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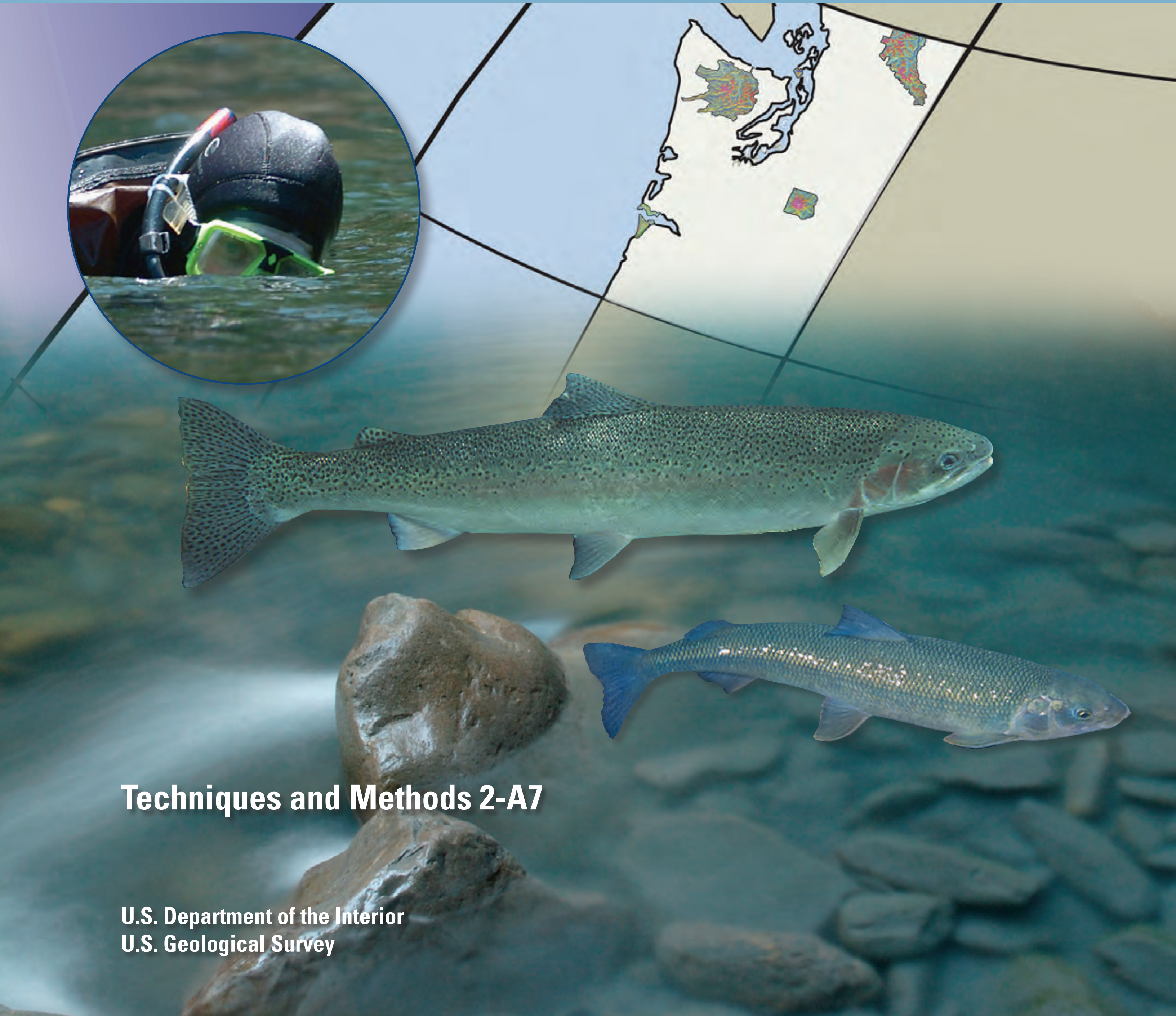
Protocol for Monitoring Fish Assemblages in Pacific Northwest National Parks

Chapter 7 of

Section A, Biological Science
Book 2, Collection of Environmental Data



Techniques and Methods 2-A7

U.S. Department of the Interior
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Cover: Photographs of diver counting fish in Olympic National Park. Photographs reprinted with permission from Tony Overmann (diver in North Fork Skokomish River), Javin Elliff (South Fork Hoh River, background), and Ernest Keeley (mountain whitefish and summer steelhead).

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By Samuel J. Brenkman, National Park Service; and Patrick J. Connolly,
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U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
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Conversion Factors

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
kilometer (km)	0.6214	mile (mi)
meter (m)	3.281	foot (ft)
	Area	
square meter (m^2)	10.76	square foot (ft^2)
hectare (ha)	2.471	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Mass	
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound, avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8.$$

Protocol for Monitoring Fish Assemblages in Pacific Northwest National Parks

By Samuel J. Brenkman, National Park Service, and Patrick J. Connolly, U.S. Geological Survey

Narrative

Version 1.0

Revision History Log:

Revision Date	Author	Changes Made	Reason for Change

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Executive Summary

Rivers and streams that drain from Olympic, Mount Rainier, and North Cascades National Parks are among the most protected corridors in the lower 48 States, and represent some of the largest tracts of contiguous, undisturbed habitat throughout the range of several key fish species of the Pacific Northwest. These watersheds are of high regional importance as freshwater habitat sanctuaries for native fish, where habitat conditions are characterized as having little to no disturbance from development, channelization, impervious surfaces, roads, diversions, or hydroelectric projects. Fishery resources are of high ecological and cultural importance in Pacific Northwest National Parks, and significantly contribute to economically important recreational, commercial, and tribal fisheries.

This protocol describes procedures to monitor trends in fish assemblages, fish abundance, and water temperature in eight rivers and five wadeable streams in Olympic National Park during summer months, and is based on 4 years of field testing. Fish assemblages link freshwater, marine, and terrestrial ecosystems. They also serve as focal resources of national parks and are excellent indicators of ecological

conditions of rivers and streams. Despite the vital importance of native anadromous and resident fish populations, there is no existing monitoring program for fish assemblages in the North Coast and Cascades Network.

Specific monitoring objectives of this protocol are to determine seasonal and annual trends in: (1) fish species composition, (2) timing of migration of adult fish, (3) relative abundance, (4) age and size structure, (5) extent of non-native and hatchery fish, and (6) water temperature. To detect seasonal and annual trends in fish assemblages in reference sites, we rely on repeated and consistent annual sampling at each monitoring site. The general rationale for the repeated sampling of reference sites is to ensure that we account for the high interannual variability in fish movements and abundances in rivers. One underlying assumption is that the monitoring program is designed in perpetuity, and consequently our capability to detect trends substantially increases with time.

The protocol describes sampling designs, methods, training procedures, safety considerations, data management, data analysis, and reporting. The allocation of sampling effort represents a balance between ecological considerations, a sound monitoring approach, and practical limitations caused by logistical constraints and a limited annual budget of $55,000. The widespread declines of native fish species in western North America highlights the importance and urgency of understanding trends in fish assemblages from undisturbed habitats. Seasonal and annual trends in fish assemblages will provide insights at the individual, population, and assemblage level.

This protocol will allow managers to detect increases and decreases in abundance of priority management species, and occurrence of non-native, hatchery, and federally listed fish. The detection of trends in fish assemblages will allow for specific management actions that may include: implementation of more appropriate fishing regulations, evaluation of existing hatchery releases, control of non-native fish species, and prioritization of habitat restoration projects. Dissemination and communication of scientific findings on North Coast and Cascades Network fish assemblages will be a core product of this protocol, which will have much relevance to decision makers, park visitors, researchers, and educators.

1. Introduction

A. Background

This protocol outlines the rationale, sampling design, and methods for monitoring fish assemblages, fish abundance, and water temperature in rivers in the North Coast and Cascades Monitoring Network (NCCN) during summer months. The protocol also outlines the sampling design and methods for monitoring juvenile fish assemblages in streams that are co-located with river monitoring sites. The protocol format and content is in accordance with Oakley and others (2003). The NCCN is 1 of 32 networks of parks in the National Park System that comprises 7 national park units in the Pacific Northwest. The NCCN includes Mount Rainier [MORA], Olympic [OLYM], and North Cascades National Parks [NOCA]) and 4 small historic-cultural parks including Ebey's Landing National Historical Reserve, Lewis and Clark National Historical Park, Fort Vancouver National Historical Park, and San Juan Island National Historical Park.

This protocol was designed for rivers in the NCCN that have high water visibility and are conducive to snorkel methods from June through September each year. Although this protocol was specifically designed for use in Pacific Northwest National Parks, it should be helpful in the development of protocols in other National Park Service units and other areas of the Pacific Northwest. The sampling of NCCN rivers is challenging because of high costs, arduous logistics, and safety concerns. The sampling design in this protocol addresses many of the challenges inherent in working in remote, roadless wilderness parks, and it is considered to be logistically feasible based on pilot studies conducted from 2004 to 2007. The protocol was extensively tested and evaluated in 10 OLYM rivers, 3 MORA rivers, and 3 OLYM streams.

The protocol will be implemented in eight rivers and five wadeable streams in OLYM based on the importance and high priority of fishery resources in that park (table 1). The protocol will not be implemented in MORA or NOCA due to other higher monitoring priorities in those parks and because of funding constraints. In this protocol, we do provide information on watersheds and fish assemblages for all three large wilderness parks in the NCCN. The inclusion of other NCCN rivers for sampling purposes (for example, NOCA: Baker, Chilliwack, North Fork Cascade, Skagit, Stehekin Rivers; MORA: Ohanapecosh) would require additional funds, field testing, and perhaps the inclusion of alternate sampling methods to accommodate local conditions.

The NCCN rivers support numerous fish species and unique populations of Pacific salmon, trout, and char. OLYM is the only national park in the lower 48 States that contains significant numbers of wild Pacific salmonids with at least 70 populations in park rivers (Houston and Contor, 1984). These salmonids are critical to ecosystem function, and link freshwater, marine, and terrestrial ecosystems. Pacific salmonids provide food for more than 130 species of aquatic and terrestrial wildlife species (Cederholm and others, 2001), and studies have shown that 20–40 percent of the phosphorus, nitrogen, and carbon in freshwater systems may be marine-derived through carcasses of spawned salmon (Kline and others, 1990, 1994; Bilby and others, 1996).

Table 1. Watershed characteristics of rivers that will be monitored for seasonal and annual trends in fish assemblages in Olympic National Park.

[**Abbreviations**: ha, hectare; km, kilometer; m, meter; m^3/s, cubic meter per second; ft^3/s, cubic foot per second; <, less than; WDOE, Washington Department of Ecology]

River	Watershed area (ha)	Percentage of watershed area in park	Elevation (m)		River length (km)		River gradients (percent)	Mean summer flow		Maximum flows safe to snorkel			Anadromous fish present	Hatchery present	Drains into which water body
			Park boundary	Head-water	Total	Total in park		m^3/s	ft^3/s	m^3/s	ft^3/s	River gage			
Bogachiel	32,849	64	103	1,288	75.3	42.1	<1	[1]5.5	[1]193	42.5	1,500	Calawah	Yes	Yes	Quillayute River
Dosewallips	30,091	63	326	1,872	45.8	25.9	Upper 2–4 Lower 4–8	NA		11.3	400	North Fork Skokomish River at Staircase	No	No	Hood Canal
East Fork Quinault	23,278	100	117	2,245	21.4	21.4	<1	NA		42.5	1,500	Quinalt River	Yes	Yes	Quinault River
North Fork Quinault	20,837	100	115	1,238	30.8	30.8	<1	NA		39.6	1,400	Quinalt River	Yes	Yes	Quinault River
North Fork Skokomish	31,081	48	225	1,622	[2]51.8	22.7	Upper 2–4 Lower <1	8.7	306	10.6	375	North Fork Skokomish River at Staircase	No	Yes	Lake Cushman
South Fork Hoh	11,338	79	244	1,318	31	24.3	<1	[1]8.1	[1]287	42.5	1,500	Hoh River	Yes	No	Hoh River
Sol Duc	19,442	29	318	1,440	105.6	25.9	1-2	[1]3.8	[1]134	34.0	1,200	Sol Duc, WDOE	Yes	Yes	Quillayute River
North Fork Sol Duc	7,965	100	329	1,520	24.3	24.3	Upper 1–2 Lower 2–4	[1]2.6	[1]91	28.3	1,000	Sol Duc, WDOE	Yes	Yes	Sol Duc River

[1]Lieb and Thomas (2005).

[2]Includes reservoirs.

In NCCN rivers, fishery resources are of high ecological and cultural importance, and contribute significantly to recreational, commercial, and tribal fisheries. Fish communities were ranked third among all potential vital signs to monitor in the NCCN. Fish assemblages that inhabit these rivers and streams serve as important benchmarks that define natural limits of variation and monitoring will identify rivers where management actions are necessary (Jenkins and others, 2003). The decline in native fish species in western North America highlights the importance of understanding patterns observed in least-disturbed habitats within the park boundaries.

Rivers and streams that drain from OLYM, MORA, and NOCA also have many key fish species other than Pacific salmon. There are several fish species in the NCCN that are non-commercially viable yet are ecologically and recreationally important. For instance, mountain whitefish have received little attention despite being one of the most abundant fish species in many river systems (Northcote and Ennis, 1994). Additionally, cutthroat trout are an important species targeted by recreational anglers. There are no existing monitoring programs for non-commercial fish species in watersheds that drain from OLYM (table 2).

Despite the vital importance of native anadromous and resident fish populations (Jenkins and others, 2003), there is no integrated monitoring program for fish assemblages in the NCCN. Historically, the monitoring of fish assemblages in rivers and streams has been extremely limited, and there are no published studies that describe the monitoring of fish assemblages in the any of the NCCN rivers. Perhaps this is not surprising due to the physical challenges (for example, visibility, high riverflows, and poor access) associated with sampling rivers in those national parks. Additionally, there has been an absence of fisheries scientists in the NCCN until the late 1980s.

Generally, the fisheries studies that have occurred in NCCN rivers were limited in duration, limited to the summer sample season, or focused on a single species and not the entire fish assemblage (table 2). Recently, formal fish inventories were conducted in selected river basins in the NCCN (Brenkman and others, 2004, 2007a; Zyskowski, 2007), and annual monitoring now occurs for several salmonid stocks in OLYM rivers where trend data dates back to 1989. There also have been species-specific studies published from rivers in OLYM (Brenkman and others, 2001; Brenkman and Corbett, 2005; Brenkman and others, 2007b, 2008a, 2008b; Connolly and Brenkman, 2008). Lastly, OLYM, Washington Department of Fish and Wildlife, and coastal tribes monitor escapements of selected stocks in portions of OLYM rivers as related to harvest management (table 2).

Table 2. Existing monitoring of Pacific salmonids that occur near reference sites of the eight rivers in the Olympic National Park outlined in this protocol.

[No monitoring programs exist for non-salmonid fish species and all other monitoring programs are single-species focused. Information for surveys conducted by Quinault Indian Nation and Washington Department of Fish and Wildlife was based on personal communications with Larry Gilbertson and Roger Mosely, respectively. **Abbreviations**: rkm, river kilometer; OLYM, Olympic National Park; WDFW, Washington Department of Fish and Wildlife; N/A, not applicable]

River	Fish species	Survey source: Agency/Tribe	Type of survey	Duration of monitoring	General location of monitoring sites (rkm)
Bogachiel	Winter steelhead	WDFW/OLYM	Redds–Helicopter	April–June	36.5–54.8
Dosewallips	None	None	None	None	None
East Fork Quinault	Winter steelhead	Quinault Indian Nation	Redds-Walking	April–June	75.8–77.8
	Spring Chinook	Quinault Indian Nation	Redds-Walking	August–September	75.8–85.2
	Fall Chinook	Quinault Indian Nation	Redds-Walking	October–November	75.8–77.8
	Fall coho	Quinault Indian Nation	Redds-Walking	November–January	75.8–77.8
North Fork Quinault	Winter steelhead	Quinault Indian Nation	Redds-Helicopter	May	12.1–0
	Spring Chinook	Quinault Indian Nation	Redds-Helicopter	September	12.1–0
	Fall Chinook	Quinault Indian Nation	Redds-Helicopter	N/A	12.1–0
North Fork Skokomish	Bull trout	OLYM	Snorkel	October to December	48.1–45.5
South Fork Hoh	Winter steelhead	Hoh Tribe	Redds-Walking	March–June	0–2.6; 9.9–13.4
	Spring Chinook	WDFW	Redds-Walking	September–October	0–2.6; 9.9–13.4
	Fall Chinook	WDFW	Redds-Walking	October–December	0–2.6; 10.5–14.9
	Fall coho	WDFW	Redds-Walking	October–January	10.5–14.9
Sol Duc	Summer coho	OLYM	Redds-Walking	October–December	97.2–104.3
	Winter steelhead	OLYM/WDFW	Redds-Walking	April–June	98.9–104.7
North Fork Sol Duc	Winter steelhead	OLYM	Redds-Walking	April–June	3.6–6.8

There have been widespread declines or extirpations of native fish populations in the Pacific Northwest rivers that have led to increased numbers of threatened or endangered species (Williams and others,1989; Nehlsen and others, 1991). Native fish in the NCCN face several potential threats that include overharvest, deleterious effects from hatchery fish, and non-native fish invasions. The decline of Pacific salmonids on the West Coast has been attributed to overharvest, displacement by non-native fish, influence of hatchery fish on wild fish, and habitat degradation (Bottom, 1995; Emmett and Schiewe, 1997; Francis, 1997). Of the 41 salmonid stocks on the Washington coast and Puget Sound, 26 were categorized as being at high risk of extinction, 8 at moderate risk, and 7 of special concern (Nehlsen and others, 1991). In the NCCN, a total of five fish species are listed as threatened under the Endangered Species Act including Puget Sound Chinook salmon, Puget Sound steelhead, Puget Sound/Coastal bull trout, Hood Canal summer chum salmon, and Lake Ozette sockeye salmon. MORA and NOCA each contain three federally threatened fish species. There are five fish species that are federally threatened in OLYM that occur in rivers that drain into the Hood Canal, Strait of Juan de Fuca, and the Washington coast. The rivers along the Washington coast that drain from OLYM contain some of the last remaining areas on the West Coast without a federally threatened salmon or steelhead ESU.

In OLYM rivers, migratory salmonids are especially vulnerable to harvest because they migrate outside the park for most of their life cycle, or require multiple watersheds throughout their life history (Brenkman and others, 2007b). Pacific salmon and steelhead are subjected to intensive recreational and commercial gill-net fisheries that operate most weeks of the year in coastal rivers of the NCCN. Recreational fishing is allowed within OLYM, MORA and NOCA, and is a $850 million industry each year in Washington State. Ultimately, commercial and recreational fishery's greatly influence the number of adult salmonids that return to National Park waters.

Past and present State and Tribal hatchery practices also pose threats to wild salmonids in the NCCN. Hatchery-produced fish are used to supplement recreational and commercial fisheries with limited regard to their influence on park resources. The establishment of hatchery-origin fish in National Park rivers and streams is of particular concern based on the deleterious genetic effects of hatchery fish on wild populations. Hatchery fish, through interbreeding with wild fish, genetically alter wild populations, reduce fitness, and reduce genetic differentiation among stocks (Reisenbichler and McIntyre, 1977; Chilcote and others, 1986; Araki and others, 2007).

Invasions of non-native fish species also pose imminent threats to native fish fauna in NCCN rivers, and they are cited as a primary factor negatively influencing native fish assemblages throughout western North America (Fausch and others, 2006). Potentially significant threats to native fish in OLYM may be the invasion of Atlantic salmon (*Salmo salar*). Atlantic salmon are commercially raised in marine net pens in Washington State and British Columbia. Annual escapes of Atlantic salmon from pens are difficult to quantify but may approach 500,000 fish annually in British Columbia where Atlantic salmon have been documented ascending at least 78 coastal rivers (www.biology.ualberta.ca/faculty/john_volpe). In Washington, catastrophic events resulted in the escape of 107,000; 369,000; and 115,000 Atlantic salmon in 1996, 1997, and 1999, respectively (Amos and Appleby, 1999). Atlantic salmon have been observed in Olympic Peninsula rivers including the Elwha and Quillayute Rivers, both of which drain from the park.

Non-native brook trout (*Salvelinus fontinalis*) also occur throughout MORA, NOCA, and OLYM, and became established from historic introductions in those parks. Brook trout pose particular threats to federally threatened bull trout (Markle, 1992; Rieman and McIntyre, 1993) and other important native fish species such as cutthroat trout (Peterson and Fausch, 2003; Peterson and others, 2004) and Chinook salmon (Levin and others, 2002; Izaak and others, 2007).

B. Rationale for Monitoring Fish Assemblages and Water Temperature as Indicators of Ecological Integrity

Rivers are among the most intensively managed and most severely degraded ecosystems on earth (Oberdorff and others, 2002). In the NCCN, rivers that drain from the large national parks are some of the last remaining free-flowing and unregulated systems in the lower 48 States. In the Pacific Northwest, there is limited information on fish assemblages from relatively pristine rivers such as those that drain from the NCCN parks. These rivers represent some of the largest tracts of contiguous, undisturbed aquatic habitat throughout the range of several west coast fish species, and are regionally important as freshwater habitat refuges for wild salmonids and other native fish species. These rivers serve as sanctuaries for critical life stages (for example, spawning and early rearing) of many species and many populations. The rivers also serve as relative undisturbed control systems to help gauge past and future changes in river systems throughout the Pacific Northwest.

Every important aspect of the river ecosystem begins in headwater streams (Freeman and others, 2007). Protected river and stream corridors such as those at OLYM are rare in the Pacific Northwest where the best remaining habitats for native fish species are often restricted to higher elevations (Li and others, 1995). Habitat conditions in portions of rivers and streams identified in this protocol generally are undeveloped with little or no impervious surfaces, diversions, or hydroelectric projects inside the national parks. Consequently, the watersheds in OLYM are not subject to large-scale consequences of headwater alteration including downstream euthrophication, lower secondary productivity in downstream sites, and reduced viability of freshwater biota (see Freeman and others, 2007).

The fundamental sampling entity in this monitoring plan is the fish assemblage, which will serve as an indicator of ecological integrity. Fish assemblages in the NCCN are focal resources of parks (see Jenkins and others, 2003). Fish assemblages that inhabit rivers and streams represent critical components of biological integrity from ecosystem and public interest perspectives (Peck, D.V., and others, U.S. Environmental Protection Agency, unpub. data, 2000). These fish assemblages also can serve as excellent indicators of ecological conditions because they integrate effects from lower trophic levels (for example, fish being key predators and consumers in aquatic food webs), they integrate environmental variability at different spatial scales (Oberdorff and others, 2002), and they are reasonably easy to identify (Plafkin and others, 1989). At the temporal scale, the longevity of fishes helps to “register” environmental alterations across long time periods (Schmutz and others, 2000). The life histories of many fish species are well understood, and therefore the presence or absence of specific taxa can be easily interpreted (Flotemersch and others, 2006). Freshwater and anadromous fish species also provide recreation for anglers and viewing by non-anglers. One disadvantage of using fishes as indicators in rivers is that fisheries management activities such as continuous stocking and harvest make it more difficult to distinguish between fishery-caused impacts and other anthropogenic alterations (Schmutz and others, 2000).

C. Monitoring Goals and Objectives

To guide monitoring in the National Park units, the goals for the National Park Service Inventory and Monitoring Program are to: (1) determine the status and trends in selected indicators of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources, (2) provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management, (3) provide data to better understand the dynamic nature and condition of park ecosystems, (4) provide reference points for comparisons with other, altered environments, (5) provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment, and (6) provide a means of measuring progress towards performance goals (http://science.nature.nps.gov/im/monitor/docs/Vital_Signs_Overview.doc).

The primary goal of this monitoring protocol is to determine seasonal and annual trends in fish assemblages throughout reference sites of rivers and streams during summer months and disseminate that information to the public and decision makers. Trends are identified as continuing directional change in value of an indicator, generally up or down within season or among years (Larsen and others, 2004). Specific objectives of the protocol are to determine trends in: (1) fish species composition, (2) timing of migration of adult fish, (3) relative abundance, (4) age and size structure of juvenile fish, (5) extent of non-native fish and hatchery salmonids in reference sites throughout the park, and (6) water temperature.

D. Management Implications

This protocol is designed to provide an understanding of trends in fish assemblages from reference sites of OLYM rivers and streams. The protocol will provide insights at the individual, population, and assemblage level. Information derived from this monitoring may facilitate better management and conservation of native fishes in national parks. The scientific information obtained through this protocol has multiple applications for management decision-making, research, education, and promoting public understanding of park resources (http://science.nature.nps.gov/im/monitor/Reporting.cfm). Specific management actions that may be linked to this protocol include harvest management, hatchery supplementation, control of non-native fish species, and habitat restoration projects.

This protocol will allow park managers to detect trends in high priority management species (for example, economically important species) with information on the number of fish species increasing and decreasing in abundance, the extent of non-native and hatchery fish invasions, and trends in federally threatened fish species (for example, bull trout). The protocol also provides information on magnitude of abundance of each fish species (10, 100, or 1,000), timing of migration of adult fishes, and growth of juvenile salmonids within reference sites. From a fish assemblage perspective, the protocol tracks changes in fish species composition within a river and allows general comparisons and correlations of trends in fish assemblages among rivers.

The seasonal and long-term trends in fish assemblages will provide specific and critical data to better inform park management. Knowledge of the presence, timing, and numbers of threatened fish species within a reference site can be used for compliance purposes and to establish work windows for road management projects along river corridors. Such information on fish assemblages also can be used to prioritize and maximize the benefits of habitat restoration projects such as culvert replacements and bridge constructions that improve fish passage.

Information about migratory timing and relative abundance of fish species within reference sites can used to evaluate the most appropriate fishing regulations in a given river. As an example, the documentation of migratory timing of federally threatened North Fork Skokomish River bull trout was used to develop a fishing season (June to September) that provided recreational opportunity during summer months while protecting bull trout during their spawning migration from late September to December (for example, river closed).

Information on the relative numbers of hatchery fish in reference sites is critical to the successful management of wild fish. During pilot surveys for this protocol, we detected hatchery coho salmon and hatchery summer steelhead in the South Fork Hoh River—a river basin with no hatchery releases for those two species. That information was immediately used to attain funding to address the origin of those fish (for example, which hatchery) and to examine the extent of genetic introgression between hatchery and wild fish in that river. Additionally, information about hatchery fish inhabiting a reference site highlights the importance of implementing fishing regulations that target the harvest of hatchery salmon or steelhead in park waters.

Finally, the detection of non-native fish (for example, brook trout) in reference sites of rivers will provide an early warning signal for alien fish invasions in OLYM rivers. With annual sampling over several years, any future detection of non-native brook trout would prompt management actions that address the control of non-native fish in park rivers.

2. Sampling Design

There is a lack of widely accepted sampling protocols for monitoring trends in fish assemblages in river systems. Aquatic environments are inherently difficult to sample (Fausch and others, 2002), and pose numerous challenges to sampling fish populations. Streams that are considered to be wadeable are relatively easy to sample when compared to sampling in rivers, and consequently the development of protocols for lotic systems has focused on wadeable streams (D.V. Peck and others, U.S. Environmental Protection Agency, unpub. data, 2000; Flotemersch and others, 2006). However, many of the sampling techniques for wadeable streams are infeasible in river systems (Flotemersch and others, 2006). In the NCCN, rivers are particularly challenging to sample using traditional fisheries techniques because of prolonged periods of high flow, low water visibility from glacial melt, poor access, safety concerns, and limitations on sampling methods that are allowed in National Park waters. Additionally, these challenges are compounded by the presence of migratory fishes, whose extensive movements in rivers add complexity to sampling (Torgersen, 2002).

The Environmental Monitoring and Assessment Program (EMAP; U.S. Environmental Protection Agency), Aquatic Riparian Effectiveness Monitoring Program (AREMP; U.S. Forest Service), and National Water-Quality Assessment Program (NAWQA; U.S. Geological Survey) are existing aquatic protocols that focus on monitoring fish, macroinvertebrates, and water quality metrics (Meador and others, 1993; D.V. Peck and others, U.S. Environmental Protection Agency, unpub. data, 2000; Moulton, 2002). Additionally, there are protocols designed to monitor fish in National Park units. Programs include the monitoring of coral reef fish in the South Florida and Caribbean Network and the monitoring of warmwater fish communities in the Buffalo National River and Ozark National Scenic Riverways in the Ozark Plateaus of Arkansas and Missouri (Menza and others, 2006; Petersen and others, 2008).

Many of the existing aquatic protocols use probability-based sampling (for example, EMAP) and are designed to evaluate changes in environmental conditions that vary across regions and change gradually over time (for example, pH in wadeable streams or mountain lakes) often with the explicit purpose of evaluating compliance with water quality standards. These protocols provide an understanding of the status or condition of natural resources, and allow inference over a large geographic area (for example, Western United States). Inferential designs in those protocols necessarily spread sampling across a broad area and focus on short sample reaches that are randomly chosen. This approach can be powerful because it avoids biases associated with selecting sites based on convenience and/or tradition. However, there are limitations to a probabilistic design.

Ideally, we want a monitoring program to provide meaningful extrapolation to an entire park and/or network of parks. However, given our program constraints, it is not possible to achieve an adequate sample size and/or frequency to be able to detect seasonal and annual trends in fish assemblages within an area as large as an entire park the size of MORA, NOCA, or OLYM. Under these circumstances, a viable alternative is to use a reference design, where sample size or frequency is adequate to detect the desired level of change. If changes are detected in the reference systems, additional work can confirm the scope of the change and suggest causal factors.

In this protocol, seasonal and annual trends in fish assemblages are determined by intensive and repeated sampling of reference sites in eight rivers and five wadeable streams. The general rationale for the repeated sampling of reference sites (about 10 surveys per river per year) is to ensure that we account for the high interannual variability in fish movements and abundances in rivers. We provide a sampling foundation of rivers distributed throughout the park from which additional reference sites may be added with additional funding. To detect seasonal and annual trends in fish assemblages in reference sites, we rely on repeated and consistent annual sampling at each monitoring location. One underlying assumption is that the monitoring program is designed in perpetuity, and consequently our capability to detect trends substantially increases with time.

With respect to monitoring fish assemblages in NCCN parks, a probability-based design is not easily adapted to monitor fish movements or to examine seasonal and annual trends. A probability-based sampling design would only be effective to detect trends in OLYM rivers if sampling in both space and time were substantially increased. To attain A denser array and more frequent sampling of sites spread throughout the many aquatic habitats of OLYM would be desirable to attain, but the associated costs with this level of effort would increase by at least an order of magnitude. By annual sampling of all eight rivers that are conducive to snorkel methods during the summer, a large benefit is gained and allows for extrapolation of trends to the lower ends of OLYM rivers near the park boundary without the use of inferential statistics.

Because of the geographic diversity within OLYM (and the NCCN), we explored the possibility of a stratified design for sampling rivers in the four diverse regions of OLYM. A stratified design has some promise to intensify the efforts within a river, which would increase the ability to extrapolate to the watershed level. However, the uneven distribution of rivers within regions (n=1 to 4 per region) prevented extensive efficiency gained by stratification.

Some limitations of the sampling approach in this protocol include: (1) reduced capability to extrapolate information gained to the watershed level, (2) lack of information on explanatory habitat variables (for example, flow, woody debris, habitat complexity), and (3) challenges in counting fish assemblages in shallow riffles during summer low-flow conditions.

A. Study Area

We include information on watersheds and fish assemblages for three large wilderness parks, OLYM, MORA, and NOCA.

