

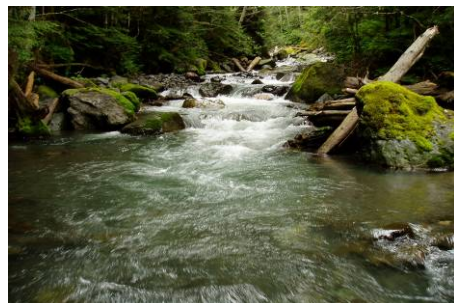
**Stream Fish Inventories
2001 to 2003,
North Cascades National Park
Service Complex and Mount
Rainier National Park,
Washington**

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September 2007



United States Department of the Interior
National Park Service



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**Funding Sources:
National Park Service Inventory and Monitoring, North Coast and Cascades Network
Mount Rainier National Park Base Funds
North Cascades National Park Service Complex Base Funds**

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Acknowledgements

This inventory was funded by the National Park Service. Thanks to Hugh Anthony, Andrew Beckman, Steve Borego, Pat Buller, Chris Clark, Mike Florin, Reed Glesne, Scott Hastie, Heather Moran, Ashley Rawhouser, Mike Ward, Carmen Welch and Stefan Wodzicki for their assistance with inventory and sampling, and Natasha Antonova for preparation of GIS-based graphics. In addition, special thanks to Lise Grace, Reed Glesne and Barbara Samora for review and editing assistance of this document.

Executive Summary

Stream fish populations are an important component of biological integrity from both ecosystem and public interest perspectives and are good indicators of ecological health. In North Cascades National Park Service Complex (NOCA) and Mount Rainier National Park (MORA), fish populations contribute to recreational fisheries and are of aesthetic importance. Currently specific information related to presence and distribution of stream fish populations in NOCA and MORA is limited and generally dated. Species occurrence and spatial distributions are necessary to understand ecological interactions among species to make informed management decisions related to fish and aquatic resources. The lack of scientific information on spatial distributions of fish species poses challenges for resource managers related to biological diversity issues and compliance under the Endangered Species Act.

This report summarizes a three-summer effort of stream sampling somewhat concentrated in NOCA and distributed near the perimeter of MORA. Stream selection favored streams that had little or no current fish population information. The purpose of the surveys was to begin a more comprehensive assessment of stream fish species presence and abundance in the two Parks. Specific objectives of this study were to:

- 1) Identify pool-sampling units for the fish abundance objective.
- 2) Evaluate relationships between stream habitat characteristics and diver and electrofishing capture probabilities.
- 3) Investigate relationships between stream width, gradient, and large woody debris with the number of qualifying pools in a reach (consideration for determining sampling effort for the fish abundance objective).
- 4) Evaluate relationships of habitat attributes to fish species distributions and abundance.
- 5) Provide additional stream habitat inventory data for NOCA and MORA streams.

These stream inventories are a thorough, yet incomplete representation of the composition of fish species in 14 tributaries in 2 large river systems in NOCA and 10 tributaries in 5 large river systems in MORA. The detection of 7 fish species in these basins was consistent with known distribution patterns for each species. The presence of non-native brook trout in surveyed streams was limited to Hozomeen Creek in NOCA and Paradise River and MO-04 (Mowich River tributary) in MORA. Native char (Dolly Varden/bull trout) were observed in 6 tributaries in NOCA and 1 tributary in MORA.

Additional spatial and temporal sampling is necessary to document species assemblage throughout both Parks. Knowledge of fish distribution is essential in the development of future monitoring efforts to detect trends in species distribution and composition in wadeable streams in NOCA and MORA. Information related to species occurrence and spatial distribution is necessary to understand ecological interactions among species, to

address the extent of non-native fish invasions, and to make informed management decisions regarding fish resources.

North Cascades National Park Service Complex

Fish Inventory surveys in North Cascades National Park Service Complex included: **single-pass snorkeling** in 7 tributaries to the upper Skagit River, 5 tributaries to Ross Lake (reservoir in the upper Skagit River), and 2 tributaries to the upper Stehekin River; **four-pass snorkeling** in 4 tributaries to the upper Skagit River, 5 tributaries to Ross Lake, and 2 tributaries to the upper Stehekin River; and **three-pass (minimum) electrofishing** in 2 tributaries to the upper Skagit River, 2 tributaries to Ross Lake, and 1 tributary to the upper Stehekin River.

Fish observed in the upper Skagit River tributaries included: rainbow trout (*Oncorhynchus mykiss*) in all 7 surveyed streams; bull trout (*Salvelinus confluentus*) / Dolly Varden (*Salvelinus malma*) in 4 surveyed streams; coho salmon (*Oncorhynchus kisutch*) in 2 surveyed streams; and mountain whitefish (*Prosopium williamsoni*) in 1 surveyed stream. Fish observed in the Ross Lake tributaries included: rainbow trout in 3 (of 5) surveyed streams; westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in 1 surveyed stream; bull trout / Dolly Varden in 2 surveyed streams; and brook trout (*Salvelinus fontinalis*) in 1 surveyed stream. Fish observed in the 2 Stehekin River tributaries surveyed were all westslope cutthroat trout.

Mount Rainier National Park

Stream Fish Inventory surveys in Mount Rainier National Park included: **single-pass snorkeling** in 2 tributaries to the upper White River, 2 tributaries to the upper Carbon River, 2 tributaries to the upper Cowlitz River, 2 tributaries to the upper Nisqually River, and 2 tributaries to the upper Puyallup River; **four-pass snorkeling** in 2 tributaries to the upper White River, 2 tributaries to the upper Carbon River, 2 tributaries to the upper Cowlitz River, 2 tributaries to the upper Nisqually River, and 2 tributaries to the upper Puyallup River; and **three-pass (minimum) electrofishing** in 1 tributary to the upper Carbon River, and 1 tributary to the upper Nisqually River.

Fish observed in the upper White River tributaries included unspecified *Oncorhynchus* sp. (cutthroat or rainbow) in both surveyed streams. Fish observed in the upper Carbon River tributaries included: cutthroat trout (*Oncorhynchus clarkii*) in 1 of 2 surveyed streams; bull trout (*Salvelinus confluentus*) / Dolly Varden (*Salvelinus malma*) in 1 surveyed stream; and sculpin (*Cottus* sp.) in 1 surveyed stream. No fish were observed in a second surveyed stream (Tolmie Creek). Fish observed in the upper Cowlitz River tributaries included: cutthroat trout in 1 of 2 surveyed streams; and unspecified *Oncorhynchus* sp. (cutthroat or rainbow) in the other surveyed stream. Fish observed in the upper Nisqually River tributaries included: cutthroat trout in both surveyed streams; unspecified *Oncorhynchus* sp. (cutthroat or rainbow) in Paradise River the second time it was surveyed (2003), these were identified as cutthroat during the first survey (2001); brook trout (*Salvelinus fontinalis*) in 1 surveyed stream; and sculpin in 1 surveyed stream. Fish observed in the

upper Puyallup River tributaries included: rainbow trout (*Oncorhynchus mykiss*) in 1 of 2 surveyed streams; cutthroat trout in both surveyed streams; brook trout in 1 surveyed stream; and sculpin in 1 surveyed stream.

Introduction

Inventory and monitoring of stream resident fish populations in parks of the National Park Service (NPS) North Coast and Cascade Network has been identified as an important objective by network resource management staff. Fish represent a significant component of biological integrity from both ecosystem and public interest perspectives and are good indicators of ecological health. Fish populations within North Cascades National Park Service Complex (NOCA) and Mount Rainier National Park (MORA) are recreationally and aesthetically important and contribute to recreational fisheries. NOCA and MORA contain some of the only undisturbed habitat throughout the range of numerous fish species. Funding was secured from the NPS Network Inventory and Monitoring Programs and (NOCA) Long-Term Ecological Monitoring Program.

The primary goals of the stream fish inventory study were to provide additional information concerning freshwater fish occurrence and distribution at NOCA and MORA and to begin development of long-term monitoring protocols.

There is little specific information related to presence and spatial distributions of fish species throughout NOCA and MORA. Species occurrence and spatial distributions are necessary to understand ecological interactions among species to make informed management decisions related to fish and aquatic resources. The lack of scientific information on spatial distributions of fish species poses challenges for resource managers related to biological diversity issues and compliance under the Endangered Species Act.

North Cascades National Park Service Complex

The Fish Inventory surveys were spread throughout NOCA. Most of the inventoried streams were major tributaries in the upper Skagit River (including tributaries to Ross Reservoir) and Stehekin River watersheds.

A total of 24 native freshwater fish species have been observed in NOCA rivers, streams, and lakes including: five species of Pacific salmon: chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), sockeye (*Oncorhynchus nerka*), chum (*Oncorhynchus keta*), and pink salmon (*Oncorhynchus gorbuscha*); and rainbow or steelhead trout (*Oncorhynchus mykiss*); cutthroat trout (*Oncorhynchus clarkii*); golden trout (*Oncorhynchus aguabonita*); lake trout (*Salvelinus namaycush*); bull trout (*Salvelinus confluentus*); Dolly Varden (*Salvelinus malma*); longnose sucker (*Catostomus catostomus*); largescale sucker (*Catostomus macrocheilus*); coastrange sculpin (*Cottus aleuticus*); prickly sculpin (*Cottus asper*); slimy sculpin (*Cottus cognatus*); threespine stickleback (*Gasterosteus aculeatus*); burbot (*Lota lota*); pygmy whitefish (*Prosopium coulterii*); mountain whitefish (*Prosopium williamsoni*); northern pikeminnow (*Ptychocheilus oregonensis*); longnose dace (*Rhinichthys cataractae*); peamouth (*Mylocheilus caurinus*); and redbside shiner (*Richardsonius balteatus*). The presence of the above species is based on published and unpublished studies summarized in the NOCA fisheries database.

Hatchery strains of rainbow, inland cutthroat trout and eastern brook trout (*Salvelinus fontinalis*) were widely stocked throughout the park and may have hybridized or replaced native stocks within their historic ranges.

Mount Rainier National Park

The Fish Inventory surveys were spread near the perimeter of MORA. The inventoried streams were well distributed with at least one survey in each major basin (with the exception of the West Fork of the White River).

Nineteen species potentially occur within MORA. Six species (32%) have been verified. Native salmonids include: chinook; coho, and rainbow or steelhead trout, coastal cutthroat trout (*Oncorhynchus clarkii clarkii*), and bull trout and/or Dolly Varden. Five species of salmonids are listed as special status species (bull trout, chinook, coho, cutthroat, and steelhead). Mountain whitefish and several species of sculpins (*Cottus sp.*) also occur within the park.

The hatchery strains of rainbow, inland cutthroat trout and eastern brook trout were widely stocked throughout the park and may have hybridized or replaced native stocks within their historic ranges.

Construction of the Electron Dam on the Puyallup-Mowich drainage and Alder and LaGrande Dam on the Nisqually River has blocked anadromous passage to these rivers and their upstream tributaries within the park. Mud Mountain Dam on the White River also blocks fish passage, but anadromous fish (chinook, coho, and steelhead) are transported around the dam, thereby allowing access to the upper White River, West Fork of the White River, and Huckleberry Creek basins. Dams at Riffe Lake and Mayfield Lake block salmon migration in the Cowlitz and Ohanapecosh Rivers. However, coho salmon are transported around the dams. The Carbon River is the only major drainage without man-made dams blocking fish passage. Both steelhead and coho are found in the upper Carbon River.

Fish stocking continues on lands located outside of the park. Hatchery reared cutthroat stock continue to be stocked in Huckleberry Creek. The non-native kokanee salmon (*Oncorhynchus nerka*) is stocked in the Nisqually watershed and have been observed spawning in streams inside the park. Other streams adjacent to the park are also stocked with mostly salmonid species and have the potential to enter park streams. Non-native species of sculpins have been introduced into the park in the past and are likely present in park streams today.

More recent observations of fish in a limited number of streams have been documented since 1989 (Samora personal communication). Non-native fish have also been documented in at least 29 lakes (Samora personal communication).

Stream Fish Inventory Objectives

The primary goals of the stream fish inventory study were to provide additional information concerning freshwater fish occurrence and distribution at NOCA and MORA and to begin development of long-term monitoring protocols. Two different objectives were identified to meet Park Service monitoring needs. The first objective focuses on a quantitative approach that provides a reach-wide estimator of abundance of fish from pool habitats within standard reaches (***standard reach – a relatively homogenous section of stream having a repetitious sequence of habitat types and relatively uniform physical attributes such as channel slope, habitat width, habitat depth, streambed substrate, and degree of interaction with its floodplain***). The second objective provides a qualitative/semi-quantitative approach that focuses on monitoring species distributions using frequency of occurrence of a particular species among 100 meters sample units within a standard reach. In this study reach level data were collected following U.S. Forest Service Level II Stream Inventory method (Hankin and Reeves 1988) with additional data collected at qualifying pools following a combination of USFS Level II Stream Inventory method and Timber, Fish and Wildlife Ambient Monitoring Program method (Pleus et al. 1999). This habitat information was collected to:

- Identify pool-sampling units for the fish abundance objective.
- Evaluate relationships between stream habitat characteristics and diver and electrofishing capture probabilities.
- Investigate relationships between stream width, gradient, and large woody debris with the number of qualifying pools in a reach (consideration for determining sampling effort for the fish abundance objective).
- Evaluate relationships of habitat attributes to fish species distributions and abundance.
- Provide additional stream habitat inventory data for NOCA and MORA streams.

Study Area

The Stream Fish Inventories sampled all but one major watershed in both NOCA and MORA. The Chilliwack River drainage (NOCA) was extensively surveyed for habitat and fish in the summers of 1998 to 2000 and was not covered in this inventory. The West Fork of the White River (MORA) did not have a sample site within its boundaries.

North Cascades National Park Service Complex

North Cascades National Park (204,374 hectares), Ross Lake National Recreation Area (47,350 hectares) and Lake Chelan National Recreation Area (25,091 hectares) comprise what is referred to as the North Cascades National Park Service Complex (NOCA). The Park Complex was established on October 2, 1968. The Washington Park Wilderness Act of 1988 established 256,828 hectares of the Complex as the Stephen Mather Wilderness. There are five designated and two proposed Research Natural Areas.

The Park Complex is located in the North Cascade physiographic province, in northwestern Washington. It is surrounded on the west, south and east by 1.9 million hectares of national forest lands, of which 763,890 hectares are designated wilderness. Most of these wilderness areas are contiguous to the Stephen Mather Wilderness. NOCA's northern boundary is the international boundary with the Canadian province of British Columbia. Adjacent to the boundary in British Columbia there are provincial forestlands, a recreation area, and just to the east is a provincial park.

The North Cascades National Park Service Complex spans the Cascade crest, placing within its boundary two major biogeographic zones: temperate marine and semi-arid continental. The climatic and biotic diversity is further increased by a third, transitional zone, roughly the lower elevations of the Ross Lake drainage, created by an orographic divide west of the crest. Vegetal and climatic characteristics within this zone are intermediate between the mild, wet conditions typical of the west side and the semi-arid conditions typical of the east side.

Deep, forested valleys between high, glaciated mountain peaks, characterize the Park Complex. The bedrock geology of the North Cascades differs drastically on either side of the Straight Creek Fault. West of the fault, the Shuksan metamorphic suite is composed of greenschist and phyllite. East of the fault are granite and gneiss, which compose the crystalline core of the North Cascades. The Park Complex has been shaped by a combination of uplifting of predominately granitic formations and substantial glaciation. Watersheds typically begin in high elevation glaciers and snow fields, dropping in numerous cascading streams down precipitous valley walls to classic U-shaped valley floors carved by glaciers during the Pleistocene. Mainstem streams are generally sinuous and braided across relatively broad, flat valley bottoms.

Precipitation is variable across elevation gradients and the crest of the North Cascade Range, with a maximum average of about 400 centimeters per year on the western peaks to

a minimum average of 50 centimeters per year in the Lake Chelan corridor. The intermediate zone within the lower elevations of the Ross Lake basin typically averages between 100 and 150 centimeters of precipitation per year; the slopes to the west and east of the valley typically receive 150 to 200 centimeters of precipitation per year.

A 1971 inventory identified 318 glaciers in the North Cascades NPS Complex (Post et al., 1971), more than in all of the other national parks within the conterminous states combined. A follow up inventory in 1998 identified 316 glaciers covering 109 square kilometers (Jon Riedel personal communication). Maps of former glacier boundaries indicate that the glaciated area of the park has declined approximately 40% in the last 150 years. Four of the glaciers and their contribution to stream flow have been monitored since 1993 (Jon Riedel personal communication).

One of the most notable characteristics of the North Cascades National Park Service Complex is its abundance and diversity of aquatic habitats. There are over 500 ponds and lakes, and approximately 6,500 kilometers of rivers and streams (excluding intermittent streams, which may increase the total to over 10,000 kilometers) located in the Park Complex. NOCA watersheds eventually flow into four major river systems: Columbia River, Fraser River, Skagit River and Nooksack River. There are three reservoirs within Ross Lake NRA, all behind dams built to provide hydroelectric power. A small hydroelectric project on Newhalem Creek provides further power via a stream diversion. Lake Chelan, which developed within a deep glacial trough, is the third deepest natural lake in the United States. It was dammed in the 1920's to regulate its elevation for hydroelectric power. Chelan PUD operates a small stream diversion hydroelectric facility on Company Creek (a tributary to the Stehekin River). All four reservoirs (Gorge, Diablo, Ross and Chelan) provide recreation opportunities and transportation routes as well as power. Dams also influence stream processes downstream, and the migration of fish throughout the watershed. Reservoirs affect microclimate, cause erosion of terrestrial habitat and limit the ranges of terrestrial species.

