppm) for extended periods of time. Modeling conducted by the Bureau of Reclamation estimates that turbidity will periodically exceed 10,000 ppm during the final stages of dam removal and may exceed 30,000 ppm for short durations (BOR 1996). Most of the finer material will be flushed out of the system after the first major flood event.

At relatively low levels of suspended sediment loading (50 – 100 ppm) which occur naturally in the Elwha River, fish may stop feeding, suffer from gill abrasion, and suffer a loss of fitness due to stress (Cook-Tabor 1995). At higher levels of turbidity, more serious effects on fish health are observed, including mortality directly associated with turbidity at levels higher than 1,000 ppm (Cook-Tabor 1995).

Coarser sediment will move downstream for a period of years following dam removal, with elevated bedloads anticipated for up to 10 years (BOR 1996). Significant aggradation is expected in some areas, with permanent increases of up to 1 meter in bed elevation in lower gradient areas. The river channel in some reaches below the dam may destabilize during this time, resulting in temporary decreases in the quality of natural fish habitat, including loss of pools.

Rapidly changing conditions in the historic reservoir beds and stream channel below the two dams present a challenging and potentially dangerous work environment. Accelerated erosion of stream banks has been observed recently, while accumulations of very fine sediment or large woody debris can make foot travel in certain areas inadvisable. This type of uncertainty is expected to continue into the future. Therefore, this monitoring plan has been developed to be flexible from year to year, and even month to month. Safety will be an overarching consideration before initiating any proposed activity, and will continually be monitored and assessed to determine whether the activity should be limited or discontinued at any time.

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Table 3. Tools and methods by other agencies useful for monitoring the abundance of salmon.

Abundance Indicator	Tools	Method	Sampling Area	Extent of Tributary Sampling	Period of Monitoring	Frequency of Sampling	Leads	Data Mgmt	Annual Cost	Limitations
Harvest	Ocean catch reporting	Backwards FRAM	SEAK, CAN, and US fisheries	N/A	Jan – Dec	Daily	WDFW DFO ADFG	CTC	N/A	Unknown accuracy or precision
	Terminal area catch reporting	User catch reports	All river areas open to fishing	N/A	Jul – Oct	Daily	WDFW LEKT	WDFW LEKT	N/A	Rely on accurate user reports
Broodstock	Broodstock collection	Count	Near WDFW Hatchery	None	Sept	Daily	WDFW	WDFW	N/A	Low visibility below dam sites
Hatchery Rack	Hatchery rack return	Count	WDFW/LEKT/Morse Facilities	None	Jul-Oct	Daily	WDFW LEKT	WDFW	N/A	N/A
Spawning escapement	Foot surveys (redd, live count)	Area under curve	Mouth to Glines Canyon Powerhouse	Bosco upstream to Long Creek	Aug-Oct	7-10	WDFW LEKT/ ONP	WDFW	$24K	Low visibility below dam sites
	DIDSON SONAR	Count or bootstrap for missing hours/day	Mouth, above Elwha dam site	None	Feb-Oct	Daily	NOAA/ LEKT	NOAA LEKT	$200,000 for 2 sites + $80,000 yr 1 for second DIDSON	Species identification & composition difficult
	Weir	Count	Rkm 6	None	Feb-Oct.	Daily	WDFW	WDFW	$281K	Trap aversion
	Weir + Smolt Trap	Parentage Genetic Mark Recapture	Entire watershed	All	Weir: Feb-Oct Smolt Trap: Jan - June	Daily	WDFW LEKT	WDFW LEKT	$65K	Representative sample of entire juvenile outmigration
	Aerial redd surveys	Peak count	Rkm 0.0 to 65	TBD	Aug-Sep	1-2flights	ONP	ONP	$1K	Low visibility below dam sites
	Boat surveys (redd, live count)	Count; redd life measure	Rkm 0.0 to 25	None	Aug-Oct	Weekly	WDFW	WDFW	See foot surveys	Low visibility below dam sites

Table 4. Tools and methods by other agencies useful for monitoring the annual stock composition of salmon.

Stock Composition Indicator	Tools	Method	Sampling Area	Extent of Tributary Sampling	Period of Monitoring	Frequency of Sampling	Leads	Data Mgmt	Annual Cost	Limitations
pNOS	Carcass sampling (weir, surveys)	Thermal otolith mark interpretation	River	Representative	Aug - Oct	Weekly	WDFW LEKT ONP	WDFW	$4.2K for analysis	Clarity of thermal mark
		CWT recovery & reading	River	Representative	Aug – Oct	Weekly	WDFW LEKT ONP	WDFW (RMIS)	N/A	Tag loss
PNI	Carcass sampling (weir, surveys)	Thermal otolith mark interpretation	River, Hatchery	Representative	Aug - Oct	Weekly	WDFW LEKT ONP	WDFW	$4.2K for analysis	Clarity of thermal mark
		CWT recovery & reading	River, Hatchery	Representative	Aug – Oct	Weekly	WDFW LEKT ONP	WDFW (RMIS)	N/A	Tag loss

Table 5. Tools and methods by other agencies useful for monitoring the productivity of Elwha River Chinook salmon.