Olympic National Park

Olympic National Park, a designated World Heritage Site and Biosphere Reserve located on the Olympic Peninsula, contains one of the largest contiguous areas of relatively pristine habitat throughout the range of several west coast fish species. Olympic National Park encompasses 373,133 ha (922,000 acres) including the upper portions of 12 major river basins and 5,600 km of streams. The park is 96 percent designated wilderness, with roads, campgrounds, and structures comprising less than 1 percent of the total area of the park (Jenkins and others, 2003). The western part of the park receives the greatest precipitation in the conterminous United States with annual precipitation ranging from 180 to 600 cm on Mount Olympus (Jenkins and others, 2003). Most of the precipitation occurs as rain in lowland areas and snowfall may exceed 1,300 cm. In most rivers, river discharge is strongly influenced by rainfall in winter and snowmelt in spring. Watersheds in the park generally are characterized as having steep slopes, short drainages, and high amounts of annual precipitation that cause river discharges to rise and decline rapidly with frequent high flows in the winter.

We identified four ecoregions within OLYM based on differences in climate, drainage aspect, downstream outlet, and accessibility to anadromous fish. Of the eight rivers in the protocol, four are located in the northwest region, two are located in the southwest region, and two are located in the southeast region (fig. 1). The remaining rivers that drain from OLYM were not included in this protocol because of poor water visibility during the summer months and/or high costs to access. These rivers include the Calawah, Duckabush, Elwha, Greywolf, Hamma Hamma, Hoh, Ozette, and Queets Rivers.

Ranges of values for watershed characteristics for this protocol include 7,965 to 32,849 ha of watershed area, 29 to 100 percent of watershed in the park, 103 to 329 m of elevation at park boundary, 1,288 to 2,245 m of elevation at headwaters, and 21 to 106 total river length in kilometers (table 1). Watersheds that drain the westside of the park (n=6) contain anadromous and non-anadromous species and watersheds that drain the eastside of the park (n=2) are inhabited strictly by potamodromous (for example, migrate entirely within freshwater) fish species because of natural barriers and dams that prevent upstream migration of anadromous fish.

Fish fauna in OLYM consists of primarily coldwater species in the families Salmonidae and Cottidae. There are nine species of Pacific salmonids and at least 70 unique populations (OLYM files). A total of 31 native and 5 non-native freshwater fish species from 11 different families have been documented in OLYM waters (table 3). Both native wild populations and hatchery stocks of Pacific salmonids occur in OLYM. Photographs of fish species commonly observed in rivers and streams in this protocol are in appendix A.

On the western Olympic Peninsula, State and Tribal hatcheries produce and release millions of hatchery salmonids annually. There are widespread annual releases of hatchery winter steelhead, summer steelhead, fall coho salmon, summer coho salmon, sockeye salmon, chum salmon, and spring Chinook salmon in portions of rivers located outside park boundaries. As an example, more than 196 million hatchery sockeye salmon were released in the Quinault Basin since 1916 and about 1 million sockeye were released into

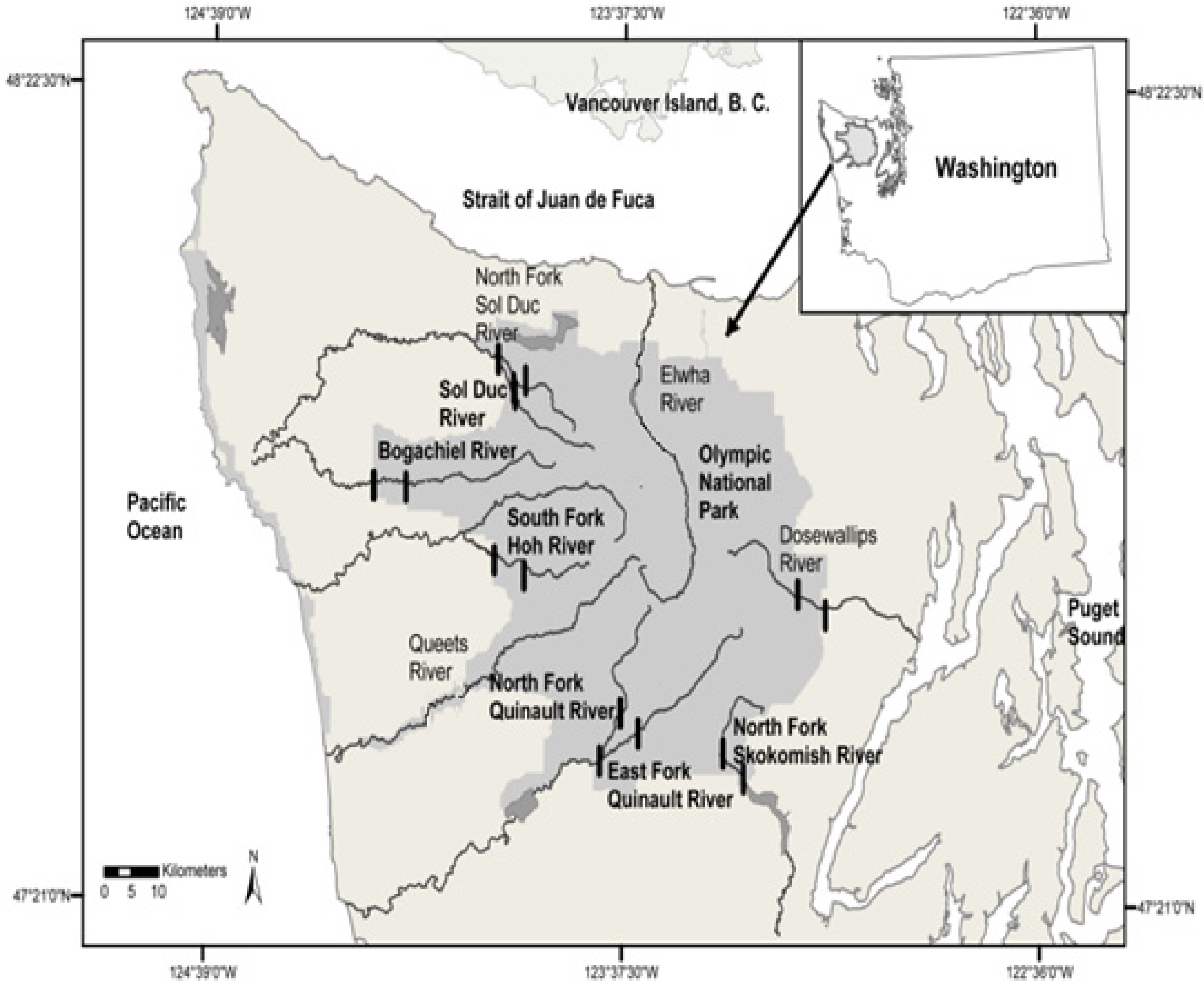

Figure 1. Location of eight reference sites for long-term monitoring of fish assemblages in OLYM rivers. Bars depict general location of reference sites that extend upstream of the park boundary.

Lake Ozette since 1937 (OLYM files). There also are total annual releases of 4.8 million coho salmon and 850,000 winter steelhead into Peninsula rivers (National Oceanic and Atmospheric Administration, 1997; http://www.nwfsc.noaa.gov/publications/techmemos/tm24/tm24.htm#toc). These released smolts are largely derived from only a few parent stocks (Busby and others, 1996). Recent estimates of the proportion of hatchery steelhead on natural spawning grounds in Olympic Peninsula rivers ranged from 16 (Quillayute River) to 44 percent (Quinault River) (Busby and others, 1996).

OLYM has exclusive jurisdiction over recreational fishing in the park, and generally permits fishing throughout the year. Coastal rivers provide popular sport fisheries for Pacific salmonids throughout the year, with angler effort typically the highest during periods when salmon and steelhead are migrating upstream. The park offers diverse fishing opportunities with an emphasis on catch-and-release of wild fish species and retention of hatchery and non-native fish. Tribal gill-net fisheries occur at the river mouths of coastal systems with netting scheduled during most weeks of the year.

Table 3. Native and non-native fish species that inhabit watersheds that drain from Olympic National Park with specific reference to river basins where species have previously been observed.

[From OLYM files, Mongillo and Hallock (1997), Brenkman (1998), and Brenkman and others (2004). The presence of a fish species in a given watershed does not necessarily imply it occurs within OLYM. **Abbreviations**: OLYM, Olympic National Park; BOGA, Bogachiel; DOSE, Dosewallips; EFQR, East Fork Quinault; ELWH, Elwha; LCRES, Lake Crescent; NFQR, North Fork Quinault; NFSK, North Fork Skokomish; NFSR, North Fork Sol Duc; OZET, Ozette; QUEE, Queets; QUIL, Quillayute; QUIN, Quinault; SFHR, South Fork Hoh; SOLD, Sol Duc]

Common name	Family	Genus	Species	River(s)
Longnose sucker	Catostomidae	*Catostomus*	*catostomus*	NFSR
Largescale sucker	Catostomidae	*Catostomus*	*macrocheilus*	EFQR; QUIN
Largemouth bass[1]	Centrarchidae	*Micropterus*	*salmoides*	NFSR, OZET
American shad[1]	Clupeidae	*Alosa*	*sapidissima*	OZET
Riffle sculpin	Cottidae	*Cottus*	*gulosus*	BOGA; HOH; SOLD; QUIL; QUIN
Prickly sculpin	Cottidae	*Cottus*	*asper*	LCRES; NFSR; OZET; QUEE; QUIL; QUIN
Shorthead sculpin	Cottidae	*Cottus*	*confusus*	BOGA; NFSR; NFQR; QUIN; SFHR; SOLD;
Coastrange sculpin	Cottidae	*Cottus*	*aleuticus*	DOSE; HOH; QUIL; QUEE; QUIN
Torrent sculpin	Cottidae	*Cottus*	*rhotheus*	BOGA; EFQR; HOH; NFQR; QUEE; QUIL; QUIN; SFHR; SOLD
Reticulate sculpin	Cottidae	*Cottus*	*perplexus*	HOH; SFHR; QUEE; QUIL; QUIN; SOLD
Slimy sculpin	Cottidae	*Cottus*	*cognatus*	OZET
Peamouth	Cyprinidae	*Mylocheilus*	*caurinus*	OZET; QUIN
Northern pikeminnow	Cyprinidae	*Ptychocheilus*	*oregonensis*	OZET; QUIN
Speckled dace	Cyprinidae	*Rhynichthys*	*osculus*	NFSR; QUEE; QUIN
Longnose dace	Cyprinidae	*Rhynichthys*	*cataractae*	HOH; QUEE; QUIL; QUIN
Redside shiner	Cyprinidae	*Richardsonius*	*balteatus*	OZET
Threespine stickleback	Gasterosteidae	*Gasterosteus*	*aculeatus*	ELWH; HOH; OZET; QUEE; QUIN
Yellow bullhead[1]	Ictaluridae	*Ictalurus*	*natalis*	OZET
Yellow perch[1]	Percidae	*Perca*	*flavescens*	OZET
Pacific lamprey	Petromyzontidae	*Lampetra*	*tridentata*	BOGA, ELWH; HOH; OZET; QUIN; SOLD; SFHR
Western brook lamprey	Petromyzontidae	*Lampetra*	*richardsoni*	OZET; QUEE; QUIL; QUIN
Chinook salmon	Salmonidae	*Oncorhynchus*	*tshawytscha*	BOGA; EFQR; ELWH; HOH; NFSK[2]; NFSR; NFQR; OZET; QUIN; QUIL; SFHR; SOLD
Pink salmon	Salmonidae	*Oncorhynchus*	*gorbuscha*	ELWH; HOH; SFHR; QUIN
Chum salmon	Salmonidae	*Oncorhynchus*	*keta*	BOGA; EFQR; ELWH; HOH; OZET; QUEE; QUIL; QUIN; SFHR
Sockeye salmon	Salmonidae	*Oncorhynchus*	*nerka*	BOGA; EFQR; ELWH; HOH; OZET; QUIL; QUIN; SOLD; SFHR
Coho salmon	Salmonidae	*Oncorhynchus*	*kisutch*	BOGA; EFQR; ELWH; HOH; NFSR; NFQR; OZET; QUIL; QUIN; SFHR; SOLD
Steelhead	Salmonidae	*Oncorhynchus*	*mykiss*	BOGA; EFQR; ELWH; HOH; NFSR; NFQR; OZET; QUIL; QUIN; SFHR; SOLD
Rainbow trout[3]	Salmonidae	*Oncorhynchus*	*mykiss*	DOSE; ELWH; LCRES; NFSR
Kokanee salmon	Salmonidae	*Oncorhynchus*	*nerka*	ELWH; NFSR; LCRES; OZET
Cutthroat trout	Salmonidae	*Oncorhynchus*	*clarkii*	BOGA; EFQR; ELWH; LCRES; NFSK; NFSR; NFQR; SFHR; SOLD
Mountain whitefish	Salmonidae	*Prosopium*	*williamsoni*	BOGA; EFQR; HOH; NFSK; NFQR; QUIL; QUIN; SFHR; SOLD
Pygmy whitefish	Salmonidae	*Prosopium*	*coulteri*	LCRES
Atlantic salmon[1]	Salmonidae	*Salmo*	*salar*	ELWH; QUIL
Bull trout	Salmonidae	*Salvelinus*	*confluentus*	EFQR; ELWH; HOH; NFSK; NFQR; SFHR; QUIN
Dolly Varden	Salmonidae	*Salvelinus*	*malma*	EFQR; SOLD
Eastern brook trout[1]	Salmonidae	*Salvelinus*	*fontinalis*	DOSE; ELWH; NFSR
Olympic mudminnow	Umbridae	*Novumbra*	*hubbsi*	HOH; OZET; QUIL QUIN; QUEE

[1] Non-native fish species.

[2] Landlocked Chinook salmon.

[3] Landlocked rainbow trout.

Mount Rainier National Park

Mount Rainier National Park encompasses 95,357 ha (235,625 acres), is 97 percent designated Wilderness, and has 91 km^2 (35 mi^2) of permanent ice and snow. There are a total of 1,063 linear kilometers of rivers and creeks in MORA (151 km of rivers; 912 km of creeks; Barbara Samora, MORA, written commun., 2007). The major glacial rivers that drain from MORA include the Carbon, Nisqually, Puyallup (South and North Forks), Mowich (South and North Forks), Paradise, White (West Fork), Ohanapecosh, and Muddy Fork Rivers. The Ohanapecosh and Muddy Fork Rivers ultimately drain into the Columbia River and the other six rivers drain into the Puget Sound near Tacoma, Washington. The Ohanapecosh River is the only river at MORA that is conducive to sampling methods outlined in this protocol. It is not possible to conduct snorkel methods in the other rivers during summer months due to extreme flows, glacial melt, and low to no visibility.

The presence of hydroelectric dams precludes anadromous fish passage in the Puyallup, Mowich, Ohanapecosh, and Nisqually Rivers. Anadromous salmonids are transported above Mud Mountain Dam on the White River. The Carbon River is the only major basin that drains from MORA without a dam (http:/www.nps.gov/mora/naturescience/fish.htm, accessed January 7, 2008).

Fish fauna in MORA consists of coldwater species in the families Salmonidae and Cottidae. Mount Rainier National Park contains at least 10 species of fish (table 4). Of those 10 species, 7 are native to park waters and the others were introduced. There are three federally threatened fish species including Puget Sound Chinook salmon, Puget Sound steelhead and coastal and Puget Sound bull trout. Species that inhabit the park from previous hatchery plantings since around 1918 include brook trout, rainbow trout, Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*), and Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) (table 4). Brook trout and cutthroat trout inhabit the Ohanapecosh River. MORA maintains exclusive federal jurisdiction of recreational fisheries, and park fishing regulations generally are in accordance with those of the surrounding area waters of the State of Washington. The Ohanapecosh River is the only river with special regulations that limits it to fly fishing only.

Table 4. Fish species known to occur in Mount Rainier National Park and their conservation status.

[From Barbara Samora, Mount Rainier National Park, written commun., November 14, 2007. N/A, not applicable]

Common name	Scientific name	Origin	Federal status
Coastal cutthroat trout	*Oncorhynchus clarkii*	Native	None
Westslope cutthroat trout	*Oncorhynchus clarkii lewisi*	Introduced	None
Yellowstone cutthroat trout	*Oncorhynchus clarkii bouvieri*	Introduced	None
Rainbow trout/Steelhead	*Oncorhynchus mykiss*	Native and introduced stock	Steelhead threatened
Bull trout[1]	*Salvelinus confluentus*	Native	Threatened
Eastern brook trout	*Salvelinus fontinalis*	Non-native	None
Coho salmon	*Oncorhynchus kisutch*	Native	Species of concern
Chinook salmon	*Oncorhynchus tschawytscha*	Native	Threatened
Sockeye salmon	*Oncorhynchus nerka*	Unknown	None
Kokanee salmon	*Oncorhynchus nerka*	Introduced	None
Mountain whitefish	*Prosopium williamsoni*	Native	None
Shorthead sculpin	*Cottus confusus*	Native	None
Torrent sculpin	*Cottus rhotheus*	N/A	None

[1]From Dehaan and others (2007).

North Cascades National Park

North Cascades National Park was designated in 1968 and encompasses 276,815 ha (684,000 acres). The park includes portions of the Baker, Cascade, Chilliwack, Nooksack, Skagit, and Stehekin Rivers. The upper Baker, Chilliwack, North Fork Cascade, Skagit, and Stehekin Rivers are systems at NOCA that may be conducive to snorkel sampling methods outlined in this protocol (Ashley Rawhouser, NOCA, written commun., December 31, 2007). Watersheds that drain from NOCA eventually flow into four major river systems: Columbia River, Fraser River, Skagit River and Nooksack River (Zyskowski, 2007). There are a total of about 6,500 km of rivers and creeks in NOCA (Zyskowski, 2007).

North Cascades National Park contains 28 fish species from seven different families (table 5). Of those 28 species, 25 are native to park waters. Non-native fish species in NOCA include golden trout, lake trout, and brook trout.

There are three federally listed and threatened fish species including Puget Sound Chinook salmon, Puget Sound steelhead and coastal and Puget Sound bull trout. NOCA maintains concurrent jurisdiction of recreational fisheries with Washington Department of Fish and Wildlife. The following was excerpted from http://198.238.33.67/fish/papers/north_cascades_high_lakes/index.htm (accessed on January 7, 2008).

> Introduction of fish into lakes within boundary of NOCA occurred as early as 1915 and by the early 20th century, Federal and county agencies were stocking many wilderness lakes, including high-elevation lakes within the current NOCA boundaries, with brook trout, rainbow trout, and cutthroat trout. By the time the Washington Department of Game was formed in 1933, several lakes within current park boundaries had already received fish introductions and harbored reproducing populations or were stocked periodically. Throughout the 1940s, 1950s, and 1960s, the high lake fishery resource within current park boundaries continued to expand.

Table 5. Native and non-native fish species that inhabit watersheds that drain from North Cascades National Park.

[From Ron Holmes, North Cascades National Park, oral commun., December 18, 2007; National Park Service Species database]

Common name	Family	Genus	Species	Origin
Longnose sucker	Catostomidae	*Catostomus*	*catostomus*	Native
Largescale sucker	Catostomidae	*Catostomus*	*macrocheilus*	Native
Burbot	Gadidae	*Lota*	*lota*	Native
Prickly sculpin	Cottidae	*Cottus*	*asper*	Native
Coastrange sculpin	Cottidae	*Cottus*	*aleuticus*	Native
Torrent sculpin	Cottidae	*Cottus*	*rhotheus*	Native
Slimy sculpin	Cottidae	*Cottus*	*cognatus*	Native
Peamouth	Cyprinidae	*Mylocheilus*	*caurinus*	Native
Northern pikeminnow	Cyprinidae	*Ptychocheilus*	*oregonensis*	Native
Longnose dace	Cyprinidae	*Rhynichthys*	*cataractae*	Native
Redside shiner	Cyprinidae	*Richardsonius*	*balteatus*	Native
Threespine stickleback	Gasterosteidae	*Gasterosteus*	*aculeatus*	Native
Western brook lamprey	Petromyzontidae	*Lampetra*	*richardsoni*	Native
Chinook salmon	Salmonidae	*Oncorhynchus*	*tshawytscha*	Native
Pink salmon	Salmonidae	*Oncorhynchus*	*gorbuscha*	Native
Chum salmon	Salmonidae	*Oncorhynchus*	*keta*	Native
Sockeye salmon	Salmonidae	*Oncorhynchus*	*nerka*	Native
Coho salmon	Salmonidae	*Oncorhynchus*	*kisutch*	Native
Steelhead	Salmonidae	*Oncorhynchus*	*mykiss*	Native
Rainbow trout[1]	Salmonidae	*Oncorhynchus*	*mykiss*	Native
Kokanee salmon	Salmonidae	*Oncorhynchus*	*nerka*	Native
Cutthroat trout	Salmonidae	*Oncorhynchus*	*clarkii*	Native
Golden trout	Salmonidae	*Oncorhynchus*	*aquabonita*	Non-native
Mountain whitefish	Salmonidae	*Prosopium*	*williamsoni*	Native
Pygmy whitefish	Salmonidae	*Prosopium*	*coulteri*	Native
Bull trout	Salmonidae	*Salvelinus*	*confluentus*	Native
Dolly Varden	Salmonidae	*Salvelinus*	*malma*	Native
Lake trout	Salmonidae	*Salvelinus*	*namaycush*	Non-native
Eastern brook trout	Salmonidae	*Salvelinus*	*fontinalis*	Non-native

[1]Landlocked rainbow trout.

B. Allocation of Sampling Effort Relative to Budget

The allocation of sampling effort in this protocol represents a balance between ecological considerations, a sound monitoring approach, and practical limitations caused by logistical and financial constraints. The general rationale for the repeated sampling of reference sites (about two surveys per month per river) is to ensure that we account for the high interannual variability in fish movements and abundances in rivers. The goal is to maximize the number of surveys in each reference site throughout the summer. Typically, snorkel counts are conducted every 7 to 10 days from June to September with as many as 10 surveys per reference site per year. Based on pilot fieldwork from 2004 to 2007, the sample design is repeatable and has minimal observer bias when using snorkel counts in rivers (McDonald, 2006).

The sampling of NCCN rivers is difficult because of high costs, arduous logistics, safety concerns, and financial constraints. The sampling design in this protocol is designed to accommodate many of these challenges and is considered to be logistically feasible based on pilot studies conducted from 2004 to 2007. Substantial portions of rivers are rendered essentially inaccessible by prohibitively steep slopes, narrow canyons, periods of high flows, long distances from trails, and dangerous river crossings (Siegel and others, 2007). There are portions of rivers in the more remote parts of MORA, NOCA, and OLYM where a single fish sampling survey may require over a week of a crew’s time to reach, sample, and return.

Constraints of funding necessitate the allocation of two field crews (four people total) to conduct snorkel and electrofishing surveys in reference sites from June to September. The protocol is cost effective and ensures that a number of sites are sampled under extremely limited budgets. Given the tight financial constraints currently anticipated for this project coupled with safety concerns, attempting to reach more remote places would consume an inordinate proportion of available resources and would greatly reduce the number of visits each year (see Siegel and others, 2007).

C. Number and Location of Sampling Sites

Fish assemblages will be monitored in reference sites located immediately upstream of the park boundary in each of eight rivers (fig. 1; table 1; appendix B). The protocol emphasizes portions of rivers immediately upstream of the park boundary as these reference sites typically minimize challenges to access. Specific locations of reference sites are included in table 6. The reference sites of rivers outlined in this protocol are comprised of mainstem and side-channel habitats with multiple types of habitat units (for example, pools, riffles, glides) throughout each reference site. Location of sites at the park boundary has the advantage of reflecting the integrated conditions of the watershed (appendix B). These river reference sites to be sampled in OLYM generally are characterized as unconstrained, productive floodplains that are utilized by numerous fish species when compared to remote reaches of upper watersheds that are largely confined and where physical barriers and waterfalls prevent upstream movements of migratory fish.

Table 6. Specific locations of river reference sites in Olympic National Park and Mount Rainier National Park based on Global Positioning System and pilot fieldwork.

[rkm, river kilometer]

River	Downstream boundary		Upstream boundary		Location (rkm)
	Latitude	Longitude	Latitude	Longitude	
Bogachiel	47.52.74	124.14.83	47.52.94	124.11.39	40.5–35.6
Dosewallips	47.43.58	123.09.15	47.44.14	123.00.07	25.9–23.5
East Fork Quinault	47.32.30	123.40.15	47.33.44	123.36.71	82.6–76.9
North Fork Quinault	47.32.31	123.40.18	47.34.11	123.38.93	4.4–0.0
North Fork Skokomish	47.30.13	123.19.06	47.31.19	123.20.04	48.1–45.5
South Fork Hoh	47.47.40	123.56.10	47.46.71	123.54.41	10.5–7.8
Sol Duc	47.59.19	123.53.70	47.59.19	123.53.70	101.6–97.2
North Fork Sol Duc	48.01.43	123.54.45	48.00.29	123.53.36	7.1–3.6
Ohanapecosh	46.45.36	121.33.53	46.46.98	121.33.31	10.1–6.3

The completion of pilot work in OLYM rivers (2004–07), OLYM wadeable streams (2005 to 2007), and MORA rivers (2006–07) provided opportunities to test and streamline field methodologies and analytical approaches. The pilot studies produced datasets that were used to allocate effort (table 7).

Selection criteria for reference sites included: no physical barriers to fish movements, high underwater visibility, and safe access. Minimum criteria for depth, river size, and visibility need to be met for snorkel surveys to be optimal (Johnson and others, 2007). The selected rivers and corresponding reference sites met the following criteria: minimum recommended depth of 20 cm (Johnson and others, 2007); underwater visibility of at least 5 m from June to September; and gradients of less than 4 percent. Additionally, reference sites needed to be accessible by road or trail with hike times less than 4 h/d.

The following are approximate drive times (round trip from Port Angeles), duration of hiking, and duration of snorkeling for each reference site:

Reference site	Drive time (h)	Duration of hiking (h)	Duration of snorkeling (h)
Bogachiel	3.0	7.5 mi in 2 h	2.0–3.5
Dosewallips	3.0	5–6 mi in 2 h	1.0–1.5
East Fork Quinault	5.5	0.50	2.0–3.75
North Fork Quinault	5.5	0.50	2.0–3.75
North Fork Skokomish	5.0	0.50	1.5–2.5
North Fork Sol Duc	2.0	1	2.5–4.0
Sol Duc	2.0	0.75	2.25–3.5
South Fork Hoh	4.5	1.75	1.5–3.0

Table 7. Distribution of snorkel surveys in rivers in Olympic National Park and Mount Rainier National Park during pilot field work, 2005–07.

[Dates of snorkel surveys: X, 2005; Y, 2006; Z, 2007]

Rivers	Dates of snorkel surveys								
	May 15	May 22	May 29	June 5	June 12	June 19	June 26	July 3	July 10	July 17
North Fork Skokomish	X		X	X		X, Y		X, Y, Z	X, Y, Z	X, Z
Dosewallips										
North Fork Quinault							X			X, Y, Z
East Fork Quinault					X		X		X, Y	Z
Sol Duc		Y	X		X, Y		X, Y, Z	X, Y, Z	Z	X, Z
North Fork Sol Duc	Y					Y	Z		Z	Y
Bogachiel		Y	X	Y	X, Z	Y	X, Y, Z	Y	X, Y, Z	X, Z
South Fork Hoh				X		X,Y		X, Z	X	X, Y
Ohanapecosh		Z								Y

Rivers	Dates of snorkel surveys									
	July 24	July 31	Aug. 7	Aug. 14	Aug. 21	Aug. 28	Sept. 4	Sept. 11	Sept. 18	Sept. 25
North Fork Skokomish	X	X, Z	X, Z	Z	X	X, Y, Z		Z	Y	
Dosewallips			Z	Y		Y, Z		Z	Y, Z	
North Fork Quinault	X,Y	Y, Z	Z	Y	X, Y	Z	X,Y	Z	Y, Z	X, Z
East Fork Quinault	X, Y	X, Y, Z	X, Z	Y	X, Y	Z	X, Z	Y, Z	Y, Z	X
Sol Duc	X, Y	Y, Z	Y, Z	X, Z		X, Y, Z		X, Z		Y
North Fork Sol Duc		Z			Y					Y, Z
Bogachiel	X, Y, Z	X, Y	Y, Z	X	Y	X, Z	Z	X	Y, Z	
South Fork Hoh	X, Y	X, Y, Z	Y, Z	X, Z	X, Y	Z	Z	X	X, Z	Y, Z
Ohanapecosh				Z		Y		Z	Y	

D. Co-Location of Wadeable Stream Sites

Although snorkel surveys in this protocol provide key information on fish assemblages in rivers, they do not provide complete life history information because young-of-the-year and juvenile fish are not counted. An approach to document trends in early life history stages is to use electrofishing techniques in wadeable streams that are co-located with river sites. The complementary use of snorkel and electrofishing surveys provides a more complete understanding of adult and juvenile fish assemblages.

Because tributary streams are highly linked to life history patterns and strategies for many of the fish species within park boundaries, it is considered important to include wadeable streams in the protocol. Many wadeable tributary streams represent natal and rearing areas for Pacific salmon, steelhead, bull trout, and other species. Juvenile and adult fish use small tributary for various lengths of time (hours to months) for various reasons (for example, spawning, feeding, predator avoidance, thermal refugia). Efficiency can be gained if sampling efforts in wadeable tributary streams are located near river sampling sites. Without this co-location, the additional effort to sample wadeable streams would likely be infeasible because of anticipated funding limits. If funding is not an issue, then the constraint of co-locating wadeable sites with river sites could be dropped, and in its place, could be a stratified design that includes enough wadeable streams to represent the inherent variability.

Wadeable streams offer enhanced sampling opportunity. In small wadeable streams, backpack electrofishing is an effective way to collect fish under a defined sampling methodology that will allow important fish metrics to be collected. With fish in hand, samplers can readily measure length and weight, as well record species, take samples of tissue (for example, scales for ageing, fin clip for genetics), and make general observations of fish health.

Budget constraints limited sampling to five wadeable streams (table 8). Selection criteria for reference sites included: no physical barriers to fish movements, safe access, and the presence of anadromous and/or potamodromous fish species. Reference sites include Mink Lake Creek (Sol Duc), Slate Creek (North Fork Skokomish River), Indian Creek (Bogachiel River), Pass Creek (Dosewallips River), and Big Creek (Quinault River).

The following are approximate round trip drive times (from Port Angeles), hike times, and duration of electrofishing surveys in reference sites of wadeable streams.

Reference sites of wadeable streams	Drive time (h)	Duration of hiking (h)	Duration of electrofishing survey (h)
Mink Lake	2.0	0.5	2.0–3.5
Slate Creek	5.0	0.5	2.0–3.5
Indian Creek	3.0	10 mi in 3.5 h	2.0–3.5
Pass Creek	2.0	10 mi in 3.5 h	2.0–3.5
Big Creek	5.0	0.25	2.0–3.5

E. Frequency and Timing of Sampling

The frequency and timing of sampling differs with the gear being used (snorkeling or electrofishing) and with the type of site being sampled (wadeable stream or river). Snorkel surveys will be conducted every 7–10 days from June to September throughout the 5-km or less reference sites with as many as eight surveys per river per year. Sampling of wadeable streams by electrofishing will occur in five streams per year with each stream to be sampled once in July and once in September.

Table 8. Characteristics of stream reference sites that will be monitored for seasonal and annual trends in fish assemblages in Olympic National Park.