The abundance of water and the wide variation in landforms, soil types, elevation, slope and aspect all support a great diversity of flora and fauna. There are 81 mammal species, 214 bird species, 28 fish species, 21 reptile and amphibian species and some 1,400 species of vascular plants within the Park Complex. Of these, 5 mammal, 7 bird, 1 amphibian, 3 fish and 16 plant species are listed federally or by Washington State as sensitive, threatened or endangered; an additional 4 mammal, 9 bird, 1 fish and 1 amphibian species are candidates for State and/or federal listing. Primary fish species inhabiting the park include all five species of pacific salmon, steelhead and rainbow trout, cutthroat trout, and bull trout. The natural distribution of fish within the park has been altered by construction of dams and by introduction of hatchery fish into waters that were previously barren of fish.

Mount Rainier National Park

Mount Rainier National Park encompasses 235,625 acres on the west-side of the Cascade Range, and is located about 100 kilometers (50 miles) southeast of the Seattle-Tacoma metropolitan area. The park was established in 1899 to "*...provide for the preservation from injury or spoliation of all timber, mineral deposits, natural curiosities, or wonders...and their retention in their natural condition...grant parcels of ground at such places shall require the erection of buildings for the accommodation of visitors...provide against the wanton destruction of the fish and game found in the park*" (Mount Rainier National Park Act 1899). As directed by the NPS Organic Act, the Redwood Act for Expansion and its enabling legislation, the major activities conducted by Mount Rainier National Park are the protection and preservation of natural and cultural resources and the provision for use of the park by visitors. Mount Rainier National Park is approximately 97 percent wilderness and 3 percent National Historic Landmark District and receives approximately 2 million visitors per year.

At 14,411 feet (4,393 meters), Mount Rainier is the most prominent peak in the Cascade Range. It dominates the landscape of a large part of western Washington State. The mountain stands nearly three miles higher than the lowlands to the west and one and one-half miles higher than the adjacent mountains. It is an active volcano that last erupted approximately 150 years ago.

Mount Rainier National Park is located in the central Cascade Mountains of western Washington. The park is surrounded mostly by U.S. Forest Service lands (87%), with 33% of these lands designated as Wilderness. Thirteen percent of lands surrounding the park are held in private ownership. Within the park, 97% of the lands are designated as the Mount Rainier Wilderness (228,480 acres). The topography of the park is rugged and precipitous, consisting mainly of peaks and valleys. Nine major rivers and their tributaries drain the flanks of the mountain. These include the Nisqually, Puyallup, Mowich, Carbon, West Fork, Huckleberry, White, Ohanapecosh, and Muddy Fork Rivers. The Ohanapecosh and Huckleberry are the only non-glacial rivers. All but two park rivers empty into Puget Sound near Tacoma, Washington. The Muddy Fork and Ohanapecosh Rivers are the exception, flowing into the Cowlitz River outside the park, which drains into the Columbia River and on to the Pacific Ocean. Each major river occupies a deep canyon whose floor is 305 to 915 meters (1,000 to 3,000 feet) below the adjacent divides. Valley floor gradients are steep and increase markedly upstream. The mountain's summit towers 2,743 to 3,353 meters (9,000 to 11,000 feet) above valley floors only three to six miles away. The glacial system on the Mount Rainier is the largest single mountain system in the contiguous 48 states and consists of 26 major glaciers covering 35 square miles. Approximately 470 mapped rivers and streams, 382 mapped lakes and ponds, over 3,000 acres of other wetland types, numerous waterfalls, and mineral springs occur within the park boundary. With a few exceptions, the headwaters of most park streams are located within the park boundary.

Vegetation is diverse, reflecting the varied climatic and environmental conditions encountered across the park's 3,871 meters (12,700 feet.) elevation gradient. Approximately 58% of the park is forested. Low-elevation forests are distributed from the

park's boundary at 518 to about 823 meters (1,219 to 2,700 feet.) elevation and are dominated by western hemlock, Douglas fir, and western red cedar. Mid-elevation forests extend upward to 1,219 to 1,829 meters (4,000 to 6,000 feet) elevation and contain Pacific silver fir, Alaska yellow cedar, western white pine, and noble fir. Above 1,373 meters (4,500 feet), trees become less dense as the forest grades into subalpine parkland. Forest ages range from young stands (less than 100 years old) invading on moraines left by receding glaciers and on burned areas to old-growth stands 1,000 or more years old. The subalpine parkland covers approximately 23 percent of the park; vegetation in this zone is a mosaic of tree clumps and herbaceous meadows extending from 1,524 to about 2,134 meters (5,000 to 7,000 feet) elevation. The alpine zone extends from tree line to the mountain's summit. Approximately 50% of this zone is permanent snow and ice and the remainder is alpine vegetation.

Species known or thought to occur in the park include more than 800 vascular plants, 159 birds, 63 mammals, 16 amphibians, 5 reptiles, and 18 native fishes. Of these vertebrates, there are 4 federally listed threatened or endangered species known to occur in the park, including 3 birds and 1 fish. Four other species (gray wolf, grizzly bear, Canada lynx, and Chinook salmon) historically occurred in the park, but their present status is unknown.

Survey Locations and Methods

The Fish Inventories in North Cascades National Park Service Complex (NOCA) and Mount Rainier National Park (MORA) began in 2001 and continued through 2003. Streams were chosen based on several factors: 1) suspected to be fish bearing; 2) watersheds where there is little fish related information (i.e. previous surveys); 3) relatively low gradient and wadeable; 4) relatively accessible. Sample sites represented contiguous sections of stream (standard reaches) based on gradient and flow contribution (tributary input). Fish data were collected while snorkeling and electrofishing. In addition to fish data, habitat related data were collected at the standard reach level. Complete details are found in Appendix C: *Fish Inventory survey forms and methods* (Zyskowski 2005, unpublished). Additional data were collected at qualifying pools throughout the surveyed reach. To qualify as a pool, a unit must have: little or no water surface gradient; hydraulic control which spans the channel; residual depth; and length must exceed width unless it is a channel-spanning plunge pool. In order to evaluate how many significant pools may be left out of the protocol if only those spanning the channel are included alternative pools were also included (width must exceed 2/3 of the wetted channel width, determined at the widest point in the pool). The primary data collection method generally followed the U.S. Forest Service Level II Stream Inventory (Hankin and Reeves 1988), while the data collection method at qualifying pools followed a combination of USFS Level II Stream Inventory (Hankin and Reeves 1988) and Timber, Fish and Wildlife Ambient Monitoring Program method (Pleus et al. 1999).

Fish Sampling Procedure Method

A dive crew of two people followed the habitat crew. One person on the crew performed the fish counts while the other followed recording fish count information. Prior to each survey water temperature was recorded. Horizontal visibility in the water was also determined by measuring the distance a diver just loses sight of a standard secchi disk. This was done at least once in the morning and once in the afternoon in sample pools after the diver survey was completed.

Upon reaching a designated pool the diver performed a single-pass count, followed by three more passes for those sample units requiring bounded counts. Counts of fish by species and age group (juvenile and adult) were recorded. Diver surveys continued through the reach snorkeling all of the designated sample units.

An electrofishing crew of at least three people followed the dive crew, working upstream. Multi-pass electrofishing was accomplished at each of the randomly designated sample units selected from the pool of sample units where bounded diver counts were performed. Block nets were placed at the boundaries of the pool sample unit. The electrofishing crew completed at least three separate passes of equal effort, recording the number of fish by species and age group and then releasing them outside of the block nets. Additional passes were required if there was less than a 50% reduction in the number of fish captured compared to the previous pass.

Proper settings for the electrofisher were determined before use in the sample units. Tests for determining the most efficient electro-fisher settings was accomplished in other sections of the stream that were not being sampled and USFWS guidelines for electrofishing in waters with bull trout were followed.

Electrofishing was completed no more than one day following the diver counts (usually the same day). Long reaches were divided into sections that could be completed in a single day, working sequentially upstream.

The purpose of the qualitative sampling protocol was to provide basic fish inventory data and to evaluate changes in species distributions over time through the use of single pass snorkeling of 100 meter segments. A systematic sample of every other 100-meter segment within a reach was used to determine species presence and frequency of occurrence for each reach. Sampling was conducted concurrently with the quantitative (four pass pool snorkeling and electrofishing) fish survey work.

Single-pass diver counts were used for collection of fish presence data. These surveys were completed by the same crew working on the quantitative fish survey of pools, while working upstream from the bottom of the reach. Any pool sample units that fell within the qualitative sample segment were snorkeled first. Two divers were used in wider channels or segments that had split channels (one for each side). Number of fish by species and age group were recorded as in the quantitative fish sampling protocol. The dive crew also collected the habitat attribute data.

More complete details are found in Appendix B: *Stream Resident Fish Monitoring Protocol Development: FY 2001 Pilot Study Methods* (Zyskowski 2001, unpublished).

North Cascades National Park Service Complex

There were 27 stream-reaches surveyed in NOCA (Figures 1 and 2) concentrated where relatively little fish distribution information has been collected in the past. The sampled streams included: **single-pass snorkeling** in 7 tributaries to the upper Skagit River, 5 tributaries to Ross Lake (reservoir in the upper Skagit River), and 2 tributaries to the upper Stehekin River; **four-pass snorkeling** in 4 tributaries to the upper Skagit River, 5 tributaries to Ross Lake, and 2 tributaries to the upper Stehekin River; and **three-pass (minimum) electrofishing** in 2 tributaries to the upper Skagit River, 2 tributaries to Ross Lake, and 1 tributary to the upper Stehekin River. Stream channel gradients ranged from 1.5 to 7.6 percent, and sampled elevations ranged from 280 to 963 meters.

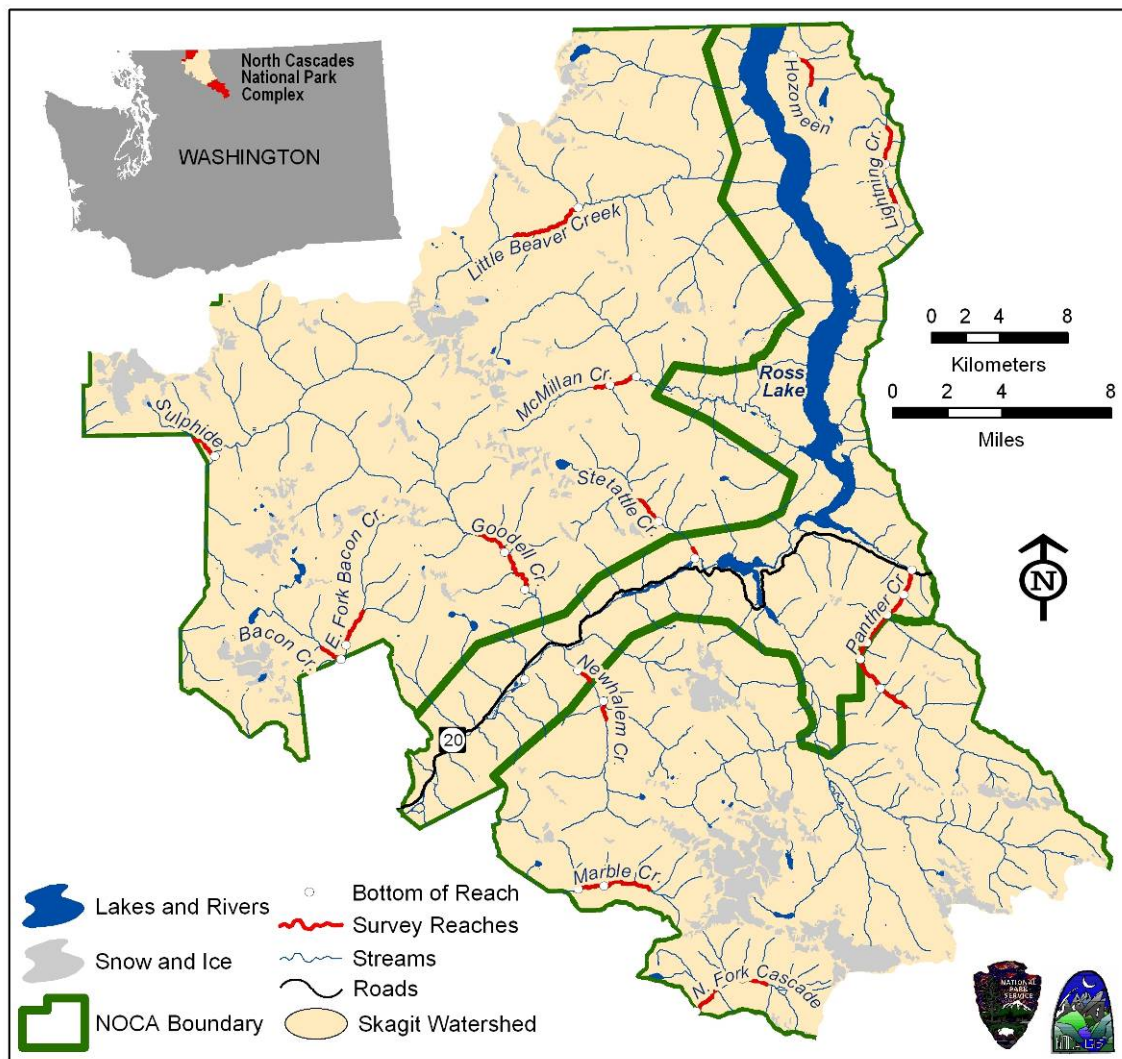


Figure 1. Fish Population Sampled Segments (Skagit)

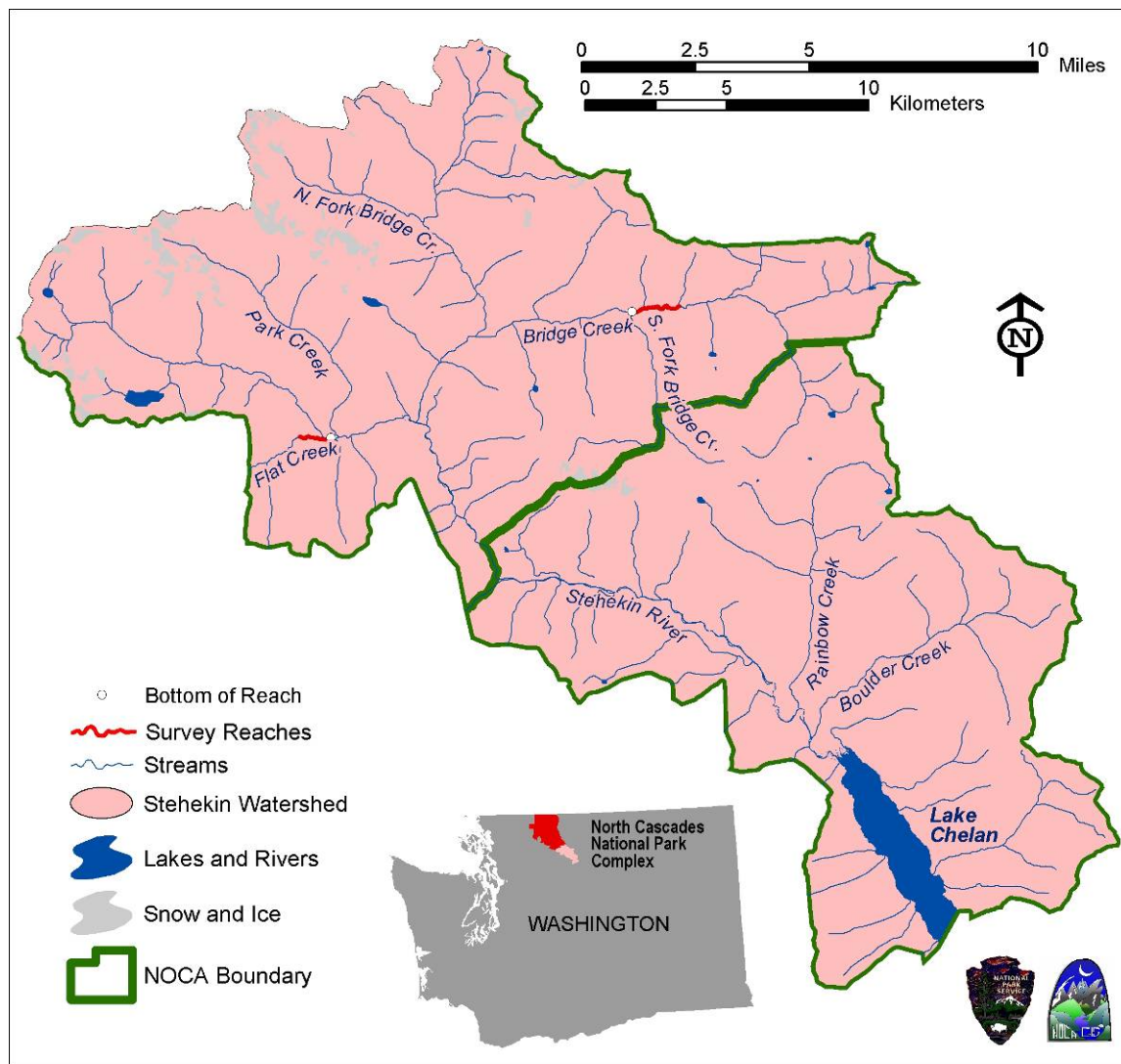


Figure 2. Fish Population Sampled Segments (Stehekin)

Mount Rainier National Park

There were 11 stream-reaches (Paradise River was surveyed two times with different reach lengths) surveyed in MORA (Figure 3) spread around the perimeter of the Park (Mount Rainier occupies the interior) where relatively little fish distribution information has been collected in the past. The sampled streams included: **single-pass snorkeling** in 2 tributaries to the upper White River, 2 tributaries to the upper Carbon River, 2 tributaries to the upper Cowlitz River, 2 tributaries to the upper Nisqually River, and 2 tributaries to the upper Puyallup River; **four-pass snorkeling** in 2 tributaries to the upper White River, 2 tributaries to the upper Carbon River, 2 tributaries to the upper Cowlitz River, 2 tributaries to the upper Nisqually River, and 2 tributaries to the upper Puyallup River; and **three-pass (minimum) electrofishing** in 1 tributary to the upper Carbon River, and 1 tributary to the

upper Nisqually River. Stream channel gradients ranged from 3.5 to 9.6 percent, and sampled elevations ranged from 778 to 1131 meters.