Productivity Indicator	Tools	Method	Sampling Area	Extent of Tributary Sampling	Period of Monitoring	Frequency of Sampling	Leads	Data Mgmt	Annual Cost	Limitations
Freshwater productivity	Smolt Trap	Mark-recapture	River mouth	None	Jan – Aug	Daily	LEKT	LEKT (JMX)	$60K	Missed catch due to hatchery releases
	Spawner Escapement	Parentage Genetic Mark Recapture	Entire watershed	All	Weir: Feb-Oct Smolt Trap: Jan - June	Daily	WDFW LEKT	WDFW LEKT	See table 3	Representative sample of entire juvenile outmigration
Spawner Recruit per Spawner	Carcass sampling (Weir, Foot & Boat Surveys)	Thermal otolith mark interpretation	River, Hatchery	Representative	Aug - Oct	Weekly	WDFW LEKT ONP	WDFW (SGS)	$30K for analysis	Clarity of thermal mark
		CWT recovery & reading	River, Hatchery	Representative	Aug – Oct	Weekly	WDFW LEKT ONP	WDFW (RMIS)	N/A	Tag loss
		Scale analysis	River, Hatchery	Representative	Aug – Oct	Weekly	WDFW LEKT ONP	WDFW	N/A	Clarity of scale annuli
	Spawner Escapement	Parentage Genetic Mark Recapture	Entire watershed	All	Weir: Feb-Oct Smolt Trap: Jan - June	Daily	WDFW LEKT	WDFW LEKT	See table 3	Representative sample of entire juvenile outmigration
Pre-fishing Recruit per Spawner	Ocean catch reporting	Backwards FRAM	SEAK, CAN, and US fisheries	N/A	Jan – Dec	Daily	WDFW DFO ADFG	CTC	See table 3	Unknown accuracy or precision
	Terminal area catch reports and sampling	User catch reports	All river areas open to fishing	N/A	Jul – Oct	Daily	WDFW LEKT	WDFW LEKT	See table 3	Rely on accurate user reports
	Hatchery rack return	Count	WDFW LEKT Morse	None	Jul-Oct	Daily	WDFW LEKT	WDFW	N/A	N/A
	Broodstock collection	Count	Near WDFW Hatchery	None	Sept	Daily	WDFW	WDFW	N/A	Low visibility below dam sites
	Carcass sampling (Weir, Surveys)	Otoliths, CWT, Scales	River, Hatchery	Representative	Aug - Oct	Weekly	WDFW LEKT ONP	WDFW LEKT ONP	See above	N/A
	Spawner Escapement	Parentage Genetic Mark Recapture	Entire watershed	All	Weir: Feb-Oct Smolt Trap: Jan - June	Daily	WDFW LEKT	WDFW LEKT	See table 3	Representative sample of entire juvenile outmigration

Table 6. Tools and methods by other agencies useful for monitoring the diversity of Elwha River Chinook salmon.

Stock Composition Indicator	Tools	Method	Sampling Area	Extent of Tributary Sampling	Period of Monitoring	Frequency of Sampling	Leads	Data Mgmt	Annual Cost	Limitations
Genetic Diversity	Carcass sampling (weir, surveys)	Number of alleles	River, Hatchery	Representative	Aug - Oct	Weekly	WDFW LEKT ONP	WDFW (SGS)	$9K for genetics	Assume HW Eq.
		Expected heterozygosity	River, Hatchery	Representative	Aug – Oct	Weekly	WDFW LEKT ONP	WDFW (RMIS)	See above	Assume HW Eq.
Life History Diversity	Carcass sampling (weir, foot and boat surveys)	Scale analysis	River, Hatchery	Representative	Aug - Oct	Weekly	WDFW LEKT ONP	WDFW	N/A	Clarity of scale annuli
	DIDSON SONAR	Count or bootstrap for missing hours/day	Mouth	None	Feb-Oct	Daily	NOAA/ LEKT	NOAA LEKT	See table 3	Species identification & composition difficult
	Weir	Count	Rkm 6	None	Feb-Oct.	Daily	WDFW	WDFW	See table 3	Trap aversion

Table 7. Habitat metrics that will be used by other agencies to help identify changes in the quantity and quality of aquatic habitat in the Elwha River