[**Length**: From Phinney and Bucknell (1975). **Fish species**: From Brenkman and others (2004) and OLYM files. **Abbreviations**: km, kilometer; ha, hectare; OLYM, Olympic National Park]

Creek/ river	Length (km)	Estimated watershed area (ha)	Percent of watershed in OLYM	Fish species
Mink Lake Creek, Sol Duc	3.7	639	100	Brook trout, coho salmon, cutthroat trout, rainbow trout/ steelhead, and sculpin spp.
Slate Creek, North Fork Skokomish	4.2	688	100	Bull trout, cutthroat trout, and sculpin spp.
Indian Creek, Bogachiel	2.3	267	100	Cutthroat trout, rainbow/steelhead, riffle sculpin.
Big Creek, Quinault	16.2	2,226	100	Chinook salmon, coho salmon, sockeye salmon, rainbow/ steelhead, torrent sculpin, and prickly sculpin.
Pass Creek, Dosewallips	2.9	344	100	Rainbow trout.

F. Selected Monitoring Variables

The following variables will be measured in each reference site of eight rivers: (1) relative abundance and density (fish/km) of each species by date, (2) species composition by date, (3) mean onset, peak, and end of migration, (4) percent of hatchery and wild salmonids, and (5) number of non-native fish species by date (table 9). For reference sites in streams, the following variables will be measured: (1) relative abundance, (2) fish biomass (g/m^2), (3) fish density ($fish/m^2$), (4) species composition by date, (5) and fish growth (July and September) (table 10).

We will monitor continuous water temperature in rivers and streams. The reported metrics include daily maximum, daily minimum, and daily average water temperature at each reference site in rivers and streams.

Table 9. Summary of response variables to detect seasonal and annual trends in fish assemblages in rivers.

Monitoring metric	Response	Data summary	Reported by	Frequency of reporting
Fish	Trends in relative abundance (rivers)	Annual peak count; regression versus time	Species for each river in each year	Annually
	Species composition (rivers)	Mean monthly species composition (percent)	Species for each river in each month	
	Migration timing (rivers)	Mean onset, peak, and end of migration; smoothed counts versus Julian date	Species for each river	
	Observer variability (rivers)	Estimate residual standard error; coefficients of variation	Species for each river during dates of replicate surveys	Once every 3–5 years
	Abrupt change detection (rivers)	Regression over time on past data and computation of 95 percent prediction interval for next point	Species for each river	Once in 5 years
Continuous water temperature	Daily average (rivers)	Average and averages over warmest and coolest 7-day period	River	Annually
	Daily maximum (rivers)	Average and maximum daily average; average over warmest consecutive 7-day period		
	Daily minimum (rivers)	Average		

Table 10. Summary of response variables to detect seasonal and annual trends in fish assemblages in wadeable streams.

[g/m^2., gram per square meter]

Monitoring metric	Response	Data summary	Reported by	Frequency of reporting
Fish	Age/size (streams)	Length frequency distribution (ages 0 and 1)	Species by month in each year	Annually
	Species composition (streams)	Mean monthly species composition (percent)	Species for each river in each month	
	Fish growth (streams) Fish biomass (streams)	Mean length (age 1 fish); g/m^2	Species for each stream in each month	
Continuous water temperature	Daily maximum (rivers and streams)	Average and maximum daily average; average over warmest consecutive 7-day period	Stream	Annually
	Daily minimum (rivers and streams)	Average		
	Daily average (rivers and streams)	Average and averages over warmest and coolest; 7-day period		

G. Level of Change That Can Be Detected for the Amount and Type of Sampling

The statistical power of the proposed sampling program to detect seasonal and annual trends in fish abundance within reference sites was evaluated by WEST Inc. We examined data from snorkel surveys conducted in the North Fork Skokomish River from 1994 to 2005. The snorkel methods used to collect these data were identical to those outlined in this protocol.

The following summary of results was taken from McDonald (2006). Given the importance of estimating trends in relative abundance, it was important to investigate the statistical power and which metric (for example, annual peak count, average of three peak counts) was most responsive to long-term trends in run size. This investigation involved a power analysis, which computed the ability of each estimator to detect trends when it was used as the response in a regression model. Power of each estimator was investigated at both the regional (multiple river) and individual river scales.

To estimate power, appropriate regional and individual trend detection analyses were required. Using regression, annual trends in relative abundance was estimated as the slope of the line that resulted when abundance was fitted onto year of the survey. If slope of this regression line was significantly non-zero, a trend was defined to have been detected. Statistical power was the probability that this regression analysis correctly detected a trend. In other words, statistical power was the probability that the null hypothesis of no slope was rejected, assuming that the true slope was non-zero. The regression analysis used to detect trend in run size is illustrated in figure 2.

Regional trend analyses were designed to detect a consistent change in the size of all runs in rivers that contained a certain fish species. Power to detect trends on a regional scale was estimated from a regression analysis that fitted a common slope to run sizes on all rivers in the analysis. Similar to the individual river analysis, power was defined as the probability of correctly rejecting the null hypothesis that the

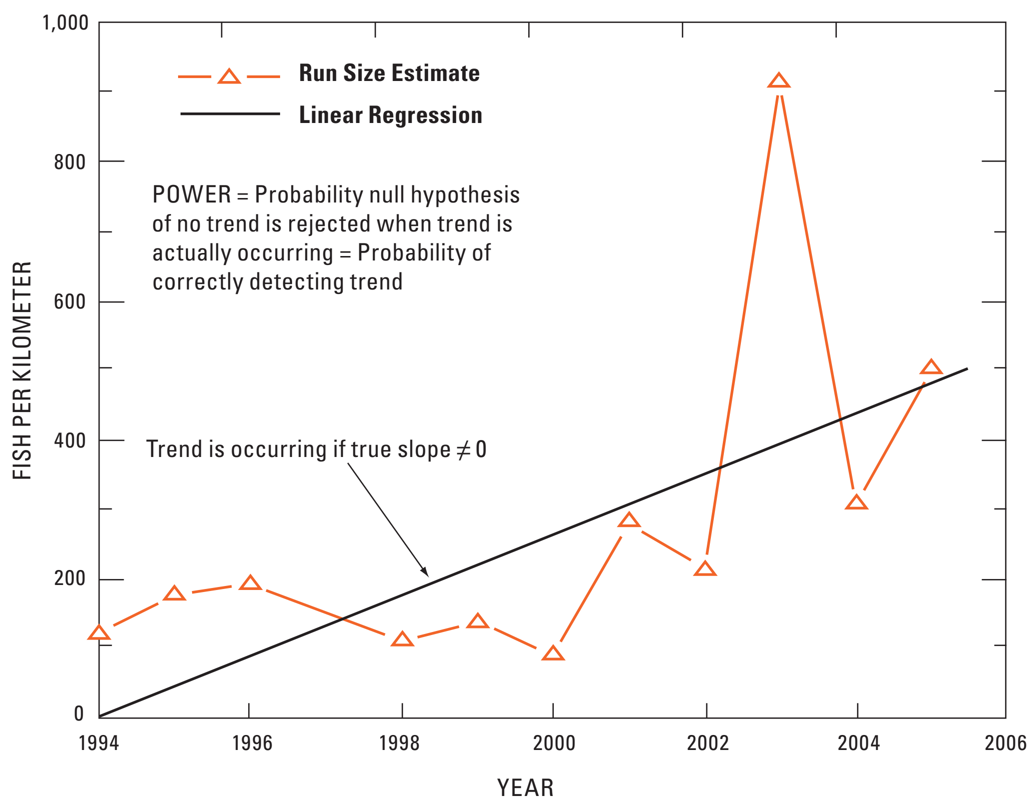

Figure 2. Regression analysis used to detect long-term trend in run size of bull trout in the North Fork Skokomish River from 1994 to 2005.

Statistical power is defined as the probability that the regression analysis correctly rejects the null hypothesis H0: slope = 0 (McDonald, 2006). Power=Probability that the null hypothesis of no trend is rejected when trend is actually occurring=probability of correctly detecting trend.

common slope across all rivers was 0. In general, the regional analysis should have more statistical power to detect a trend than individual river analyses because the regional regression analysis has many more points. The regression analysis that estimates a regional slope, assuming two rivers contained the same species of interest, is illustrated in figure 3.

Given these regional and individual river regression analyses, statistical power was computed using the statistical theory surrounding each analysis. Under the assumption that run size estimates follow a normal distribution and that correlation through time in residuals of the analysis followed an exponential model, the probability of declaring an estimated slope to be significantly different from zero was computed.

Power of the analysis to detect different sized true trends was computed and graphed. True trends were defined as total percent change after *T* years, where *T* was set to 5, 7, 10 and 15 years. The trend (total percent change) that could be detected with 80 percent power after 10 years of sampling was also computed. The run size estimator with highest power for a given true trend, or the estimator detecting the lowest total percent change with 80 percent power after 10 years, was the estimator deemed most responsive to trends in run size.

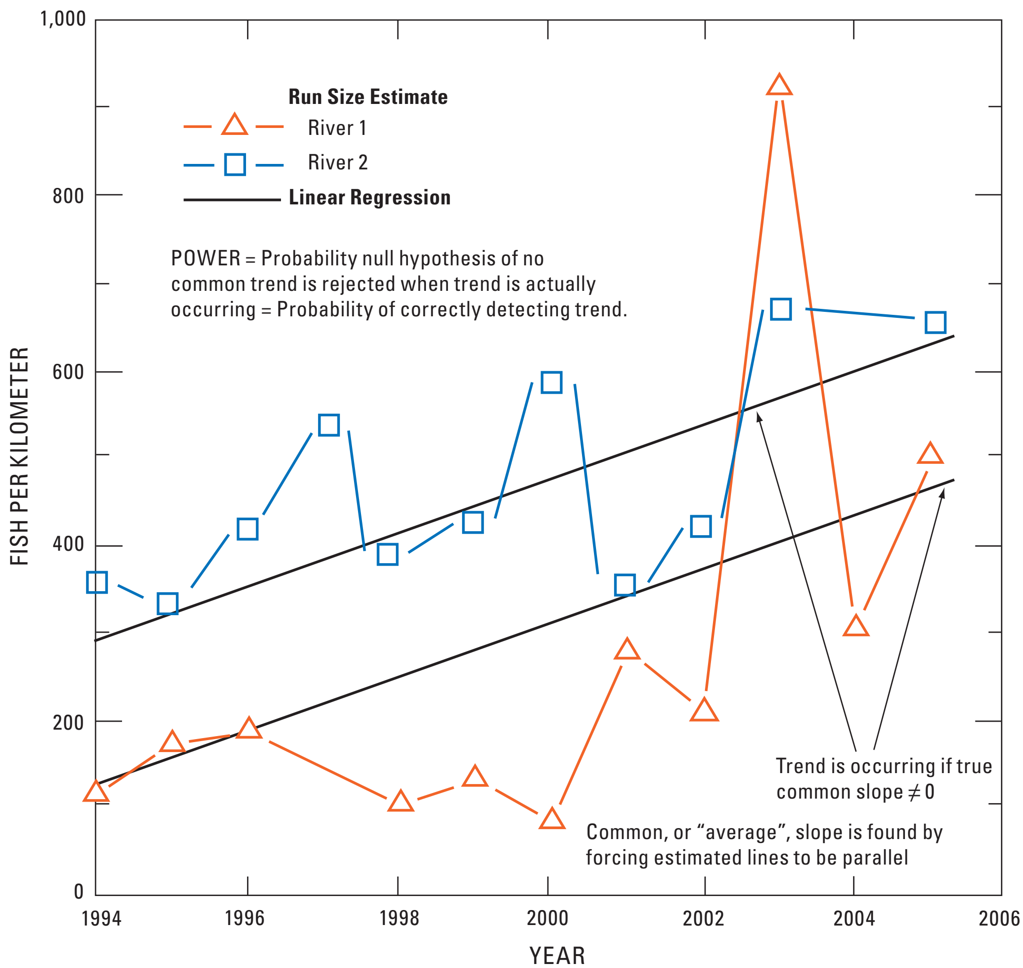

Figure 3. Regional run size regression analysis used to detect long-term trends on multiple rivers.

A common slope was estimated for the two rivers and regional trend was defined to be occurring if the common slope was significantly different from zero. Power=the probability that the null hypothesis of no common trend is rejected when the trend is actually occurring=probability of correctly detecting trend.

The North Fork Skokomish was the only river with multiple years of snorkel surveys that could be used to estimate power to detect trends on an individual river. This river also dominated computation of means, variance, and correlations in the regional analysis. Consequently, the primary difference between reported power to detect trends at the regional scale and power to detect trend on an individual river was the reduced overall sample size of the individual analysis (for example, one river's data versus n rivers' data).

Mean run size statistics, variation, coefficient of variation, and auto-correlation estimated from a linear regression of fish density on year and river, and used in the regional power analysis are shown in table 11. The regional trend detectable with 80 percent power after 10 years of data collection using each of the three candidate run size estimators (maximum count, mean of three maximum counts, and smoothed maximum) also is included in table 11. Total change detectable with 80 percent power after 10 years was consistently smaller for maximum count than the other two run size statistics. This implied that maximum count on any single snorkel survey provided the highest power to detect regional trends (table 11). Power curves from which the numbers in table 11 were computed appear for maximum count only (appendix C). Power curves for the other two run size statistics were lower than those for maximum count.

The three estimators of runs size performed similarly relative to one another when used to detect a trend on individual rivers. That is, maximum count on a single snorkel survey appeared to have the highest power to detect trends. Because of the reduced sample size when analyzing data from one river, power to detect trends on individual rivers was less than power to detect trends in a region (appendix D). Means, variance, and autocorrelations used in the power analysis, and estimated from North Fork Skokomish, are shown in appendix D.

From the power analysis, the maximum observed count (for example, annual peak count) provided the highest power to detect trends in regional and individual river fish populations. This result was somewhat unexpected. Little difference was expected *a priori* between power of maximum count and power of the mean of the three maximum counts, and the smoothed maximum. Although relatively little difference in power between these three estimators was observed (table 11), power of the maximum count was consistently higher than that of the others. The higher power of the maximum count was attributed to its responsiveness and ability to change quickly. The other estimators, being averages, were naturally less responsive and changed more slowly. Higher responsiveness can, in some cases, also mean higher variance, but apparently this was not true here. The maximum count apparently had low enough natural variation that it was able to respond to real changes in fish abundance quicker than the other two estimators.

Although the power analysis was primarily designed to assess and compare power of the three run size estimators, it also can be used to gauge the relative number of rivers required to detect a certain sized trend. Assuming that trends are assessed after 10 years of data collection, the current level of effort (for example, about one survey every 2 weeks) can detect from 89 to 121 percent regional trend with 80 percent power using data from four to six rivers (table 11). These numbers indicate that a doubling or halving of the regional population in 10 years would be detected with 80 percent power.

Table 11. Values of mean, variance, CV, auto-correlation, and number of rivers used in the regional power analysis.

[**Total change detectable**: Total percent change in run parameters detectable with 80 percent power after 10 years of data collection (adapted from McDonald, 2006). **Abbreviations**: CV, coefficient of variation; %, percent; Max, maximum]

Species	Response	Mean	Residual variance	CV	Auto-correlation (ρ)	Number of rivers (*n*)	Total change detectable (%)
Bull trout	Max count	41.7	19.86	0.48	0.26	4	88.9
	Mean max	27.9	20.24	.72	-.3	4	90.1
	Smooth max	29.7	17.22	.58	.29	4	110.2
Mountain whitefish	Max count	222.1	196.59	0.89	-0.25	5	102.3
	Mean max	157.4	119.40	.76	.19	5	120.7
	Smooth max	164.2	138.82	.85	-.03	5	116.2
Cutthroat/ rainbow trout	Max count	66.5	51.78	0.78	-0.14	6	89.7
	Mean max	49.3	45.70	.93	-.28	6	95.3
	Smooth max	41.7	34.33	.82	-.14	6	94.9
Chinook salmon	Max count	3.6	3.19	0.88	-0.18	6	99.1
	Mean max	2.1	1.83	.88	-.11	6	103.3
	Smooth max	2.2	2.32	1.03	-.19	6	114.6

Decreasing the size of trend detected with 80 percent power further would require the sampling of more rivers. The results from pilot surveys included four to six rivers for each species. Power to detect long-term trends would not increase appreciably if more surveys were conducted annually in each river. Although not specifically estimated, eye-balled extrapolation of the values in appendix C indicates that the size of trend detectable with 80 percent power would decrease to approximately 50 percent if the number of rivers sampled doubled to 10 to 12 rivers. In this protocol, we intend to sample nine rivers. It is anticipated that the size of the detectable trend would not decrease appreciably less than 50 percent if more than 10–12 rivers were sampled due to inherent year-to-year variation in run size.

H. Start-Up and Annual Costs

The annual budget for the protocol as designed is $55,154 based on costs for fiscal year 2008, NPS personnel services (table 12). The protocol requires four seasonal employees for 8 to 10 pay periods.

Table 12. Proposed annual budget for implementation of the NCCN Fish Assemblages Protocol in eight OLYM rivers and five OLYM wadeable streams.

[**Abbreviations**: NCCN, North Coast and Cascades Monitoring Network; OLYM, Olympic National Park; Tech., technician; GS, general schedule; pp, pay period]

Proposed annual budget for protocol implementation in OLYM rivers and wadeable streams	
Personnel	**Cost**
Biological Science Tech. GS-7/1, term (10 pp)	$20,017
Biological Science Tech. GS-6/1 (9pp)	$12,678
Biological Science Tech. GS-5/1 (8 pp)	$10,004
Biological Science Tech. GS-5/1 (8pp)	$10,004
Operations and Equipment	
Wading shoes, drysuit/s, thermograph replacement	$1,750
Travel	
In park per diem/travel	$701
Total annual cost	**$55,154**

3. Methods of Sampling

This protocol relies on a combination of snorkel and electrofishing methodologies to maximize detection of trends in juvenile and adult fish assemblages in NCCN rivers and wadeable streams. These methods are useful across non-glacial rivers and streams in the NCCN. For a long-term monitoring program in the NCCN, methods such as boat electrofishing or gill-netting were not suitable for trend detection or repeat sampling because of lack of access and vulnerability of native fish to direct and indirect mortality.

A. Day Snorkeling in Rivers

The seasonal movements, assemblage structure, and relative abundances of riverine fishes during summer months will be determined by snorkel counts in each river. Day snorkeling from June through September has been shown to be an effective method to determine seasonal movements and enumerate fish during summer months based on reliable periods of high water visibility and pilot field work. Night snorkel surveys in relatively remote portions of rivers are too hazardous, and snorkeling during fall, winter, and spring is too difficult because of high flows and low water visibility.

Snorkel surveys are an important tool to study fish populations in lotic systems, and these surveys are known to provide precise and reliable estimates of fish abundance (Northcote and Wilkie 1963; Schill and Griffith 1984; Thurow 1994). Snorkel surveys are feasible in deep, clear rivers where the effectiveness of other methods are limited. By design, snorkel surveys have a multi-species focus. Snorkel surveys also are feasible in logistically remote terrain and roadless areas because of the relatively small amount of equipment (Thurow, 1994). Snorkeling is a passive technique (that is, no handling of fish) that is conducive to sampling fish stocks that are protected or that inhabit natural areas where invasive sample methods are less desired. Day snorkel surveys are not effective at enumerating species typically observed at night (for example, juvenile bull trout) or species associated with the benthos such as sculpin *spp*.

Two divers, one on each side of the river, will proceed downstream and count each species that is greater than 15 cm in length (fig. 4). Snorkelers will move downstream at the speed of the current, and look side to side to the farthest point visible. The diver on the left bank (looking downstream) will count and record fish from the midpoint of the river channel to the left bank. The diver on the right bank will count fish from the midpoint of the river channel to the right bank. The primary target species in this protocol are Pacific salmonids and mountain whitefish based on their relative abundance and ease of identification. We will record sculpins, longnose dace, lamprey or other fish species, but will not include those fish in the analysis because they are rarely observed. When fish species are observed in large aggregations, divers commonly will make two passes in their respective lanes and average the counts. Divers will make frequent data recording stops (about every 100 m) to compare observations and minimize duplication of counts. In portions of the river where wood jams exist, divers will move carefully and slowly and often average counts after two passes. Because of the difficulty in distinguishing between cutthroat trout and rainbow trout underwater, counts of these two species will be combined as

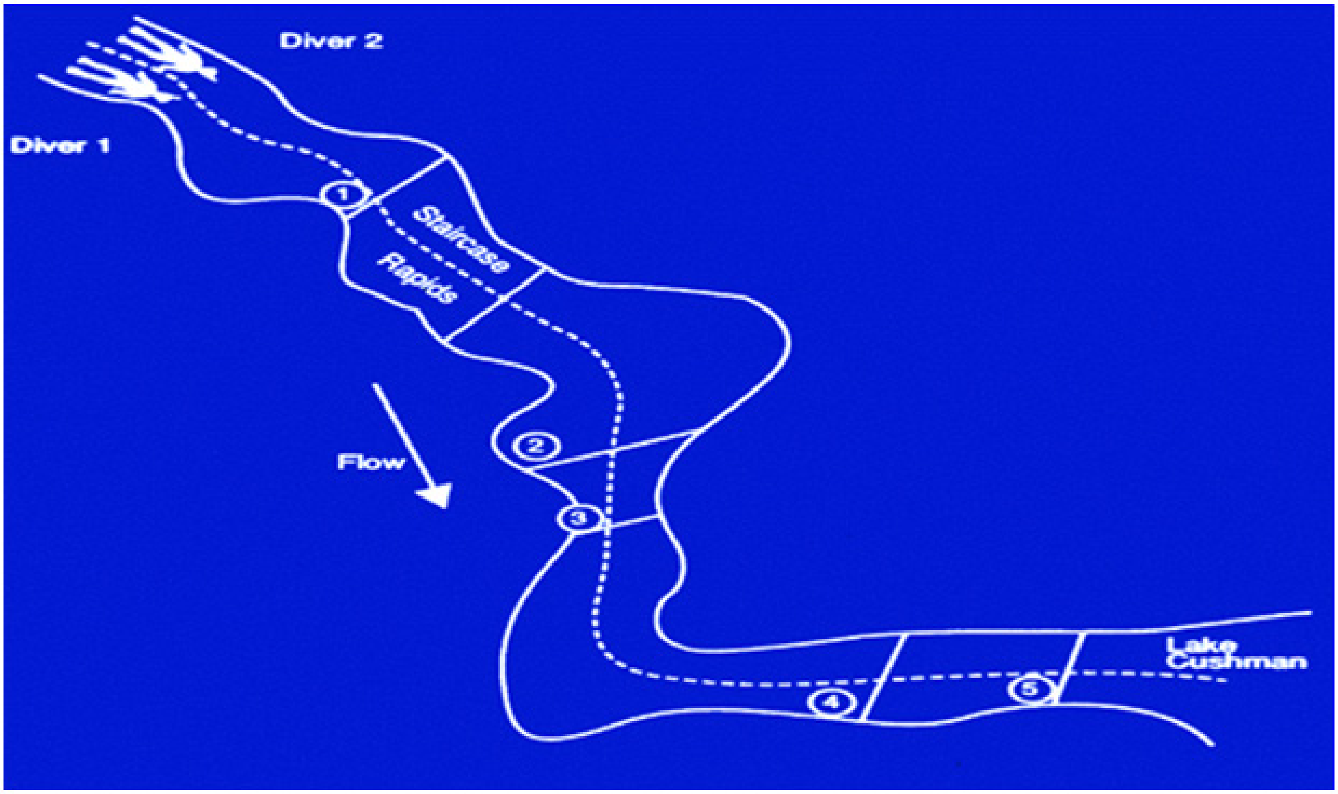

Figure 4. Schematic diagram that depicts two divers snorkeling downstream to count fish species in the reference site in the North Fork Skokomish River, OLYM.

cutthroat/rainbow trout. The sampling procedure of snorkel counts will be consistent within and among years and consistent among rivers.

To address observer variability in snorkel counts during pilot field work, we will conduct two-pass replicate snorkel counts in six rivers on the same date over the same <5-km reference site. Replication of snorkel surveys should be completed after fish have had time to recover from disturbance but before conditions of the river change (for example, flow or turbidity) (Johnson and others, 2007). Two divers typically conducted the second pass 20 to 60 minutes after divers began the first pass. Replicates surveys occurred on the following dates:

- East Fork Quinault River (August 10, 2005),
- North Fork Quinault River (August 11, 2005),
- North Fork Skokomish River (August 9, 2005),
- Bogachiel River (June 28, 2005) and
- South Fork Hoh River (June 9, 2005).

Replicate counts should occur in each river every 3 to 5 years to address observer variability in fish counts.

B. Backpack Electrofishing in Wadeable Streams

To collect fish in wadeable streams, a crew of four will proceed upstream without block-nets from the start of the first riffle upstream of the mouth to 1-km upstream sampling from left to right streambank. One crew member will operate a backpack electrofisher (I-5 settings on unit), one to two-crew members will net fish using dip-nets, and one crew member will handle buckets (fig. 5). In general, the electrofishing settings should be: 60 Hz, 6 ms, and 400–600 v, which follows Connolly and Brenkman (2008), but these settings can be judiciously changed depending on conditions. When feasible, as many as 50 individuals per fish species should be collected. In the event that 50 fish of a species are not captured in the 1-km section, surveyors should assess whether they can attain a total of 50 individuals by sampling a short distance more, but keeping these fish and their associated data separate in the field.

Figure 5. Sampling methods for electrofishing in streams (Mink Lake Creek, Sol Duc River, OLYM).

Photograph taken by Philip RS Johnson.

As the crew proceeds upstream, a few habitat measures will be taken. Observers will measure the length of pools and non-pools within the sampled 1-km section. Pools will be delineated by their smooth-water surface and by having a maximum depth >20 cm. Maximum depth of each pool will be measured. All data will be recorded as specified on the data sheet in appendix F.

C. Fish Handling and Measurements

Fish that are collected by backpack electrofisher will be immediately placed in aerated 5 gal buckets. Fish held in buckets will be monitored regularly to minimize stressful conditions. If necessary, fish will be lightly anesthetized with 50 mg/L MS-222 buffered with an equal amount of sodium bicarbonate. All fish will be identified to species (exceptions: sculpin and lamprey to genus; rainbow trout and cutthroat trout under 60 mm will be recorded as “trout”) and enumerated. Fish will be weighed to the nearest 0.1 g, and measured for fork length to the nearest millimeter. General observations of fish health and condition should be noted. All fish will be held in ambient temperature stream water until they fully recover, and then they will be released near their point of capture.

D. Collection of Water Temperature Data

Water temperature will be monitored at all river and stream sites near the park boundary with the exception of the North Fork Skokomish River where water temperatures are recorded continuously and retrieved from the USGS gaging station 12056500 in OLYM. Use of continuous recording devices with twice yearly downloads will cost little additional effort or dollars beyond the initial cost of the devices and their replacement every 5 years. Water temperature will be monitored throughout the year using the Stowaway® Tidbit® devices by Onset® and following guidelines outlined in Dunham and others (2005). The Tidbit® model TBI32-05+37 has the following specifications: range -4 to 37ºC; accuracy ±0.2 at 20ºC; resolution 0.6 at 20ºC; and has a 5-year non-replaceable battery. The loggers are set to record a value every 30 minutes, and will last 165 days. The data logger will be submersed and placed in each reference site from June to September.

The temperature loggers will be placed near the park boundary of each reference site. The location of each logger will be determined by GPS and in accordance with SOP #1: Use of GPS and Data Downloading. The loggers will be attached to a flow-through PVC pipe with pre-drilled holes and placed in the river or wadeable stream. Data loggers placed in solid housing units will not be in direct contact with the water and will be recording air temperature within the sealed housing (Dunham and others, 2005). The PVC pipe will be attached to a metal fence post and the PVC pipe will be secured to the post with plastic zip ties. It is important to maintain an exchange of water through the housing to minimize bias in temperature readings (Dunham and others, 2005). The metal fence posts will be pounded into the substrate in a protected area of the river. Ideally, the logger will remain in an area of significant flow throughout the summer and will be sheltered from occasional high flow events in the fall. One should avoid tributary junctions and known ground-water springs when selecting the sample site.

All temperature loggers should be calibrated prior to deployment using the “ice bucket” method. The following steps are necessary (excerpted from Dunham and others, 2005):

1. Deploy the data logger at a 1-min sampling interval;
2. Submerge data logger in a large cooler with fresh water and ice;

3. Ensure water temperature in water bath is 0°C using thermometer;
4. After 1 h, remove data logger and download the data. The temperature readings of a calibrated logger should level out at 0°C.

Error screening should be conducted after retrieval of the logger, and any observations that exceed 3°C per hour or a daily mean change of greater than 3°C between two consecutive days should be flagged. Flagged observations should then be reverified with personnel involved in the programming and field sampling (Dunham and others, 2005).

E. GPS Mapping of Reference Sites

Rivers and wadeable streams within OLYM and other NCCN parks are subject to seasonal and annual changes in channel morphology that typically occur during winter storm events (Bureau of Reclamation, 2004, 2005). Little changes occur during summer months when there are prolonged periods of low flows. As channel sinuosity increases or decreases from year to year, the lineal river distance between any two fixed points on the river changes accordingly. In some cases, these changes may be significant, and can result in changes to the length of a reference site. It is important to have an accurate measurement of distance surveyed each year because fish per kilometer is a key metric of relative abundance in this protocol. These measurements also will provide a means to monitor channel sinuosity and length in the reference sites over the years.

Each year, the lineal distance and location of the wetted channel will be determined for each reference site based on waypoints collected with a Thales® MobleMapper® handheld Global Positioning Systems (GPS) receiver. Waypoints will be recorded in the mid-channel of the thalweg of the river on every meander bend or every 200 m (about 25 waypoints/reference site), which ever is more frequent. Each GPS waypoint will be collected within 3 min. We expect to achieve 10 m horizontal accuracy at 95 percent confidence (Roger Hoffman, GIS Specialist, OLYM, written commun., 2008). Sampling will occur in each reference site during periods of low riverflows in August or September. Waypoints will be transferred to the ArcMap GIS data system for use in determining the length of the survey reach.

4. Pre-Field Operations

A. Personnel and Operational Requirements

The success of the Monitoring Program for Fish Assemblages is dependent on hiring well-qualified crew members from GS-05 to GS-07 levels with prior snorkeling and electrofishing experience, preferably in Pacific Northwest rivers and streams. General sampling methods and fish identification skills can be honed, but it is essential that all crew members are experienced fisheries technicians who are very physically fit, comfortable with spending extensive periods of time in water, and are educated in aquatic sciences. It is desirable to maintain consistency of the crew from year to year, to minimize annual start-up costs and to improve data quality. The process of advertising, interviewing, and hiring should begin by March of each year (table 13).

Once personnel are hired, they should be sent the Protocol, species lists, and other introductory materials that will enable them to be as familiar as possible with the park and fish communities that inhabit each river. In March, equipment should be inventoried and any needed items should be purchased. Data forms should be printed or copied (all on rain-proof paper), and topographic maps (1:24,000 scale) secured.

A government vehicle will be provided for each crew from June through September of each year. Crew members will be provided office space in the Natural Resources South Building at Olympic National Park headquarters in Port Angeles. At present, two computers are available in the Fisheries Office of that building. Crews will be provided park housing if available.

Table 13. Monthly schedule for hiring, training, field operations, data entry, and reporting for monitoring of rivers and wadeable streams.