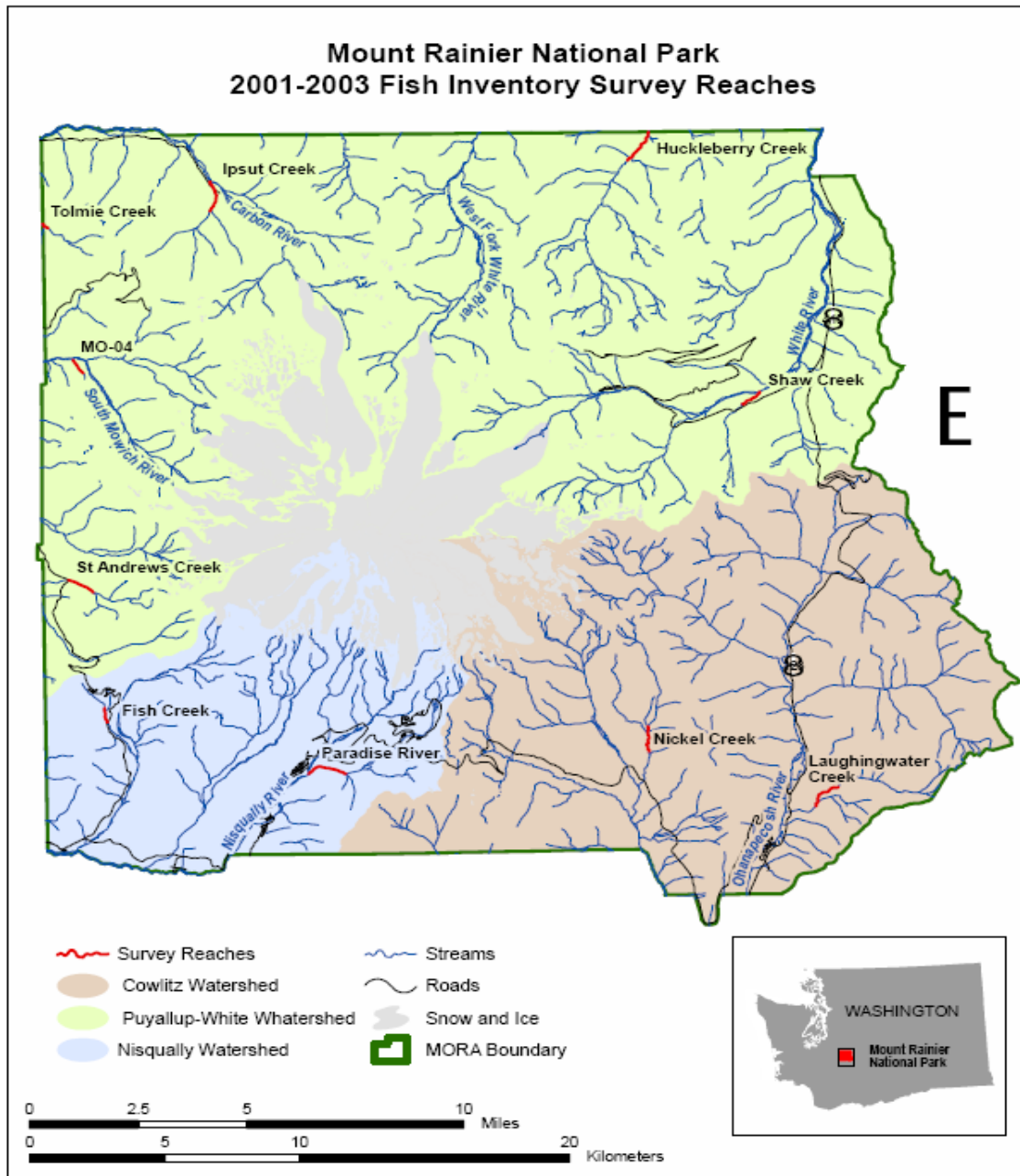


Figure 3. Fish Population Sampled Segments (Mount Rainier)

Results

North Cascades National Park Service Complex

During the summers of 2001 through 2003, we sampled a total of 56.1 kilometers in 14 tributaries to the Skagit (including Ross Reservoir) and Stehekin Rivers. Habitat surveys were completed on the total length surveyed. Habitat summaries are included in Appendix A, and complete description of the methods and forms are included in Appendix C. Of the 56.1 kilometers surveyed 19.6 kilometers were surveyed using single pass snorkeling of individual 100-meter segments. A summary of the segment survey data is located in Table 1. A total of 271 pools were sampled using the four pass snorkel method (38,342 m²) and of these 57 pools were also surveyed using three pass (minimum) electrofishing (6,954 m²). A summary of the four pass snorkeling and three pass electrofishing data is located in Table 2.

All surveyed tributaries contained fish. These included five native fish species including: rainbow trout, westslope cutthroat trout, bull trout / Dolly Varden, coho salmon and mountain whitefish and one non-native fish species: brook trout. Rainbow trout were most numerous and were observed in 10 of the surveyed tributaries. Bull trout / Dolly Varden were observed in 6 surveyed tributaries and westslope cutthroat were observed in 3 surveyed tributaries. Coho salmon were observed in the lower anadromous sections of 2 tributaries to the upper Skagit downstream of the dams. Mountain whitefish (2 total fish) were observed in Sulfide Creek (tributary to the Baker River on the Skagit system). Brook trout were observed in Hozomeen Creek (drains Hozomeen Lake which was stocked with these non-native fish).

Table 1. NOCA Fish Inventory 2001 - 2003 Fish Segments Summary

Basin	Stream Name	Reach Number	Species	Segments Sampled (100m)	Total Fish Observed	% Fish > 150mm	% Sampled Segments with Species
Skagit River							
Baker River	Sulfide	NA	Rainbow	9	5	80	56
			Mt. Whitefish	9	2	100	22
			Bull Trout / DV	9	5	60	56
Cascade River	Marble	1	Rainbow	7	78	47	100
			Bull Trout / DV	7	3	100	29
	Marble	2	Rainbow	5	22	59	100
			Bull Trout / DV	5	2	100	20
Upper Skagit	NF Cascade	1	Rainbow	7	86	55	100
	NF Cascade	3	Rainbow	5	100	54	100
	Bacon (West Fork)	NA	Rainbow	6	171	18	100
			Coho	6	121	0	100
			Bull Trout / DV	6	4	100	50
	Bacon (East Fork)	NA	Rainbow	8	223	30	100
	Goodell	1	Rainbow	10	128	45	90
			Coho	10	538	6	80
			Bull Trout / DV	10	55	85	100
	Goodell	2	Rainbow	8	48	90	100
			Bull Trout / DV	8	4	75	38
	Newhalem	1	Rainbow	5	309	60	100
	Newhalem	2	Rainbow	6	380	65	100
	Stetattle	1	Rainbow	4	20	35	75
	Stetattle	2	Rainbow	7	114	54	100
Ross Reservoir							
	Panther	1	Rainbow	7	188	43	100
	Panther	2	Rainbow	4	180	21	100
			Bull Trout / DV	4	2	50	25
	Panther	3	Rainbow	7	85	66	100
	Panther	4	Rainbow	4	46	65	100
	Panther	5	Rainbow	8	146	46	100
	Panther	6	Rainbow	7	94	30	100
	Little Beaver	5	Rainbow	15	110	65	93
	McMillan	1	Cutthroat	5	18	44	60
	McMillan	2	No Fish	4	0	0	0
	Lightning	1	Rainbow	7	230	55	100
			Bull Trout / DV	7	380	28	100
	Lightning	2	Rainbow	8	219	32	100
			Bull Trout / DV	8	35	23	75
	Hozomeen	NA	Brook Trout	8	82	13	88
Stehekin River							
Upper Stehekin	Bridge	NA	Cutthroat	10	271	54	100
	Flat	NA	Cutthroat	15	461	86	100

Table 2. NOCA Fish Inventory 2001 - 2003 Fish Pools Summary

Basin	Stream Name	Reach Number	Species	Pools Sampled	Pool Area Sampled (m ²)	Method ¹	Fish per m ²	% Fish > 150mm	% Sampled Pools w/ Species
Skagit River									
Cascade River	Marble	1	Rainbow	7	1252	Snorkel	0.0120	56	100
			Bull Trout / DV	7	1252	Snorkel	0.0016	78	29
	Marble	2	Rainbow	3	360	Snorkel	0.0222	87	67
	NF Cascade	1	Rainbow	5	642	Snorkel	0.0654	39	100
	NF Cascade	3	Rainbow	4	346	Snorkel	0.0867	36	100
Upper Skagit	Goodell	2	Rainbow	9	1756	Snorkel	0.0046	88	67
			Rainbow	8	1284	Electrofishing	0.0101	62	88
			Bull Trout / DV	9	1756	Snorkel	0.0040	73	67
			Bull Trout / DV	8	1284	Electrofishing	0.0273	40	100
	New halem	1	Rainbow	20	2645	Snorkel	0.0964	68	100
			Rainbow	12	1694	Electrofishing	0.1647	32	100
	New halem	2	Rainbow	17	2338	Snorkel	0.1527	66	100
Ross Reservoir									
	Panther	1	Rainbow	10	911	Snorkel	0.0659	44	100
			Bull Trout / DV	10	911	Snorkel	0.0011	0	10
	Panther	2	Rainbow	8	1376	Snorkel	0.0676	44	100
	Panther	3	Rainbow	7	649	Snorkel	0.0385	45	86
	Panther	4	Rainbow	5	446	Snorkel	0.0090	35	80
	Panther	5	Rainbow	9	1329	Snorkel	0.0158	46	100
	Panther	6	Rainbow	9	1522	Snorkel	0.0368	47	78
	Little Beaver	5	Rainbow	11	2005	Snorkel	0.0973	62	91
	McMillan	1	Cutthroat	6	360	Snorkel	0.0222	78	83
	McMillan	2	No Fish	3	1043	Snorkel	0.0134	NA	0
	Lightning	1	Rainbow	25	4873	Snorkel	0.0885	57	100
			Rainbow	5	1151	Electrofishing	0.0417	33	100
			Bull Trout / DV	25	4873	Snorkel	0.1615	36	100
			Bull Trout / DV	5	1151	Electrofishing	0.1121	1	100
	Lightning	2	Rainbow	26	3910	Snorkel	0.0760	38	100
			Rainbow	10	1334	Electrofishing	0.1079	19	100
			Bull Trout / DV	26	3910	Snorkel	0.0371	21	77
			Bull Trout / DV	10	1334	Electrofishing	0.1657	1	75
	Hozomeen	NA	Brook Trout	32	1196	Snorkel	0.0753	17	97
			Brook Trout	8	326	Electrofishing	0.1288	5	100
Stehekin River									
Upper Stehekin	Bridge	NA	Cutthroat	25	2209	Snorkel	0.1019	55	96
			Cutthroat	14	1165	Electrofishing	0.1837	51	100
	Flat	NA	Cutthroat	30	7174	Snorkel	0.0737	89	100
Method ¹ = Snorkeling is four pass and Electrofishing is at least 3 pass.									

Mount Rainier National Park

During the summers of 2001 through 2003, we sampled a total of 12.9 kilometers in 10 tributaries to the White, Carbon, Cowlitz, Nisqually and Puyallup Rivers. Habitat surveys were completed on the total length surveyed. Habitat summaries are included in Appendix A, and complete description of the methods and forms are included in Appendix C. Of the 12.9 kilometers surveyed 3.8 kilometers were surveyed using single pass snorkeling of individual 100-meter segments. A summary of the segment survey data is located in Table 3. A total of 141 pools were sampled using the four pass snorkel method (6,823 m²) and of these 37 pools were also surveyed using three pass (minimum) electrofishing (1,754 m²). A summary of the four pass snorkeling and three pass electrofishing data is located in Table 2.

All surveyed tributaries contained fish with the exception of Tolmie Creek. These included four native fish species including: rainbow trout, westslope cutthroat trout, bull trout / Dolly Varden and sculpin and one non-native fish species: brook trout. Cutthroat trout were the most numerous and were observed in 9 of the surveyed tributaries. Rainbow trout were observed in 5 surveyed tributaries and sculpin were observed in 3 surveyed tributaries. Bull trout / Dolly Varden were observed in 1 surveyed tributary. Brook trout were observed in Paradise River and tributary MO-04.

Table 3. MORA Fish Inventory 2001 – 2003 Fish Segments Summary

Basin	Stream Name	Reach Number	Species	Segments Sampled (100m)	Total Fish Observed	% Fish > 150mm	% Sampled Segments with Species
White River							
	Huckleberry	NA	Rainbow / Cutthroat	6	36	58	100
	Shaw	NA	Rainbow / Cutthroat	4	3	67	75
Carbon River							
	Ipsut	NA	Cutthroat	6	2	50	17
			Bull Trout / DV	6	1	0	17
			Sculpin	6	1	0	17
	Tolmie	NA	No fish	1	0	NA	0
Cowlitz River							
	Laughingwater	NA	Cutthroat	4	11	73	75
	Nichol	NA	Rainbow / Cutthroat	4	16	38	75
			Cutthroat	4	5	100	25
Nisqually River							
	Fish	NA	Cutthroat	1	11	55	100
			Sculpin	1	1	0	100
Paradise River	Paradise River 2001	NA	Cutthroat	3	25	88	100
			Brook	3	1	100	33
	Paradise River 2003	NA	Rainbow / Cutthroat	6	41	66	83
			Cutthroat	6	38	82	100
Puyallup River							
Mowich River	MO-04	NA	Rainbow / Cutthroat	3	7	0	100
			Cutthroat	3	9	0	100
	Saint Andrews	NA	Cutthroat	4	32	94	100

Table 4. MORA Fish Inventory 2001 – 2003 Fish Pools Summary

Basin	Stream Name	Reach Number	Species	Pools Sampled	Pool Area Sampled (m ²)	Method ¹	Fish per m ²	% Fish > 150mm	% Sampled Pools with Species
White River									
	Huckleberry	NA	Rainbow / Cutthroat	8	426	Snorkel	0.0452	48	88
			Sculpin	8	426	Snorkel	0.0012	0	25
	Shaw	NA	Rainbow / Cutthroat	13	787	Snorkel	0.0076	33	23
			Cutthroat	13	787	Snorkel	0.0076	33	23
			Sculpin	13	787	Snorkel	0.0003	0	8
Carbon River									
	Ipsut	NA	Cutthroat	29	1436	Snorkel	0.0084	25	14
			Cutthroat	24	1168	Electrofishing	0.0188	36	50
			Bull Trout / DV	29	1436	Snorkel	0.0014	13	7
			Bull Trout / DV	24	1168	Electrofishing	0.0068	75	21
			Sculpin	29	1436	Snorkel	0.0037	0	17
			Sculpin	24	1168	Electrofishing	0.2098	0	96
			Brook	24	1168	Electrofishing	0.0043	20	21
	Tolmie	NA	No Fish	5	186	Snorkel	0	NA	0
Cowlitz River									
	Laughingwater	NA	Cutthroat	16	418	Snorkel	0.0311	52	38
	Nichol	NA	Rainbow / Cutthroat	6	435	Snorkel	0.0184	53	67
			Cutthroat	6	435	Snorkel	0.0201	97	50
Nisqually River									
	Fish	NA	Cutthroat	4	438	Snorkel	0.0325	98	100
			Sculpin	4	438	Snorkel	0.0006	0	25
Paradise River	Paradise River	NA	Cutthroat	17	902	Snorkel	0.0349	82	65
	2001		Cutthroat	13	586	Electrofishing	0.1570	49	92
			Brook	17	902	Snorkel	0.0014	100	12
			Brook	13	586	Electrofishing	0.0017	0	8
	Paradise River	NA	Rainbow / Cutthroat	14	818	Snorkel	0.0449	67	79
	2003		Cutthroat	14	818	Snorkel	0.0263	99	71
			Brook	14	818	Snorkel	0.0031	100	21
Puyallup River									
Mowich River	MO-04	NA	Rainbow / Cutthroat	13	142	Snorkel	0.0123	0	38
			Cutthroat	13	142	Snorkel	0.0246	0	54
			Sculpin	13	142	Snorkel	0.0018	0	8
	Saint Andrews	NA	Cutthroat	16	835	Snorkel	0.0326	97	100
Method ¹ = Snorkeling is four pass and Electrofishing is at least 3 pass.									

Discussion

This fish inventory is a thorough, yet incomplete representation of composition and relative distributions of fish species in specific lower gradient reaches of tributaries of two of the large river basins in NOCA and five of the large river basins in MORA. Results from this study established baseline inventories and relative spatial distributions of fish species.

North Cascades National Park Service Complex

Baseline inventories and relative spatial distribution of fish species were established in 27 reaches of 14 tributaries to the upper Skagit (including Ross Reservoir) and upper Stehekin Basins in NOCA. The detection of 6 different species of fish from three Families during this inventory was consistent with known distribution patterns of each species. We documented 28% of the known freshwater fish species that inhabit the entire park. No range extensions or additional non-native species were detected when compared to the existing list of fish species known to inhabit NOCA. Information in this study may be used to design an aquatic monitoring plan to detect trends in species distribution, frequency of occupancy and richness in streams of NOCA. Information related to species occurrence and spatial distributions also is necessary to understand ecological interactions among species, to address the extent of non-native fish invasions, and to make informed management decisions on fish resources.

The failure to detect other fish species known to inhabit NOCA during this study may be attributed to the localized distributions of many species, sampling methods, and the limited temporal sampling effort. The range of the inventory should be expanded to include sampling throughout the entire Park (some of the other drainages were surveyed following other methods prior to this inventory, i.e. Chilliwack River and Thunder Creek basins). Additional work during autumn and winter months may be necessary to determine the total fish species assemblage and associated spatial distributions of migratory species such as Pacific salmonids.