Habitat category	Indicator	Tools	Methods	Sampling area	Monitoring period	Sampling Frequency	Lead	Data Mgmt	Annual cost	Limitations
Spawning habitat quantity	Particle Size Distribution	Pebble counts	Quantification of proportion of spawnable area by species for each riffle crest.	Lower, Middle, and portions of Upper Elwha.	Low flow (Aug-Sept)	Annual	NOAA	NOAA	$15,000	Does not incorporate all spawnable areas
	Residual Pool Depth	Main stem residual pool depth	Cumulative distribution of pool depths	Lower, Middle, and portions of Upper Elwha.	Low flow (Aug-Sept)	Annual				
Spawning habitat quality	% fine sediment (less than 2mm)	Bulk sampling	Quantification of % less than 2mm at a subset of riffle crests.	Lower, Middle, and portions of Upper Elwha.	Low flow (Aug-Sept)	Annual	USFWS	NOAA	$60,000	Does not incorporate all spawnable areas
Rearing habitat area	Proportion of slow/ shallow water habitats	Remote sensing and wadable stream habitat surveys, longitudinal profiles, bathymetry for main stem	Quantification of slower water habitat area in mainstem & floodplains	Lower, Middle, and portions of Upper Elwha.	Low flow (Aug-Sept)	Bi-annual	BOR, LEKT, NOAA	NOAA, BOR	$15,000 (cost does not include BOR)	Will not include all habitats
Rearing habitat quality	Residual pool depth	Remote sensing ; wadable stream habitat surveys, longitudinal profiles, bathymetry for main stem	Variation in residual pool depth	Lower, Middle, and portions of Upper Elwha.	Low flow (Aug-Sept)		BOR, LEKT, NOAA	NOAA, BOR	$30,000 (cost does not include BOR)	Will not include all habitats
	Habitat complexity		Increased habitat complexity as determined by change in cover							

Table 7. Continued.

Habitat category	Metric	Tools	Methods	Sampling area	Monitoring period	Sampling Frequency	Lead	Data Mgmt	Annual cost	Limitations
Water quality	Stream temp.	Thermograph in mainstem locations to assess longitudinal changes	Proportion of time above identified thresholds	Lower, Middle, and portions of Upper Elwha.	continuous		LEKT	LEKT, NOAA		
	Turbidity	Turbidity gage (2), optical sensor	Proportion of time above identified thresholds	Mainstem Upper Elwha above former Lake Mills. Mainstem Elwha below both at Rkm 5.	15 minute intervals		USGS		$30,000/yr for 6 years	Limited to 2 points locations in the Mainstem. (No funding after 6 years)
		Portable turbidity meter	Proportion of time above identified thresholds	Lower and Middle Elwha. 14 locations.	daily		NOAA		~$20,000/yr for 14 locations	Daily point estimates. Funding ends 2013
		Conductivity, temperature, and depth sensors with turbidity gage (4), SET datapins (14)	Proportion of time above identified thresholds	Estuary - 4 locations	15 minute intervals		USGS, LEKT		~$15,000/yr ~$10,000/yr	Funding ends 2013
		Multi-instrument tripods (2)	Proportion of time above identified thresholds	Nearshore	15 minute intervals		USGS		~$20,000/yr	Funding ends 2013
		Turbidity data to suspended load	Calibrate to suspended load	Mainstem Elwha below both at Rkm 5.	Monthly		USGS		~$30,000/yr	Funding ends 2013

Table 8. Ecosystem response metrics that will/could be used by NOAA and USGS to help identify ecological changes post Elwha River dam removal.

Category	Indicator	Tools	Methods	Lead	Frequency	Annual Cost	Limitations
Primary productivity	Periphyton density	Rock cobble sampling	Gravimetric determination of ash-free dry mass (AFDM)	NOAA USGS	Semi-annually	~ $20,000	Standing crop only; highly variable
	Algal density	Rock cobble sampling	Pigment analysis of chlorophyll-*a* via fluorometry	NOAA USGS	Semi-annually	Included in above	Standing crop only; funding ends 2013
	Microbial community structure	Rock cobble sampling	Biolog microtiter system and PCR analyses for functional and genetic diversity	None	Semi-annually	Unknown	Lack of expertise, funding
	Diatom taxonomic composition	Rock cobble sampling	Slide-mount of sub-sample (800 valves), identification to species or genus	USGS NOAA	Semi-annually	$18,000	Lack of funding
Secondary productivity	Invertebrate Density	Benthic Slack net sampling	Invertebrate enumeration and measurement	USGS NOAA	Quarterly	~ $20,000	Standing crop only; highly variable
	Taxonomic composition	Benthic Slack net sampling	Identification to lowest practical taxonomic level	USGS NOAA	Quarterly	$15,000	Funding ends 2013
Nutrient dynamics	Total nitrogen, phosphorous	Water grab samples	Continuous flow Alpkem RFA/2 system, persulfate digestion	USGS NOAA	Semi-annually	~ $5,000	Daily point estimate
	Dissolved NO_3, NO_2, NH_4, PO_4	Water grab samples	Continuous flow Alpkem RFA/2 system	USGS NOAA	Semi-annually	~ $5,000	Daily point estimate
	δ^{15N} δ^{13C}	Tissue from multiple trophic levels	Isotope ratio mass spectroscopy with elemental analyzer	USGS NOAA	Semi-annually	~ $35,000	No funding
Fish diet	Prey selectivity, diet overlap	Gastric lavage	Invertebrate enumeration and measurement	NOAA USGS	Quarterly	~ $28,000	Funding ends 2013
	Invertebrate Density	Drift net sampling	Invertebrate enumeration and measurement	NOAA USGS	Quarterly	~ $5,000	Highly variable
	Taxonomic composition	Drift net sampling	Identification to lowest practical taxonomic level	NOAA USGS	Quarterly	$15,000	Funding ends 2013