[**Abbreviations**: X, month when activity takes place; S, snorkel surveys in references sites in rivers; E, electrofishing surveys in Olympic National Park wadeable streams that are co-located with river reference sites; QA/QC, quality assurance/quality control]

Activity	January	February	March	April	May	June	July	August	September	October	November	December
Hiring			X									
Apply for permits		X										
Training						X						
Data collection					S	S	S, E	S	S, E			
Data entry						X	X	X	X			
QA/QC						X	X	X	X			
Analysis and reporting										X	X	X

B. Roles and Responsibilities

[OLYM, Olympic National Park; GS, General Schedule; GIS, geographic information systems; NCCN, North Coast and Cascades Monitoring Network]

Role and Responsibilities	Name / Position
Project Lead • Project administration, operations, and implementation • Track project objectives, budget, requirements, and progress toward meeting objectives • Coordinate and ratify changes to protocol • Assist or Lead training of field crews • Maintain and archive project records • Assist in performing data summaries or analysis • Certify each season's data for quality and completeness • Complete reports, metadata, and other products according to schedule • Facilitate logistics planning and coordination • Review reports, data and other project deliverables • Train and ensure safety of field crew • Insure compliance is up-to-date	Supervisory Fishery Biologist, OLYM
Data analyst • Perform data summaries and analysis, assist interpretation and report preparation	
Field crew lead • Assist in training and ensuring safety of field crew • Plan and execute field visits • Acquire and maintain field equipment • Oversee data collection and entry, verify accurate data transcription into database • Complete a field season report	Seasonal technician (GS-7, term).
Technicians • Collect, record, enter and verify data	Seasonal technicians (GS 5-6), volunteers and interns
Data manager • Consultant on data management activities • Facilitate check-in, review and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule • Maintain and update database application • Provide database training as needed	Data Manager, OLYM
GIS specialist • Consultant on GPS use and spatial analysis techniques • Facilitate map and figure output generation • Primary steward of GIS data and products	GIS Specialist, OLYM
Network Coordinator • Review annual reports for completeness and compliance with I&M standards and expectations	NCCN Network Coordinator

C. Training

In June, a 5-day training session will be given on snorkel methods, river safety, electrofishing, fish identification, First-Aid and CPR, and use of radios each year. To gain familiarity with reference sites, it will be necessary to conduct pre-season reconnaissance at river and stream by all crew members. Crew members also will be given fish identification books (Pollard and others, 1997; Moyle, 2002; and Wydoski and Whitney, 2003) and species lists for each river, and will be trained to ensure familiarity with fish species commonly encountered in reference sites for each river. Additionally, crews will review digital photographs in OLYM files, and watch underwater video of fish assemblages from OLYM rivers.

D. Equipment Needs

Snorkel Equipment:

The following equipment is necessary for safe snorkeling:

- Park-issued waterproof radio with back-up batteries
- Felt-soled wading shoes
- Knee and elbow pads
- Dry suits, dive mask, snorkel, and PVC dive slate for recording data
- Fleece liner, neoprene gloves, neoprene snorkel hood, #2 pencils, and an eraser
- Liquid silicone ("Seal-Saver") to protect gaskets on dry suit
- A stick of wax for drysuit zippers
- NRS dry bag backpack, size 3.3
- Camping equipment (tent, stove, sleeping bag, and water filter)
- Fish identification books
- Snorkel data sheets (appendix E)
- GPS unit
- Dive throwbags and First-Aid kit for safety

Electrofishing Equipment

The following equipment is necessary for safe electrofishing:

- Park issued waterproof radio with back-up batteries
- Felt soled wading shoes
- Chest waders
- Collapsible buckets with oxygen aerators
- Plexi-glass view tube
- Smith-Root Model 12A electrofisher with extra batteries
- Two sets of anodes and cathodes and two dip-nets
- Rubber gloves rated to 10,000 volts
- A calibrated conductivity meter
- Scale accurate to nearest 0.1 g, capable of weighing fish as much as 300 g, with extra batteries
- Hand-held scale capable of weighing fish as much as 4.5 kg
- Electrofishing data sheets (appendix F)
- GPS unit and pencils

Water Temperature Equipment

The following equipment is necessary to install temperature loggers:

- Water temperature logger
- Fence posts
- Post pounder
- Twist ties (large size)
- Flow-through PVC pipe
- Pliers
- Wrench
- Stainless steel washers, nuts, and bolts with extras of each
- Software on computer
- GPS unit

E. Collection of Permits

To conduct electrofishing in OLYM and MORA, it is necessary to obtain Section 10A1a research sampling permits under the Endangered Species Act from NOAA (Puget Sound Chinook salmon, Puget Sound Steelhead) and USFWS (Puget Sound and Coastal bull trout). These permits may be obtained on an annual basis, and “take” coverage may be requested for as many as 5 years. It also is necessary to fulfill reporting requirements associated with each permit by the end of the calendar year. Currently, OLYM and MORA have permits from USFWS valid through 2010 and MORA has a permit from NOAA valid through 2011 (appendix G).

5. Field Operations

A. Sequence of Events During Field Cycle

The monitoring will occur daily on a continual basis from early June to September 30 each year. The field season and extent of sampling effort will depend on flows in each river. Certain rivers are more conducive to sampling in early June (for example, Bogachiel River) although others may not be sampled until late July (for example, Dosewallips River). Crews will conduct snorkel surveys in each river at 7- to 10-day intervals. Sampling of the five co-located, wadeable streams will occur in July and September.

The team leader will be responsible for the review of site information with the crew. Team leaders also will contact local area rangers prior to each survey. The team leader will prepare the itinerary for day and week. Team members will prepare and load sampling gear and check equipment to ensure appropriate operation.

B. Safety Guidelines for Field Operations

Personnel at OLYM specialize in sampling relatively remote rivers and have developed and adopted a safety-based work culture that places safety of workers above all project objectives.

Personal safety of the crew is the highest priority and must be emphasized in safety plans for the field, laboratory, and driving. Risks to personal safety and health include drowning, electrical shock, hypothermia, pathogens, contusions, slips, trips, and falls.

Safe behavior along rivers and during river crossings is paramount to the success of this program. It is important to recognize that every river is different and flows vary from day to day and even from hour to hour. We outline the relative range of safe flows for snorkeling each river in this protocol (table 1). The range of safe flows for each river should be re-evaluated on an annual basis due to regular geomorphic changes in channel conditions.

High flows increase the danger associated with log jams and other obstacles (fig. 6). Due to the overall increased hydraulic force of the river at higher flows, speed and power increase dramatically, thus decreasing the ability and time to react to situations that may not be safe. Compensation must be made for these conditions.

Fisheries staff at OLYM prepared a Job Hazard Analyses for snorkeling, electrofishing, and wading in rivers and streams (OLYM files). The following safety guidelines for work in lotic systems must be strictly adhered to at all times:

1. Record location of survey, time of departure, and time of expected return on fisheries scheduling board and inform Supervisor of planned activities each day.

2. When crossing a river or stream, examine the waterway from the highest vantage point possible and pick a route through the widest channels or where there are multiple channels that distribute the flow. Always wear felt soled boots for traction and a dry suit with snorkel and mask. Braided areas and areas of smaller substrate generally are best for crossing when compared to deep channels or swift areas with larger substrate. Try to find an exit area on the far riverbank. It also is important to plan an option for a retreat back to the shore should the crossing become too difficult. Do not cross in areas of whitewater.

3. Always unbuckle the waist and chest straps on your drybag and carefully note substrate size (smaller generally is better), depth, and velocity prior to crossing. If wearing waders, ensure that the waistbelt is properly secured to reduce the likelihood of filling waders.

4. Only cross the river at *slow* flowing portions of the river when water depth is no more than about knee deep. To cross moderately fast portions of rivers, the water depth should be less than ankle-deep and where one can clearly see the river bottom. Areas of whitewater, fast flowing water, significant depth, velocity, or large substrate should be avoided.

5. When crossing, stand sideways and cross the river with a partner. Never face downstream as flowing water can cause knees to buckle. Move one foot at a time and plant each foot firmly before each step. One may use a stout stick to increase balance in the river. If swept away: stay calm, drop pack, use whistle, and attempt to float feet first with head slightly raised. Remember to swim across the current to the riverbank and not against the current.

6. Know your limits as a snorkeler.

7. Maintain hydration throughout the day and know early signs and symptoms of heat exhaustion and dehydration in hot weather.

8. Never attach ropes or straps to a diver.

9. At the beginning of each day, check current river flow conditions on the USGS real-time river data page located on the web (http://waterdata.usgs.gov/wa/nwis/nwis) or at the Washington Department of Ecology streamflow site. Check the maximum acceptable flows for each individual river. These guidelines were established during summer 2005 to 2007. Never snorkel when maximum established flow is exceeded in any river.

10. No survey shall be conducted if one diver is uncomfortable with existing flow conditions.

11. Always carry waterproof radios and First Aid kits in dry bags at all times.

12. There shall be at least two divers at all times and a third person on riverbank whenever available.

Figure 6. A large woody debris complex in the Sol Duc River that would be potentially hazardous at flows higher than those depicted.

This photograph was taken during record low summer flows in 2005.

13. Move slowly and take time to scout questionable sections of the river before attempting to survey them.
14. Always walk around hazardous areas if there is any question as to the safety of the section or the comfort level of the survey crew.

C. Equipment Care

After each field season, sampling and camping equipment will be repaired as needed and stored in the Fisheries storage area at OLYM headquarters in Port Angeles. Electrofishing equipment (including probes and batteries) should be checked by the manufacturer to identify needs for repair or replacement.

D. End of the Season Procedures

At the end of the season, the Field Crew Leader will prepare a brief (less than 3 pages) summary report that includes the following:

- A table that depicts the allocation of surveys for each river during the season.
- Local precipitation and climatic conditions for each watershed attained from the NCCN Climate Protocol.
- Description of any logistic difficulties and safety concerns for each river.
- Clear documentation and explanation of any diversions from established protocols.
- Points out any interesting or potentially important observations about the parks' fish communities that may have been noted during the field season (for example, apparent changes in phenology from previous years, or notable changes in apparent abundance of particular species).
- Provides suggestions for improving the training session or field season logistics in the future.

Field Crew Leader reports will be archived. The Field Crew Leader will be responsible for ensuring that all equipment is properly inventoried, cleaned, and stored. The Field Crew Leader also will ensure that all close-out materials (keys, park passes, personnel forms) are completed by each crew member prior to their departure.

6. Data Handling, Analysis, and Reporting

This section describes the procedures for data handling, analysis, and report development. Additional details and context for this section are provided in the NCCN Data Management Plan (Boetsch and others, 2005), which describes the overall information management strategy for the network. The NCCN website also contains guidance documents on various information management topics (for example, report development, GIS development, GPS use).

A. Project Information Management Overview

Project information management may be best understood as an ongoing or cyclic process, as shown in figure 7. Specific yearly information management tasks for this project and their timing are described in appendix H: Yearly Project Task List. Readers also may refer to each respective section for additional guidance and instructions.

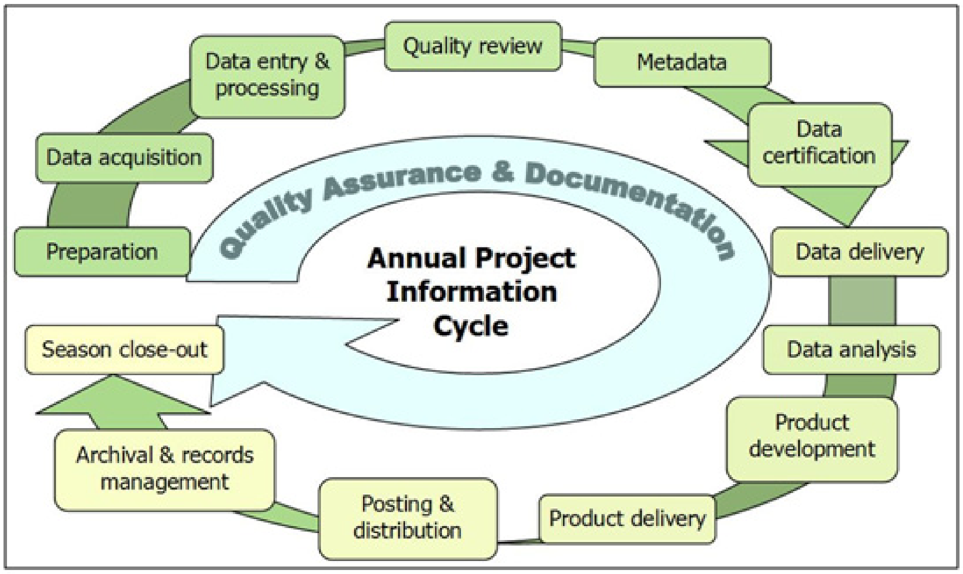

Figure 7. Idealized flow schematic of the cyclical stages of project information management, from pre-season preparation to season close-out.

Note that quality assurance and documentation are thematic and not limited to any particular stage.

The stages of this cycle are described in greater depth in later sections of this chapter, but can be briefly summarized as follows:

- *Preparation* – Training, logistics planning, print forms and maps
- *Data acquisition* – Field trips to acquire data
- *Data entry & processing* – Data entry and uploads into the working copy of the database, GPS data processing, etc.
- *Quality review* – Data are reviewed for quality and logical consistency
- *Metadata* – Documentation of the year's data collection and results of the quality review
- *Data certification* – Data are certified as complete for the period of record
- *Data delivery* – Certified data and metadata are delivered for archiving and upload to the master project database
- *Data analysis* – Data are summarized and analyzed
- *Product development* – Reports, maps, and other products are developed
- *Product delivery* – Deliver reports and other products for posting and archiving
- *Posting and distribution* – Distribute products as planned and/or post to NPS clearinghouses
- *Archiving and records management* – Review analog and digital files for retention (or destruction) according to NPS Director's Order 19. Retained files are renamed and stored as needed.
- *Season close-out* – Review and document needed improvements to project procedures or infrastructure, complete administrative reports, and develop work plans for the coming season.

B. Pre-Season Preparations for Information Management

Project Workspace Setup

A section of the networked file server at OLYM is reserved for this project, and access permissions are established so that project staff members have access to needed files within this workspace. Prior to each season, the Project Lead should make sure that network accounts are established for each new staff member, and that the Data Manager is notified to ensure access to the project workspace and databases. The recommended file structure within this workspace is shown in figure 8. Certain folders—especially those for GPS data and images—should be retained in separate folders for each calendar year as shown in figure 8. This will make it easier to identify and move these files to the project archives at the end of each season.

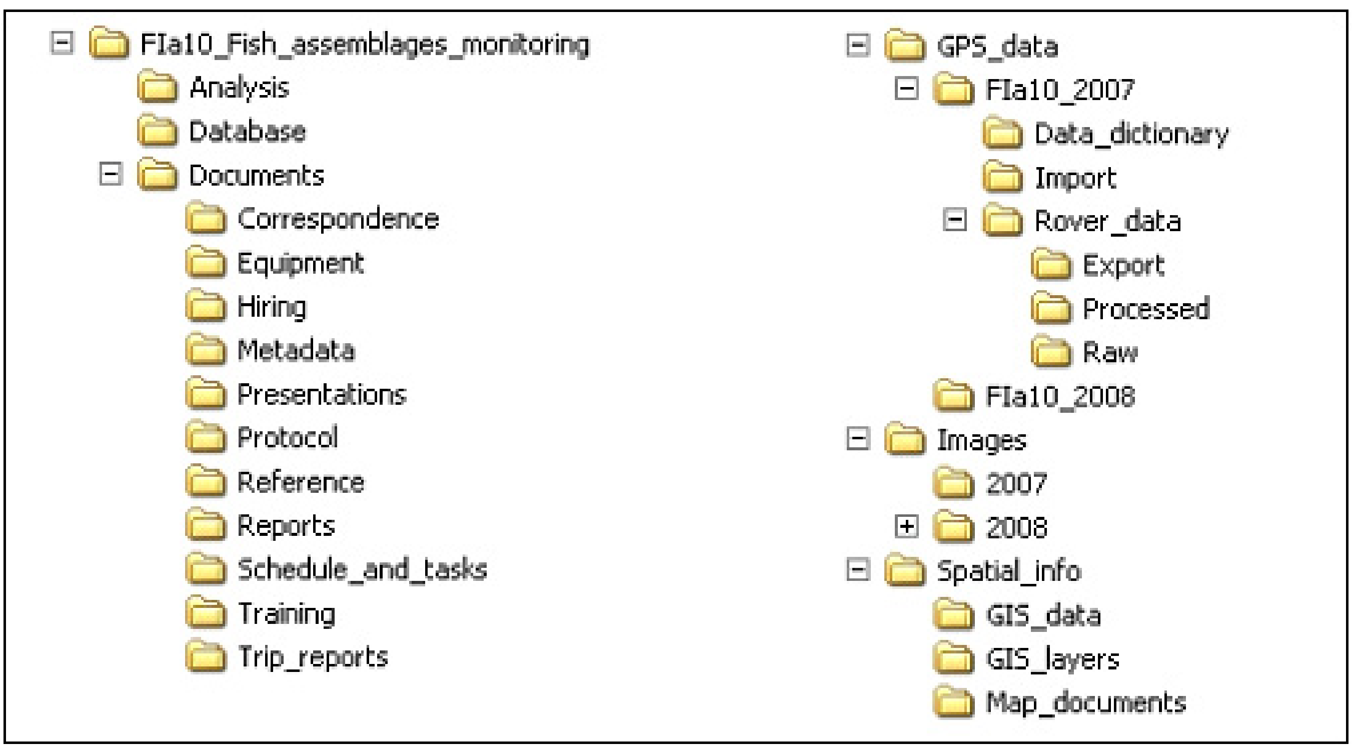

Figure 8. Recommended file structure for project workspace.

Note: The workspace folder name includes 'FIa10', the NCCN project code.

Each major subfolder is described as follows:

- Analysis – Contains working files associated with data analysis.
- Database – Contains the working database file for the season. The master database for the project is stored in the enterprise data management system (Boetsch and others, 2005).
- Documents – Contains subfolders to categorize documents as needed for various stages of project implementation.
- GPS data – Contains GPS data dictionaries and raw and processed GPS data files.
  Note: This folder contains subfolders to arrange files by year. Each of these subfolders also contains the project code (that is, 'FIa10') to make it easier to select the correct project folder within the GPS processing software (refer to SOP #1: Use of GPS and Data Downloading).
- Images – For storing images associated with the project. The following structure contains subfolders to arrange files by year, and permits data images to be stored and managed separately from non-record and miscellaneous images collected during the course of the project. This structure also provides separate space for image processing and storage of originals.

[Year] The appropriate year – 2008, 2009, etc.

_Processing	Processing workspace
Data	Data images
[Site_code]	Arranged by reach, for images taken at reaches
[Date]	Arranged by date, for images not taken at reaches
Miscellaneous	Non-data images taken by project staff
[Site_code]	Arranged by reach, for images taken at reaches
[Date]	Arranged by date, for images not taken at reaches
Originals	Renamed but otherwise unedited image file copies
[Site_code]	Arranged by reach, for images taken at reaches
[Date]	Arranged by date, for images not taken at reaches
Non-NPS	Images acquired from other sources

- Spatial info – Contains files related to visualizing and interacting with GIS data.
  - GIS data – New working shapefiles and coverages specific to the project.
  - GIS layers – Pointer files to centralized GIS base themes and coverages.
  - Map documents – Map composition files (.mxd).

Folder Naming Standards

In all cases, the following guidelines should be followed for folder names: (1) no spaces or special characters in the folder name, (2) use the underbar ("_") character to separate words in folder names, (3) try to limit folder names to 20 characters or fewer, and (4) dates should be formatted as YYYYMMDD for better sorting.

GPS Preparation

The GIS Specialist and Project Lead should work together to ensure that target coordinates and data dictionaries are loaded into the GPS units prior to the onset of field work, and that GPS download software is available and ready for use. Additional details on GPS use and GPS data handling are provided in SOP #1: Use of GPS and Data Downloading, and in NCCN GPS Guidelines (North Coast and Cascades Network-National Park Service 2006a).

Implementing Working Database Copy

Prior to the field season, the Data Manager will implement a blank copy of the working database and ensure proper access on the part of the project staff. Refer to Section 6C, Overview of Database Design for additional information about the database design and implementation strategy.

C. Overview of Database Design

We maintain a customized relational database application to store and manipulate the data associated with this project. The design of this database is consistent with NPS I&M and NCCN standards (see the data dictionary and other documentation in Appendix I: Database Documentation). The Data Manager is responsible for development and maintenance of the database, including customization of data summarization and export routines.

The database is divided into two components—one for entering, editing, and error-checking data for the current season (“working database copy”), and another that contains the complete set of certified data for the monitoring project (“master project database”). A functional comparison of these two components is provided in table 14.

Each of these components is based on an identical underlying data structure (tables, fields and relationships, as documented in Appendix I: Database Documentation). The working database is implemented in Microsoft© Access to permit greater flexibility when implementing on computers with limited or unreliable network access. The master database is implemented in Microsoft© SQL Server to take advantage of the backup and transaction logging capabilities of this enterprise database software.

Both components have an associated front-end database application (“user interface” with forms, queries, etc.) implemented in Microsoft© Access. The working database application has separate screens for data entry, data review, and quality validation tools. The master database application contains the analysis and summarization tools, including pre-formatted report output and exports to other software (for example, for analysis and graphics production).

During the field season, each project crew will be provided with their own copy of a working database into which they enter, process, and quality-check data for the current season (refer to Section 6D, Data Entry and Processing and SOP #2: Data Entry and Verification). Once data for the field season have been certified, they will be uploaded into the master database, which is then used for all reporting and analysis. This upload process is performed by the Data Manager, using a series of pre-built append queries.

Table 14. Functional comparison of the master project database and the working database copy.

Project database functions and capabilities	Working database	Master database
Software platform for back-end data	Microsoft© Access	Microsoft© SQL Server.
Contains full list of sampling locations and taxa	X	X
Portable for remote data entry	X	
Forms for entering and editing current year data	X	
Quality assurance and data validation tools	X	X
Preliminary data summarization capabilities	X	
Full analysis, summarization and export tools		X
Pre-formatted report output		X
Contains certified data for all observation years		X
Limited editing capabilities, edits are logged		X
Full automated backups and transaction logging		X

D. Data Entry and Processing

After each field trip, technicians should enter data in order to keep current with data entry tasks, and to identify any errors or problems as close to the time of data collection as possible. The working database application is found in the project workspace. For enhanced performance, it is recommended that users copy the front-end database onto their workstation hard drives and open it there. This front-end copy may be considered “disposable” because it does not contain any data, but rather acts as a pointer to the data that reside in the back-end working database. Whenever updates to the front-end application are made available by the Data Manager, an updated front-end database should be copied from the project workspace to the workstation hard drive.

The functional components for data entry into the working database are described in SOP #2: Data Entry and Verification. Each data entry form is patterned after the structure of the field form, and has built-in quality assurance components such as pick lists and validation rules to test for missing data or illogical combinations. Although the database permits users to view the raw data tables and other database objects, users are strongly encouraged only to use these pre-built forms as a way of ensuring the maximum level of quality assurance.

Regular Data Backups

Upon opening the working database, the user will be prompted to make a backup of the underlying data (see SOP #2: Data Entry and Verification). It is recommended that backups be made on a regular basis – perhaps every day that new data are entered – to save time in case of mistakes or database file corruption. These periodic backup files should be compressed to save drive space, and may be deleted once enough subsequent backups are made. All such backups may be deleted after the quality review and certification of the data.

Data Verification

As data are being entered, the person doing the data entry should visually review them to make sure that the data on screen match the field forms. This should be done for each record prior to moving to the next form for data entry. At regular intervals and at the end of the field season, the Field Lead should inspect the data being entered to check for completeness and perhaps identify avoidable errors. The Field Lead also may periodically run the Quality

Assurance Tools that are built into the front-end working database application to check for logical inconsistencies and data outliers (this step is described in greater detail in Section 6E, Quality Review and also in SOP #3: Data Quality Review and Certification).

Field Form Handling Procedures

As field data forms are part of the permanent record for project data, they should be handled in a way that preserves their future interpretability and information content. If changes to data on the forms need to be made subsequent to data collection, the original values should not be erased or otherwise rendered illegible. Instead, changes should be made as follows:

- Draw a horizontal line through the original value, and write the new value adjacent to the original value with the date and initials of the person making the change.
- All corrections should be accompanied by a written explanation in the appropriate notes section on the field form. These notes also should be dated and initialed.
- If possible, edits and revisions should be made in a different color ink to make it easier for subsequent viewers to be able to retrace the edit history.
- Edits should be made on the original field forms and on any photocopied forms.

These procedures should be followed throughout data entry and data revision. On a 5-year basis, data sheets are to be scanned as PDF documents and archived (see the product delivery specifications in Section 6J, Product Delivery, Posting and Distribution). The PDF files may then serve as a convenient digital reference of the original if needed.

Image Handling Procedures

This section covers photographic images collected by project staff or volunteers during the course of conducting project-related activities. Images that are acquired by other means—for example, downloaded from a website or those taken by a cooperating researcher—are not project records and should be handled separately.

Data photographs are often linked to specific records within the database, and are stored in a manner that permits the preservation of those database links. Other photographs—for example, of field crew members at work, or photographs showing the morphology of a certain fish species—also may be retained but are not necessarily linked with database records.

Effectively managing hundreds of photographic images requires a consistent method for downloading, naming, editing and documenting. The general process for managing data photographs proceeds as follows:

1. Image file structure setup – Set up the file organization for images prior to acquisition, according to the project workspace structure indicated in Section 6B, Pre-Season Preparations.

2. Image acquisition – Capture images at an appropriate resolution that balances space limitations with the intended use of the images. Although photographs taken to facilitate future navigation to the site do not need to be stored at the same resolution as those that may be used to indicate gross environmental change at the site, it may be more efficient to capture all images at the same resolution initially. A recommended minimum raw resolution is 1600 × 1200 pixels (approximately 2 megapixels).

3. Download and process – **Note**: Large groups of photographs acquired under sub-optimal exposure or lighting can be batch processed to enhance contrast or brightness. Batch processing can also be used to rename groups of photographs according to a convention, or to resize images for use on the web. Batch processing may be done in ThumbsPlus®, Extensis© Portfolio or a similar image software package.

    a. Download the raw, unedited images from the camera into the appropriate "_Processing" folder.

    b. Rename the images according to convention (refer to the image naming standards section). If image file names were noted on the field data forms, be sure to update these to reflect the new image file name prior to data entry. In cases where there are small quantities of photographs it is practical to individually rename these files. However, for larger numbers, it may be useful to rename files in batches. This may be done in ThumbsPlus®, Extensis© Portfolio or a similar image software package. A somewhat less sophisticated alternative is to batch rename files in Windows Explorer©, by first selecting the files to be renamed and then selecting File > Rename. The edits made to one file will be made to all others, although with the unpleasant side effect of often adding spaces and special characters (for example, parentheses) that will then need to be removed manually. Renaming photographs may be most efficient as a two part event – first a batch process to insert the date and transect number at the beginning of the photo name, after which a descriptive component is manually added to each file name.

c. Copy the images to the 'Originals' folder and set the contents as read-only by right clicking in Windows Explorer© and checking the appropriate box. These originals are the image backup to be referred to in case of unintended file alteration or deletion.

d. Delete any poor quality photographs, repeats, or otherwise unnecessary photographs. Low quality photographs might be retained if the subject is highly unique, or the photograph is an irreplaceable data photograph.

e. Rotate the image to make the horizon level.

f. Photographs of people should have 'red eye' glare removed.

g. Photographs should be cropped to remove edge areas that grossly distract from the subject.

h. When finished, move the image files that are to be retained and possibly linked in the database to the appropriate folder—data images under the Data folder, other images under the Miscellaneous folder. Photographs of interest to a greater audience should be copied to the park Digital Image Library. To minimize the chance for accidental deletion or overwriting of needed files, no stray files should remain in the processing folder between downloads.

i. Depending on the size of the files and storage limitations, contents of the Originals folder may be deleted once all desired files are accounted for after processing.

4. Establish database links—During data entry and processing, the database application will provide the functionality required to establish a link between each database record and the appropriate image file(s). To establish the link, the database prompts the user to indicate the root project workspace directory path, the specific image folder within the project workspace, and the specific file name. This way, the entire workspace may be later moved to a different directory (that is, the NCCN Digital Library) and the links will still be valid after changing only the root path. Refer to SOP #2: Data Entry and Verification for additional details on establishing these links.
Note: Files must keep the same name and relative organization once these database links have been established. Users should not rename or reorganize the directory structure for linked image files without first consulting with the Data Manager.

5. Deliver image files for final storage—At the end of the season, and once the year's data are certified, data images for the year may be delivered along with the working copy of the database to the Data Manager on a CD or DVD. To do this, simply copy the folder for the appropriate year(s) and all associated subfolders and images onto the disk. These files will be loaded into the project section of the NCCN Digital Library, and the database links to data images will be updated accordingly. Prior to delivery, make sure that all processing folders are empty. Upon delivery, the delivered folders should be made read-only to prevent unintended changes. Refer to Section 6J, Product Delivery, Posting, and Distribution for additional information.

GPS Data Procedures Image Handling Procedures

The following general procedures should be followed for GPS data (see SOP #1: Use of GPS Data and Downloading and Appendix H: Yearly Project Task List):

1. GPS data should be downloaded by the field crew from the units at the end of each field trip and stored in the project workspace.

2. Raw files should be sent in a timely manner to the GIS Specialist for processing and correction.

3. The GIS Specialist will process the raw GPS data and store the processed data in the project workspace.

4. The GIS Specialist will upload corrected coordinate information into the database and create any GIS data sets.

The Field Lead should periodically review the processed GPS data to make sure that any errors or inconsistencies are identified early.

E. Quality Review

After the data have been entered and processed, they need to be reviewed by the Project Lead for quality, completeness and logical consistency. The working database application facilitates this process by showing the results of pre-built queries that check for data integrity, data outliers and missing values, and illogical values. The user may then fix these problems and document the fixes. Not all errors and inconsistencies can be fixed, in which case a description of the resulting errors and why edits were not made is then documented and included in the metadata and certification report (see Sections 6F, Metadata Procedures and 6G, Data Certification and Delivery, and SOP #3: Data Quality Review and Certification).

Data Edits Before and After Certification

Due to the high volume of data changes and/or corrections during data entry, it is not efficient to log all changes until after data are certified and uploaded into the master database. Prior to certification, daily backups of the working database provide a crude means of restoring data to the previous day's state. After certification, all data edits in the master database are tracked in an edit log (refer to appendix I: Database Documentation) so that future data users will be aware of changes made after certification. In case future users need to restore data to the certified version, we also retain a separate, read-only copy of the original, certified data for each year in the NCCN Digital Library (see Section 6J, Product Delivery, Posting and Distribution).

Geospatial Data

The Project Lead and GIS Specialist may work together to review the surveyed coordinates and other geospatial data for accuracy. The purpose of this joint review is to make sure that geospatial data are complete and reasonably accurate, and also to determine which coordinates will be used for subsequent mapping and field work.

F. Metadata Procedures

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, condition and other characteristics of a given data set. Additionally, metadata provide the means to catalog and search among data sets, thus making them available to a broad range of potential data users. Metadata for all NCCN monitoring data will conform to Federal Geographic Data Committee (FGDC) guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized.

At the conclusion of the field season (according to the schedule in Appendix H: Yearly Project Task List), the Project Lead will be responsible for providing a completed, up-to-date metadata interview form to the Data Manager. The Data Manager and GIS Specialist will facilitate metadata development by consulting on the use of the metadata interview form, by creating and parsing metadata records from the information in the interview form, and by posting such records to national clearinghouses.

An up-to-date metadata record is a required deliverable that should accompany each season's certified data. For long-term projects such as this one, metadata creation is most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years then only need to be updated to reflect changes in contact information and taxonomic conventions, to include recent publications, to update data disposition and quality descriptions, and to describe any changes in collection methods, analysis approaches or quality assurance for the project.