We detected the presence of non-native brook trout in Hozomeen Creek (upper Skagit, Ross Reservoir). Brook trout are native to eastern and northeastern North America. Brook trout were introduced into several backcountry lakes in the park. There are a number of biological concerns related to brook trout including the possibility of hybridization with native bull trout / Dolly Varden. Based on NPS Policy, eradication of exotic species should be considered whenever such species threaten park resources. Bull trout currently are listed as a threatened species under the Endangered Species Act. Future studies should address the extent and pathways of brook trout invasion in park waters with an emphasis on streams that contain native bull trout / Dolly Varden.

Skagit Basin

The four fish species (rainbow trout, bull trout / Dolly Varden, coho salmon and mountain whitefish) observed in tributaries of the Skagit Basin (downstream of Ross Reservoir) were consistent with distribution of fishes found in other northern Puget Sound rivers. Surveyors

failed to detect chinook salmon, sockeye salmon, chum salmon, and cutthroat trout, all of which are known to occur in the basin. The lack of detection of these species presumably was the result of limited seasonal sampling effort and an emphasis on specific reaches in tributary streams and not the main stem river.

Ross Reservoir (Upper Skagit Basin)

The four fish species (rainbow trout, cutthroat trout, bull trout / Dolly Varden, and brook trout) observed in tributaries to Ross Reservoir (upper Skagit Basin) were consistent with distribution of fishes found in other northern Puget Sound rivers. Surveyors failed to detect any salmon species, which are known to occur in the basin. The lack of detection of salmon species in Ross Reservoir tributaries is due to the upper basin location above three impassable dams (Gorge, Diablo and Ross). It is assumed that Pacific Salmon Species never inhabited the upper Skagit Basin due to impassable barriers (falls and chutes) in the river section just above the present location of the town of Newhalem. Non-native eastern brook trout were detected throughout Hozomeen Creek. These brook trout have moved downstream from stock planted in Hozomeen Lake. The effects of these fish on native bull trout/Dolly Varden are a concern and should be investigated.

Stehekin Basin

A single fish species (cutthroat trout) was observed in tributaries to the Stehekin. The location of the surveyed reaches in the upper basin above significant barriers precludes other non-introduced fish species. The detection of cutthroat trout in upper reaches of tributaries and rivers is consistent with distribution of fishes found in East Slope (east of Cascade mountains) river systems. It is believed bull trout / Dolly Varden once inhabited portions of the upper Stehekin basin, but none were detected in this survey.

Mount Rainier National Park

Baseline inventories and relative spatial distribution of fish species were established in 10 reaches of 10 tributaries to the upper White, Carbon, Cowlitz, Nisqually and Puyallup Basins in MORA. The detection of 5 different species of fish from three Families during this inventory was consistent with known distribution patterns of each species. We documented 26% of the known freshwater fish species that inhabit the entire park. No range extensions or additional non-native species were detected when compared to the existing list of fish species known to inhabit MORA. Information in this study may be used to design an aquatic monitoring plan to detect trends in species distribution, frequency of occupancy and richness in streams of MORA. Information related to species occurrence and spatial distributions also is necessary to understand ecological interactions among species, to address the extent of non-native fish invasions, and to make informed management decisions on fish resources.

The failure to detect other fish species known to inhabit MORA during this study may be attributed to the localized distributions of many species, sampling methods, and the limited temporal sampling effort. The range of the inventory should be expanded to include

sampling throughout the entire Park. Additional work during autumn and winter months may be necessary to determine the total fish species assemblage and associated spatial distributions of migratory species such as Pacific salmonids.

We detected the presence of non-native brook trout in Paradise River (Nisqually Basin). Brook trout are native to eastern and northeastern North America. Brook trout were introduced into several backcountry lakes in the park. There are a number of biological concerns related to brook trout including the possibility of hybridization with native bull trout / Dolly Varden. Based on NPS Policy, eradication of exotic species should be considered whenever such species threaten park resources. Bull trout currently are listed as a threatened species under the Endangered Species Act. Future studies should address the extent and pathways of brook trout invasion in park waters with an emphasis on streams that contain native bull trout / Dolly Varden.

White Basin

Potentially two fish species (rainbow trout and cutthroat trout) were observed in tributaries of the White Basin and these were consistent with distribution of fishes found in other Puget Sound rivers. Surveyors were unable to definitively distinguish between rainbow and cutthroat trout thus the fish were recorded as rainbow/cutthroat. Surveyors failed to detect any salmon species, and bull trout / Dolly Varden, all of which are known to occur in the basin. The lack of detection of these species presumably was the result of limited seasonal sampling effort and an emphasis on specific reaches in the upper extents of tributary streams above known barriers (chutes and falls) and not the main stem river.

Carbon Basin

The four fish species (cutthroat trout, bull trout / Dolly Varden, brook trout and sculpin) observed in tributaries to Carbon Basin were consistent with distribution of fishes found in other Puget Sound rivers. Surveyors failed to detect any salmon species, which are known to occur in the basin. The lack of detection of salmon species in Carbon Basin tributaries is due to the upper basin location above several sections of cascades and chutes in the Carbon River. Non-native eastern brook trout were detected in Ipsut Creek. These brook trout have moved downstream from stock planted in local high elevation lakes. The effects of these fish on native bull trout / Dolly Varden are a concern and should be investigated.

Cowlitz Basin

Potentially two fish species (rainbow trout and cutthroat trout) were observed in tributaries of the Cowlitz Basin and these were consistent with distribution of fishes found in other Puget Sound rivers. Surveyors were sometimes unable to definitively distinguish between rainbow and cutthroat trout thus these fish were recorded as rainbow/cutthroat. Surveyors failed to detect any salmon species, and bull trout / Dolly Varden, all of which are known to occur in the basin. There are two dams on the Cowlitz River (Mayfield and Mossyrock) which block the upstream movement of anadromous fish. Anadromous fish are trapped and trucked around the dams and released at several upstream sites. The lack of detection

of these species presumably was the result of limited seasonal sampling effort and an emphasis on specific reaches in the upper extents of tributary streams and not the main stem river.

Nisqually Basin

Potentially four fish species (rainbow trout, cutthroat trout, brook trout and sculpin) were observed in tributaries of the Nisqually Basin and these were consistent with distribution of fishes found in other Puget Sound rivers. Surveyors were sometimes unable to definitively distinguish between rainbow and cutthroat trout thus these fish were recorded as rainbow/cutthroat. Surveyors failed to detect any salmon species, and bull trout / Dolly Varden, all of which are known to occur in the basin. The lack of detection of these species is due to the location of surveys above two dams (La Grande and Alder) located between river mile 42 and 44 which block all upstream movement of anadromous fish. All surveyed reaches were well above these barriers in the upper extents of tributary streams and not in the main stem river.

Puyallup Basin

Potentially three fish species (rainbow trout, cutthroat trout and sculpin) were observed in tributaries of the Puyallup Basin and these were consistent with distribution of fishes found in other Puget Sound rivers. Surveyors were sometimes unable to definitively distinguish between rainbow and cutthroat trout thus these fish were recorded as rainbow/cutthroat. Surveyors failed to detect any salmon species, and bull trout / Dolly Varden, all of which are known to occur in the basin. The lack of detection of these species is due to the location of surveys above a diversion dam (Electron) located near river mile 42 which blocks all upstream movement of anadromous fish. All surveyed reaches were well above this barrier in the upper extents of tributary streams and not in the main stem river.

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Appendix A

Habitat Data Summary Tables

When a data block contains a 0 this means that the site was sampled for this characteristic but there were no measured or observed features. When a block contains “NA” this means that this characteristic is “Not Applicable” (usually due to lack of measured or observed information in order to calculate an average or maximum). When a block contains “NR” this means that this characteristic was “Not Recorded” during the survey.

Habitat Data Descriptions:

Reach

Reach Length – measured kilometers.

Elevation – meters above mean sea level.

% Gradient – average measured gradient (percent) over total length of reach.

Determination of gradient was an office procedure (using topographic maps or Topo! Map Program) for longer contiguous reaches, and a field measured procedure (level and rod) for shorter more intense surveys.

Flow – spot measured in cubic feet per second at a representative site within reach.

Average Bankfull Width – average of all bankfull width measurements in reach (meters).

Average Bankfull Depth – average of all bankfull depth average measurements in reach (meters). Each bankfull cross section contains a number of measurements which are combined to produce an average for a specific bankfull site.

Width / Depth – numeric ratio: the average bankfull width divided by the average bankfull depth.

Substrate (Dom/Sub) – measured or observed dominant and subdominant substrate.

Choices are: SA – sand (< 2 millimeters); GR – gravel (2 to 32 millimeters); CO – Cobble (33 to 180 millimeters); BD – boulder (181 to 1024 millimeters); LB – large boulder (> 1025 millimeters); and BR – bedrock. All measurements are across the intermediate axis.

Percent Fines ($\leq 2\text{mm}$) – total percent of the measured substrate that is equal to or less than 2 millimeters across the intermediate axis (dimension of the particle which controls whether or not it will pass through a soil sieve).

D50 (median particle value) (mm) – median particle size of all measured substrate (measured across intermediate axis - dimension of the particle which controls whether or not it will pass through a soil sieve).

Habitat

% Riffle – measured or estimated percent of total wetted surveyed area that contains riffle habitat. Riffle habitat includes: riffles (generally less than 3.5% gradient); cascades (generally greater than 3.5% gradient); and glides (low gradient flowing sections that do not have the residual depth of a pool).

% Pool - measured or estimated percent of total wetted surveyed area that contains pool habitat. Pool habitat includes: pools (generally areas of little or no gradient with measurable residual depth); and tailouts (the lower end of pools below the area of residual depth and above the head of the downstream riffle – pool tail crest). Tailouts were separated out in some surveys.

Total Number of Pools – total number of pools recorded in the surveyed reach. This number could be deceiving as some surveys count only channel spanning pools (USFS) while others include “qualifying” pools (TFW). Qualifying pools are related to the average bankfull width of the reach, and the size (total wetted surface area) and residual depth of the pool.

Total Pools per kilometer – total number of pools (USFS or TFW) divided by the length of reach (kilometers).

Average Residual Pool Depth (cm) – average measured residual depth of all recorded pools in the reach to the nearest centimeter. The residual depth is the difference between the maximum pool depth and the maximum pool tailout depth, in other words it is the maximum depth of the pool when the water is lowered to the point where water no longer escapes the pool (the bathtub area).

Average Max Pool Depth (cm) – average measured maximum pool depth for all pools in the reach to the nearest centimeter. The maximum pool depth is the greatest measured distance from the water surface to the substrate within the pool area.

Wood (excluding jams) Number per kilometer

Total Pieces – LWD >2m – total number of measured or estimated pieces of large woody debris greater than 2 meters in length per kilometer of stream surveyed (excluding pieces in LWD jams). The minimum diameter of recorded pieces varied from 10 to 20 centimeters depending on the survey method. Piece diameter was measured either at the mid point or at the small end (depending on survey), but all pieces have to have a minimum diameter of either 10 or 20 centimeters (depending on survey) for 2 meters of length to qualify.

No of Rootwads – total number of measured or estimated pieces of large woody debris that qualify as a rootwad per kilometer of stream surveyed (excluding rootwads in LWD jams). A piece of large woody debris qualifies as a rootwad if it has roots attached, has a diameter of at least 20 centimeters at the root collar, and is less than 2 meters in length.

Occasionally a survey would use 50 centimeters as the minimum qualifying diameter for rootwads.

Pieces USFS Small / 35-65cm/7.6m – total number of measured pieces of large woody debris with a midpoint diameter between 35 and 65 centimeters and a minimum length of 7.6 meters (this group also includes pieces of wood greater than 65 centimeters midpoint diameter when the total length was less than 15.2 meters). This represents a piece of wood at least 25 feet long with a diameter of at least 12 inches for at least 25 feet of length. The 35 and 65 centimeters midpoint diameter measurements are derived from standard log taper charts (Dilworth 1980), in order to end up with a log of at least 12 inches in diameter for 25 feet of length.

Pieces USFS Medium / 65-95cm/15.2m - total number of measured pieces of large woody debris with a midpoint diameter between 65 and 95 centimeters and a minimum length of 15.2 meters. This represents a piece of wood at least 50 feet long with a diameter between 24 and 36 inches for at least 50 feet of length. The 65 and 95 centimeters midpoint diameter measurements are derived from standard log taper charts (Dilworth 1980), in order to end up with a log of at least 24 inches to 36 inches in diameter for 50 feet of length.

Pieces USFS Large / >95cm/15.2m - total number of measured pieces of large woody debris with a midpoint diameter greater than 95 centimeters and a minimum length of 15.2 meters. This represents a piece of wood at least 50 feet long with a diameter greater than 36 inches for at least 50 feet of length. The 95 centimeters midpoint diameter measurement is derived from standard log taper charts (Dilworth 1980), in order to end up with a log of at least 36 inches in diameter for 50 feet of length.

Total Pieces USFS Wood – total number of measured pieces of large woody debris that fit into any of the three above categories (Small, Medium, or Large).

Log Jams

No of Log Jams - total number of qualifying log jams within the surveyed reach. To qualify as a LWD jam there must be a minimum of 10 qualifying pieces of LWD (LWD must be at least 2 meters in length and at least 10 centimeters in diameter for 2 meters of length) either physically touching at one or more points, or associated with jam structure, and a minimum 0.1 meters of one LWD piece's length extending into the bankfull channel.

Average Pieces per Jam >2m – average number of total qualifying pieces of large woody debris per log jam within the surveyed reach. Total qualifying pieces of large woody debris was divided by the number of jams recorded to arrive at the average number of pieces per jam.

Jams per kilometer – number of qualifying debris jams per kilometer of surveyed stream. Total qualifying large woody debris jams was divided by the length of the survey (in

kilometers) to arrive at the number large woody debris jams per kilometer of stream surveyed.

The following were summarized: Fish Inventory 2001 – 2003. These tables provide a “general” comparison.

The summary Tables are:

Table A1. NOCA Fish Inventory 2001 - 2003 Habitat Data Summary.....	42
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Table A4. MORA Fish Inventory 2001 - 2003 Habitat Data Summary.....	45

Table A 1. NOCA Fish Inventory 2001 - 2003 Habitat Data Summary

	Basin:	Cascade				Upper Skagit			
	Sulphide	Marble	Marble	Cascade	Cascade	East	West	Goodell	Goodell
Reach:		1	2	NF 1	NF 3	Bacon	Bacon	1	2
Survey Date	2-Oct-02	9-Sep-03	11-Sep-03	27-Oct-03	8-Sep-03	20-Aug-02	19-Aug-02	23-Sep-02	24-Sep-02
Reach Length (km)	1.9	2	3.2	2	1.6	2.5	1.9	3.1	2.4
Elevation - lower (m)	280	512	524	579	658	366	280	280	354
% Gradient	3.5	1.5	2.2	1.6	4.9	3	1.7	1.7	2.3
Flow (cubic feet per second)	13.3	43.4	43.4	70.4	57.9	59.4	45	129	902
Ave Bankfull Width (m)	16.1	14.3	13.3	16.2	11.5	17.4	22.4	21.8	19
Ave Bankfull Depth (m)	0.65	0.52	0.47	0.7	0.52	0.76	0.65	0.73	0.61
Bankfull Width to Depth Ratio	24.8	27.5	28.3	23.1	22.1	22.9	34.5	29.9	31.1
Substrate (Dom/Sub)	GR/CO	GR/CO	GR/CO	GR/CO	GR/CO	CO/BD	GR/CO	GR/CO	CO/GR
Habitat									
%Pool	19	34	21	23	10	25	21	23	19
%Riffle	81	66	79	77	90	75	79	77	81
Total Number of Qualifying Pools	21	23	28	17	13	30	31	27	19
Qualifying Pools per Kilometer	11	12	9	9	8	12	16	9	8
Qualifying Pools per Bankfull Width	0.18	0.17	0.12	0.15	0.09	0.21	0.36	0.2	0.15
Pocket Pools per Kilometer	21	20	21	15	19	41	14	14	11
Pocket Pools per Bankfull Width	0.34	0.29	0.28	0.24	0.22	0.72	0.32	0.31	0.21
Average Residual Pool Depth (cm)	NR	102	81	87	77	NR	NR	NR	82
Average Max Pool Depth (cm)	NR	141	121	136	119	NR	NR	NR	121
LWD (not counting log jam logs)									
Number per kilometer									
Total Pieces - LWD >2m per Kilometer	58	150	172	152	93	82	106	105	79
Total Pieces - LWD >2m per Bankfull Width	0.9	2.1	2.3	2.5	1.1	1.4	2.4	2.3	1.5
Total Pieces USFS Wood	NR	20	30	51	44	NR	NR	NR	NR
Log Jams									
No of Log Jams	33	22	11	22	20	9	27	29	15
Average Pieces per Jam >2m	NR	27	25	41	17	NR	NR	NR	41
Jams per kilometer	17	11	3	11	13	4	14	9	6