Specific procedures for creating, parsing and posting the metadata record are provided in NCCN Metadata Development Guidelines (North Coast and Cascades Network—National Park Service, 2006b). General procedures are as follows:

1. After the annual data quality review has been performed and the data are ready for certification, the Project Lead (or a designee) updates the metadata interview form.
    a. The metadata interview form greatly facilitates metadata creation by structuring the required information into a logical arrangement of 15 primary questions, many with additional sub-questions.
    b. The first year, a new copy of the NCCN Metadata Interview form should be downloaded. Otherwise the form from the previous year can be used as a starting point, in which case the Track Changes tool in Microsoft© Word should be activated in order to make edits obvious to the person who will be updating the XML record.
    c. Complete the metadata interview form and maintain it in the project workspace. Much of the interview form can be filled out by cutting and pasting material from other documents (for example, reports, protocol narrative sections, and SOPs).
    d. The Data Manager can help answer questions about the metadata interview form.
2. Deliver the completed interview form to the Data Manager according to the product delivery specifications in Section 6J, Product Delivery, Posting, and Distribution.
3. The Data Manager (or GIS Specialist for spatial data) will then extract the information from the interview form and use it to create and update an FGDC- and NPS-compliant metadata record in XML format. Specific guidance for creating the XML record is contained in NCCN Metadata Development Guidelines (North Coast and Cascades Network—National Park Service, 2006b).
4. The Data Manager will post the record and certified data to the NPS Data Store, and maintain a local copy of the XML file for subsequent updates. The NPS Data Store has help files to guide the upload process.
5. The Project Lead should update the metadata interview content as changes to the protocol are made, and each year as additional data are accumulated.

G. Data Certification and Delivery

Data certification is a benchmark in the project information management process that indicates that: (1) data are complete for the period of record, (2) data have undergone and passed the quality assurance checks (Section 6E, Quality Review), and (3) data are appropriately documented and in a condition for archiving, posting, and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies that may or may not have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Project Lead is the primary person responsible for completing an NCCN Project Data Certification Form, available on the NCCN website. This form should be submitted with the certified data according to the timeline in Appendix 1: Yearly Project Task List. Refer to SOP #3: Data Quality Review and Certification and the delivery specifications in Section 6J, Product Delivery, Posting, and Distribution for instructions.

Water Quality Data Procedures

All water quality data collected for this monitoring project will be managed according to guidelines from the NPS Water Resources Division (WRD). NPSTORET (http://www.nature.nps.gov/water/infoanddata) and Environmental Protection Agency (EPA) STORET (http://www.epa.gov/storet/) are, respectively, the NPS and national enterprise data warehouses for water quality data. NPSTORET is maintained by WRD and is synchronized with EPA STORET on a regular basis. NPS WRD also maintains a desktop version of NPSTORET in Microsoft© Access to manage local data entry, documentation, and transfer. After the season's data are entered and reviewed in the project database, water temperature data will be uploaded to the local, desktop version of NPSTORET. We will then transfer the contents of this local copy at least annually to NPS Water Resource Division for upload to the STORET database. Once certified project data have been synchronized with WRD NPSTORET, they are automatically made available to the public through the EPA STORET data warehouse (http://www.epa.gov/storet/).

H. Data Analysis and Summaries

Seasonal and annual trends in fish assemblages are characterized by quantitative estimates of the relative abundance, species composition, fish biomass, and fish density in river and stream reference sites. To demonstrate the types of summaries to be constructed on an annual basis, we present actual data in graphical and tabular format from surveys conducted during pilot fieldwork and from an existing long-term data set from the North Fork Skokomish River (1994 to present). The results from these surveys shall be interpreted cautiously, and inferences are limited to individual reference sites within a river.

Comparisons of Seasonal Abundances of Fish Species Within and Among Rivers

The relative seasonal abundances of each fish species are determined within a river and general comparisons can be made among rivers in this protocol. Seasonal trends in abundance are reported as the number of each fish species (or fish/km) on a given sample date in each river. Graphics can be constructed for individual fish species in each river or graphics can be constructed to represent seasonal trends in relative abundances of multiple fish species in a given river (fig. 9). In the North Fork Skokomish River, there are distinct monthly changes in composition of mountain whitefish, cutthroat/rainbow trout, and adult bull trout that correspond to fish movements between the Lake Cushman (reservoir) and the river (fig. 9). To generally characterize seasonal changes in relative abundance or fish densities (fish/km) among reference sites, graphics are made for each river.

To characterize seasonal or monthly trends in fish/km for a given species among rivers, the mean monthly counts for each species are reported (fig. 10). Such information can provide a relative gauge of productivity for each species among reference sites. Graphics are made annually for fish species that are present in multiple rivers.

Comparisons of Seasonal Fish Species Composition Within and Among Rivers

The relative seasonal composition (for example, fish assemblage) of fish species is determined within each river and general comparisons can be made among rivers in this protocol. Seasonal trends in fish species composition are reported as the percent of each fish species in a given month in each river. Graphics can be constructed to represent seasonal trends in fish species composition (fig. 11).

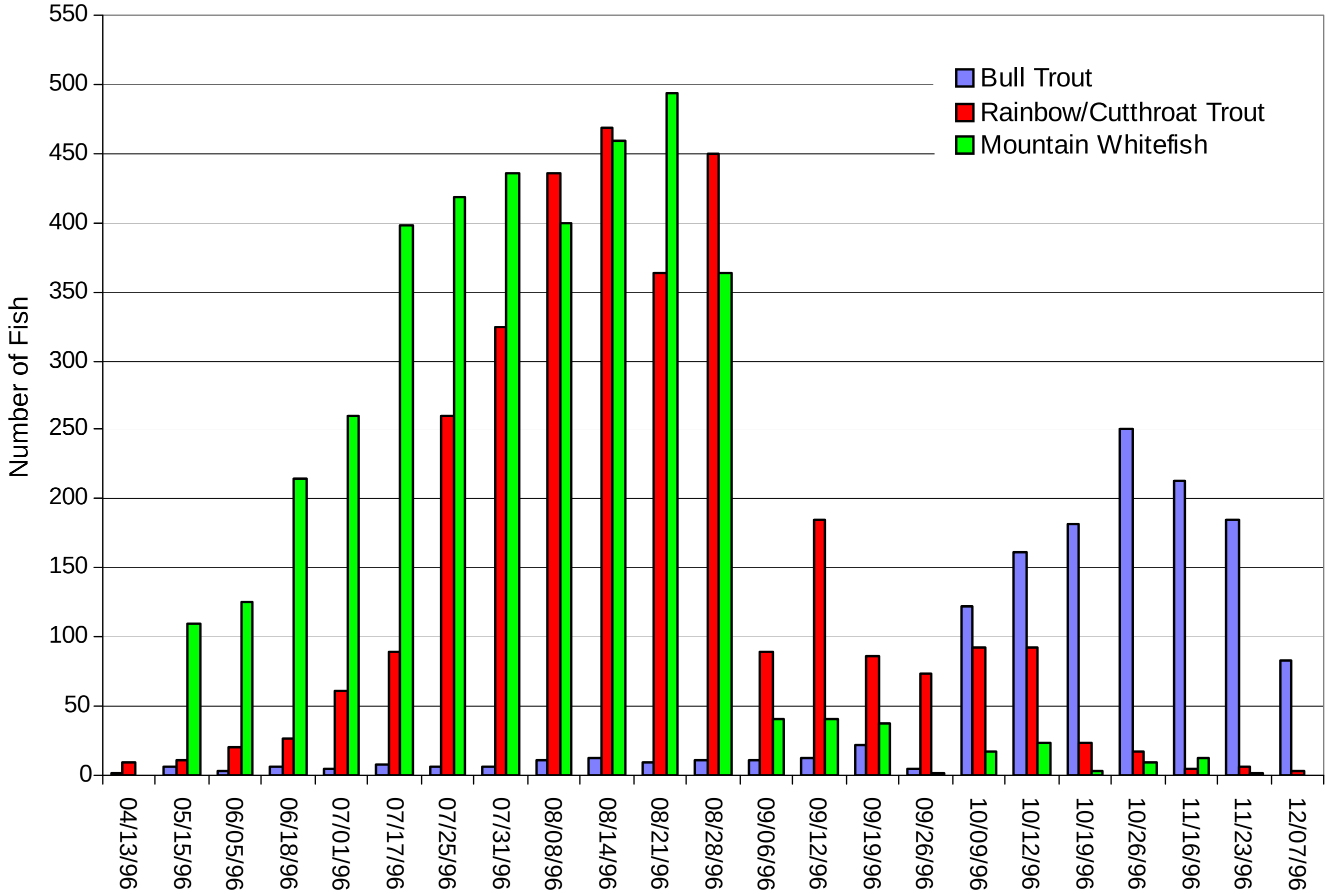

Figure 9. Numbers of adult bull trout, cutthroat/rainbow trout, and mountain whitefish in the reference site in the North Fork Skokomish River based on snorkel surveys conducted from April to December 1996.

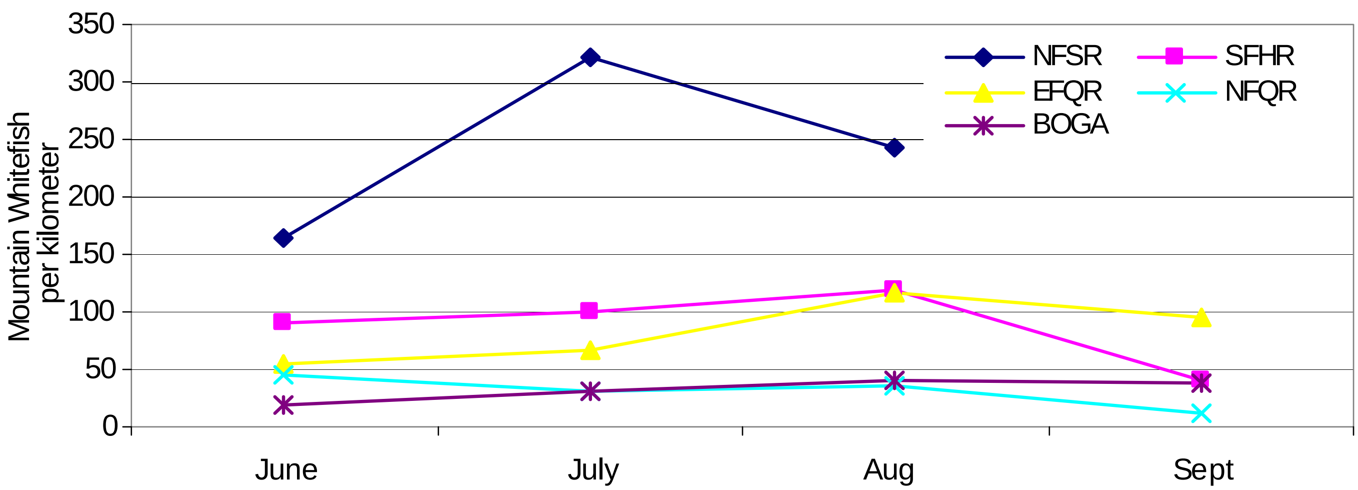

Figure 10. Comparisons of mean monthly densities (fish/km) of mountain whitefish in the East Fork Quinault (EFQR), North Fork Quinault (NFQR), North Fork Skokomish (NFSR), and South Fork Hoh Rivers (SFHR), Washington based on snorkel surveys in reference sites from June to September 2005.

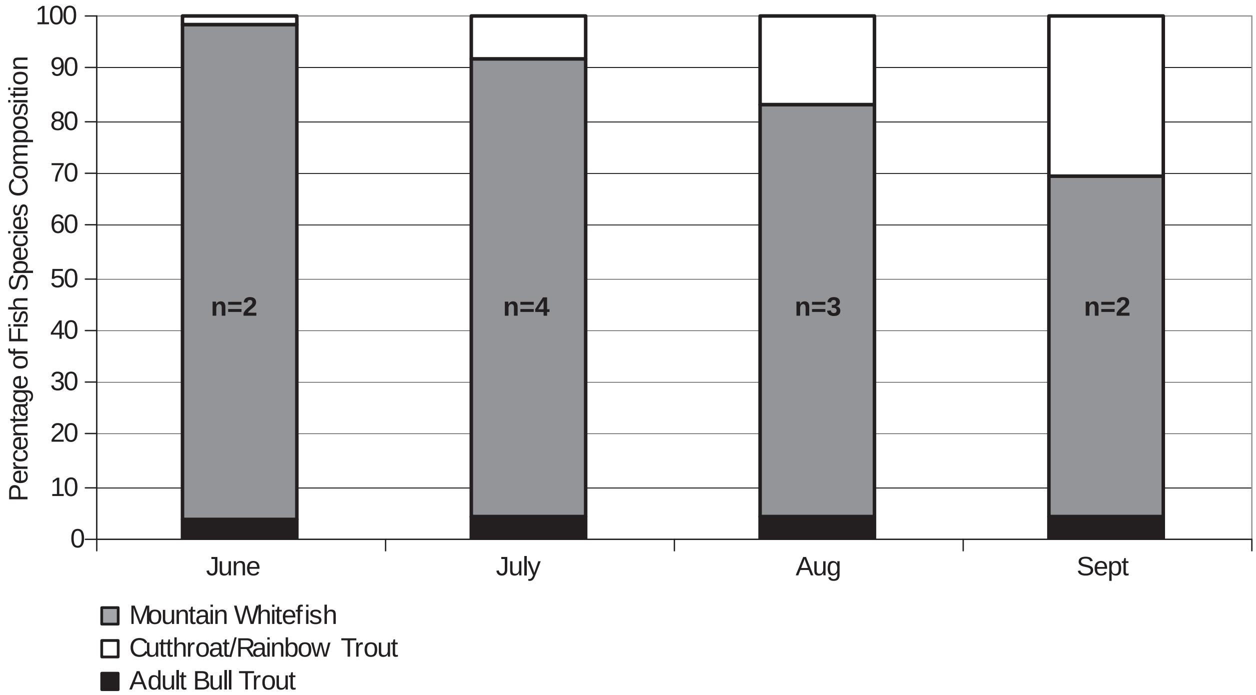

Figure 11. Mean monthly composition of adult bull trout, cutthroat/rainbow trout, and mountain whitefish in the South Fork Hoh River, Washington, based on 11 snorkel surveys conducted in the reference site from June to September 2005.

Trends in Annual Peak Counts and Fish Species Composition in Rivers

Annual trends in relative abundances are determined by comparing the maximum density or peak count for each species in a given year. To properly estimate the peak count, at least one snorkel survey at or near the peak is required. Because the true peak count of some species may occur outside our sampling frame (June–September), the comparisons among years are a measure of trends in relative abundance. Trends in annual peaks counts are reported for each species in each river every year (fig. 12).

To generally characterize migratory timing of each species among rivers, a comparison of peak counts is made among rivers (fig. 13). For instance, the general timing of peak counts for cutthroat/rainbow trout generally is consistent among rivers, and peak counts for bull trout are more variable in 2005 (fig. 13).

Annual trends in relative composition of each fish species over several years are determined by comparing the percent of each fish species in a given month among years. Trends in fish species composition are reported for each river every year (fig. 14).

After collection of multiple years (for example 10–20 years) of information, the fish assemblage in each river can be characterized with decadal information on: numerically abundant species (percent of each fish species; number of fish species; number of families); number of extirpated fish species; extent of faunal similarity within a river; and assemblage evenness that describes whether fish fauna is one with high species evenness and diversity or one with few, but abundant species.

Trends in Migratory Timing in Rivers

To estimate onset, peak, and end of migrations for selected species, multiple snorkel surveys within years are required. In this protocol, we expect to attain information on migratory timing of adult fish that migrate during the sampling period (for example June through September). Snorkel counts by species are converted to densities (fish/km) due to varying lengths of reference reaches among rivers. Average run timing parameters are estimated by plotting reach densities derived from snorkel counts against Julian day of the year. Julian day is the number of days after January 1 each year. Data are smoothed using a locally weighted non-parametric scatter-plot. The smooth line is an estimate of the average number of fish observed each day of the year.

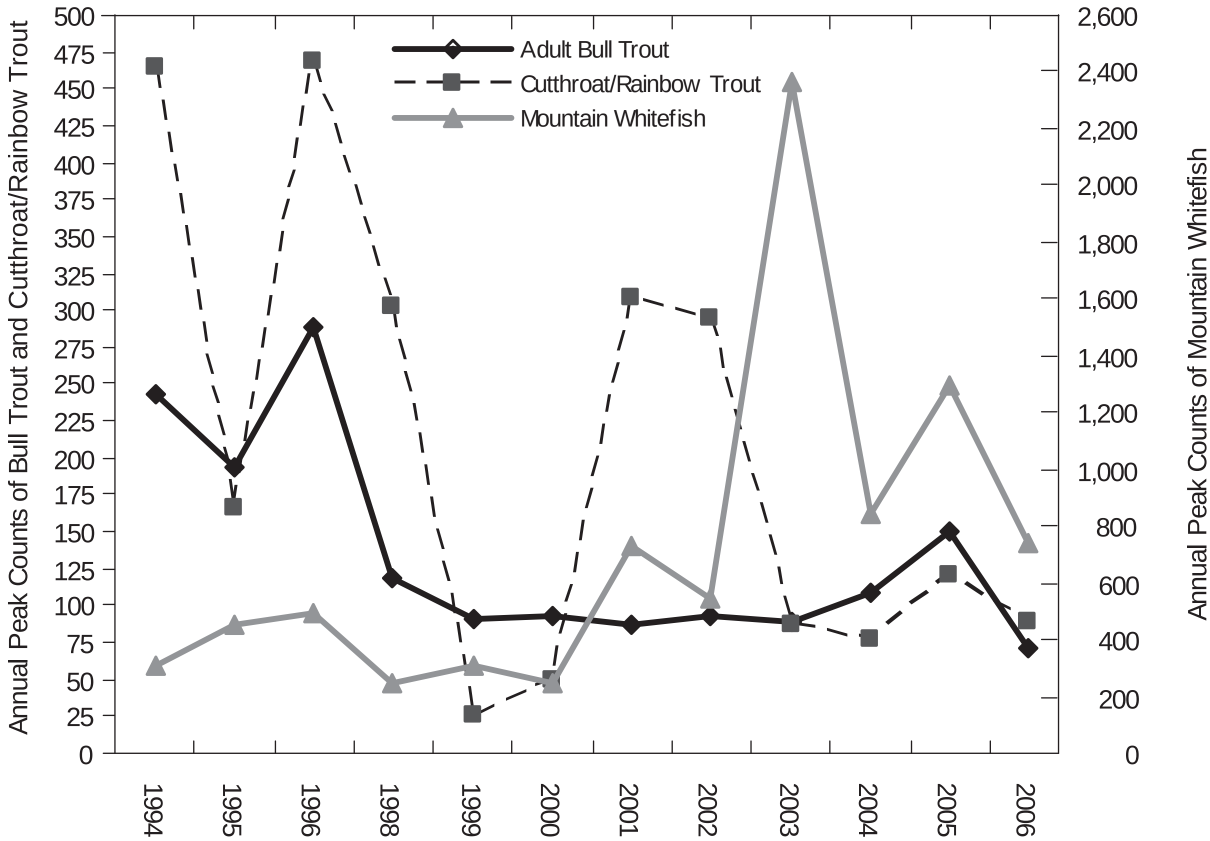

Figure 12. Trends in annual peak counts for adult bull trout and mountain whitefish in the North Fork Skokomish River, OLYM from 1994 to 2006.

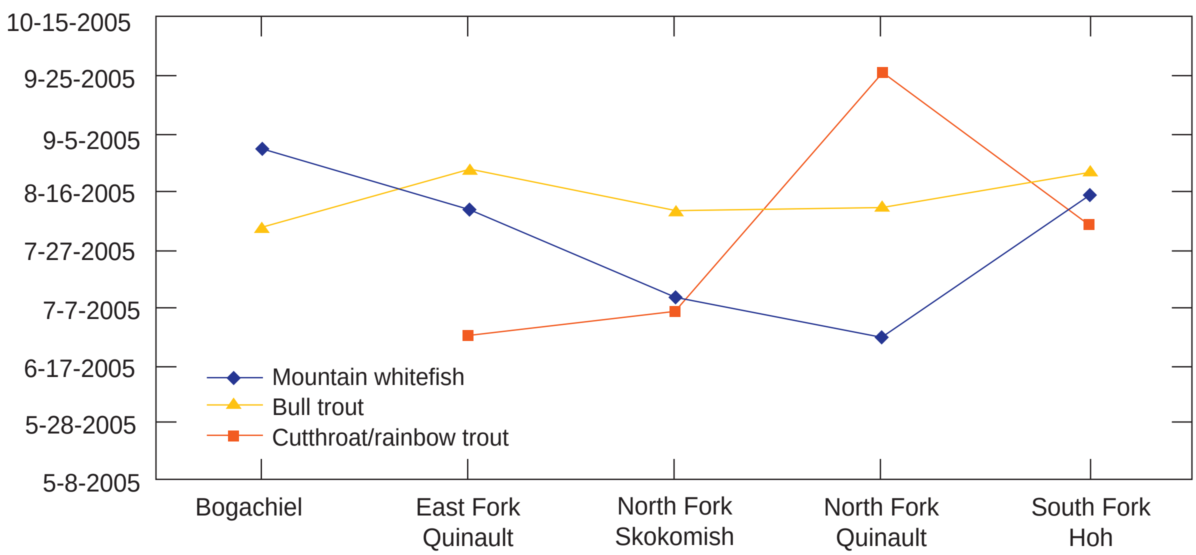

Figure 13. Comparisons of relative dates of peak counts for mountain whitefish, bull trout, and cutthroat/rainbow trout among five rivers.

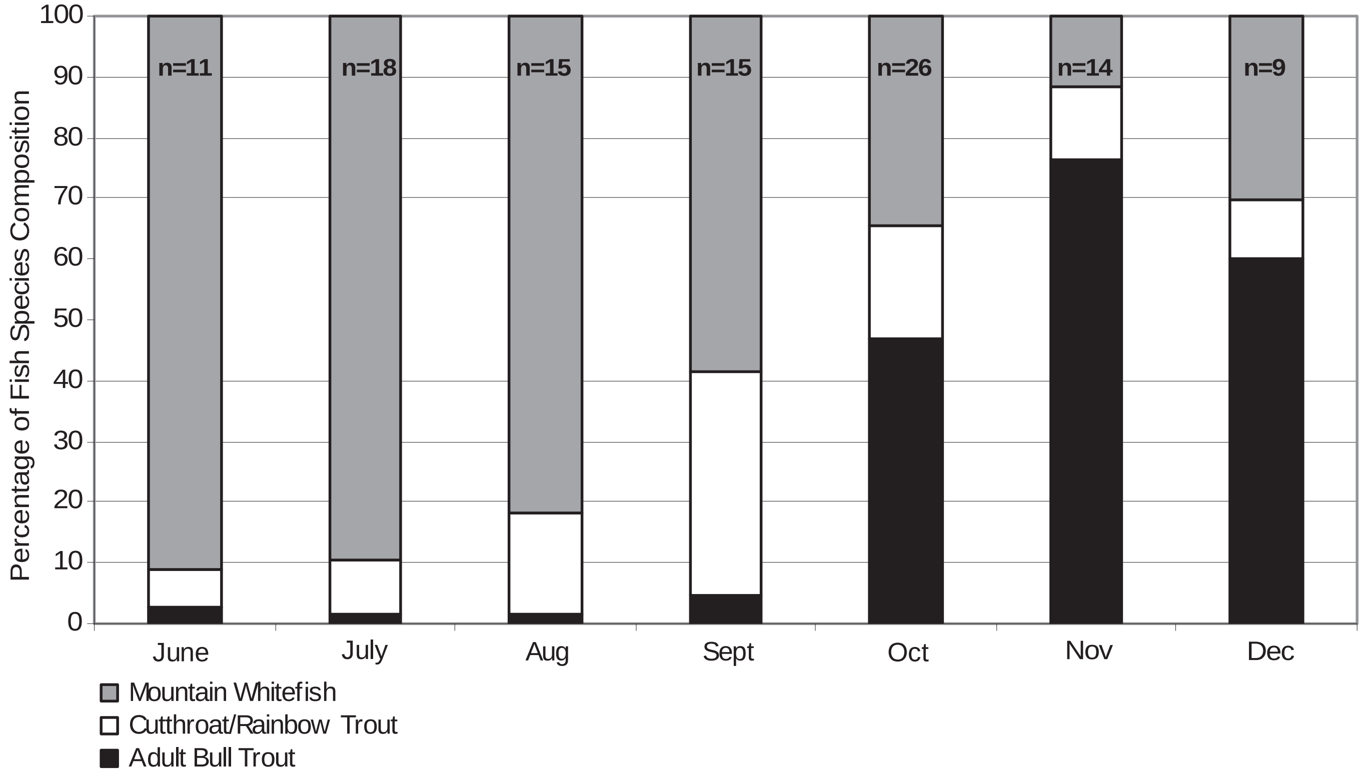

Figure 14. Mean monthly composition of adult bull trout, cutthroat/rainbow trout, and mountain whitefish in the North Fork Skokomish River, Washington based on 108 snorkel surveys conducted from June to December, 1994 to 2006.

N=number of surveys in each month.

The average timing of each species' peak is estimated as the day on which the smoothed average density of fish was highest. Average onset of the migration is estimated as the day prior to the peak during which average density of fish was 25 percent of the maximum average density. Similarly, the average end of the migration is estimated as the day post peak when the average density is 25 percent of the maximum average density (fig. 15). Estimates of the overall average migratory timing (start, peak, and end) by date for four fish species in the North Fork Skokomish appear in table 15 using data collected from 1994 to 2005.

Table 15. Average run timing statistics for bull trout, mountain whitefish, cutthroat/rainbow trout, and Chinook salmon in North Fork Skokomish River based on snorkel counts in a 5 km reference site, 1994–2005.

[**Maximum smoothed density**: This estimator was computed by smoothing all densities collected during the year using "Super Smoother", and observing the maximum smoothed estimate. **Abbreviations**: km, kilometer]

River	Species	Maximum smoothed density (fish/km)	Average run date		
			Start	Peak	End
North Fork Skokomish	Bull trout	32.44	Sept. 26	Nov. 14	Dec. 31
	Mountain whitefish	232.76	April 5	July 24	Sept. 15
	Cutthroat/ Rainbow trout	55.75	June 16	Aug. 28	Oct. 17
	Chinook salmon	1.38	Aug. 3	Oct. 16	Dec. 3

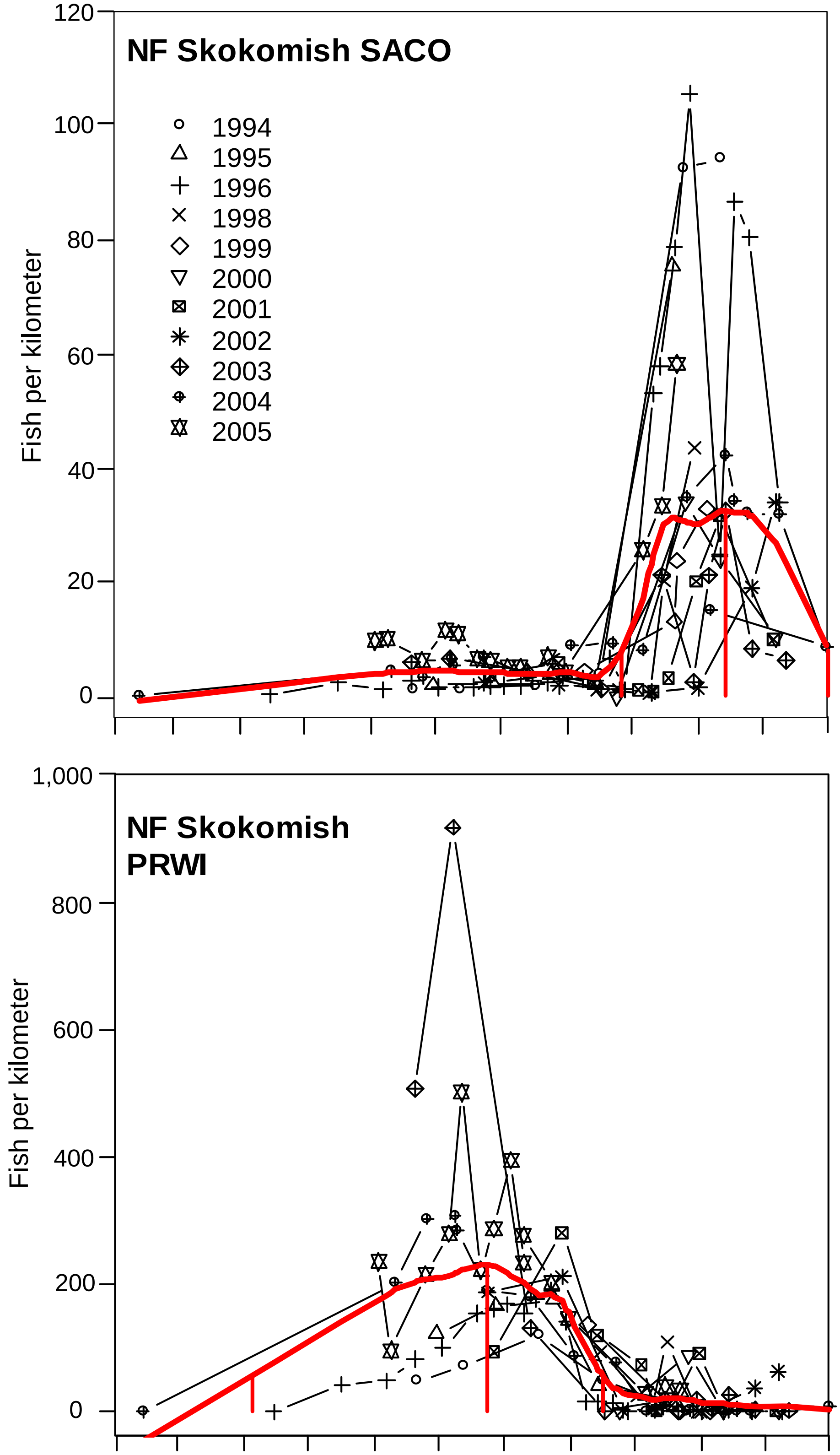

Figure 15. The estimated onset, peak, and end of migrations of adult bull trout (SACO) and mountain whitefish (PRWI) in the North Fork Skokomish River using snorkel data from 1994 to 2005.

The thickened red line is a smoothed estimate of the average density each day of the year and the vertical red lines represent the estimated start, peak, and ending dates of the average run.

Public Highlights

Every year, a narrative will be submitted to Congress that summarizes findings and public highlights (table 16). The following is an example based on pilot fieldwork: from 2005 to 2007, fisheries biologists conducted the most intensive monitoring efforts (n=180 surveys) of fish communities in NCCN rivers to date. Fisheries crews snorkeled 900 river kilometers in 10 rivers and made 57,000 individual fish observations from June through September each year. Some preliminary observations from snorkel surveys revealed that: (1) mountain whitefish were more abundant than any other fish species observed in OLYM rivers, (2) adult summer steelhead were in extremely low numbers in all coastal rivers that drain from OLYM, (3) hatchery steelhead were more abundant than wild steelhead in selected rivers, and (4) non-native fish species were observed in only 1 of the 10 rivers, the Ohanapecosh at MORA. Results from the River Monitoring Program have management and conservation implications, particularly for Pacific salmonids that have high ecological and cultural importance and significantly contribute to recreational, commercial, and subsistence fisheries.

Abrupt Change Analysis

Abrupt change in fish abundance can be detected by fitting a weighted regression to past data, constructing a 95 percent prediction interval for the current value, and observing whether the measured value is outside the interval (fig. 16).