Table A 2. NOCA Fish Inventory 2001 - 2003 Habitat Data Summary

	Basin: Upper Skagit				Ross				
	Newhalem	Newhalem	Stetattle	Stetattle	Panther	Panther	Panther	Panther	Panther
Reach:	1	2	1	2	1	2	3	4	5
Survey Date	24-Sep-01	25-Sep-01	22-Aug-02	21-Aug-02	21-Aug-03	25-Aug-03	15-Sep-03	16-Sep-03	17-Sep-03
Reach Length (km)	1.1	1.3	0.8	2	2.1	1.3	2.2	1.2	2.5
Elevation - lower (m)	305	329	268	427	503	604	410	805	841
% Gradient	2.3	2.5	2.8	2.8	6.1	7.6	4.3	3.2	2.7
Flow (cubic feet per second)	24.6	24.6	131.3	71.4	66.1	66.1	33.1	23.5	22.8
Ave Bankfull Width (m)	17.4	13.1	16.9	21.3	15.7	14.5	14.6	12.8	12.7
Ave Bankfull Depth (m)	0.72	0.64	0.89	0.72	0.75	0.65	0.7	0.47	0.51
Bankfull Width to Depth Ratio	24.2	20.5	19	29.6	20.9	22.3	20.9	27.2	24.9
Substrate (Dom/Sub)	GR/CO	CO/BD	CO/BD	CO/BD	GR/CO	CO/CO	GR/CO	GR/CO	GR/CO
Habitat									
%Pool	23	12	20	9	25	28	31	29	33
%Riffle	77	88	80	91	75	72	69	71	67
Total Number of Qualifying Pools	20	17	9	16	28	25	22	17	29
Qualifying Pools per Kilometer	18	13	11	8	13	19	10	14	12
Qualifying Pools per Bankfull Width	0.31	0.17	0.19	0.17	0.2	0.28	0.15	0.18	0.15
Pocket Pools per Kilometer	25	28	24	32	43	25	62	38	28
Pocket Pools per Bankfull Width	0.44	0.36	0.4	0.67	0.68	0.37	0.9	0.49	0.36
Average Residual Pool Depth (cm)	46	53	NR	NR	88	102	83	68	79
Average Max Pool Depth (cm)	95	99	NR	NR	152	160	124	108	109
LWD (not counting log jam logs)									
Number per kilometer									
Total Pieces - LWD >2m per Kilometer	55	98	61	52	105	122	140	135	158
Total Pieces - LWD >2m per Bankfull Width	1	1.3	1	1.1	1.6	1.8	2	1.7	2
No of Rootwads	NR	NR	NR	NR	NR	NR	NR	NR	NA
Total Pieces USFS Wood	NR	NR	NR	NR	30	38	28	20	50
Log Jams									
No of Log Jams	7	6	0	3	10	11	20	15	47
Average Pieces per Jam >2m	31	47	NR	NR	1383	37	60	32	55
Jams per kilometer	6	5	0	2	5	8	9	13	19

Table A 3. NOCA Fish Inventory 2001 - 2003 Habitat Data Summary

	Basin: Ross							Stehekin	
	Panther	Little	McMillan	McMillan	Lightning	Lightning	Hozomeen	Bridge	Flat
Reach:	6	Beaver 5	1	2	1	2			
Survey Date	29-Sep-03	11-Aug-03	23-Sep-03	25-Sep-03	6-Aug-01	16-Sep-02	22-Jul-02	10-Sep-01	24-Jul-01
Reach Length (km)	2.1	4.9	1.5	1.1	1.3	2.5	2.6	2	3
Elevation - lower (m)	902	671	576	646	585	634	649	963	677
% Gradient	1.5	2.1	2.8	2.5	1.6	2	3.8	3.6	1.7
Flow (cubic feet per second)	26.9	136.5	29.9	49.9	65.3	57.6	9.8	14.7	98.7
Ave Bankfull Width (m)	13	18.4	15.6	15.6	19.2	14.8	4.4	12.8	23.1
Ave Bankfull Depth (m)	0.45	0.65	0.54	0.52	0.6	0.65	0.3	0.52	0.71
Bankfull Width to Depth Ratio	28.9	28.3	28.9	30	32	22.8	14.7	24.6	32.5
Substrate (Dom/Sub)	GR/GR	GR/CO	GR/CO	CO/BD	GR/CO	GR/GR	SA/GR	CO/BD	GR/CO
Habitat									
%Pool	33	19	24	25	48	20	32	17	26
%Riffle	67	81	76	75	52	80	68	83	74
Total Number of Qualifying Pools	26	34	16	8	25	26	72	25	30
Qualifying Pools per Kilometer	12	7	11	7	19	10	28	13	10
Qualifying Pools per Bankfull Width	0.16	0.13	0.17	0.11	0.36	0.15	0.12	0.17	0.23
Pocket Pools per Kilometer	28	24	17	30	53	18	32	62	15
Pocket Pools per Bankfull Width	0.36	0.44	0.26	0.47	1.02	0.27	0.14	0.79	0.35
Average Residual Pool Depth (cm)	84	121	108	91	78	83	50	46	112
Average Max Pool Depth (cm)	114	169	141	130	125	132	70	78	171
LWD (not counting log jam logs)									
Number per kilometer									
Total Pieces - LWD >2m per Kilometer	140	143	93	80	109	49	45	31	172
Total Pieces - LWD >2m per Bankfull Width	1.8	2.6	1.5	1.2	2.1	0.7	0.2	0.4	4
Total Pieces USFS Wood	90	86	35	43	NR	NR	NR	NR	NR
Log Jams									
No of Log Jams	42	67	19	13	25	30	40	6	34
Average Pieces per Jam >2m	58	43	31	46	46	53	26	392	NR
Jams per kilometer	20	14	13	12	19	12	15	3	11

Table A 4. MORA Fish Inventory 2001 - 2003 Habitat Data Summary

Basin: Reach:	White		Carbon		Cowlitz		Nisqually			Puyallup	
	Huckle- berry	Shaw	Ipsut	Tolmie	Laughing- water	Nickel	Fish	Paradise River	Paradise River	MO-04	Saint Andrews
Survey Date	2-Sep-03	29-Jul-03	17-Sep-01	7-Jul-03	23-Jul-03	18-Aug-03	17-Jun-03	20-Sep-01	11-Aug-03	5-Aug-03	10-Jul-03
Reach Length (km)	1.64	1.1	1.5	0.3	1.3	1.05	0.5	0.6	1.65	0.8	1.43
Elevation - lower (m)	944	1047	839	1019	847	1021	891	1012	1088	778	1131
% Gradient	3.5	5.2	9.6	6.3	7.7	3.9	3.8	4.3	7.8	8.1	5.4
Flow (cubic feet per second)	25.5	NR	2.5	NR	0.83	4.7	NR	7.5	7.5	NR	4.5
Ave Bankfull Width (m)	8.6	5.2	9.6	6.4	5.7	10.8	5.9	11.7	10.7	2.4	5.7
Ave Bankfull Depth (m)	0.35	0.31	0.49	0.31	0.29	0.32	0.36	0.46	0.49	0.20	0.28
Bankfull Width to Depth Ratio	24.6	16.8	19.6	20.6	19.7	33.8	16.4	25.4	21.8	12.0	19.3
Substrate (Dom/Sub)	GR/CO	GR/CO	GR/CO	GR/CO	GR/CO	GR/CO	GR/CO	CO/BD	CO/CO	GR/CO	GR/CO
Habitat											
%Pool	8	15	25	50	15	37	37	25	33	23	41
%Riffle	92	85	75	50	85	63	63	75	67	77	59
Total Number of Qualifying Pools	16 ¹	33 ¹	29	24 ¹	39 ¹	21 ¹	9	15	50 ¹	32 ¹	86 ¹
Qualifying Pools per Kilometer	10	30	19	80	30	20	18	25	30	26	60
Qualifying Pools per Bankfull Width	0.09	0.16	0.18	0.51	0.21	0.22	0.11	0.29	0.32	0.06	0.34
Pocket Pools per Kilometer	22	20	12	50	50	25	6	38	50	7	20
Pocket Pools per Bankfull Width	0.19	0.1	0.12	0.32	0.29	0.27	0.04	0.45	0.54	0.02	0.11
Average Residual Pool Depth (cm)	50	51	57	35	49	58	40	54	85	16	51
Average Max Pool Depth (cm)	83	66	75	53	64	83	66	88	111	26	70
LWD (not counting log jam logs)											
Number per kilometer											
Total Pieces - LWD >2m per Kilometer	245	220	117	450	300	235	28	47	130	167	500
Total Pieces - LWD >2m per Bankfull Width	2.1	1.1	1.12	2.9	1.7	2.5	0.17	0.54	1.4	0.4	2.85
Total Pieces USFS Wood	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Log Jams											
No of Log Jams	5	3	14	0	0	3	0	3	3	0	14
Average Pieces per Jam >2m	NR	NR	47	NA	NA	NR	NA	39	NR	NA	NR
Jams per kilometer	3	3	9	NA	NA	3	NA	5	2	NA	10

Footnote:¹ estimate from subsample

Appendix B

Stream Resident Fish Monitoring Protocol Development: FY 2001 Pilot Study Methods

Inventory and monitoring of stream resident fish populations in parks of the NPS North Coast and Cascade Network has been identified as an important objective by network resource management staff. Funding was secured from the NPS Network Inventory and Monitoring Programs, North Cascades National Park Service Complex (NOCA) Long-Term Ecological Monitoring Program, and Olympic National Park (OLYM) Long-Term Ecological Monitoring Program. The primary goal of this year's effort was to begin development of long-term monitoring protocols and to provide additional information concerning freshwater fish occurrence and distribution at Mount Rainier National Park (MORA), NOCA, and OLYM.

Network aquatic resource management staff met in June, 2001 with a statistician (Trent McDonald, West-Inc.) to develop objectives, discuss sampling methods, sampling designs, data analysis procedures, and logistical considerations. Two different objectives were identified to meet our monitoring needs. The first objective focuses on a quantitative approach that provides a reach-wide estimator of abundance of fish from pool habitats from a selected sample reach. The second objective provides a qualitative/semi-quantitative approach that focuses on monitoring species distributions using frequency of occurrence of a particular species among 100 m sample units within a reach.

At the meeting it was determined that the objectives for this year's pilot study needed to focus on refining and improving single reach estimators for quantitative samples from pool habitats and semi-quantitative descriptors (frequency of occurrence) for all habitats in a given reach. These following tasks were identified for FY 2001 pilot study priorities:

- 1) Investigate sample size concerning the number pools required for abundance surveys including first stage – single-pass diver counts, and second stage calibration surveys using bounded counts and/or multiple-pass electro-fishing (see draft of Hankin and Mohr 2001).
- 2) Investigate sample size concerning number of 100 m sample units required for qualitative sampling protocol.
- 3) Investigate the applicability of the method of bounded counts and compare with multiple-pass electro-fishing.
- 4) Estimate diver observation probabilities and electro-fishing capture probabilities and evaluate related to individual fish species and habitat conditions (depth, visibility, cover etc.)
- 5) Develop criteria for defining pools that allows for easy identification and excludes sub-optimal pool habitat. Investigate relationships between stream width, gradient, large woody debris (LWD) and size with the number of qualifying pools in a reach (important consideration in determining future sampling effort).
- 6) Estimate costs and time requirements, and determine sampling constraints.

Methods

Reach Selection

The goal of this summer is to focus on development of single reach estimators for investigating both quantitative (pool sampling protocol) and qualitative (100 m sample segments) and will require intensive sampling within individual reaches. Because of the intensity of sampling within a particular reach we will only be able to acquire samples from 6 reaches.

Reach length selected for this year's effort will be from 1 to 1.5 mi. long. Reach boundaries should be set on geographical landmarks or other distinguishing site characteristics that will be maintained through time for future relocation. For example, tributary confluences or rock outcroppings make good reference points for reach boundaries. If notable landmarks are not available then GPS coordinates and field notes should be used to describe the reach boundaries.

During 2001 an attempt will be made to select reaches varying in size (width) and gradient. Gradient categories have been pre-selected to include reaches with gradients less than or equal to 4% and reaches with gradients between 4 and 8%. Average wetted width of stream reaches sampled should range from 5 to 20 m.

Sample Unit Delineation and Reach Habitat Data Collection

The initial steps of the survey begin with the delineation of reach boundaries and sampling units, and reach habitat data collection. One crew of 2 or 3 people work from downstream to upstream. Reaches are broken into 100 m segments using a calibrated surveyor's tape along the thalweg of the stream. At each 200 m location record the bankfull width and bankfull depth as described below. Also record the wetted width at each 200 m location. Flag the top and bottom or all qualifying pools (defined below). Additional marking is necessary to designate which pools will be sampled by bounded diver counts and electro-fishing. Selection of bounded count sample units (pools) and qualitative survey sample units (100 m segments) will be based on a systematic design with a random start. Electro-fishing calibration units (fixed sample size) will be selected at random for each reach once all of the qualifying pools in the reach are known.

Measure and record:

Wetted width: Measure the wetted width at each 200 m interval to the nearest cm.

Bankfull width (BFW): Measure the bankfull width at each 200 m interval. Bankfull is defined as the high streamflow event occurring on average every 1.5 years. This streamflow forms and maintains the channel over time. Select sections of riffles that have a straight and relatively narrow channel since such sites offer the clearest bankfull indicators. The banks along the site selected for measuring BFW must be free of obstructions that cause high flow backwater across the entire channel. An area with an

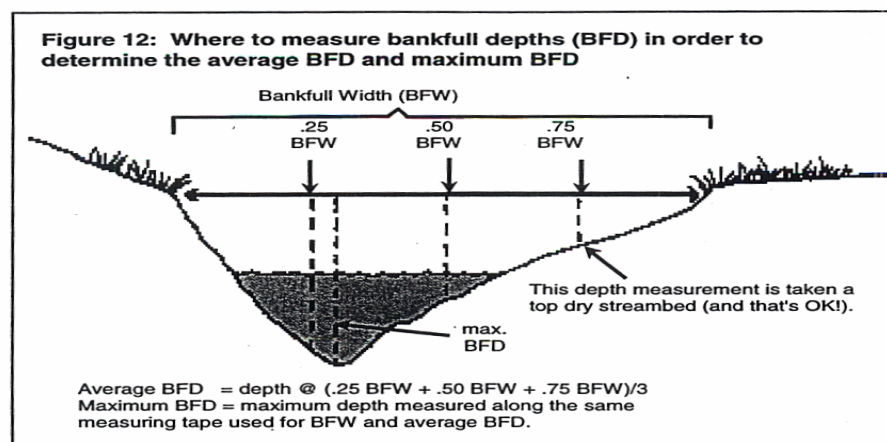
undercut bank is also a very poor choice for bankfull determination since bank slumping will give a false reading of bankfull condition. An actively eroding bank is another unreliable site for measuring bankfull flow.

Bankfull is identified by interpreting the evidence of bankfull flow atop the banks of the stream. The most consistent indicators of bankfull flow are the areas of deposition; the top of these deposits defines the active floodplain. These deposits are often known by the change in particle size. Other indications of bankfull flow are less reliable. But by using all of the evidence, accurate bankfull measurements can be obtained. The other bankfull indicators include: a change in vegetation (i.e., from none to some, or from herbaceous to woody); a change in bank topography (a change in slope of the bank above the water's edge); a line defining the lower limit of lichen colonization; a stain line visible on bare substrate; a defined scour line (exposed roots, etc.); a line of organic debris on the ground (but not debris hanging in vegetation).

Stretch a measuring tape taut, level, and perpendicular to the thalweg across the channel at the elevation of the clear bankfull indicators. Enter the measurement of BFW to the nearest centimeter.

If clear indicators of bankfull flow are absent at a 200 m interval boundary, the bankfull measurement should be moved up or downstream to the nearest acceptable site, or no bankfull measurement should be taken at the interval. Record the distance up or downstream from the interval boundary at which the BFW measurement is taken (USFS Stream Inventory Handbook 1999).

Bankfull Depth: Measure the bankfull depth at 25 percent of BFW, 50 percent of BFW, and 75 percent of BFW. This is the measured height from the streambed to the measuring tape stretched taut and level across the channel at a height equal to bankfull width (BFW). Record each bankfull depth (BFD) measurement to the nearest centimeter. It is expected that some of these measurements will be made outside of the wetted channel atop dry streambed since the surveys are performed under low streamflow conditions. (See figure 12, USFS Stream Inventory Handbook 1999, for a visual depiction of the process).

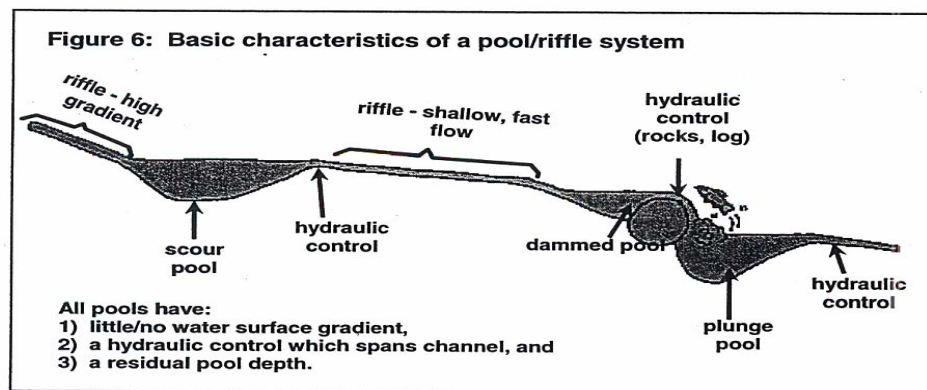


Maximum Bankfull Depth (max BFD): At the same time average bankfull depth is determined, measure and record the maximum bankfull depth along the stretched tape. This will inevitably be found along the thalweg in the wetted channel. It is simply the maximum elevation measured between the tape measure and the streambed. Record the measured value to the nearest cm.

Pool Habitat Attributes and Definition

Pools that qualify as sample units for fish abundance data collection efforts are defined as follows (also see Figure 6 from USFS Stream Inventory Handbook 1999):

- Have little or no water surface gradient
- Hydraulic control which spans the channel
- Residual pool depth
- Pool length must exceed width unless it is a channel-spanning plunge pool
- Alternative pool width must exceed 2/3 of the wetted channel width, determined at the widest point in the pool (alternative width criteria will be used to evaluate how many significant pools may be left out of the protocol if only those spanning the channel are included).
- Pools separated by short riffles (length less than average wetted width) are combined into one pool unit.



The following pool habitat attributes are measured:

Length: Measure the length (± 0.1 m) along the thalweg of the habitat unit in meters, using a calibrated surveyor's tape. If the thalweg is not accessible (e.g., because of water depth), take the length measurement at mid-point on the unit's boundary. For sinuous units, take the length as the sum of straight-line lengths along the thalweg (Johnson and Slaney 1996).

Width: Measure the wetted width (± 0.1 m) of the habitat unit as the horizontal distance perpendicular to the channel axis from water's edge on one side to water's edge on the opposite side. The wetted edge is the point at which sediment particles are no longer surrounded by water. Do not include gravel bars in the wetted width. For irregularly shaped habitat units determine an average wetted width from 3-5 measurements at equal intervals along the habitat unit (Johnson and Slaney 1996).

Maximum pool depth: Measure maximum depth for each pool (± 0.01 m). The maximum depth will be measured wherever that depth is ≤ 1.5 meters. In those habitats in which maximum depth exceeds 1.5 meters, an estimate of maximum depth will be made.

Maximum pool tail crest: Measure maximum depth (± 0.01 m) at the tail crest for every pool habitat unit. This location is at the point where the surface slope breaks into the downstream riffle or plunges to a pool below the upstream pool. Measure the maximum depth at this point along the width of the hydraulic control feature that forms the pool. The hydraulic control can be viewed as a dam holding back the pool's water. The "dam" is rarely in a straight line across the downstream end of the pool, rather it usually forms an irregular curve. To identify the location of the maximum depth along the hydraulic control (pool tail crest), visualize a condition in which streamflow has almost stopped, but a trickle of water is still exiting the pool (USFS Stream Inventory Handbook 1999).

Residual Pool: Calculate the residual depth of the pool as the difference between the maximum pool depth and the pool tail crest (or pool outlet depth) (Figure 20 from TFW Habitat Survey Manual 1999). Pools must have a residual pool depth to be counted (Johnson and Slaney 1996).

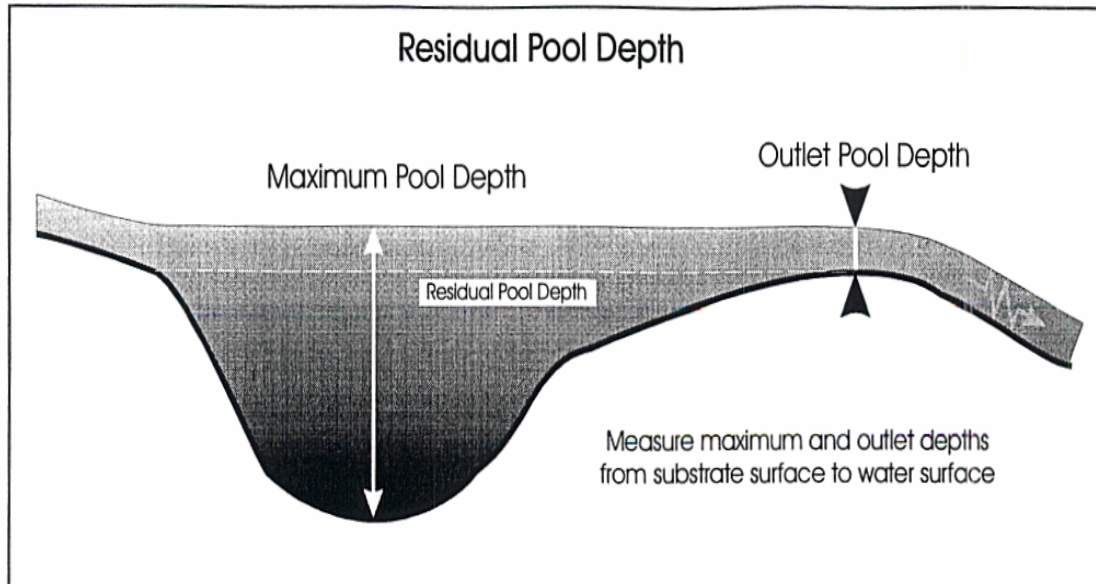


Figure 20. Measure the outlet and maximum pool depths for pool unit identification and calculation of residual pool depth.

Substrate: Substrate will be visually estimated as one of four categories: 1) sand/gravel 2) gravel/cobble, 3) cobble/boulder, or 4) large boulder/bedrock.

Sand/gravel = diameter of 2 to 32 millimeters

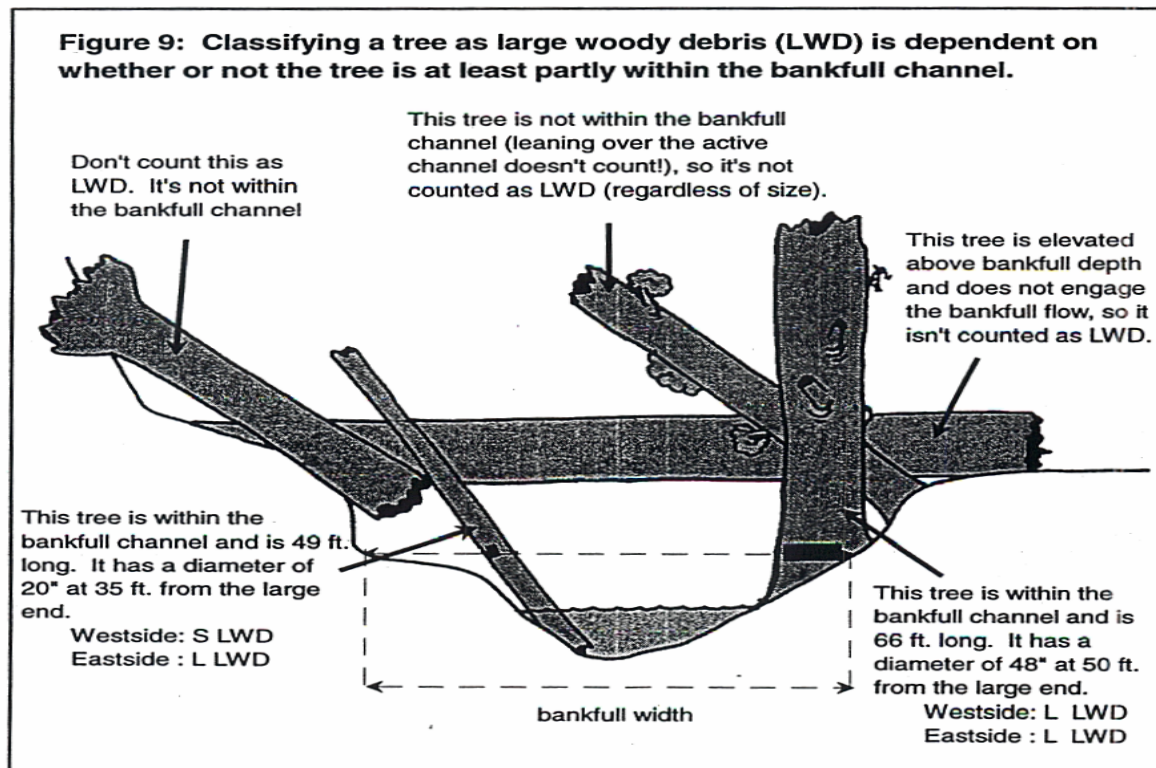
Gravel/cobble = diameter of 33 to 180 millimeters

Cobble/boulder = diameter of 181 to 1024 millimeters

Large boulder/bedrock = diameter > 1025 millimeters

Large woody debris: Record the number of pieces of large woody debris (LWD) within the bankfull channel for each pool habitat unit. The presence of LWD in the bankfull channel decreases the force of high flow events, tends to capture substrate, and offers cover for fish and refuge from the force of storm events.

To be included, the tree bole or root swell of live or dead trees must interact with the streamflow at bankfull conditions (see figure 9 from USFS Stream Inventory Handbook 1999). The bole of a tree is the trunk of a tree, and is known by its gentle taper from the bottom to the top of the tree. The root swell is the portion of the tree between the roots and the bole; root swell is the fusion of individual roots, creating a sharply tapered portion of the tree. The stump of a tree is largely root swell. The roots are the subterranean branched network of a tree.



If a log or tree leans over the bankfull channel or spans the wetted channel, but does not interact with the streamflow during bankfull conditions, do not count it as LWD. Leaning trees (i.e., potential LWD) are not included in the LWD recorded. If only the roots of a tree intercept bankfull flow, the tree is not counted as LWD.

Measure the diameter (nearest cm) and length (nearest 0.1 m) of all pieces of large woody debris that are at least 2 m long and greater than 10 cm at the midpoint along the length of the log.

Logjams: Large woody debris jams are defined as channel-influencing structures formed by accumulations of 10 or more qualifying logs. Accumulations of less than 10 pieces are recorded as individual LWD pieces. Individual jam pieces are tallied by the following size categories: Rootwads (diam. > 20 cm), Small Log (diam. ≥ 10 cm < 20 cm), Medium Logs (diam. ≥ 20 cm < 50 cm), and Large Logs (diam. > 50 cm). Pieces must be "in contact" to be associated with a jam (TFW Ambient Monitoring program manual 1994 and 1999).

Pool cover attributes: Estimates of percent cover of several pool features affecting fish distribution and abundance will be made for each pool sampled. This information will

also be useful for evaluating the relationship between diver observation probabilities and habitat complexity of pools. Percent area coverage of the following attributes will be estimated to the nearest 10% of the pool sample unit:

- Undercut banks
- Overhanging vegetation
- Aquatic vegetation
- LWD
- Boulders

Habitat Attribute Data Collection for Qualitative Fish Sample Units

In the qualitative fish sampling protocol single-pass diver counts will be made in a systematic sample of 100 m segments within a reach. Within these sample segments the following habitat attribute data will be recorded or estimated.

- Estimate the percent pool and riffle area to the nearest 10%. Pool area for this purpose is defined as all flat and low velocity water, and riffles are defined as faster more turbulent water.
- Record the number of qualifying sample unit pools (as previously defined).
- Record the number of pocket pools. Pocket pools are all pools having residual depth but do not meet the size requirements of sample unit pools).
- Record the predominant substrate size (as previously defined)
- Record the number of log jams and individual pieces of qualifying LWD. Pieces in jams do not need to be counted.
- Record number of side channels within the segment.
-

Quantitative Fish Sampling Protocols (pool samples)

Background: Quantitative fish sampling protocols rely on estimates of fish species abundance in pool habitat (see qualifying criteria in habitat methods section) using single-pass diver counts calibrated by a more intensive sampling method. Intensive sampling methods include multiple-pass electro-fishing and bounded diver counts. The method of bounded counts (multiple-pass diver counts) has only recently been applied to fish monitoring and has been evaluated in recent work by Hankin and Mohr (unpublished draft). Bounded counts require much less effort than electro-fishing and therefore can save considerable time in a monitoring program. Electro-fishing calibration requires more gear and setup time, and also presents some different safety hazards as well as possible fish mortalities. Bounded counts appear to be better estimators of abundance where < 20 fish are observed in single-pass diver counts and for samples from deeper pools.

The effectiveness of bounded counts depends on the diver observation probabilities (% of the true number of fish in a sample unit that are actually counted by divers). Observation probabilities vary between habitat types and within habitat types as a function of the complexity of the habitat, depth and clarity of the water, and fish species

being sampled. Electro-fishing capture probabilities are similarly affected. Bounded counts and electro-fishing will be used to calibrate single-pass diver counts and electro-fishing will also be used to compare estimates of abundance between the two methods and to develop diver observation probabilities for the bounded count method.

Sampling Effort: In order to meet our objectives, sampling effort for this summer's field activities will be much more intensive than the actual monitoring program. Stream survey data from NOCA and Mt. Baker NF show a range of 6 to 40 pools/mile (based on the USFS Region 6, Level II stream survey criteria) with a median near 20 pools/mile. Several of the reaches selected for this year approach 1.5 miles in length, which would possibly include a total of 30 qualifying pools. Two levels of sampling effort will be used during the 2001 field season – 'intensive bounded count' and 'intensive single-pass diver survey'.

Two reaches will be used for collecting fish abundance information using the 'intensive bounded count' level of effort. In these reaches all pools encountered will be sampled by the 4-pass bounded count method. Multiple-pass electro-fishing survey removal efforts will be accomplished for a random sample of 8 pools in each of the two reaches.

Other reaches sampled this summer will follow the 'intensive single-pass diver survey' level of effort. All pools in these reaches will be sampled by a single-pass diver survey. An additional 3 passes (bounded counts) will be performed on 1 out of every 2 pools in the reach. Multiple-pass electro-fishing will be accomplished for a systematic sample of 1 out of every 3 of the pools where bounded counts occur.

Table 1. Example of sampling effort (number of pools) for an average reach of 1.5 miles with 20 pools/mile.

	Total Pools	Single-Pass	Bounded Count	Multi-pass EF
Intensive – bounded count	30	30*	30	8**
Intensive – single-pass diver survey	30	30	15	5

* first-pass of bounded count

** fixed number per reach

Table 2. Overall estimated sample sizes (number of pools) for calibration efforts in reaches (average of 30 pools/reach) sampled in 2001

	Reaches	Total Pools	Bounded Count	Multi-pass EF
Intensive – bounded count	2	60	60	16
Intensive – single-pass diver survey	4	120	60	20
Totals	6	180	120	36

Total sampling effort is high, as shown in Table 2, to facilitate evaluations concerning determination of sample size, calibration effort, determination of diver observation probabilities and evaluation of bounded counts.

Fish Sampling Procedure: A dive crew of two people follows the habitat crew. One person on the crew performs the fish counts while the other follows recording fish count information. Prior to each survey water temperature is recorded. Horizontal visibility in the water is also determined by measuring the distance from which a diver just loses sight of a standard secchi disk. This should be done at least once in the morning and once in the afternoon in sample pools after the diver survey is completed.

Upon reaching a designated pool the diver performs a single-pass count, followed by three more passes for those sample units requiring bounded counts. Counts of fish by species and age group (juvenile and adult) are recorded. Diver surveys continue through the reach snorkeling all designated sample units.

An electro-fishing crew of at least three people follows the dive crew, working upstream. Multi-pass electrofishing is accomplished at each of the randomly designated sample units selected from the pool of sample units where bounded diver counts were performed. Block nets are placed at the boundaries of the pool sample unit. The electro-fishing crew completes at least three separate passes of equal effort, recording the number of fish by species and age group and then releasing them outside of the block nets. Additional passes are required if there is less than a 50% reduction in the number of fish captured compared to the previous pass.

Proper settings for the electro-fisher should be determined before use in the sample units. Conductivity should be measured and tests for determining the most efficient electro-fisher settings can be accomplished in other sections of the stream that are not being sampled (USFWS guidelines for electro-fishing in waters with bull trout will be followed).

Electro-fishing shall be completed by no more than one day following the diver counts. However, it is preferable to conduct the sampling during the same day if possible. In order to do this in longer reaches it will be necessary to divide the reach into sections that can be completed in a single day (working sequentially upstream). Following completion of the electro-fishing all flagging tape should be removed.

Qualitative Fish Sampling Protocols (100 meter sample segments)

The purpose of the qualitative sampling protocol is to provide basic inventory data and to evaluate changes in species distributions over time. A systematic sample of every other 100 m segments within a reach will be used to determine species presence and frequency of occurrence for that reach. Sampling will be conducted concurrently with the quantitative fish survey work, on all six of the reaches scheduled this year.

Single-pass diver counts will be used for collection of fish presence data. These surveys can be completed by the same crew working on the quantitative fish survey of pools, while working upstream from the bottom of the reach. Any pool sample units that fall within the qualitative sample segment should be snorkeled first. Two divers will be required in wider channels or segments that have split channels. Number of fish by species and age group will be recorded as in the quantitative fish sampling protocol. The dive crew will also collect the habitat attribute data previously discussed (see - Habitat Attribute Data Collection for Qualitative Fish Sample Units).

Literature Cited

- Johnston, N.T. and Slaney P.A. 1996. Fish Habitat Assessments Procedures. Watershed Restoration Technical Circular No. 8.
- Timber, Fish and Wildlife. 1994 and 1999. Ambient Monitoring Program Manual. TFW AM9-93-001. Olympia, WA. Large Woody Debris module.
- United States Department of Agriculture, 1999. Stream Inventory Handbook, Level I and II. USFS Pacific Northwest Region, Region 6.

Appendix C

Fish Population Monitoring Survey Forms and Methods

The following Appendix contains the complete data collection methods, including forms and specific instructions for each data entry. Some of the methods are established procedures (Northwest Indian Fisheries Commission, Timber, Fish and Wildlife Ambient Monitoring Program (Schuett-Hames et al. 1994 and Pleus et al. 1999); USFS Pacific Northwest Region, Region 6, Stream Inventory (Hankin and Reeves 1988); and Canada Fish Habitat Assessment Procedures (Johnston and Slaney 1996) but many are modifications of these methods.

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Introduction

Fish are an integral part of the North Cascades ecosystem. Wild trout, salmon, char, and other fish have been a principal part of the economic, cultural, and ecological fabric of the Northwest for thousands of years. Over the last several decades, native fish have declined across the region, and today, many wild-fish populations face the threat of extinction. Only wild fish hold the genetic and life history diversity necessary for long-term adaptation, productivity, and survival. Only by preserving wild-fish diversity, as well as critical habitats, can we ensure that robust, healthy fish populations will survive to satisfy our continuing cultural and economic needs.

Inventory and monitoring of stream resident fish populations in parks of the NPS North Coast and Cascade Network has been identified as an important objective by network resource management staff. Funding was secured from the NPS Network Inventory and Monitoring Programs, North Cascades National Park Service Complex (NOCA) Long-Term Ecological Monitoring Program, and Olympic National Park (OLYM) Long-Term Ecological Monitoring Program. The primary goal of this monitoring effort is to provide data concerning freshwater fish occurrence and distribution within Mount Rainier National Park (MORA), NOCA, and OLYM.