Variation of Replicate Snorkel Counts in Rivers

The variation of repeated snorkel surveys will be determined every 3 to 5 years and is computed as a measure of the reproducibility of snorkel counts. Statistically, this variation was an estimate of the measurement error associated snorkel counts. Variation is computed among replicate counts for each of the primary species, and is reported as both the coefficient of variation (CV) and the ½ width of an approximate 95 percent confidence interval on the mean count. The CV for replicate counts x_1 and x_2 of the same species was

$$cv(x) = \frac{\sqrt{(x_1^2 + x_2^2) - 0.5(x_1 + x_2)^2}}{0.5(x_1 + x_2)}$$

The ½ width of an approximate 95 percent confidence interval was computed as 2 times the standard error, or $2cv(x)[0.5(x_1 + x_2)]$.

In our analysis from pilot studies, mountain whitefish (PRWI) were by far the most abundance species during replicate surveys among rivers in 2005 (table 17). Precision of replicate surveys was generally good, with coefficients of variation ranging from 0.097 to 0.241 across the four species analyzed here (table 17). The coefficient of variation for mountain whitefish was the smallest among the four species, but also had the largest confidence interval ½ width due to the large numbers.

The coefficients of variation observed during repeated surveys of the same river reach were surprisingly low given the variable nature of fish population, their mobility, and the difficulty identifying fish while snorkeling. Average coefficients of variation for the four species were less than 25 percent, with 3 out of 4 less than18 percent. This level of variation in repeated counts is acceptable given the high variation in run timing and size that was observed. This level of observed variation in replicate counts is acceptable and largely inconsequential toward meeting the objectives of determining seasonal and annual trends in community composition and relative abundance. It would be surprising if an alternative fish counting methodology had lower inherent variability yet was as easy to conduct as snorkel surveys.

Table 16. Summary of the number of fish observed by river and total number of snorkel surveys from May through September 2005, based on pilot fieldwork.

[NA, not applicable}

River	Total number						
	Fish observed	Percentage of total	Snorkel surveys	Chinook	Bull trout	Chum salmon	Mountain whitefish
North Fork Skokomish	10,351	39	18	0	756	NA	8,506
North Fork Quinault	1,715	6	9	8	102	0	1,227
East Fork Quinault	6,482	25	10	100	365	0	5,081
Sol Duc	1,084	4	12	2	NA	0	NA
Bogachiel	3,044	12	11	15	NA	19	1,651
South Fork Hoh	3,740	14	12	56	155	5	3,001
Total	26,416	100	72	181	1,378	24	19,466

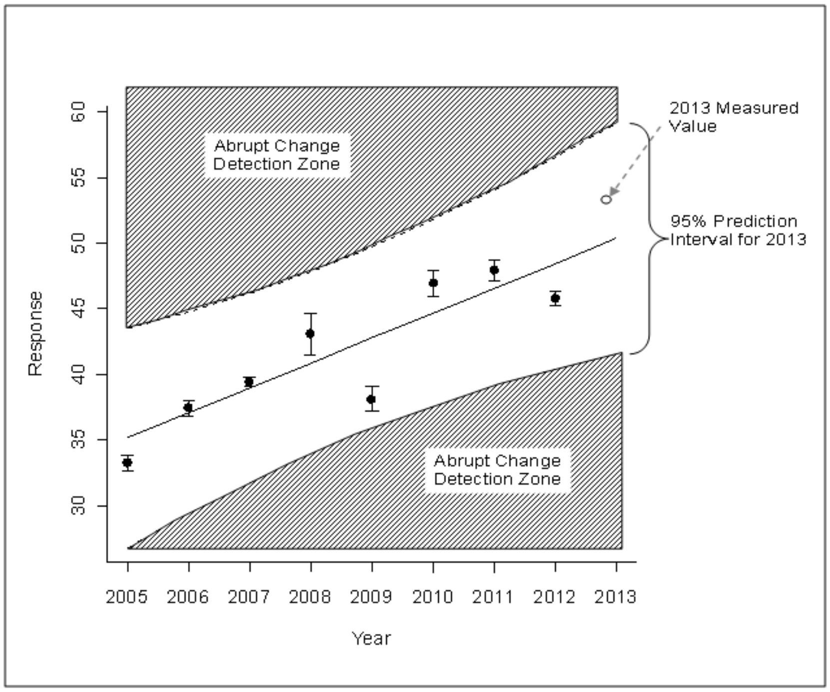

Figure 16. Regression method for detecting abrupt change.

Filled circles are previous estimates of relative abundance for a given species. Bars are ±1 standard error. Assuming uncorrelated errors, weighted regression can be used to fit a linear regression to data from 2005 through 2012, and a prediction interval for 2013 can be constructed. Abrupt change would be detected if the measured value for 2013 fell outside this interval, that is, in one of the 'Abrupt Change Detection Zones'.

Table 17. Means and coefficient of variations observed during replicate surveys of the same river reach on the same day in 2005 for each of six rivers.

[**Abbreviations:** CV, coefficient of variation; std, standard; SACO, bull trout; PRWI, mountain whitefish; ONXX, cutthroat/rainbow trout; ONTS, Chinook salmon. NA indicates that the species was not found in that river]

River	Mean				CV=std/mean				Confidence Interval Width=2*std			
	SACO	PRWI	ONXX	ONTS	SACO	PRWI	ONXX	ONTS	SACO	PRWI	ONXX	ONTS
Bogachiel	NA	139.5	137.5	NA	NA	0.096	0.231	NA	NA	26.87	63.64	NA
East Fork Quinault	32.5	740.0	150.5	8.0	0.239	.141	.127	0.177	15.56	209.30	38.18	2.83
North Fork Quinault	9.5	178.0	70.0	NA	.223	.072	.162	NA	4.24	25.46	22.63	NA
North Fork Skokomish	13.0	658.0	128.5	NA	.000	.120	.083	NA	.00	158.39	21.21	NA
South Fork Hoh	9.0	183.5	8.5	NA	.157	.058	.749	NA	2.83	21.21	12.73	NA
Sol Duc	NA	NA	79.5	NA	NA	NA	.098	NA	NA	NA	15.56	NA
Average	16.0	379.8	95.8	8.0	.155	.097	.241	.177	5.66	88.25	28.99	2.83

Trends in Proportions of Hatchery and Wild Fish in Rivers

Seasonal and annual trends of proportions of hatchery (that is, fin clipped) versus wild salmonids are determined by observations of marked and unmarked fish a reference site on a given date. The observations of marked fish provide a relative gage to the extent of hatchery fish invasions in park rivers (table 18). These observations only apply to adult salmonids. Annual observations of the proportion of hatchery to wild salmonids will be evaluated by species within a given river.

Juvenile Fish Data from Wadeable Streams

We will examine young-of-the-year and juvenile fish assemblages and determine changes in relative densities [(fish/100 g)/m^2] and length frequency distributions for each species in reference sites of streams. Seasonal trends in fish species composition are reported as the number and percent of each fish species in a given month in each river (table 19). Length-frequency analysis can show a clear distinction in size distribution and growth of age-0 rainbow trout during summer months (fig. 17; Connolly and Brenkman, 2008). Additionally, relative timing of emergence of age-0 trout is evident from plots of length frequency distributions.

Water Temperatures

Water temperature is a readily obtained and relatively inexpensive metric that is important for understanding fish assemblage structure, fish growth, and productivity. Water temperature also is of widespread interest in aquatic ecosystems, and is affected by many different natural and anthropogenic influences (Dunham and others, 2005). For detailed information on water temperature monitoring (for example measurement interval, field sampling, error screening, data summaries), see Dunham and others (2005).

We summarize continuous water temperature in reference sites of rivers and streams. The following metrics will be analyzed: daily maximum water temperature (maximum daily average), the highest average temperatures over a continuous 7 days during summer, average daily minimum temperature, and the average temperature recorded across all observations from June to September 30.

Table 18. Example of annual summary of the relative proportions of hatchery (marked) and wild (unmarked) adult Chinook salmon, coho salmon, and steelhead among reference sites in three coastal rivers.

[The relative number of marked versus unmarked fish is based on the total number of observations from June through September, using data collected during pilot surveys in 2006. NA, not applicable]

River	Chinook salmon		Coho salmon		Summer steelhead	
	Marked	Unmarked	Marked	Unmarked	Marked	Unmarked
East Fork Quinault	7	23	NA	NA	5	35
North Fork Quinault	0	16	NA	NA	2	3
South Fork Hoh[1]	16	23	0	0	15	11

[1]There are no hatchery releases of Chinook salmon, coho salmon, or summer steelhead in the Hoh River Basin.

Table 19. Example of a summary of the number of fish observed in a stream reference site during electrofishing surveys in July and September of a given year.

Creek	Coho salmon		Bull trout		Rainbow/Steelhead		Brook trout		Sculpin spp.	
	July	Sept.	July	Sept.	July	Sept.	July	Sept.	July	Sept.
Mink Lake Creek, Sol Duc	569	754	0	0	246	278	0	0	238	278
Big Creek, Quinault	350	91	0	0	16	29	0	0	15	198
Pass Creek, Dosewallips	0	0	0	0	0	0	28	38	0	0
Indian Creek, Bogachiel	293	349	0	0	126	479	0	0	45	123
Slate Creek, North Fork Skokomish	0	0	129	198	28	79	0	0	18	38

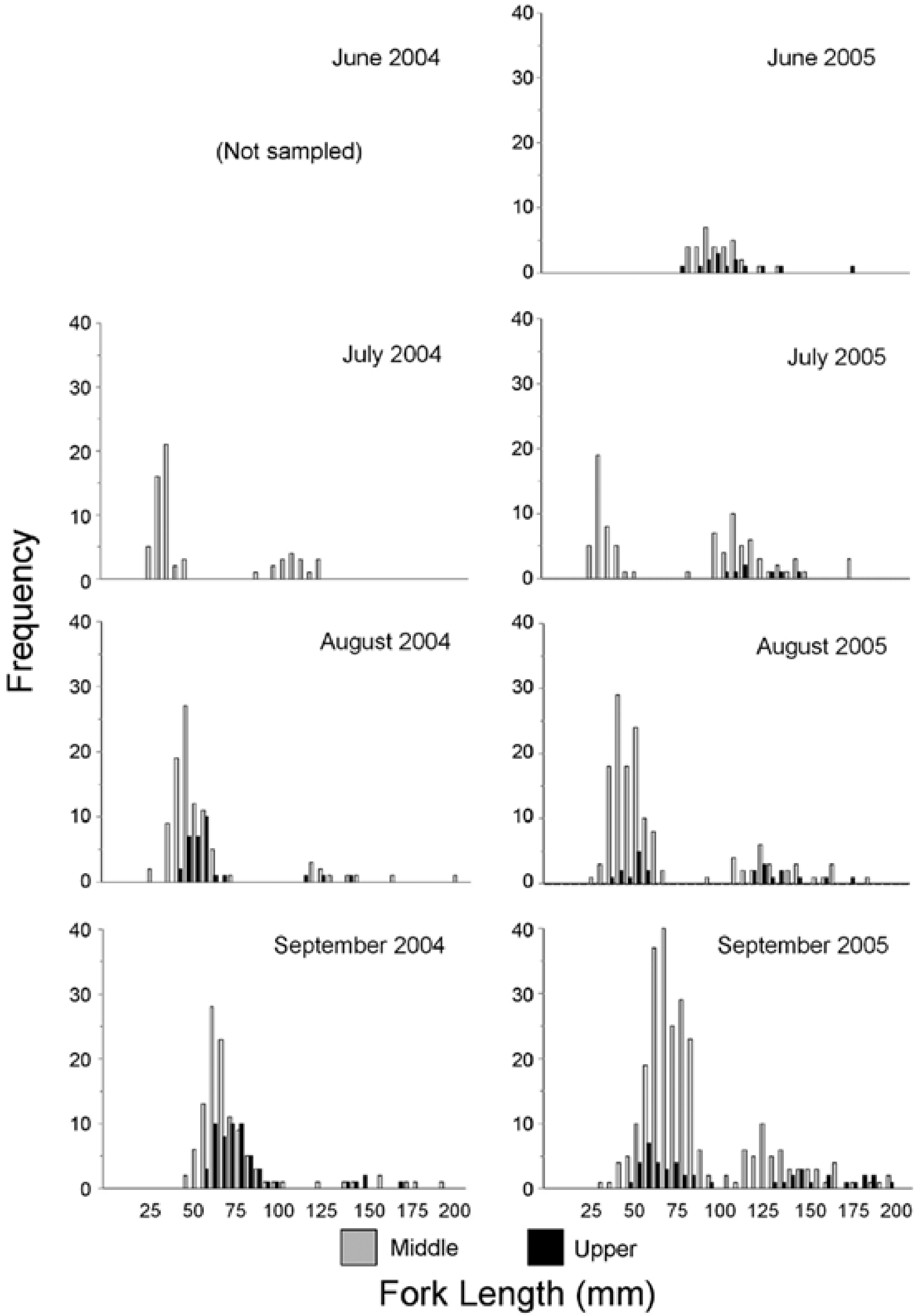

Figure 17. Length-frequency histograms for rainbow trout in the middle and upper Elwha River in June, July, August, and September 2004 and 2005 based on backpack electrofishing.

(From Connolly and Brenkman, 2008.)

Calibration of data loggers is important, and a relatively simple process. The procedure involves the following steps from Dunham and others (2005):

1. Deploy the data loggers at a short sampling interval (for example, 1 minute);
2. Submerge data loggers in an insulated, well-mixed water bath with a generous amount of melting ice (for example, large cooler with ice water);
3. If possible, record water temperatures using a thermometer to ensure the temperature of the water bath is 0ºC;
4. After at least 1 hour, remove the data loggers and download the data. If calibrated correctly, the temperature readings should level out at 0ºC.

Data archiving is one of the most important steps in temperature monitoring (Dunham and others, 2005; table 20). There are three important types of information to include in water temperature databases: (1) pre-deployment information, (2) field deployment information, and (3) post-deployment information (Dunham and others, 2005).

I. Reporting and Product Development

We recommend that a summary report be produced annually, with a more detailed report produced every 5 years.

Standard Report Format

Annual reports and trend analysis reports will use the NPS Natural Resource Publications template, a pre-formatted Microsoft© Word template document based on current NPS formatting standards. Annual reports will use the Natural Resource Report template, and trend analysis and other peer-reviewed technical reports will use the Natural Resource Technical Report template. These templates and documentation of the NPS publication standards (National Park Service, 2005) are available at: http://www.nature.nps.gov/publications/NRPM/index.cfm.

Table 20. Example of a relational database application for storage of temperature data collected using data loggers.

[From Dunham and others, 2005]

Table name	Field name	Description
Site	Site ID	Auto number assigning consecutive numbers to sites
	Stream name	Name of stream sampled
	Site	Number of descriptor of site within stream
	Basin	River basin
	Quad 24K	Quad name
	UTM X	UTM easting coordinate
	UTM Y	UTM northing coordinate
	Elevation	Elevation in meters of site
Logger	Logger ID	Unique ID or serial number of logger
	Type	Manufacturer and/or model of logger
	Year	Year of sample
Deployed	Site ID	Site ID of stream and site (relates back to Site table)
	Logger ID	Unique ID of logger deployed in the stream (relates back to Logger table)
	Date	Date logger placed in water
	Time	Time logger placed in water
	Interval	Time interval of samples
	Depth	Depth of logger
Removal	Site ID	Site ID of stream and site (relates back to Site table)
	Date	Date logger removed from water
	Time	Time logger removed from water
	Comments	Any site differences from time of deployment to time of removal
Temperature	Site ID	Site ID of stream and site (relates back to Site table)
	Date	Date of sample
	Time	Time of sample
	Temperature	Temperature (in Celsius or Fahrenheit) of sample

Sensitive Information Procedures

Certain project information related to the specific locations of rare or threatened taxa may meet criteria for protection and as such should not be shared outside NPS except where a written confidentiality agreement is in place prior to sharing. Before preparing data in any format for sharing outside NPS – including presentations, reports, and publications – the Project Lead should refer to the information contained in this section. Information that may convey specific locations of sensitive resources may need to be screened or redacted from public versions of products prior to release. There also will be adherence to USGS policy on information dissemination.

Although it is the general NPS policy to share information widely, the NPS also realizes that providing information about the location of park resources may sometimes place those resources at risk of harm, theft, or destruction. This can occur, for example, with regard to federally threatened fish species. Therefore, information will be withheld when the NPS foresees that disclosure would be harmful to an interest protected by an exemption under the Freedom of Information Act (FOIA). The National Parks Omnibus Management Act, Section 207, 16 U.S.C. 5937, is interpreted to prohibit the release of information regarding the “nature or specific location” of certain cultural and natural resources in the national park system. Additional details and information about the legal basis for this policy are in the NPS Management Policies (National Park Service, 2006), and in Director’s Order #66.

These guidelines apply to all NCCN staff, cooperators, contractors, and other partners who are likely to obtain or have access to information about protected NPS resources. The Project Lead has primary responsibility for ensuring adequate protection of sensitive information related to this project. Additionally, USGS staff shall adhere to policies on information dissemination.

The following are highlights of the strategy for protecting this information:

- *Protected resources*, in the context of the NCCN Inventory and Monitoring Program, include species that have State- or Federally-listed status, and other species deemed rare or sensitive by local park taxa experts.
- *Sensitive information* is defined as information about protected resources that may reveal the “nature or specific location” of protected resources. Such information must not be shared outside the National Park Service, unless a signed confidentiality agreement is in place.
- In general, if information is withheld from one requesting party, it must be withheld from anyone else who requests it, and if information is provided to one requesting party without a confidentiality agreement, it must be provided to anyone else who requests it.
- To share information as broadly as legally possible, and to provide a consistent, tractable approach for handling sensitive information, the following shall apply if a project is likely to collect and store sensitive information:
    - Random coordinate offsets of up to 2 km for data collection locations, and
    - Removal of data fields from the released copy that are likely to contain sensitive information.

a. What Kinds of Information Can and Can Not Be Shared?

- <u>Do not share</u>: Project staff and cooperators should not share any information outside NPS that reveals details about the “nature or specific location” of protected resources, unless a confidentiality agreement is in place. Specifically, the following information should be omitted from shared copies of all data, presentations, reports, or other published forms of information.
    - *Exact coordinates* – Instead, public coordinates are to be generated that include a random offset azimuth and distance. These offset coordinates can be shared freely.
    - *Other descriptive location data* – Examples may include travel descriptions, location descriptions, or other fields that contain information that may reveal the specific location of the protected resource(s).
    - *Protected resource observations at disclosed locations* – If specific location information has already been made publicly available, the occurrence of protected resources at that location cannot be shared outside NPS without a confidentiality agreement. For example, if the exact coordinates for a monitoring station location are posted to a website or put into a publication, then at a later point in time a spotted owl nest is observed at that monitoring station, that nest cannot be mentioned or referred to in any report, presentation, data set, or publication that will be shared outside NPS.
- <u>Do share</u>: All other information about the protected resource(s) may be freely shared, so long as the information does not reveal details about the “nature or specific location” of the protected resource(s) that are not already readily available to the general public in some form (for example, other published material). Species tallies and other types of data presentations that do not disclose the precise locations of protected resources may be shared, unless by indicating the presence of the species the specific location is also revealed (for example, in the case of a small park).

Whenever products such as databases and reports are being generated, handled, and stored, they should be created explicitly for one of the following purposes:

1. *Public or general-use* – Intended for general distribution, sharing with cooperators, or posting to public websites. They may be derived from products that contain sensitive information so long as the sensitive information is either removed or otherwise rendered in a manner consistent with other guidance in this document.

2. *Internal NPS use* – These are products that contain sensitive information and should be stored and distributed only in a manner that ensures their continued protection. These products should clearly indicate that they are solely for internal NPS use by containing the phrase: "Internal NPS Use Only – Not For Release." These products can only be shared within NPS or in cases where a confidentiality agreement is in place. They do not need to be revised in a way that conceals the location of protected resources.

b. Data Sets

To create a copy of a data set that will be posted or shared outside NPS:

1. Make sure the public offset coordinates have been populated for each sample or observation location in tbl_Locations.

2. Remove tbl_Coordinates, tbl_Target_Coordinates, and tbl_GPS_Info.

3. Delete the following database objects to ensure consistent omission of fields that may contain specific, identifying information about locations of protected resources:

    a. tbl_Sites.Site_notes
    b. tbl_Locations.Travel_notes
    c. tbl_Locations.Elevation, Elev_units, Elev_source
    d. tbl_Locations.Location_desc
    e. tbl_Locations.Location_notes
    f. tbl_Features
    g. tbl_Markers

The local, master copy of the database contains the exact coordinates and all data fields. The Data Manager and/or GIS Specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information.

c. Presentations and Reports

Public or general-use reports and presentations should adhere to the following guidelines:

1. Do not list exact coordinates or specific location information in any text, figure, table, or graphic in the report or presentation. If a list of coordinates is necessary, use only offset coordinates and clearly indicate that coordinates have been purposely offset to protect the resource(s) as required by law and NPS policy.

2. Use only general use maps as specified in the section on maps and other GIS output.

3. Indicate whether the information has been peer reviewed or whether results are preliminary.

If a report is intended for internal use only, these restrictions do not apply. However, each page of the report should be clearly marked with the following phrase: "Internal NPS Use Only – Not For Release."

J. Product Delivery, Posting, and Distribution

Product Delivery Schedule and Specifications

[**Abbreviations**: NCCN, North Coast and Cascades Monitoring Network; GPS, global positioning system; GIS, geographic information system; NPS, National Park Service; EPA, Environmental Protection Agency; XML, Extensible Markup Language; I&M, inventory and monitoring; PDF, portable document format]

Deliverable product	Primary responsibility	Target date	Instructions
Field season report	Field Crew Lead	September 30 of the same year	Upload digital file in Microsoft© Word format to the NCCN Digital Library[1] submissions folder.
Raw GPS data files	Field Crew Lead	September 30 of the same year	Zip and send all digital files to the GIS Specialist.
Processed GPS data files	GIS Specialist	October 30 of the same year	Zip and upload raw and processed files to the NCCN Digital Library[1].
Digital photographs	Project Lead	November 30 of the same year	Organize, name and maintain photographic images in the project workspace according to the image handling procedures in Section 6D, Data Entry and Processing.
Certified working database	Project Lead	Delivered by November 30 of the same year, data are not posted to public sites until June of the second year	Refer to the following section on delivering certified data and related materials. The final destination is the master project database and GIS data sets, NPSTORET[2] and EPA STORET[2] (for water temperature data), NPSpecies[3], the NCCN Digital Library[1], and the NPS Data Store[4].
Certified geospatial data	Project Lead with GIS Specialist		
Data certification report	Project Lead		
Metadata interview form	Project Lead		
Full metadata (parsed XML)	Data Manager and GIS Specialist	March 15 of the following year	Upload the parsed XML record to the NPS Data Store[4], and store in the NCCN Digital Library[1].
Annual I&M report	Project Lead	May 1 of the following year	Refer to the following section on reports and publications. The final destination is NatureBib[5], NCCN Digital Library[1], and printout to local park collections.
5-year analysis report	Project Lead and Data Analyst	Every 5 years by May	
Other publications	Project Lead and Data Analyst	As completed	
Field data forms	Project Lead	Every 5 years by January 31	Scan original, marked-up field forms as PDF files and upload these to the NCCN Digital Library[1] submissions folder. Originals go to the Park Curator for archival.
Other records	Project Lead	Review for retention every January	Organize and send analog files to Park Curator for archival. Digital files that are slated for permanent retention should be uploaded to the NCCN Digital Library[1]. Retain or dispose of records following *NPS Director's Order #19*[6].

[1] The NCCN Digital Library is a hierarchical digital filing system stored on the NCCN file servers (Boetsch and others, 2005). Network users have read-only access to these files, except where information sensitivity may preclude general access.

[2] NPSTORET (http://www.nature.nps.gov/water/infoanddata) and EPA STORET (http://www.epa.gov/storet/) are, respectively, the NPS and national enterprise data warehouses for water quality data. NPSTORET is maintained by NPS-Water Resources Division (WRD) and is synchronized with EPA STORET on a regular basis.

[3] NPSpecies is the NPS database and application for maintaining park-specific species lists and observation data (http://science.nature.nps.gov/im/apps/npspp/index.htm).

[4] NPS Data Store is a clearinghouse for natural resource data and metadata (http://science.nature.nps.gov/nrdata). Only non-sensitive information is posted to NPS Data Store. Refer to the section on sensitive information in Section 6J, Product Delivery, Posting and Distribution for details.

[5] NatureBib is the NPS bibliographic database (http://www.nature.nps.gov/nrbib/index.htm). This application has the capability of storing and providing public access to image data (for example, PDF files) associated with each record.

[6] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://data2.itc.nps.gov/npspolicy/DOrders.cfm.

All digital file submissions that are sent by email should be accompanied by a product submission form, which briefly captures the following information about the products:

- Submission date
- Name of the person submitting the product(s)
- Name and file format of each product
- Indication of whether or not each product contains sensitive information (see Section 6I, Reporting and Product Development for a definition).

This form can be downloaded from the NCCN website or obtained from the Data Manager. People who submit digital files directly to the NCCN Digital Library will be prompted for the same information, and so a submission form is not required.

Upon notification and/or receipt of the completed products, the Data Manager or GIS Specialist will check them into the NCCN project tracking application.

Delivering Certified Data and Related Materials

Data certification is a benchmark in the project information management process that indicates that: (1) data are complete for the period of record, (2) data have undergone and passed the quality assurance checks; and (3) data are appropriately documented and in a condition for archiving, posting and distribution as appropriate. To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. For more information, refer to SOP #3: Data Quality Review and Certification.

The following deliverables should be delivered as a package:

- *Certified working database* – Database in Microsoft© Access format containing data for the current season that has been through the quality assurance checks documented in SOP #3: Data Quality Review and Certification.
- *Certified geospatial data* – GIS themes in ESRI coverage or shapefile format. Refer to NCCN GIS Development Guidelines (North Coast and Cascades Network, 2006c) and NCCN GIS Product Specifications (North Coast and Cascades Network, 2005a) for more information.
- *Data certification report* – A brief questionnaire in Microsoft© Word that describes the certified data product(s) being submitted. A template form is available on the NCCN website at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm.
- *Metadata interview form* – The metadata interview form is a Microsoft© Word questionnaire that greatly facilitates metadata creation. It is available on the NCCN website at: http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm. For more details, refer to Section 6F, Metadata Procedures.

After the quality review is completed, the Project Lead should package the certification materials for delivery as follows:

1. Open the certified back-end database file and compact it (in Microsoft© Access, Tools > Database Utilities > Compact and Repair Database). This will make the file size much smaller. Back-end files are typically indicated with the letters "_be" in the name (for example, Fish_Assemblages_FIa10_be_2007.mdb).
2. Rename the certified back-end file with the project code ("FIa10"), the year or span of years for the data being certified, and the word "certified". For example: FIa10_2007_certified.mdb.
3. Create a compressed file (using WinZip® or similar software) and add the back-end database file to that file. **Note**: The front-end application does not contain project data and as such should not be included in the delivery file.
4. Add the completed metadata interview and data certification forms to the compressed file. Both files should be named in a manner consistent with the naming conventions described elsewhere in this document.
5. Add any geospatial data files that are not already in the possession of the GIS Specialist. Geospatial data files should be developed and named according to NCCN GIS Naming Conventions (North Coast and Cascades Network, 2005b).
6. Upload the compressed file containing all certification materials to the new submissions folder of the NCCN Digital Library. If the Project Lead does not have intranet access to the NCCN Digital Library, then certification materials should be delivered as follows:
   a. If the compressed file is under 5 mb in size, it may be delivered directly to the NPS Lead and Data Manager by email.
   b. If the compressed file is larger than 5 mb, it should be copied to a CD or DVD and delivered in this manner. Under no circumstances should products containing sensitive information be posted to an FTP site or other unsecured web portal (refer to Section 6I, Reporting and Product Development for a definition of sensitive information).
7. Notify the Data Manager by email that the certification materials have been uploaded or otherwise sent.

Upon receiving the certification materials, the Data Manager will:

1. Review them for completeness and work with the Project Lead if there are any questions.
2. Notify the GIS Specialist if any geospatial data are submitted. The GIS Specialist will then review the data, and update any project GIS data sets and metadata accordingly.
3. Check in the delivered products using the NCCN project tracking application.
4. Store the certified products together in the NCCN Digital Library.
5. Upload the certified data to the master project database.
6. Export temperature data and submit these to NPS Water Resources Division (WRD) staff to be uploaded to WRD NPSTORET and EPA STORET.
7. Notify the Project Lead that the year's data have been successfully uploaded and processed. The Project Lead may then proceed with data summarization, analysis, and reporting.
8. Update species observation data records in NPSpecies.
9. Develop, parse, and post the XML metadata record to the NPS Data Store.
10. After a holding period of 2 years, the Data Manager will upload the certified data to the NPS Data Store. This holding period is to protect professional authorship priority and to provide sufficient time to catch any undetected quality assurance problems.

No sensitive information (for example, information about the specific nature or location of protected resources) may be posted to the NPS Data Store or another publicly-accessible website, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Only products that are intended for public/general-use may be posted to public websites and clearinghouses–these may not contain sensitive information.

Instructions for Reports and Publications

In general, the procedures for reports and publications are as follows:

1. The document should be formatted using the NPS Natural Resource Publications template. Formatting according to NPS standards is easiest when using the template from the very beginning, as opposed to reformatting an existing document.
2. The document should be peer reviewed at the appropriate level. For example, I&M Annual Reports should be reviewed by other members of the appropriate project work group. The Network Coordinator also will review all annual reports for completeness and compliance with I&M standards and expectations.
3. Upon completing the peer review, acquire a publication series number from the NPS Technical Information Center or the appropriate local or regional key official (currently the Regional I&M Coordinator).
4. Upload the file in PDF and Microsoft© Word formats to the NCCN Digital Library submissions folder.
5. Send a printout to each Park Curator.
6. The Data Manager or a designee will create a bibliographic record and upload the PDF document to NatureBib according to document sensitivity.

File Naming Standards

Prior to submitting digital products, files should be named according to the naming conventions appropriate to each product type.

a. Images

The image file name should consist of the following parts:

1. Date of data capture (formatted as YYYYMMDD)
2. Reference name
3. Optional: a brief descriptive word or phrase
4 Optional: a sequential number if multiple images were captured
5. Optional: time (formatted as HHMM)

b. Reports and Publications

- No spaces or special characters in the file name.
- Use the underbar ("_") character to separate file name components.
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters.
- Dates should be formatted as YYYYMMDD.
- As appropriate, include the project code (for example, "FIa10"), network code ("NCCN") or park code, and year in the file name. Examples: NCCN_FIa10_2007_Annual_report.pdf
- NCCN_FIa10_2007_Field_season_report.doc; NCCN_FIa10_2007_Certification_report.doc

c. Other Files

Unless otherwise specified, files for other product types should be named as follows:

- No spaces or special characters in the file name.
- Use the underbar ("_") character to separate file name components.
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters.
- Dates should be formatted as YYYYMMDD.
- Correspondence files should be named as YYYYMMDD_AuthorName_subject.ext.

Holding Period for Project Data

To permit sufficient time for priority in publication, certified project data will be held upon delivery for a period not to exceed 2 years after it was originally collected. After the 2-year period has elapsed, all certified, non-sensitive data will be posted to the NPS Data Store.
Note: This hold only applies to raw data, and not to metadata, reports or other products that are posted to NPS clearinghouses immediately after being received and processed.