Fish population monitoring in North Cascades National Park Complex began in 2001 and continued through 2003. Streams that had little fish data with locations spread throughout the Park were targeted. Fish data were collected while snorkeling and electrofishing. In addition to fish data, habitat related data were collected for each reach. Basic habitat related data were collected at the reach level. Additional data were collected at the qualifying pools throughout the reach. The basic data generally followed the USFS Level II Stream Inventory (Hankin and Reeves 1988), while the additional data at qualifying pools followed a combination of USFS Level II Stream Inventory method and Timber Fish and Wildlife method (Pleus et al. 1999).

The Fish Sampling Protocol – Work Effort form (below) includes the following data:

Fish Sampling Protocol – Work Effort Form Pg ____ of ____				
Watershed _____ Stream Name _____				
Reach Number _____ Reach Location _____				
Crew Members _____				
Date (mm/dd/yy)	Work Component	No. of people	No. of hours	Total No. hours
	Pool Habitat			
	Reach Habitat			
	Discharge			
	Diver - segment single pass			
	Diver - pool single pass			
	Diver- pool bounded count			
	Electrofisch - pool			
Date (mm/dd/yy)	Work Component	No. of people	No. of hours	Total No. hours
	Pool Habitat			
	Reach Habitat			
	Discharge			
	Diver - segment single pass			
	Diver - pool single pass			
	Diver- pool bounded count			
	Electrofisch - pool			
Date (mm/dd/yy)	Work Component	No. of people	No. of hours	Total No. hours
	Pool Habitat			
	Reach Habitat			
	Discharge			
	Diver - segment single pass			
	Diver - pool single pass			
	Diver- pool bounded count			
	Electrofisch - pool			

Watershed – Record the major river system name (e.g. Skagit River) and associated details (such as reservoir stream flows into).

Stream Name – Record the major stream name (e.g. Little Beaver, Lightening, etc.).

Reach Number - Record the number assigned to the reach (segment).

Reach Location - Record any helpful location defining information (e.g. lower, upper, above canyon, etc.).

Crew Members – Record the first and last initials of all biologists and technicians involved in field data collection.

Date (mm/dd/yy) – Record the date of the survey in the defined format (e.g. 08/11/03).

No. of people – Record the number of people (crew) involved in the each **Work Component** for the date recorded.

No. of hours – Record the number of hours the crew worked on the identified **Work Component** for the date recorded.

Total No. hours – Record the total number of hours of work for each identified **Work Component** for the date recorded (total hours is (**No. of people**) times (**No. of hours**)).

Stream Segment Discharge

The surface area of the wetted channel and individual habitat units change with discharge, so measurements are affected by the amount of water flowing in the channel at the time of the survey. The USFS Level II survey method is designed to be applied during relatively stable flow conditions characteristic of the summer low flow period. Surveys should not be conducted during periods of high water associated with summer storms, during extreme low base-flow conditions when sections of typically perennial streams are dry, or during periods of rapidly fluctuating discharge.

Discharge is determined by using the following standard stream flow measurement methods. Begin by selecting a suitable location (within the segment being surveyed) with adequate depth and smooth, laminar flow. A suitable site should not have flow diversions, side-channels, or undercut banks. Select sites relatively free of turbulence and flow obstructions such as large rocks, logs, and aquatic vegetation.

The Stream Segment discharge form (below) includes the following data:

APPENDIX B		TFW Ambient Monitoring Program		Page ____ of ____	
Stream Segment Discharge			Discharge Date ____/____/____		
Stream Name _____			W.R.I.A. _____		
Basin Name _____			Segment # _____ ☐ LB ☐ RB		
Downstrm Ref Pt. # _____ Distance from _____ (m)			Survey Start Date ____/____/____		
Crew Lead _____			Affiliation _____		
Recorder _____					
Record Station Location	Cell Width	Station Depth	Velocity at Station	Cell Discharge	
Left Edge					Add this column together to get Total Discharge
Right Edge					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
Conversion: Cubic Feet/Second (CFS) to Cubic Meters/Second (CMS)				Total Discharge	
_____ CFS x .0283 =				CMS	

Stream Name – Record the stream name where the discharge measurement is taken (e.g. Little Beaver Creek, Lightening Creek, etc.).

Basin Name – Record the basin name (the lowest watershed receiving flow in the survey area, e.g. Thunder).

Downstrm Ref Pt # (Downstream reference point number) - Record the number of the nearest downstream reference point (100 meter segment number) to the stream discharge measurement location. Record the distance (meters) from the nearest downstream reference point.

Crew Lead – Record the first and last initials of the lead biologist or technician for field related data collection.

Recorder – Record the first and last initials of the biologist or technician recording field data.

Discharge Date – Record the month, date and year the discharge data were collected.

WRIA # - Not recorded for this survey.

Segment # - Record the number assigned to the segment (reach).

Survey Start Date – Record the month, date and year when any module for this segment was started.

Affiliation - Record the agency collecting the data (e.g. National Park Service, etc.).

Record Station Location - Record each station's location as distance along the transect tape to the nearest 0.1 meters.

Cell Width – Record the total cell width to the nearest 0.1 meters (half the distance from the last station plus half the distance to the next station). Edge cell widths are calculated by adding the distance from the wetted edge to the adjacent station plus half the distance to the next station.

Station Depth – Record the distance from the water surface to the channel bed to the nearest 0.1 meters with the wading rod held vertically plumb. On higher velocity streams, read the water depth off the rod as the average distance between the stacked water level on the upstream side and the depression level on the downstream side.

Velocity at Station – Record the measured velocity at each station to the nearest 0.01 meters per second (mps). The velocity is measured with the wading rod held vertically plumb, the sensor unit at a 90 degree angle to and just downstream of the transect line, averaged over a minimum period of time, and using either the six-tenths or two-point sensor depth technique (station depth of water < 2.5 feet / 0.6 meters: take one velocity at

0.6 of depth (from surface) at station, station depth $\geq$ 2.5 feet / 0.6 meters: take velocities at 0.2 and 0.8 of depth at station and average together). Note whether velocity measurements are in meters per second (mps) or feet per second (fps).

Cell Discharge – Record the calculated discharge for each cell to the nearest 0.01 cubic meters per second. The calculated discharge is the result of multiplying together the following three factors along the same row: Cell width (x) Station Depth (x) Station Velocity. Make sure that all three numbers were recorded in the same measurement units (meters, feet and inches, or feet and tenths).

Total Discharge CMS (Cubic Meters per Second) – Record the total discharge to the nearest 0.01 CMS. The total discharge is the result of adding together all measurements in the cell discharge column.

Reach and Pool Habitat Survey

Habitat unit survey refers to the identifying and measuring of characteristics of habitat units. Hydraulic conditions such as water depth and velocity vary within stream channels. This variation often occurs in somewhat orderly patterns with distinct, alternating areas of deep water (pools) and shallow water (riffles). These distinct areas are referred to as habitat units.

There are two types of habitat surveys within the Fish Population Study. There is the Reach Habitat Survey and the Pool Habitat Survey. The Reach Habitat Survey is sometimes done independently but the Pool Habitat Survey is always done in combination with the Reach Habitat Survey.

The Reach Habitat Survey uses a classification system consisting of two total habitat areas (pools and riffles). Each segment is walked (starting at the downstream end) and a visual estimate of the total pool (main-channel and pocket pools) and total riffle (riffles, cascades, etc.) area is made. Area estimates are made as a percent of the total area (total wetted area equals 100%). Qualifying pools and pocket pools are enumerated separately for each segment. In addition, information on substrate, wood (TFW and USFS), bankfull, and the number of sidechannels is collected.

The Pool Habitat Survey is a pool specific survey that includes all qualifying pools. Qualifying pools are defined as slow water units that have: little or no surface water gradient; a hydraulic control which spans the channel; residual pool depth; length that exceeds width unless it is a channel-spanning plunge pool; and pool width must exceed 2/3 of the channel width. Pools separated by short riffles (length less than average wetted width) are combined into a single pool unit. During this survey qualifying pools are measured (length, width, depth and tail crest) and additional information is collected for substrate and cover.

Start Date – Record the month, date and year when any module for this reach was started.

End Date – Record the month, date and year when all modules for this reach were completed.

Affiliation - Record the agency collecting the data (e.g. National Park Service, etc.).

Elevation - Record the elevation at the lower end of the surveyed reach. Elevation is from GPS unit on site (this was not always taken, due to availability of GPS units and availability of satellites at time of the attempted reading).

Coordinates - Record the GPS coordinates at the lower end of the surveyed reach. Coordinates are from GPS unit (UTM) on site (this was not always taken, due to availability of GPS units and availability of satellites at time of the attempted reading).

Conductivity - Record the conductivity of the water at the lower end of the surveyed reach. Conductivity is taken with hand-held conductivity meter (this was rarely taken, due to availability of conductivity meter).

Temperature - Record the water temperature at the lower end of the surveyed reach. Water temperature is taken with a hand-held thermometer, in flowing water, in the shade (degrees in either Celsius or Fahrenheit).

Segment Number – Record the segment number. Each 100 meter segment of the reach is given a unique number. The downstream segment of the reach is always numbered 0 and additional upstream segments are numbered sequentially to the upper end of the reach.

Reach Percent Pools – Record the estimated area of the wetted channel that is represented by pool habitat (as percent of total, with total equaling 100). All pool habitat is included (main-channel pools as well as pocket pools). A visual estimate is made by the surveyor as he/she progresses upstream for each 100 meter segment (measured).

Reach Percent Riffles – Record the estimated area of the wetted channel that is represented by riffle habitat (as percent of total, with total equaling 100). All riffle habitats are included (riffles, cascades, falls, etc.) A visual estimate is made by the surveyor as he/she progresses upstream for each 100 meter segment (measured).

Reach Qualifying Pools – Record the total number of qualifying pools within each 100 meter segment. Qualifying pools are defined as slow water units that have: little or no surface water gradient; a hydraulic control which spans the channel; residual pool depth; length that exceeds width unless it is a channel-spanning plunge pool. For this survey an alternative pool width was applied. The pool width must exceed 2/3 of the wetted channel width (not full channel), determined at the widest point in the pool (alternative

width criteria will be used to evaluate how many significant pools may be left out of the protocol if only those spanning the channel are included). Pools separated by short riffles (length less than average wetted width) are combined into a single pool unit.

Reach Number Pocket Pools – Record the total number of pocket pools within each 100 meter segment. Pocket pools are defined as slow water with little or no surface water gradient located within fast water units (riffle). Some areas where pocket pools are found are behind large boulders and wood, and near the edges of riffle units.

Substrate Dominant – Record the dominant substrate within the wetted channel for each 100 meter segment. Substrate is visually estimated as one of four categories: **(1)** sand/gravel (diameter of 2 to 32 millimeters); **(2)** gravel/cobble (diameter of 33 to 180 millimeters); **(3)** cobble/boulder (diameter of 181 to 1024 millimeters); or **(4)** large boulder/bedrock (diameter $\geq$ 1025 millimeters).

Wood TFW Log Jams – Record the total number of log jams within each 100 meter segment. Large woody debris jams are defined as channel-influencing structures formed by the accumulations of 10 or more qualifying logs or rootwads (qualifying logs must have a length of at least 2 meters and a diameter of greater than 10 centimeters for 2 meters of length of the log; and qualifying rootwads must be less than 2 meters long (except for old-growth stumps) and have a root system attached, and must have a diameter 20 centimeters or greater at the base of the stem). Qualifying logs (and rootwads) must be in contact to be associated with a jam.

Wood TFW Pieces – Record the total number of pieces of qualifying wood within each 100 meter segment. To qualify as a log a piece of wood must: 1) be dead (or eminently dying with no chance of survival); 2) have a root system that is wholly or partially detached and is no longer capable of supporting the log's weight; 3) have a diameter of at least 10 centimeters for at least 2 meters of its length; and 4) intrude into the bankfull channel. To qualify as a rootwad, a piece: 1) must be less than 2 meters long (except for old-growth stumps) and have a root system attached; 2) have a diameter of at least 20 centimeters at the base of the stem where it meets the root; 3) must have roots that are detached from their original position on the floodplain or terrace; and/or the rootwad has the ability to fall over; and 4) must intrude into the bankfull channel.

Wood USFS Small – Record the total number of pieces that qualify as USFS small wood within each 100 meter segment. To qualify as a small log a piece of wood must: 1) be dead (or eminently dying with no chance of survival); 2) have a root system that is wholly or partially detached and is no longer capable of supporting the log's weight; 3) have a diameter of at least 12 inches (30 centimeters) at a length of 25 feet (7.5 meters) from the large end; 4) intrude into the bankfull channel. This measurement was added to the survey in 2003.

Wood USFS Medium – Record the total number of pieces that qualify as USFS medium wood within each 100 meter segment. To qualify as a medium log a piece of wood must: 1) be dead (or eminently dying with no chance of survival); 2) have a root system that is wholly or partially detached and is no longer capable of supporting the log's weight; 3)

have a diameter of at least 24 inches. (60 centimeters) at a length of 50 feet (15 meters) from the large end; and 4) intrude into the bankfull channel. This measurement was added to the survey in 2003.

Wood USFS Large – Record the total number of pieces that qualify as USFS large wood within each 100 meter segment. To qualify as a large log a piece of wood must: 1) be dead (or eminently dying with no chance of survival); 2) have a root system that is wholly or partially detached and is no longer capable of supporting the log's weight; 3) have a diameter of at least 36 inches (90 centimeters) at a length of 50 feet (15 meters) from the large end; and 4) intrude into the bankfull channel. This measurement was added to the survey in 2003.

Bankfull Width – Record the measured bankfull width at every second segment break (200 meters) to the nearest 0.1 meters. Bankfull is defined as the high streamflow event occurring on average every 1.5 years. Bankfull width is the measured distance, perpendicular to the stream-flow, from the bankfull indicator on the left bank to the bankfull indicator on the right bank (or level line distance from the best indicator to the point where the line intersects the bank (ground) on the opposite side of the stream). Select sections of fast water units that have a straight and relatively narrow channel since such sites offer the clearest bankfull indicators.

Bankfull Depth $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ – Record the measured bankfull depth (distance from bankfull width tape to the any element of the channel bed) at 25 percent of the bankfull width (BFW), 50 percent of BFW, and 75 percent of BFW, to the nearest 0.01 meters. It is expected that some of these measurements will be made outside of the wetted channel atop dry streambed since the survey is performed under low streamflow conditions.

Bankfull Depth Maximum – Record the measured maximum bankfull depth along the bankfull transect (maximum distance from bankfull width tape to the any element of the channel bed) to the nearest 0.01 meters.

Number Side Channels – Record the total number of side channels within each 100 meter segment. A side channel is a section of stream isolated from the main channel by an island. An island must: 1) have a length equal to at least two bankfull widths; and 2) be colonized by perennial woody vegetation. This measurement was added to the survey in 2003.

The Fish Population Study – Pools form (below) includes the following data:

[illegible]

Stream Name – Record the major stream name where the survey was taken (e.g. Little Beaver Creek, Marble Creek, etc.).

Basin Name – Record the basin name (the lowest watershed receiving flow in the survey area, e.g. Skagit).

River Mile from / to – Record the stream mile at the lower end of the reach (from) and at the upper end of the reach (to).

Crew – Record the first and last initials of the biologists and technicians participating in field data collection.

Recorder – Record the first and last initials of the biologist or technician recording field data.

WRIA # - Not recorded for this survey.

Reach # - Record the number assigned to the reach.

Survey Date – Record the month, date and year when data were collected and this form was filled out.

Start Date – Record the month, date and year when any module for this reach was started.

End Date – Record the month, date and year when all modules for this reach were completed.

Affiliation - Record the agency collecting the data (e.g. National Park Service, etc.).

Pool / Segment – Record the pool, and the 100 meter segment number where the pool resides (separated by a /). Pools must qualify to be counted. Qualifying pools are defined as slow water units that have: little or no surface water gradient; a hydraulic control which spans the channel; residual pool depth; length that exceeds width unless it is a channel-spanning plunge pool. Pools separated by short riffles (length less than average wetted width) are combined into a single pool unit. Each pool (width must exceed 2/3 of the channel width) is given a unique number. The downstream pool of the reach is always numbered 1 and additional upstream pools are numbered sequentially to the upper end of the reach. Each 100 meter segment of the reach is given a unique number. The downstream segment of the reach is always numbered 0 and additional upstream segments are numbered sequentially to the upper end of the reach.

Pools Type – Record the pool type as **2/3** or **full**. To qualify as a 2/3 pool, the pool width must exceed 2/3 of the wetted channel and be less than the full wetted channel width (determined at the widest point in the pool). To qualify as a full pool, the pool width must include the full wetted width of the channel.

Pools Length – Record the measured length of each qualifying pool. Pool length is measured along the thalweg to the nearest 0.1 meters. If the thalweg is not accessible (e.g. because of water depth), take the length measurement at mid-point on the unit's boundary. For sinuous units, take the length as the sum of straight-line lengths along the thalweg (Johnson and Slaney 1996).

Pools Width – Record the measured average width of each pool. Pool width is the measured horizontal distance perpendicular to the channel axis from water's edge on one side to water's edge on the opposite side to the nearest 0.1 meters. Do not include gravel bars in the wetted width. For irregularly shaped habitat units determine an average wetted width from 3 - 5 measurements at equal intervals along the habitat unit (Johnson and Slaney 1996).

Pools Max. Depth (m) – Record the maximum measured depth of each pool. The maximum pool depth is (deepest point in the pool) measured to the nearest 0.01 meters. The maximum depth will be measured wherever that depth is ≤ 1.5 meters. In pools where the maximum depth exceeds 1.5 meters, and estimate of the maximum depth will be made.

Pools Residual Depth (m) – Record the residual pool depth for each qualifying pool. Calculate the residual depth of the qualifying pool as the difference between the

maximum pool depth and the pool tail crest (or pool outlet depth). Pools must have a residual pool depth to be counted (Johnson and Slaney 1996).

Pools Tail Crest Depth (m) – Record the measured pool tail crest depth for each qualifying pool. The pool tail crest is the location where the surface water slope breaks into the downstream riffle or plunges to a pool below the upstream pool. Measure the maximum depth (to the nearest 0.01 meters) along the width of the hydraulic control feature that forms the pool. The hydraulic control can be viewed as a dam holding back the pool's water. The dam is rarely in a straight line across the downstream end of the pool rather it usually forms an irregular curve. To identify the location of the maximum depth along the hydraulic control (pool tail crest), visualize a condition in which stream-flow has almost stopped, but a trickle of water is still exiting the pool (USFS Stream Inventory Handbook 1999).

Substrate Dom. – Record the dominant substrate within the wetted channel for each qualifying pool. The dominant substrate is the most common bed material within the boundaries of the pool unit. Substrate is visually estimated as one of four categories: **(1)** sand/gravel (diameter of 2 to 32 millimeters); **(2)** gravel/cobble (diameter of 33 to 180 millimeters); **(3)** cobble/boulder (diameter of 181 to 1024 millimeters); or **(4)** large boulder/bedrock (diameter $\geq$ 1025 millimeters).

Substrate Sub. – Record the subdominant substrate within the wetted channel for each qualifying pool. The subdominant substrate is the second most common bed material within the boundaries of the pool unit. Substrate is visually estimated as one of four categories: **(1)** sand/gravel (diameter of 2 to 32 millimeters); **(2)** gravel/cobble (diameter of 33 to 180 millimeters); **(3)** cobble/boulder (diameter of 181 to 1024 millimeters); or **(4)** large boulder/bedrock (diameter $\geq$ 1025 millimeters).

Cover (%) Undercut Banks – Record the estimated percent cover provided by undercut banks for each qualifying pool. An undercut bank is a bank that has had its base cut away by water action along the natural or man-made overhangs in the stream. Record cover area provided to the nearest one percent (total surface area of pool equals 100%).

Cover (%) Overhanging Vegetation – Record the estimated percent cover provided by overhanging vegetation for each qualifying pool. Overhanging vegetation is any live plants (grass, forbs, shrubs, and trees) that extend over the stream at least 12 inches from the bank and within 12 inches of the water's surface at stable low flow. Record cover area provided to the nearest one percent (total surface area of pool equals 100%).

Cover (%) Aquatic Vegetation – Record the estimated percent cover provided by aquatic vegetation for each qualifying pool. Aquatic vegetation is rooted vegetation which grows under water. Record cover area provided to the nearest one percent (total surface area of pool equals 100%).

Cover (%) LWD – Record the estimated percent cover provided by large woody debris for each qualifying pool. Large woody debris must: 1) be dead (or eminently dying with no chance of survival); 2) have a root system that is wholly or partially detached and is

no longer capable of supporting the log's weight; 3) have a diameter of at least 10 centimeters for at least 2 meters of it's length; and 4) intrude into the bankfull channel. Record cover area provided to the nearest one percent (total surface area of pool equals 100%).

Cover (%) Boulders – Record the estimated percent cover provided by boulder substrate for each qualifying pool. Boulders are rock substrate larger than 256 millimeters in diameter. To count as cover boulders must be in groups capable of providing cover for juvenile fish. Record cover area provided to the nearest one percent (total surface area of pool equals 100%).

Large Woody Debris Survey

Large woody debris (LWD) is an important component of stream channels in the Pacific Northwest. It plays an integral role in the formation of channel morphology and fish habitat. Logs and rootwads enter stream channels due to bank cutting, blowdown, and mass wasting. Once in the channel, the effect of LWD is related to the size, stability and longevity of the individual pieces and to the tendency of wood to collect in large accumulations known as debris jams.

Large woody debris influences channel morphology in several ways. Pools often form in association with LWD, due to adjacent scouring or impoundment of water behind channel-spanning pieces. Large woody debris often traps and stores sediment, having a moderating effect on sediment transport rates. In steeper, smaller channels, it often forms distinct steps that capture sediment on the upstream side and dissipate energy as the flow drops over the step.

During the Fish Population Survey large woody debris information was collected during the Reach Habitat Survey (general counts of TFW and USFS wood for each segment), and the Pool Habitat Survey (detailed TFW based information collected at qualifying pools).

The Fish Population Study – LWD in Pools form (below) includes the following data:

[illegible]

Page – Record the page number and total page number for this module and the reach.

Watershed – Record the watershed name (the lowest watershed receiving flow in the survey area, e.g. Skagit).

Stream Name – Record the major stream name where the survey was taken (e.g. Little Beaver Creek, Marble Creek, etc.).

Reach Location - Record any helpful location defining information (e.g. lower, upper, above canyon, etc.).

Crew Members – Record the first and last initials of the biologists and technicians participating in field data collection.

Date – Record the month, date and year of data collection.

Piece # (Piece number) – Assign each qualifying LWD piece a unique piece number, beginning with 1 at the lower end of the reach and continuing sequentially upstream to the last piece in the stream reach. Fill-out one row on the LWD in Pools form for each qualifying piece of wood (except those in LWD jams). To qualify a piece of wood must be: dead; the root system (if present) no longer supports the weight of the stem/bole; minimum diameter 0.1 meters (10 centimeters) along 2 meters of its length; and minimum of 0.1 meters of length extending into the bankfull channel.

Dwn RP # (Downstream reference point number) – Record the number of the nearest downstream segment number using the mid-point of the log or rootwad.

Piece Cat (L-R) – Record **L** for log or **R** for rootwad for each qualifying piece of wood. To qualify as a log a piece of wood must: 1) be dead (or eminently dying with no chance of survival); 2) have a root system that is wholly or partially detached and is no longer capable of supporting the log's weight; 3) have a diameter of at least 10 centimeters for at least 2 meters of its length; and 4) intrude into the bankfull channel. To qualify as a rootwad, a piece of wood must: 1) be less than 2 meters long (except for old-growth stumps) and have a root system attached; 2) have a diameter of at least 20 centimeters at the base of the stem where it meets the root; 3) have roots that are detached from their original position on the floodplain or terrace; and/or the rootwad has the ability to fall over; and 4) intrude into the bankfull channel.

Piece Dia. (CM) (Piece Diameter in centimeters) – Record the measured diameter (to the nearest centimeter at the midpoint along the length of the piece) in the diameter column. Document estimated measurements due to buried or obstructed pieces in the Field Notes section.

Piece Lgth (m) (Piece length in meters) – Record the total piece length for each qualifying log or rootwad. Lengths are measured to the nearest 0.1 meters unless estimated and documented in the Field Notes section.

Species Cat (C-D-U) – Record the type of wood using: **(C)** for Conifer; **(D)** for Deciduous; or **(U)** for Unknown.

Pool FF (Y-N) (Pool forming function) – After determining if the log or rootwad is associated (directly or indirectly) with the forming of a qualifying pool, record **(Y)** for Yes and **(N)** for No.

Large Woody Debris Jams

Large woody debris jams consist of accumulations of ten or more qualifying pieces (either logs or rootwads) that are touching. A portion of the jam must extend into Zone 1 or 2 (Zone 3 optional) to be counted as part of a LWD jam. The LWD jam information is collected while walking around the outside of the jam and does not necessitate actual measurement of individual pieces of wood.

The Fish Population Study – LWD Jams form (below) includes the following data:

TFW Monitoring Program										Stream Name		Crew Lead _____ Other(s) _____		Page ____ of ____	
LWD JAM SURVEY										☐ KEY PIECES ☐ ZONE 3		FIELD DATA		FORM 4.3	
WRIA # _____				Unlisted Trb ☐ RB ☐ LB		Segment # _____		Sub-Segment Code _____		Date ____/____/____					
Jam #	DWN RP #	LOWEST Zone (1-3)	POOL FF (Y-N)	Rtwd Dia ≥ 20 cm	KEY PIECES	Small - LOG ≥ 10 cm to < 20 cm	KEY PIECES	Medium - LOG ≥ 20 cm to < 50 cm	KEY PIECES	Large - LOG ≥ 50 cm	KEY PIECES	Field Notes			
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 Northwest Indian Fisheries Commission, 6730 Martin Way E., Olympia, WA 98516 (360)438-1180

ERROR CHECKED by: _____ Date: ____/____/____

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Stream Name – Record the major stream name (e.g. Chilliwack, Little Beaver Creek, Marble Creek, etc.).

Crew Lead – Record the first and last initials of the lead biologist or technician for field related data collection.

Other(s) – Record the first and last initials of the biologists and technicians participating in field data collection.

Page – Record the page number and total page number for this module and segment.

WRIA # - Not recorded for this survey.

Segment # - Record the number assigned to the segment (reach).

Date – Record the month, date and year of data collection.

Jam # (LWD jam number) – Assign each LWD jam in the reach a unique number beginning with 1 and sequentially numbering each jam to the end of the reach. Fill-out one row of Form 4.3 for each qualifying LWD jam (10 or more interconnected qualifying pieces of wood).

Dwn RP # (Downstream reference point number) – Record the number of the nearest downstream segment number using the mid-point of the log or rootwad.

Lowest Zone – Record the zone number (1 or 2) documenting the lowest zone the LWD jam intrudes into the bankfull channel.

Pool FF (Y-N) (Pool forming function) – After determining if the LWD jam is associated (directly or indirectly) with the forming of a qualifying pool, record (Y) for Yes and (N) for No.

Tally of Visible Pieces – Record the total number of individual pieces of LWD in the appropriate type and size classes: **Rtwd** – Record the total number of rootwads (≥ 20 centimeters diameter and < 2 meters in length) in the LWD jam; **Small Log** – Record the total number of small logs (≥ 10 centimeters diameter to < 20 centimeters diameter at the mid-point of log and > 2 meters in length) in the LWD jam; **Medium Log** – Record the total number of medium logs (≥ 20 centimeters diameter to < 50 centimeters diameter at the mid-point of log and > 2 meters in length) in the LWD jam; **Large Log** – Record the total number of large logs (≥ 50 centimeters diameter at the mid-point of log and > 2 meters in length) in the LWD jam; and **Key Pieces** – For each category record the total number of key pieces. Key pieces are larger pieces expected to stay in place during most flood events and provide stable base logs for a LWD jam at the current location.

Field Notes – Record any additional LWD jam specific information (e.g. location, photos numbers, etc.).

Error Checked - Not recorded during this survey.

Fish Survey

Fish are an integral part of the North Cascades ecosystem. Wild trout, salmon, char, and other fish have been a part of the economic, cultural, and ecological fabric of the Northwest for thousands of years. Over the last several decades, native fish have declined across the region, and today, many wild-fish populations face the threat of extinction.

Only wild fish hold the genetic and life-history diversity necessary for long-term adaptation, productivity, and survival. Only by preserving wild-fish diversity, as well as critical habitats, can we ensure that robust, healthy fish populations will survive to satisfy our continuing cultural and economic needs.

Fish were surveyed to establish information regarding species present, distribution and relative abundance. The fish surveys in the Fish Population Study are done either by snorkeling (both single pass and 4 pass), and electrofishing.

The Fish Population Study – Fish Reaches form (below) includes the following data:

[illegible]

Stream Name – Record the major stream name (e.g. Little Beaver Creek, Marble Creek, etc.).

Basin Name – Record the basin name (the lowest watershed receiving flow in the survey area, e.g. Skagit).

River Mile from / to – Record the stream mile at the lower end of the reach (**from**) and at the upper end of the reach (**to**).

Crew – Record the first and last initials of the biologists and technicians participating in field data collection.

Recorder – Record the first and last initials of the biologist or technician recording field data.

WRIA # - Not recorded for this survey.

Reach # - Record the number assigned to the reach during the reach identification process.

Survey Date – Record the month, date and year when data were collected and this form was filled out.

Start Date – Record the month, date and year when any module for this reach was started.

End Date – Record the month, date and year when all modules for this reach were completed.

Affiliation - Record the agency collecting the data (e.g. National Park Service, etc.).

Segment Number – Record the number of the segment you are sampling. Each 100 meter segment of the reach is given a unique number. The downstream segment of the reach is always numbered 0 and additional upstream segments are numbered sequentially to the upper end of the reach.

Qualifying Pools – Record the number of qualifying pools in the segment. Qualifying pools are defined as slow water units that have: little or no surface water gradient; a hydraulic control which spans the channel; residual pool depth; length that exceeds width unless it is a channel-spanning plunge pool; and width must exceed 2/3 of the wetted channel width.

Number Divers – Record number of divers participating in each survey pass.

Fish Species – Record the species of fish observed. Each pass is recorded on a separate line. In addition if there are more than one species observed per pass, each species has a separate line. For species identification, use scientific names, common names or common abbreviations.

Fish Total > 150mm – Record the total number of fish greater than 150 millimeters in length. Each pass is recorded on a separate line. In addition, make sure the numbers relate to specific species recorded in previous column.

Fish Total < 150mm – Record the total number of fish less than 150 millimeters in length. Each pass is recorded on a separate line. In addition make sure the numbers relate to specific species recorded in previous column.

Underwater Visibility – Record the underwater horizontal visibility (meters). The horizontal visibility in the water is determined by measuring the distance from which a diver just loses sight of a standard secchi disk (8 inch diameter, round, solid white plastic disk). This measurement should be taken at least once in the morning and once in the afternoon in sample pools after the dive survey is completed.

Time Start – Record the time (hours, minutes and seconds) the diver(s) start(s) a survey pass. If a stopwatch is used only the total time is recorded.

Time Finish – Record the time (hours, minutes and seconds) the diver(s) finished a survey pass. If a stopwatch is used only the total time is recorded.

Total Time – Record the total time the diver(s) take(s) to complete a single survey pass. Time is recorded in minutes and seconds (and hours if applicable).

The Fish Population Study – Fish Pools form (below) includes the following data:

[illegible]

Stream Name – Record the major stream name (e.g. Little Beaver Creek, Marble Creek, etc.).

Basin Name – Record the basin name (the lowest watershed receiving flow in the survey area, e.g. Skagit).

River Mile from / to – Record the stream mile at the lower end of the reach (**from**) and at the upper end of the reach (**to**).

Crew – Record the first and last initials of the biologists and technicians participating in field data collection.

Recorder – Record the first and last initials of the biologist or technician recording field data.

WRIA # - Not recorded for this survey.

Reach # - Record the number assigned to the reach.

Survey Date – Record the month, date and year when data were collected and this form was filled out.

Start Date – Record the month, date and year when any module for this segment was started.

End Date – Record the month, date and year when all modules for this segment were completed.

Affiliation - Record the agency collecting the data (e.g. National Park Service, etc.).

Pool Number – Record the pool number (assigned during Pool Habitat Survey) of each electrofished pool.

Segment Number – Record the segment number (assigned during the Reach Habitat Survey).

Number Divers – Record number of divers participating in each survey pass.

Fish Species – Record the species of fish observed. Each pass is recorded on a separate line. In addition if there are more than one species observed per pass, each species has a separate line. For species identification, use scientific names, common names or common abbreviations.

Fish Total > 150mm – Record the total number of fish greater than 150 millimeters in length. Each pass is recorded on a separate line. In addition make sure the numbers relate to specific species recorded in previous column.

Fish Total < 150mm – Record the total number of fish less than 150 millimeters in length. Each pass is recorded on a separate line. In addition make sure the numbers relate to specific species recorded in previous column.

Underwater Visibility – Record the underwater horizontal visibility (meters). The horizontal visibility in the water is determined by measuring the distance from which a diver just loses sight of a standard secchi disk (8 inch diameter, round, solid white plastic disk). This measurement should be taken at least once in the morning and once in the afternoon in sample pools after the dive survey is completed.

Time Start – Record the time (hours, minutes and seconds) the diver(s) start(s) a survey pass. If a stopwatch is used only the total time is recorded.

Time Finish – Record the time (hours, minutes and seconds) the diver(s) finish a survey pass. If a stopwatch is used only the total time is recorded.

Total Time – Record the total time the diver(s) take to complete a single survey pass. Time is recorded in minutes and seconds (and hours if applicable).

The Fish Population Study – Pool Electrofishing form (below) includes the following data:

[illegible]

Page – Record the page number and total page number for this module and reach.

Watershed – Record the watershed name (the lowest watershed receiving flow in the survey area, e.g. Skagit).

Stream Name – Record the major stream name (e.g. Little Beaver Creek, Marble Creek, etc.).

Reach Number - Record the number assigned to the reach.

Reach Location - Record any helpful location defining information (e.g. lower, upper, above canyon, etc.).

Segment Location (Dwnstr Ref Pt) – Record the segment number (assigned during the Reach Habitat Survey).

Pool Number – Record the pool number (assigned during Pool Habitat Survey) of each electrofished pool.

Date – Record the month, date and year of data collection.

Crew Members – Record the first and last initials of the biologists and technicians participating in field data collection.

EF Settings: - Record the frequency setting (letters **A thru P**), the pulse setting (number **1 thru 16**), and the output voltage setting from the control panel of the electrofisher (left side on Smith-Root models).

Species – Record the species of fish captured. Each species captured is recorded on a separate line. For species identification, use scientific names, common names or common abbreviations.

Total (< 150mm) – Record the total number of captured fish less than 150 millimeters in length. This number must relate to the species recorded in the previous column.

Total (> 150mm) – Record the total number of captured fish greater than 150 millimeters in length. This number must relate to the species recorded in the previous column.

EF Time (sec) – Record the total time (seconds) the electrofisher is in service during each pass. Timer is located on the top of the control panel (left side on Smith-Root models).

Start Time – Record the time (hours, minutes and seconds) at the beginning of each pass.

Stop Time – Record the time (hours, minutes and seconds) at the end of each pass.