To protect professional authorship priority and to provide sufficient time to complete quality assurance measures, there is a 2-year holding period before posting or otherwise distributing finalized data. This means that certified data sets are first posted to publicly accessible websites (that is, the NPS Data Store) approximately 24 months after they are collected (for example, data collected in June 2008 becomes generally available through the NPS Data Store in June 2010). In certain circumstances, and at the discretion of the Project Lead, data may be shared before a full 2 years have elapsed.
Note: This hold only applies to raw data; all metadata, reports, or other products are to be posted to NPS clearinghouses in a timely manner as they are received and processed.

Responding to Data Requests

Occasionally, a park or project staff member may be contacted directly regarding a specific data request from another agency, organization, scientist, or from a member of the general public. The following points should be considered when responding to data requests:

- NPS is the originator and steward of the data, and the NPS Inventory and Monitoring Program should be acknowledged in any professional publication using the data.
- NPS retains distribution rights; copies of the data should not be redistributed by anyone but NPS.
- Data that project staff members and cooperators collect using public funds are public records and as such can not be considered personal or professional intellectual property.
- No sensitive information (for example, information about the specific nature or location of protected resources) may be posted to the NPS Data Store or another publicly accessible website, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Refer to Section 6I, Reporting and Product Development for a definition of sensitive information.
- For quality assurance, only certified, finalized versions of data sets should be shared with others. In cases where a provisional data set needs to be shared with others prior to certification: any accompanying communications should clearly indicate that the data set is provisional and subject to change according to our quality review process; and file names and the media it is sent on should be clearly labeled as containing provisional data not for distribution.

The Project Lead will handle all data requests as follows:

1. Discuss the request with other Park Biologists as necessary to make those with a need to know aware of the request and, if necessary, to work together on a response.
2. Notify the Data Manager of the request if s/he is needed to facilitate fulfilling the request in some manner.
3. Respond to the request in an official email or memo.
4. In the response, refer the requestor to the NPS Data Store (http://science.nature.nps.gov/nrdata), so they may download the necessary data and/or metadata. If the request can not be fulfilled in that manner – either because the data products have not been posted yet, or because the requested data include sensitive information – work with the Data Manager to discuss options for fulfilling the request directly (for example, burning data to CD or DVD). Ordinarily, only certified data sets should be shared outside NPS.
5. It is recommended that documents and presentation files be converted to PDF format prior to distribution. This is to maximize portability and to reduce the ability for others to alter and redistribute files.
6. If the request is for data that may reveal the location of protected resources, refer to the next section in this document about sensitive information and also to Section 6I, Reporting and Product Development for a definition of sensitive information.

7. After responding, provide the following information to the Data Manager, who will maintain a log of all requests in the NCCN Project Tracking database:
   a Name and affiliation of requestor
   b Request date
   c Nature of request
   d Responder
   e Response date
   f Nature of response
   g List of specific data sets and products sent (if any)

7. Freedom of Information (FOIA) Requests

All official FOIA requests will be handled according to NPS policy. The Project Lead will work with the Data Manager and the park FOIA representative(s) of the park(s) for which the request applies.

8. Special Procedures for Sensitive Information

Products that have been identified upon delivery by the Project Lead as containing sensitive information will normally be revised into a form that does not disclose the locations of protected resources – most often by removing specific coordinates and only providing coordinates that include a random offset to indicate the general locality of the occurrence. If this kind of measure is not a sufficient safeguard given the nature of the product or the protected resource in question, the product(s) will withheld from posting and distribution.

If requests for distribution of products containing sensitive information are initiated by the NPS, by another Federal agency, or by another partner organization (for example, a research scientist at a university), the unedited product (that is, the full data set that includes sensitive information) may only be shared after a confidentiality agreement is established between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. All data requests will be tracked.

Once a confidentiality agreement is in place, products containing sensitive information may be shared following these guidelines:

- Always clearly indicate in accompanying correspondence that the products contain sensitive information, and specify which products contain sensitive information.
- Indicate in all correspondence that products containing sensitive information should be stored and maintained separately from non-sensitive information, and protected from accidental release or re-distribution.
- Indicate that NPS retains all distribution rights; copies of the data should not be redistributed by anyone but NPS.
- Include the following standard disclaimer in a text file with all digital media upon distribution:

  The following files contain protected information. This information was provided by the National Park Service under a confidentiality agreement. It is not to be published, handled, re-distributed or used in a manner inconsistent with that agreement.

  The text file also should specify the file(s) containing sensitive information.
- If the products are being sent on physical media (for example, CD or DVD), the media should be marked in such a way that clearly indicates that media contains sensitive information provided by the National Park Service.

a. Confidentiality Agreements

Confidentiality agreements may be created between NPS and another organization or individual to ensure that protected information is not inadvertently released. When contracts or other agreements with a non-federal partner do not include a specific provision to prevent the release of protected information, the written document must include the following standard Confidentiality Agreement:

> **Confidentiality Agreement** – I agree to keep confidential any protected information that I may develop or otherwise acquire as part of my work with the National Park Service. I understand that with regard to protected information, I am an agent of the National Park Service and must not release that information. I also understand that by law I may not share protected information with anyone through any means except as specifically authorized by the National Park Service. I understand that protected information concerns the nature and specific location of endangered, threatened, rare, commercially valuable, mineral, paleontological, or cultural patrimony resources such as threatened or endangered species, rare features, archeological sites, museum collections, caves, fossil sites, gemstones, and sacred ceremonial sites. Lastly, I understand that protected information must not be inadvertently disclosed through any means including websites, maps, scientific articles, presentation, and speeches.

K. Archiving and Records Management

All project files should be reviewed, cleaned up, and organized by the Project Lead on a regular basis (for example, annually in January). Decisions on what to retain and what to destroy should be made following guidelines stipulated in NPS Director's Order 19, which provides a schedule indicating the amount of time that the various kinds of records should be retained. Many of the files for this project may be scheduled for permanent retention, so it is important to isolate and protect them, rather than lose them in the midst of a large, disordered array of miscellaneous project files. Because this is a long-term monitoring project, good records management practices are critical for ensuring the continuity of project information. Files will be more useful to others if they are well organized, well named, and stored in a common format. In addition, files containing sensitive information must be stored in a manner that will enable quick identification. Refer to Section 6I, Reporting and Product Development for a definition for a definition of sensitive information.

To help ensure safe and organized electronic file management, NCCN has implemented a system called the NCCN Digital Library, which is a hierarchical digital filing system stored on the NCCN file servers (Boetsch and others, 2005). The typical arrangement is by project, then by year to facilitate easy access. Network users have read-only access to these files, except where information sensitivity may preclude general access.

As digital products are delivered for long-term storage according to the schedule in Section 6J, Product Delivery, Posting and Distribution, they will be catalogued in the NCCN project tracking database and filed within this the NCCN Digital Library. Analog (non-digital) materials are to be handled according to current practices of the individual park collections.

I. Season Close-out

After the conclusion of the field season, the Project Lead, Data Manager, and GIS Specialist should meet to discuss the recent field season, and to document any needed changes to the field sampling protocols, the working database application, or to any of the SOPs associated with the protocol.

7. Revisions to Protocol

All protocol revisions will be documented in the revision logs. Small changes to the protocol (for example, adding or modifying a variable) will be reviewed by the Project Lead, and approved by the Network Coordinator. More drastic changes (for example, modifications to the sample design or analytical methods for trend detection) will trigger an outside review to be conducted by the NPS Pacific West Regional Office or designated review panel as directed by the NPS Inventory and Monitoring Program.

This section explains how to make and track changes to the NCCN Fish Assemblages Monitoring Protocol, including its accompanying SOPs. Project staff should refer to these guidelines whenever edits are necessary, and should be familiar with the protocol versioning system in order to identify and use the most current versions of the protocol documents. Required revisions should be made in a timely manner to minimize disruptions to project planning and operations.

This protocol attempts to incorporate the best and most cost-effective methods for monitoring and information management. As new technologies, methods, and equipment become available, this protocol will be updated as appropriate, by balancing current best practices against the continuity of protocol information. All changes will be made in a timely manner with the appropriate level of review.

All edits require review for clarity and technical soundness. Small changes to existing documents – for example, formatting, simple clarification of existing content, small changes in the task schedule or project budget, or general updates to information management handling SOPs – may be reviewed in-house by project cooperators and NCCN staff. However, changes to data collection or analysis techniques, sampling design, or response design will trigger an outside review to be coordinated by the Pacific West Regional Office.

Procedures

1. Discuss proposed changes with other project staff prior to making modifications. It is especially important to consult with the Data Manager prior to making changes because certain types of changes may jeopardize data set integrity unless they are planned and executed with data set integrity in mind. Because certain changes may require altering the database structure or functionality, advance notice of changes is important to minimize disruptions to project operations. Consensus should be reached on who will be making the changes and in what timeframe.

2. Make the agreed-upon changes in the current, primary version of the appropriate protocol document (that is, not the most recent versioned copy – see below).
   Note that the protocol is split into separate documents for each appendix and SOP.
   Note: A change in one document also may necessitate other changes elsewhere in the protocol. For example, a change in the narrative may require changes to several SOPs; similarly renumbering an SOP may mean changing document references in several other documents. The project task list and other appendixes also may need to be updated to reflect changes in timing or responsibilities for the various project tasks.

3. Document all edits in the Revision History Log embedded in the protocol narrative and each SOP. Log changes only in the document being edited (that is, if there is a change to an SOP, log those changes only in that document). Record the date of the changes (that is, the date on which all changes were finalized), author of the revision, describe the change and cite the paragraph(s) and page(s) where changes are made, and briefly indicate the reason for making the changes.

4. Circulate the changed document for internal review among project staff and cooperators.

5. Upon ratification and finalizing changes:
   a. Ensure that the version date (last saved date field code in the document header) and file name (field code in the document footer) are updated properly throughout the document.
   b. Make a copy of each changed file to the protocol archive folder (that is, a subfolder under the Protocol folder in the project workspace).
   c. The copied files should be renamed by appending the revision date in YYYYMMDD format. In this manner, the revision date becomes the version number, and this copy becomes the 'versioned' copy to be archived and distributed.
   d. The current, primary version of the document (that is, not the versioned document just copied and renamed) does not have a date stamp associated with it.
   e. To avoid unplanned edits to the document, reset the document to read-only by right-clicking on the document in Windows Explorer and checking the appropriate box in the Properties popup.
   f. Inform the Data Manager so the new version number(s) can be incorporated into the project metadata.

6. As appropriate, create PDF files of the versioned documents to post to the Internet and share with others. These PDF files should have the same name and be made from the versioned copy of the file.

7. Post the versioned copies of revised documents to the NCCN Digital Library and forward copies to all individuals who had been using a previous version of the affected document.

Example of Document Revision

1. SOP_1_GPS_Use.doc is revised on October 31, 2008, and circulated for review.

2. Changes are accepted by the group and changes are finalized on November 6, 2008.

3. The revised SOP is:
   a. Copied into the Archive folder.
   b. That versioned copy is renamed as SOP_1_GPS_Use_20081106.doc.
   c. Both the current, primary version and the versioned copy are set to read-only.
   d. A PDF of the document is created from the versioned copy and named SOP_1_GPS_Use_20081106.pdf.
   e. Both the PDF and the versioned document are uploaded to the NCCN Digital Library.

The PDF is sent to any cooperators.

8. References Cited

Amos, K.H., and Appleby, A., 1999, Atlantic salmon in Washington State: A fish management perspective: Olympia, Washington Department of Fish and Wildlife.

Araki, H., Ardren, W.R., Olsen, E., Cooper, B., and Blouin, M.S., 2007, Reproductive success of captive-bred steelhead trout in the wild: Evaluation of three hatchery programs in the Hood River: Conservation Biology, v. 21, no. 1, p. 181-190.

Bilby, R.E., Fransen, B.R., and Bisson, P.A., 1996, Incorporation of nitrogen and carbon from spawning coho salmon into the trophic systems of small streams: Evidence from stable isotopes: Canadian Journal of Fisheries and Aquatic Sciences, v. 53, p. 164-173.

Boetsch, J.R., Christoe, B., and Holmes, R.E., 2005, Data management plan for the North Coast and Cascades Network Inventory and Monitoring Program: USDI National Park Service, Port Angeles, WA., 88 p., accessed January 1, 2008, at http://science.nature.nps.gov/im/units/nccn/datamgmt.cfm

Bottom, D.L., 1995, Restoring salmon ecosystems–Myth and reality: Restoration and Management Notes, v. 13, p. 162-170.

Brenkman, S.J., 1998, Factors influencing spawning migration of bull trout in the North Fork Skokomish River, Olympic National Park, Washington: Corvallis, Oregon State University, Masters thesis, 92 p.

Brenkman, S.J., and Corbett, S.C., 2005, Extent of anadromy in bull trout: Implications for conservation of a threatened species: North American Journal of Fisheries Management, v. 25, p. 1073-1081.

Brenkman, S.J., Corbett, S.C., and Kennedy, P.R., 2007a, Inventory of fish species in Lewis and Clark National Historic Park, Oregon: Port Angeles, Wash., National Park Service, Olympic National Park, 29 p.

Brenkman, S.J., Corbett, S.C., and Sebring, S.H., 2004, Inventory of freshwater fish species in the Bogachiel, Dosewallips, and Quinault River Basins, Olympic National Park, Washington: Port Angeles, Wash., U.S. Department of Interior, National Park Service, 54 p.

Brenkman, S.J., Corbett, S.C., and Volk, E.C., 2007b, Use of otolith chemistry and radio telemetry to determine age-specific migratory patterns of anadromous bull trout (*Salvelinus confluentus*) in the Hoh River, Washington: Transactions of the American Fisheries Society, v. 136, p. 1-11.

Brenkman, S.J., Larson, G.L., and Gresswell, R.E., 2001, Spawning migration of lacustrine-adfluvial bull trout in a natural area: Transactions of the American Fisheries Society, v. 130, p. 981-987.

Brenkman, S.J., Mumford, S.L., House, M., and Patterson, C., 2008b, Establishing a baseline for detection of fish pathogens in Pacific salmonids prior to dam removal and subsequent recolonization by anadromous fish in the Elwha River, Washington: Northwest Science, v. 82 (Special Issue), p. 142-152.

Brenkman, S.J., Pess, G.R., Torgersen, C., Kloehn, K.K., Duda, J.J., and Corbett, S.C., 2008a, Predicting recolonization patterns and interactions between potamodromous and anadromous salmonids in response to dam removal in the Elwha River, Washington State: Northwest Science, v. 82 (Special Issue), p. 91-106.

Bureau of Reclamation, 2004, Geomorphic assessment of the Hoh River, Washington–River miles 17 to 40 between Oxbow Canyon and Mount Tom Creek: U.S. Department of Interior, Bureau of Reclamation Technical Service Center, Denver, Colo.

Bureau of Reclamation, 2005, Geomorphic investigation of Quinault River, Washington–Lake Quinault to confluence of East and North Fork Quinault: U.S. Department of Interior, Bureau of Reclamation Technical Service Center, Denver, CO.

Busby, P.J., Wainwright, T.C., Bryant, G.J., Lierheimer, L.J., Waples, R.S., Waknithz, F.W., and Lagomarsino, I.V., 1996, Status review of west coast steelhead from Washington, Idaho, Oregon, and California: U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-27, 261 p.

Cederholm, C.J., Johnson, D.H., Bilby, R.E., Dominguez, L.G., Garrett, A.M., Graeber, W.H., Greda, E.L., Kunze, M.D., Marcot, B.G., Palmisano, J.F., Plotnikoff, R.W., Pearcy, W.G., Simenstad, C.A., and Trotter, P.C., 2001, Pacific salmon and wildlife: Ecological contexts, relationships, and implications for management, *in* Johnson, D.H., and O'Neil, T.A., eds., Wildlife-Habitat Relationships in Oregon and Washington: Corvallis, Oregon State University Press, p. 628-687.

Chilcote, M.W., Leider, S.A., and Loch, J.J., 1986, Differential reproduction success of hatchery and wild summer-run steelhead under natural conditions: Transactions of the American Fisheries Society, v. 115, p. 726-735.

Connolly, P.J., and Brenkman, S.J., 2008, Fish assemblage, density, and growth in lateral habitats within natural and regulated sections of Washington’s Elwha River: Northwest Science, v. 82 (Special Issue), p. 107-118.

DeHaan, P., Diggs, M., and Ardren, W., 2007, Draft report–Genetic analysis of bull trout in Mount Rainier National Park: Report submitted to Mount Rainier National Park.

Dunham, J., Chandler, G., Rieman, B., and Martin, D., 2005, Measuring stream temperature with digital data loggers: A user's guide: Fort Collins, Colo., U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-150WWW, 15 p.

Emmett, R.L., and Schiewe, M.H., eds., 1997, Estuarine and ocean survival of northeast Pacific salmon: Proceedings of a Workshop, U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-29, 313 p.

Fausch, K.D., Rieman, B.E., Young, M.K., and Dunham, J.B., 2006, Strategies for conserving native salmonid populations at risk from nonnative fish invasions: Tradeoffs in using barriers to upstream movement: Fort Collins, Colo., U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-174, 44 p.

Fausch, K.D., Torgersen, C.E., Baxter, C.V., and Li, H.W., 2002, Landscapes to riverscapes: Bridging the gap between research and conservation of stream fishes: BioScience, v. 52, no. 6, p. 1-16.

Flotemersch, J.E., Stribling, J.B., and Paul, M.J., 2006, Concepts and approaches for the bioassessment of non-wadeable streams and rivers: Cincinnati, Ohio, U.S. Environmental Protection Agency, EPA 600-R-06-127.

Francis, R.C., 1997, Sustainable use of salmon: Its effects on biodiversity and ecosystem function, *in* Freeze, C.H., ed., Harvesting Wild Species–Implications for biodiversity conservation: Baltimore, Johns Hopkins University Press, p. 626-670.

Freeman, M.C., Pringle, C.M., and Jackson, C.R., 2007, Hydrologic connectivity and the contribution of stream headwaters to ecological integrity at regional scales: Journal of American Water Resources Association, v. 43, no. 1, p. 5-14.

Houston, D.B., and Contor, R.J., 1984, Anadromous fish in Olympic National Park: Status and management considerations, *in* Walton, J.M., and Houston, D.B., eds., Proceedings of the Olympic Wild Fish Conference, p. 97-111.

Izaak, D.J., Thurow, R.F., Rieman, B.E., and Dunham, J.B., 2007, Chinook salmon use of spawning patches: Relative roles of habitat quality, size, and connectivity: Ecological Applications, v. 17, p. 352-364.

Jenkins, K., Woodward, A., and Schreiner, E., 2003, A framework for long-term ecological monitoring in Olympic National Park: Prototype for the coniferous forest biome: U.S. Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR-2003-0006, 150 p.

Johnson, D.H., Shrier, B.M., O'Neal, J.S., Knutzen, J.A., Augerot, X., O'Neil, T.A., and Pearsons, T.N., 2007, Salmonid field protocols handbook: Techniques for assessing the status and trends in salmon and trout populations: Bethesda, Maryland, American Fisheries Society.

Kline, T.C., Goering, J.J., Mathisen, O.A., Poe, P.H., and Parker, P.L., 1990, Recycling of element transported upstream by runs of Pacific salmon: I. δ15N and δ13C evidence in Sashin Creek, southeastern Alaska: Canadian Journal of Fisheries and Aquatic Science, v. 47, p. 136-144.

Kline, T.C., Jr., Goering, J.J., Mathisen, O.A., Poe, P.H., Parker, P.L., and Scanlan, R.S., 1994, Recycling of element transported upstream by runs of Pacific salmon: II. δ15N and δ13C evidence in the Kvichak River watershed, Bristol Bay southwestern Alaska: Canadian Journal of Fisheries and Aquatic Science, v. 50, p. 2350-2365.

Larsen, D.P., Kaufmann, P.R., Kincaid, T.M., and Urquhart, N.S., 2004, Detecting persistent change in the habitat of salmon-bearing streams in the Pacific Northwest: Canadian Journal of Fisheries and Aquatic Sciences, v. 61, p. 283-291.

Levin, P.S., Achord, S., Feist, B.E., and Zabel, R.W., 2002, Non-indigenous brook trout and the demise of threatened Snake River salmon: A forgotten threat?: Proceedings of the Royal Society of London (Series B), v. 269, p. 1663-1670.

Li, H.W., Currens, K., Bottom, D., Clarke, S., Dambacher, J., Frissell, C., Harris, P., Hughes, R.M., McCullough, D., McGie, A., Moore, K., Nawa, R., and Thiele, S., 1995, Safe havens: Refuges and evolutionarily significant units: American Fisheries Symposium, v. 17, p. 371-380.

Lieb, Amy, and Perry, Thomas, 2005, Watershed conditions and seasonal variability within WRIA 20, Olympic Peninsula, Washington: U.S. Department of Interior, Bureau of Reclamation, Denver, Colo., 255 p.

Markle, D.F., 1992, Evidence of bull trout x brook trout hybrids in Oregon, *in* Howell, P.J., and Buchanan, D.V., eds., Proceedings of the Gearhart Mountain Bull Trout Workshop, Oregon Chapter of the American Fisheries Society, Corvallis, p. 58-67.

McDonald, T., 2006, Analysis of snorkel count data from Olympic National Park rivers: Cheyenne, Wyoming, Report to Olympic National Park, WEST Inc., 36 p.

Meador, M.R., Cuffney, T.F., and Gurtz, M.E., 1993, Methods for sampling fish communities as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93-104, 40 p.

Menza, C., Ault, J., Beets, J., Bohnsack, J., Caldow, C., Christensen, J., Friedlander, A., Jeffrey, C., Kendall, M., Luo, J., Monaco, M., Smith, S., and Woody, K., 2006, A guide to monitoring reef fish in the National Park Service's South Florida / Caribbean Network: NOAA Technical Memorandum NOS NCCOS 39, 166 p.

Mongillo, P.E., and Hallock, M., 1997, Distribution and habitat of native nongame stream fishes of the Olympic Peninsula, Washington: Washington Department of Fish and Wildlife Fish Management Program, Freshwater Resource Division, Technical Report #FRD 97-05, 45 p.

Moulton, S.R. II, Kennen, J.G., Goldstein, R.M., and Hambrook, J.A., 2002, Revised protocols for sampling algal, invertebrate, and fish communities in the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 02-150,75 p.

Moyle, P.B., 2002, Inland fishes of California: University of California Press, Berkeley, 502 p.

National Park Service, 2005, Reporting guidelines: U.S. Department of Interior, National Park Service, accessed January 1, 2008, at http://www.nature.nps.gov/publications/NRPM/index.cfm

National Park Service, 2006, Management policies, accessed January 1, 2008, at http://www.nps.gov/policy/mp/policies.html

Nehlsen,W., Williams, J.E., and Lichatowich, J.A., 1991, Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington: Fisheries, v. 16, no. 2, p. 4-21.

NOAA-NMFS-NWFSC TM-33: Sockeye Salmon Status Review (1997), accessed September 22, 2008, at http://www.nwfsc.noaa.gov/publications/techmemos/tm33/int.html

North Coast and Cascades Network–National Park Service, 2005a, GIS product specifications: USDI National Park Service, accessed January 1, 2008, at http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm

North Coast and Cascades Network–National Park Service, 2005b, GIS naming conventions: USDI National Park Service, accessed January 1, 2008, at http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm

North Coast and Cascades Network–National Park Service, 2006a, GPS guidelines: USDI National Park Service, accessed January 1, 2008, at http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm

North Coast and Cascades Network–National Park Service, 2006b, Metadata development guidelines: USDI National Park Service, accessed January 1, 2008, at http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm

North Coast and Cascades Network–National Park Service, 2006c, GIS development guidelines: USDI National Park Service, accessed January 1, 2008 at http://science.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm

Northcote, T.G., and Ennis, G.L., 1994, Mountain whitefish biology and habitat use in relation to compensation and improvement possibilities: Reviews in Fisheries Sciences, v. 2, no. 4, p. 347-371.

Northcote, T.G., and Wilkie, D.W., 1963, Underwater census of stream fish populations: Transactions of the American Fisheries Society, v. 92, p. 146-151.

Oakley, K.L., Thomas, L.P., and Fancy, Steven G., 2003, Guidelines for long-term monitoring protocols: Wildlife Society Bulletin, v. 31, no. 4, p. 1000-1003.

Oberdorff, T., Pont, D., Hugueny, B., and Porchers, J., 2002, Development and validation of a fish-based index for the assessment of "river health" in France: Freshwater Biology, v. 47, p. 1720-1734.

Peterson, D.P., and Fausch, K.D., 2003, Upstream movement by nonnative brook trout (*Salvelinus fontinalis*) promotes invasion of native cutthroat trout (*Oncorhynchus clarki*) habitat: Canadian Journal of Fisheries and Aquatic Sciences, v. 60, p. 1502-1516.

Peterson, D.P., Fausch, K.D., and White, G., 2004, Population ecology of an invasion: Effects of brook trout on native cutthroat trout: Ecological Applications, v. 14, p. 754-772.

Petersen, J.C., Justus, B.J., Dodd, H.R., Bowles, D.E., Morrison, L.W., Williams, M.H., and Rowell, G.A., 2008, Methods for monitoring fish communities of Buffalo National River and Ozark National Scenic Riverways in the Ozark Plateaus of Arkansas and Missouri:Version 1: U.S. Geological Survey Open-File Report 2007-1302, 94 p.

Phinney, L., and Bucknell, P., 1975, A catalog of Washington streams and salmon utilization–Vol. 2, Coastal region: I and E Division, Washington Department of Fisheries, Olympia.

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K., and Hughes, R.M., 1989, Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish: Washington, D.C., U.S. Environmental Protection Agency, EPA/440/4-89/001.

Pollard, W.R., Hartman, G.F., Groot, C., and Edgell, P., 1997, Field identification of coastal juvenile salmonids: Department of Fisheries and Oceans and Weyerhauser ltd., British Columbia, Canada.

Reisenbichler, R.R., and McIntyre, J.D., 1977, Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, *Salmo gairdneri*: Journal of the Fisheries Research Board of Canada, v. 34, p. 123-128.

Rieman, B.E., and McIntyre, J.D., 1993, Demographic and habitat requirements for conservation of bull trout: U.S. Forest Service General Technical Report INT-302, Ogden, Utah, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, 37 p.

Schill, D.J., and Griffith, J.S., 1984, Use of underwater observations to estimate cutthroat trout abundance in the Yellowstone River: North American Journal of Fisheries Management, v. 4, p. 479-487.

Schmutz, S., Kaufmann, M., Vogel, B., Jungwirth, M., and Muhar, S., 2000, A multi-level concept for fish-based, river-type-specific assessment of ecological integrity: Hydrobiologia, v. 422/423, p. 279-289.

Siegel, R.B., Wilkerson, R.L., Jenkins, K.J., Kuntz II, R.C., Boetsch, J.R., Schaberl, J.P., and Happe, P.J., 2007, Landbird monitoring protocol for national parks in the North Coast and Cascades Network: U.S. Geological Survey Techniques and Methods 2-A6, 208 p.

Thurow, R.F., 1994, Underwater methods for study of salmonids in the Intermountain West: Ogden, Utah, U.S. Forest Service, Intermountain Research Station, General Technical Report INT-GTR-307.

Torgersen, C.E., 2002, A geographical framework for assessing longitudinal patterns in stream habitat and fish distribution: Corvallis, Oregon State University, PhD dissertation.

Williams, J.E., Johnson, J.E., Hendrickson, D.A., Contreras-Balderas, S., Williams, J.D., Navarro-Mendoza, M., McAllister, D.E., and Deacon, J.E., 1989, Fishes of North America endangered, threatened, or of special concern: 1989: Fisheries, v. 14, no. 6, p. 2–19.

Wydoski, R.S., and Whitney, R.R., 2003, Inland fishes of Washington, 2nd edition, revised and expanded: American Fisheries Society and University of Washington Press, 322 p.

Zyskowski, S.E., 2007, Stream fish inventories 2001 to 2003, North Cascades National Park Complex and Mount Rainier National Park, Washington: Sedro-Woolley, Washington, U.S. Department of Interior, National Park Service, 51 p.

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Protocol for Monitoring Fish Assemblages in Pacific Northwest National Parks

Standard Operating Procedure (SOP) #1: Use of GPS and Data Downloading

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

This SOP provides step-by-step instructions for collecting position information using Thales MobileMapper GPS receivers, as well as downloading that information in preparation for sending it to the GIS Specialist. The material in this SOP is excerpted from the document NCCN Global Positioning System Data Acquisition and Processing, 2006 (*http://www1.nature.nps.gov/im/units/nccn/datamgmt_guide.cfm*), which also provides information on processing GIS data once the data have been downloaded and given to the GIS specialist.

1. General Practices for GPS Data Collection

Regardless of GPS receiver type, certain data collection standards must be followed. Most of the quality control measures below can be established by the user and should be followed whenever possible to produce the most accurate data possible.

- Satellite availability and satellite geometry (PDOP):
  GPS users can increase mapping accuracy by using planning charts and targeting their data collection to the times of day when satellite availability and geometry are best. Such timing however does not always work in the field.
- Length of time GPS data file is open
  Positional accuracy will be better the longer a file is open and the more GPS positions are collected and averaged.
- Multipath error, or signal interference
  Although mostly beyond a user's control, some adjustments can be made to minimize multipath error. These include positioning the GPS in the most unobstructed view of the sky as possible, using offsets from better satellite reception areas to the target location, and using an external antenna.
- Signal to Noise Ratio (SNR)
  This is out of a user's control, although adjusting for less multipath also will create a better SNR.

GPS file names should be recorded on hard copy datasheets or in field computers. GPS field coordinates (coordinates shown on a GPS receiver while a GPS is receiving satellite signals) and datum also should be recorded on hardcopy datasheets. In the event a GPS file is lost or corrupted, the coordinates recorded in the field from the GPS unit display window will become the best measure of location. Be aware that these coordinates can not be differentially-corrected and are in the coordinate system and datum that were chosen for the unit's display.

2. Thales MobileMapper Operating Instructions

Contact NCCN GIS staff to have MobileMapper Office software installed and to have MobileMapper GPS receivers initialized. The User Manual (.pdf) found under the Help section of MobileMapper Office is a useful reference.

Battery Options
MobileMapper GPS receivers use two AA batteries that will last approximately 8 hours with the backlight on and 14-16 hours with the backlight off.

External Antenna
MobileMapper GPS units have internal antenna at the top of the unit. External antennas are not necessary in the field, but can be used in areas with significant satellite signal obstructions. External antennas are required for mapping from aircraft or road vehicle. With the unit facing you, the antenna jack is on the upper right side underneath a small black rubber flap. Hold the unit vertically so that the internal antenna is oriented correctly.

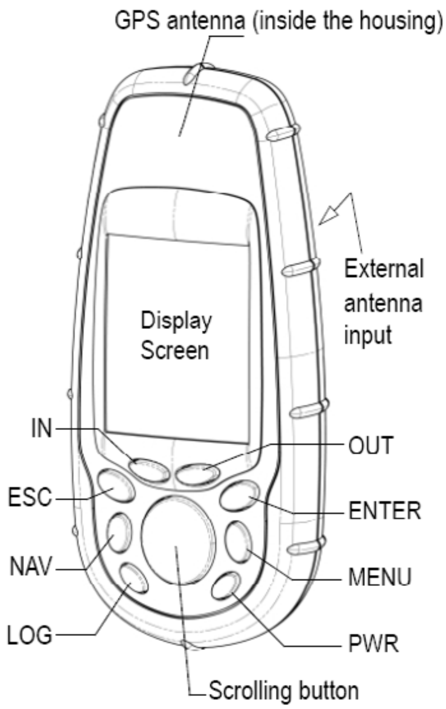
Projection and Datum
GPS units receive coordinate data from satellites in latitude and longitude in the WGS-84 datum, but can display coordinate in various projections and datums. NCCN GPS units should be set up to display coordinate information in UTM zone 10, North American Datum 1983 (NAD83).

Configuration Settings
Configuration settings in MobileMapper receivers consist of setting map display scales, selected navigation screens, coordinate display, selected background maps, and power options. Contact NCCN GIS Specialists for assistance with setting receiver configurations.

Receiver Operation and Data Collection
Power On and Off
Push PWR button to power on. Push ENTER when the disclaimer/warning screen appears or the unit will automatically shut off. To turn off the receiver, push PWR twice. Most NCCN MobileMapper units have been configured to prevent accidental shut off by forcing users to push the PWR button once and then push the ENTER button once.

Backlight

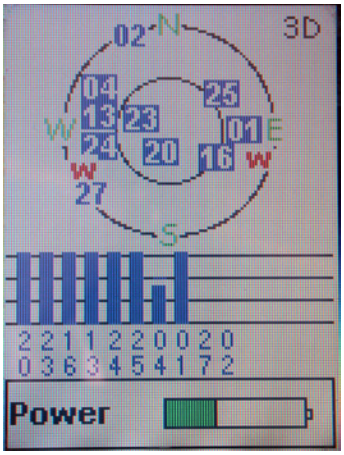
The backlight can be adjusted by using the PWR button. Push the PWR button for more than 2 seconds and then release it to change the backlight from high to low. Push the PWR button again for more than 2 seconds and then release it to change the backlight from low to off. Push the PWR button again for more than 2 seconds and then release it to turn the backlight on again.



Receiver Screens

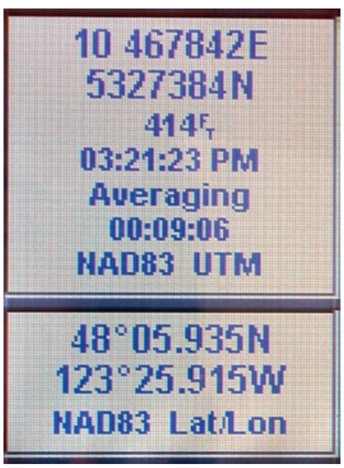
The NAV button scrolls through navigation screens. Many navigation screens have been turned off (such as the road view) during the configuration/initialization process. The screens that will be used most are the satellite chart, the background map, the position screen, and the heading and bearing screen. The ESC key steps back through previous screens.

Look for the Satellite Status screen. This shows the status of the battery power, how many satellites are being tracked (the solid bars in the graph) and whether the GPS is calculating positions in 2D or 3D mode (upper right corner). If there are four or more satellites being tracked and the 3D indicator appears then data recording can proceed.



Check Signal Reception and Current Location

Push the NAV button until the Position screen appears. This also will show the status of the strength of the satellite signals. The line that reads “Averaging” will indicate, whether the GPS is “Search – 1st sat”, “Search – 2nd sat” … or Averaging. Averaging will only show up if the GPS is getting good signals and is stationary. If it is averaging, it will also show the duration at which the unit has been receiving satellite data at that point on the next line (for example, 9 minutes and 6 seconds).



Current Position Information

Use the position screen to see current coordinates and obtain a running average of your current position. It will show the duration and average UTM’s during that duration. Relatively small movement (like shoulder width distance) will reset the duration clock and create a new running coordinate average. This screen shows a primary (at the top) and secondary (at the bottom) coordinate system (these displays are set during the configuration process). NCCN units have UTM zone 10, NAD 1983 as the primary coordinate screen. The “10” preceding the easting at the top is the UTM zone.

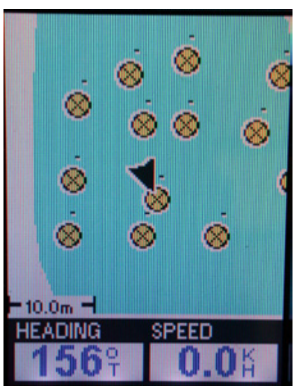
Background Maps

Background maps are useful reference for fieldwork. For example, a background map can show target points where field crews will place plots, roads, trails, and park boundaries. Background maps will display at scales set during map creation in MobileMapper Office and at a level set in the GPS unit configuration.

MobileMapper GPS receivers can display vector data (points, lines, polygons) in a background map. One attribute can be displayed for each vector feature in the background map. Shapefiles are imported in MobileMapper Office and saved as a map file (.mmp). Background maps are transferred to the receiver. Contact NCCN GIS staff for background map creation, imports, and proper configuration settings.

To view a background map in the GPS receiver, use the IN and OUT buttons to zoom in and out. Use the scroll arrows to move around the map and to set a center point for zooming in and out. A black triangle will show your present position (the triangle is really big and it is unclear if it can be made smaller). Zoom out beyond a certain scale will show a more general map. Zooming in to the scale set during map creation in MobileMapper Office will show more detail.

> **NOTE**: The black cursor on the background map will not zoom in beyond 10 meters on the display.

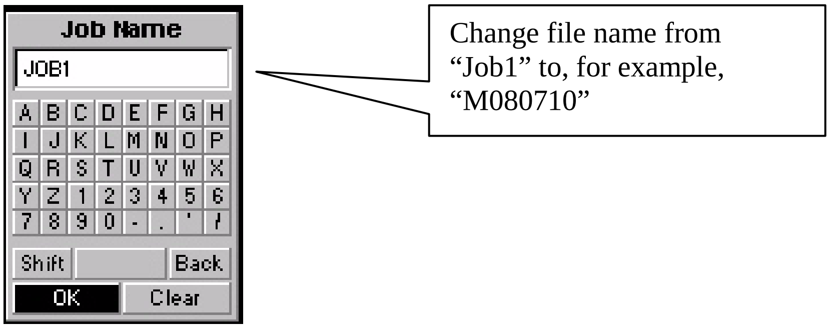


Open a File

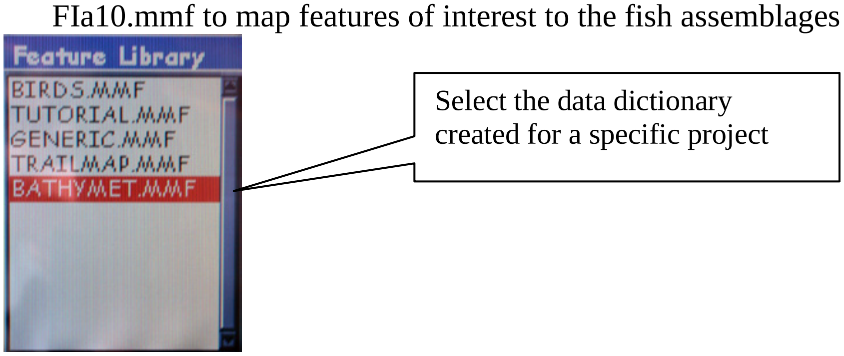
When you are ready to collect a data file,

1. push the LOG button.
2. highlight Create New Job and push ENTER

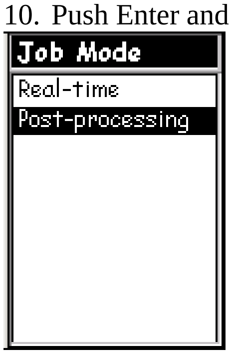
3. use the scroll arrows to get to Clear (bottom of the keyboard)



4. Push ENTER
5. Use the scroll arrows and ENTER button to type in a job file name
   job files should be named the following standard way:
   Xyymmdd
   Where:
   X = GPS unit letter (see the back of the GPS unit for its letter-code)
   Yy = last two digits of the year (for example, "08" for 2008)
   Mm = month (use two digits; for example "06" for June)
   Dd = day (use two digits; for example, "03" for the third day of the month)
6. Scroll to OK when finished typing in the job file name
7. Push ENTER
   NOTE: There is an 8 character limit in file names. After naming the job file,
8. Select a feature library (called a data dictionary in Trimble's realm)
9. Select XXXXX.mmf where XXXXX is the specific feature library. For example, select FIa10.mmf to map features of interest to the fish assemblages monitoring program.



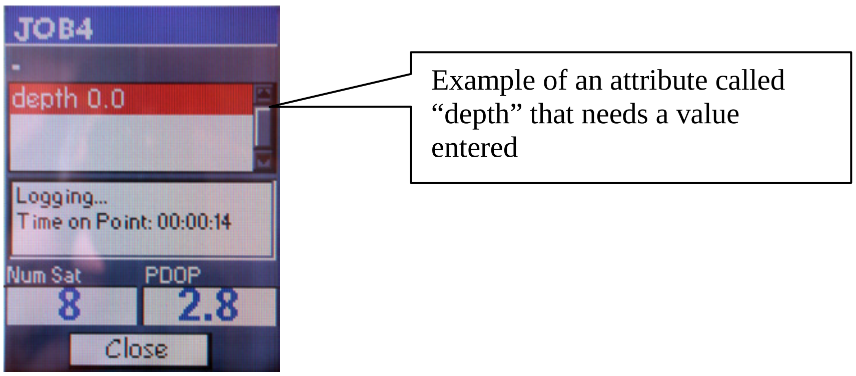
10. Push Enter and the Job Mode screen will appear



11. Select Post-processing
12. Push ENTER
    The New Feature screen will appear
13. Select the feature for which data will be collected (a point or a line feature)
14. Push ENTER

NOTE: if the default data dictionary is being used, then the screen will display choices "Point, Line, Area, Grid".
NOTE: Positions will not begin to collect in a file until the GPS unit begins receiving three or four satellite signals.
NOTE: Hold the unit vertically so that the antenna is oriented correctly

15. Once the GPS unit receives sufficient satellite signals, pushing ENTER on the selected feature in the New Feature screen will change the screen from showing feature type information (e. g. New Feature/FIa10_pt or FIa10_line) to a screen for specific feature data collection that shows: data dictionary attributes that need data entry, logging time, number of satellites, and PDOP



NOTE: The MobileMapper does not show the number of points collected in a file like Trimble files do. Try to watch the elapsed time window and keep an eye on the PDOP. Try to collect at least three minutes of PDOP =<8.0 (make your best guess).

Data Entry for a Point Feature

To map a start point or an end point of a survey reach, or to map a temperature logger location,

1. Scroll to the feature named FIa10_pt and push ENTER
2. Don't move during data collection!
3. Use the scroll keys and Enter button to type in attribute data
4. Push ENTER when finished entering attribute data
5. Try to collect approximately 2-3 minutes of location data with relatively low (=<8) PDOP
6. Select OK when finished with data collection

Close the Feature

1. Scroll to CLOSE when finished logging the feature
2. Push ENTER
   This returns to the New Feature screen.
   NOTE: This closes the feature, not the file.
3. Write the GPS file name on a hardcopy datasheet

Data Entry for a Line Feature

A line feature can be opened within the same GPS file as the point feature. When a point feature is closed, the New Feature screen will appear again. From that screen a new line feature can be opened.

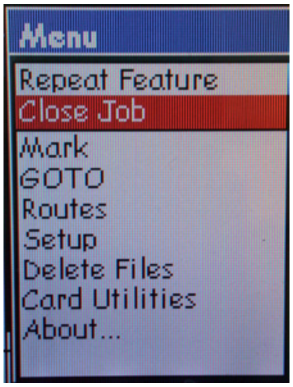
1. Scroll to the feature named FIa10_line and push ENTER
2. Use the scroll keys and Enter button to type in attribute data

3. Push ENTER when finished entering attribute data
4. Slowly walk the stream or river channel
5. Stop moving if you lose satellite signals and wait for reception to improve
6. Select OK when finished
7. Close the feature (see *Close the Feature* above)
8. Write the GPS file name on a hardcopy datasheet

Close a File

To close out of the entire job file,

1. Push MENU
2. Scroll to Close Job
3. Push ENTER



Open File Again to Collect New Feature (either a point location or a line)

To open a job file again and add further point or line features,

1. Push the LOG button
2. Select Open Existing Job
3. Push ENTER
4. Select the job file name
5. Push ENTER
6. Push LOG to get to the New Feature/Plot screen and wait for satellite signals
7. Push ENTER and log another point or line feature
8. Write the GPS file name on a hardcopy datasheet

To close out of the entire job file,

1. Push MENU
2. Scroll to Close Job
3. Push ENTER

    NOTE: You also can re-open a job from pushing the MENU button and selecting Open Job.

    NOTE: There is no set rule for how many jobs to create and how many features (plot locations or line segments) to log per job. Typically, one job file per day works well for field operations and for data management considerations.

    NOTE: Turning off the unit will close an open job file (unlike the Trimble units, the file will not stay open).

    NOTE: If batteries die during a job file, replace batteries, open a new job file and begin data collection again.

3. Transferring GPS Receiver Data to a Computer

Processing differentially correctable GPS rover files requires a computer, a data transfer cable, and GPS software. GPS receivers typically come with manufacturer-specific software and data transfer cables. Each software package operates differently, but the basic process is the same.

It is extremely important that whenever field crews return from the field, GPS files are transferred from GPS receivers to computers or network folders that are routinely backed-up. Files should be transferred to an appropriately named folder (such as, under the project's main network folder, \GPS_data\FIa10_2008\Rover_files\Raw or Backup).

Contact NCCN GIS staff to help set-up file folders, GPS software default settings, and hardware configurations for GPS data transfers. Differential processing will be done by NCCN GIS staff.

Upon completion of GPS file transfers, notify GIS staff about GPS files that are ready for processing.

NOTE: Files collected on the MobileMapper GPS receivers are termed "jobs" and files saved via MobileMapper Office are named "jobs" (both have .mmj extensions).

<u>MobileMapper Office Project Set-up</u>

1. Open MobileMapper Office program from the computer and create a job file
    - a) Click on the File menu
    - b) Select New
    - c) Click on the File menu again
    - d) Select Save As
    - e) Navigate to a computer or network directory in which a PC job file will be stored
    - f) Name the file
    - g) Push Save

2. Set the coordinate system
    - a) Click on the Options menu
    - b) Select Coordinate System
    - c) Click the drop-down arrow in the Spatial Reference System window
    - d) Select UTM/WGS84/UTM zone 10N
        - i. If no coordinate system has been selected yet, click <new> from the drop-down list
        - ii. Select "SELECT a PRE-DEFINED system"
        - iii. Click the Next button
        - iv. Scroll down to UTM in the left pane of the Coordinate System Wizard – Select window and double click
        - v. Double click on WGS 84
        - vi. Select UTM/WGS 84/UTM zone 10N from the right pane in the Coordinate System Wizard – Select window
        - vii. Click on the Finish button
        - viii. Click on the browse button to the right of the drop-down list

ix. Click on the Datum tab
x. Select NAD83 from the Datum Name: pick-list
xi. Click OK
xii. Make sure the new option is selected in the Select Coordinate System window

e) Click OK

NOTE: MobileMapper Office does not display the pick-list as NAD83; it displays as UTM/WGS 84/UTM zone 10N

3. Set the units
   a) Click on the Options menu
   b) Select Units
   c) Select m, km/hectare

Open this job file each time GPS job files are downloaded from the GPS unit to the PC desktop.

Data Transfer between GPS and MobileMapper Office

1. Connect the GPS to the computer using the serial cable
2. Turn on the GPS unit
3. Launch MobileMapper Office if it is not already open
4. In MobileMapper Office, click on the File menu
5. Select Download from GPS
6. Click on the File menu within the MobileMapper Transfer window
7. Select Connect
8. Select GPS Device via Cable

   This will bring up a list of all the files in the GPS unit on the left side pane.
9. Use the dropdown box in the right side pane to navigate to the directory to which GPS files will be copied and stored (e. g. “Raw” or “Unprocessed” folder)
10. Copy files from the left pane to the right pane by
    a) Highlighting the job(s) name (use Shift or Ctrl keys to highlight multiple files),
    b) Right clicking,
    c) And selecting Copy to

       This will automatically begin the file(s) transfer from the GPS unit to the directory in the right pane.

    NOTE: Use the Copy option, not the Move option. It appears to be safer to copy, not move. The Move option takes the files out of the GPS unit and into the directory shown in the right pane. NCCN has experienced transfer errors that corrupt GPS receiver job files using the Move option.

    NOTE: Highlight and copy only the GPS receiver job files. There is no need to copy background map and feature library files.
11. Close the data transfer window. This will return to the main MobileMapper Office job window.
12. Close the MobileMapper Office software program
13. Contact GIS staff about newly transferred files that are now ready for post-processing

Delete Files from GPS Receiver

Delete GPS files from GPS receivers only after files have been transferred to computers, backed-up, and differentially corrected (field crews may have to verify GPS file correction status with NCCN GIS staff).

Delete Files from MobileMapper Receiver
With the GPS receiver turned on,
1. Push MENU
2. Scroll to Delete Files
3. Push ENTER
4. Scroll to the file to be deleted
5. Push ENTER
6. Scroll to Yes to confirm deletion
7. Push ENTER

NOTE: Files must be deleted one at a time. There is no option for deleting all files at once from the receiver.

Delete Files from MobileMapper Receiver using MobileMapper Office
With MobileMapper Office open and the GPS receiver connected to the computer,
1. Click on the File menu
2. Select Download from GPS
3. Click on the File menu within the MobileMapper Transfer window
4. Select Connect
5. Select GPS Device via Cable
   This will bring up a list of all files in the GPS unit on the left side pane.
6. Highlight the job(s) name (use Shift or Ctrl keys to highlight multiple files) that will be deleted
7. Right click
8. Select Delete
   This will delete the selected job files from the GPS receiver.

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Protocol for Monitoring Fish Assemblages in Pacific Northwest National Parks

Standard Operating Procedure (SOP) #2: Data Entry and Verification

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview Guidelines for Data Entry and Verification

This document describes the general procedures for entry and verification of field data in the working project database. Refer also to protocol **Section 6C – Overview of Database Design**, and **Section 6D – Data Entry and Processing** for related guidance and a clarification of the distinction between the working database and the master database. The following are general guidelines to keep in mind:

1. Data entry should occur as soon after data collection as possible so that field crews keep current with data entry tasks, and catch any errors or problems as close to the time of data collection as possible.
2. The working database application will be found in the project workspace. For enhanced performance, it is recommended that users copy the front-end database onto their workstation hard drives and open it there. This front-end copy may be considered "disposable" because it does not contain any data, but rather acts as an interface with data residing in the back-end working database.
3. Each data entry form is patterned after the layout of the field form, and has built-in quality assurance components such as pick lists and validation rules to test for missing data or illogical combinations. Although the database permits users to view the raw data tables and other database objects, users are strongly encouraged only to use the pre-built forms as a way of ensuring the maximum level of quality assurance.
4. As data are being entered, the person entering the data should visually review each data form to make sure that the data on screen match the field forms. This should be done for each record prior to moving to the next form for data entry.
5. At regular intervals and at the end of the field season, the Field Lead should inspect the data that have been entered to check for completeness and perhaps catch avoidable errors. The Field Lead also may periodically run the Quality Assurance Tools that are built into the front-end working database application to check for logical inconsistencies and data outliers (this step is described in greater detail in **Section 6E: Quality Review** and also in **SOP #3: Data Quality Review and Certification**).

Database Instructions

Getting Started

The first action to be taken is to make sure the data entry workspace is set up properly on a networked drive. If you are unclear about where this should be, contact either the local park wildlife biologist or the Data Manager.

- Store the back-end database file on the server so that others can enter data into the same back end file. The back-end file has "_be_" as part of its name. Upon saving this back-end, the user may want to append the local park code to distinguish it from other back-end files associated with other crews (for example, ForestVeg_VCa02_be_2007_OLYM.mdb).
- The crew's copy of the front-end database also may be stored in the same folder.
- If it does not already exist, also create a folder in the same network folder named "backups" or "backup_copies" for storing daily backups of the back-end database file.

Prior to using the database:

- Open the front-end database. The first thing it will do is to ask to update the links to the back-end database file. This will only need to be done once for each new issue of the front-end database.

Important Reminders for Daily Database Use

- A fresh copy of the front-end will need to be copied to your workstation every day. Do not open up and use the front-end on the network as this 'bloats' the database file and makes it run more slowly.
- Backups should be made consistently at some point every day that data entry occurs. Normally, the front-end application will automatically prompt you to make a backup either upon initially opening or upon exiting the application. Backups also can be made on demand by hitting the "Back up data" button on the main menu and storing the backup file in the "backups" folder.
- To save drive space and network resources, backup files should be compacted by right-clicking on the backup file in Windows Explorer and selecting the option: "Add to Zip file". Older files may be deleted at the discretion of the project crew lead.
- New issues of the front-end application may be released as needed through the course of the field season. If this happens, there should be no need to move or alter the back-end file. Instead, the front-end file may be deleted and replaced with the new version, which will be named in a manner reflecting the update (for example, ForestVeg_2007_v2.mdb).
- If the front-end database gets bigger and slower, compact it periodically by selecting Tools > Database Utilities > Compact and Repair Database.

Database Components

The working front-end application has the following functional components, which are accessed from the main application switchboard form that opens automatically when the application starts:

- Enter / edit data – Opens a form to confirm default settings (for example, park, coordinate datum) prior to continuing to the project-specific data entry screens.
- Site task list – Keeps track of unfinished tasks associated with sample locations (for example, forgotten equipment, unfinished data collection) that one field crew can use to communicate with a future field crew.
- Lookup tables – Opens a tool for managing the lookup values for the project data set (for example, species list, list of project personnel, etc.).
- QA checks – Opens the data validation tool, which shows the results of pre-built queries that check for data integrity, missing data, and illogical values, and allows the user to fix these problems and document the fixes. See SOP #3: Data Quality Review and Certification.
- View db window – Allows the user to view database objects (tables, queries, and forms).
- Back up data – Creates a date-stamped copy of the back-end database file.
- Connect data tables – Verifies the connection to the back-end working database file, and provides the option to redirect or update that connection.

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Protocol for Monitoring Fish Assemblages in Pacific Northwest National Parks

Standard Operating Procedure (SOP) #3: Data Quality Review and Certification

Revision History Log

Revision Date	Author	Changes Made	Reason for Change

Overview

This document describes the procedures for validation and certification of data in the working project database. Refer also to protocol narrative **Section 6C – Overview of Database Design**, **Section 6E – Quality Review**, and **Section 6G – Data Certification and Delivery** for related guidance and a clarification of the distinction between the working database and the master database.

After the season's field data have been entered and processed, they need to be reviewed and certified by the Project Lead for quality, completeness, and logical consistency. Data validation is the process of checking data for completeness, structural integrity, and logical consistency. The working database application facilitates this process by showing the results of pre-built queries that check for data integrity, data outliers, missing values, and illogical values. The user may then fix these problems and document the fixes.

Once the data have been through the validation process and metadata have been developed for them, they are to be certified by completing the NCCN Project Data Certification Form, available on the NCCN website. The completed form, certified data and updated metadata may then be delivered to the NPS Lead and the Data Manager according to the timeline in **Appendix 2: Yearly Project Task List**.

Data Quality Review

The following table shows the automated validation checks that are performed on the data prior to certification. These queries are designed to return records that need to be fixed, so ideally – once all data checks have been run and any errors have been fixed – none of the queries will return records. However, not all errors and inconsistencies can be fixed, in which case a description of the resulting errors and why edits were not made is then documented and included in the metadata and certification report.

The queries are named and numbered hierarchically so that high-order data – for example from tables on the parent side of a parent-child relationship such as sample locations – should be fixed before low-order data (for example, individual species observations). The rationale for this is that one change in a high-order table affects many downstream records, and so proceeding in this fashion is the most efficient way to isolate and treat errors.

Query name	Type	Returns records meeting the following criteria
qa_a113_Overview_sampling_visit_summary	information	Summary of the number of visits made for each location, grouped by location type and survey type
qa_a113_Overview_sampling_visit_summary	information	Summary of the number of visits made for each location, grouped by location type and survey type
qa_a123_Overview_locations_visited	information	Full list of sampling events
qa_a123_Overview_locations_visited	information	Full list of sampling events
qa_a133_Overview_monitoring_locations_visited	information	Subset showing only the reference reaches visited
qa_a133_Overview_monitoring_locations_visited	information	Subset showing only the reference reaches visited
qa_a203_Sampling_event_date_ranges	information	Returns the earliest and latest sample dates in the data set
qa_a203_Sampling_event_date_ranges	information	Returns the earliest and latest sample dates in the data set
qa_a213_Quality_assurance_status	information	Quality assurance status (i.e., unverified, verified, or updated) of all sampling events in the data set
qa_a213_Quality_assurance_status	information	Quality assurance status (i.e., unverified, verified, or updated) of all sampling events in the data set
qa_a902_Unverified_events	warning	List of unverified sampling events in the data set
qa_a902_Unverified_events	warning	List of unverified sampling events in the data set
qa_d101_Locations_missing_critical_info	critical	Missing park code, location code, location type, watershed name, or watercourse type
qa_d101_Locations_missing_critical_info	critical	Missing park code, location code, location type, watershed name, or watercourse type
qa_d111_Locations_park_inconsistencies	critical	Park code inconsistent with watersheds table - may be assigned to wrong watershed
qa_d111_Locations_park_inconsistencies	critical	Park code inconsistent with watersheds table - may be assigned to wrong watershed
qa_d121_Locations_duplicates_on_park_and_loc_code	critical	Duplicate records on park code and location code
qa_d121_Locations_duplicates_on_park_and_loc_code	critical	Duplicate records on park code and location code
qa_d132_Locations_duplicates_on_park_and_loc_name	warning	Duplicate records on park code and loc name
qa_d132_Locations_duplicates_on_park_and_loc_name	warning	Duplicate records on park code and loc name
qa_d152_Locations_missing_establishment_dates	warning	Sampled locations with loc type = 'reference' or non-blank discontinued dates, but without establishment dates
qa_d152_Locations_missing_establishment_dates	warning	Sampled locations with loc type = 'reference' or non-blank discontinued dates, but without establishment dates

Query name	Type	Returns records meeting the following criteria
qa_d162_Locations_status_inconsistencies	warning	Missing location status; sampled locs w/ status = 'rejected' or 'proposed'; locs w/ establishment dates and status = 'proposed'; 'retired' locs w/o discont. dates; discont. dates w/ status other than 'retired' or 'rejected'
qa_d162_Locations_status_inconsistencies	warning	Missing location status; sampled locs w/ status = 'rejected' or 'proposed'; locs w/ establishment dates and status = 'proposed'; 'retired' locs w/o discont. dates; discont. dates w/ status other than 'retired' or 'rejected'
qa_d172_Locations_info_inconsistencies	warning	Missing WRIA code, or the downstream kilometer bounding value is greater than the upstream value
qa_d172_Locations_info_inconsistencies	warning	Missing WRIA code, or the downstream kilometer bounding value is greater than the upstream value
qa_d203_Locations_without_coordinates	information	Sampled locations without coordinate records
qa_d203_Locations_without_coordinates	information	Sampled locations without coordinate records
qa_d243_Locations_missing_sampling_events	information	Unsampled locations
qa_d243_Locations_missing_sampling_events	information	Unsampled locations
qa_d901_Location_illogical_dates	critical	Updated date prior to created date, or discontinued date prior to established date
qa_d901_Location_illogical_dates	critical	Updated date prior to created date, or discontinued date prior to established date
qa_f101_Events_missing_critical_info	critical	Missing location ID, project code, or start date
qa_f101_Events_missing_critical_info	critical	Missing location ID, project code, or start date
qa_f111_Events_duplicates_on_location	critical	Duplicate event records on location ID
qa_f111_Events_duplicates_on_location	critical	Duplicate event records on location ID
qa_f132_Events_without_observers	warning	Events without associated observers
qa_f132_Events_without_observers	warning	Events without associated observers
qa_f163_Events_missing_declination	information	Sampling events with missing declination correction values
qa_f163_Events_missing_declination	information	Sampling events with missing declination correction values
qa_f203_Events_missing_QA_info	information	Event records without entered date/by entries, or incomplete updated date/by or verified date/by entries
qa_f203_Events_missing_QA_info	information	Event records without entered date/by entries, or incomplete updated date/by or verified date/by entries
qa_f222_Events_with_more_than_one_coord	warning	Events with more than one coordinate record - verify that these are intended
qa_f222_Events_with_more_than_one_coord	warning	Events with more than one coordinate record - verify that these are intended
qa_f302_Events_sample_cycle_inconsistencies	warning	Sample cycle or visit in cycle is blank for monitoring locations, or non-blank where loc type <> 'monitoring'
qa_f302_Events_sample_cycle_inconsistencies	warning	Sample cycle or visit in cycle is blank for monitoring locations, or non-blank where loc type <> 'monitoring'
qa_f303_Events_snorkel_data_summary	information	Monitoring locations that are missing data flags for tree data, DWM data, canopy cover or plot

Query name	Type	Returns records meeting the following criteria
		completion; or having these flags where loc type <> 'monitoring'
qa_f303_Events_snorkel_data_summary	information	Monitoring locations that are missing data flags for tree data, DWM data, canopy cover or plot completion; or having these flags where loc type <> 'monitoring'
qa_f901_Events_illogical_dates	critical	Events with end dates prior to start date, or updated or verified dates prior to the record entry date
qa_f901_Events_illogical_dates	critical	Events with end dates prior to start date, or updated or verified dates prior to the record entry date
qa_g101_Coordinates_missing_critical_values	critical	Records missing event ID or coord creation date
qa_g101_Coordinates_missing_critical_values	critical	Records missing event ID or coord creation date
qa_g122_Coordinates_missing_field_UTMs	warning	Field UTMs are missing
qa_g122_Coordinates_missing_field_UTMs	warning	Field UTMs are missing
qa_g131_Coordinates_incomplete_field_UTMs	critical	A portion of the field coordinate pair is missing, field datum or field coordinate source is missing, or only a portion of offset distance or azimuth is filled in
qa_g131_Coordinates_incomplete_field_UTMs	critical	A portion of the field coordinate pair is missing, field datum or field coordinate source is missing, or only a portion of offset distance or azimuth is filled in
qa_g142_Coordinates_duplicates_on_field_UTMs	warning	Returns instances where multiple records have the same exact final UTMs
qa_g142_Coordinates_duplicates_on_field_UTMs	warning	Returns instances where multiple records have the same exact final UTMs
qa_g152_Coordinates_missing_field_horiz_error	warning	Field horizontal error is missing
qa_g152_Coordinates_missing_field_horiz_error	warning	Field horizontal error is missing
qa_g191_Coordinates_inconsistent_field_source_info	critical	Field coordinate source = 'map', however there is a GPS file name, a field horizontal error, or GPS model filled in to suggest that the source is GPS
qa_g191_Coordinates_inconsistent_field_source_info	critical	Field coordinate source = 'map', however there is a GPS file name, a field horizontal error, or GPS model filled in to suggest that the source is GPS
qa_g202_Coordinates_incomplete_GPS_info	warning	Field coordinate source = 'GPS' but missing GPS model or GPS file name
qa_g202_Coordinates_incomplete_GPS_info	warning	Field coordinate source = 'GPS' but missing GPS model or GPS file name
qa_g901_Coordinates_illogical_dates	critical	Coordinates with updated dates before creation dates
qa_g901_Coordinates_illogical_dates	critical	Coordinates with updated dates before creation dates
qa_h101_Observers_missing_critical_info	critical	Missing event ID or contact ID
qa_h101_Observers_missing_critical_info	critical	Missing event ID or contact ID
qa_i101_Project_crew_missing_critical_info	critical	Missing contact ID, project code, last name, or first name
qa_i101_Project_crew_missing_critical_info	critical	Missing contact ID, project code, last name, or first name
qa_i112_Project_crew_missing_info	warning	Missing organization or position title
qa_i112_Project_crew_missing_info	warning	Missing organization or position title

Query name	Type	Returns records meeting the following criteria
qa_j101_Project_taxa_missing_or_illogical_info	critical	Missing taxon ID, project code, species code, category, record status, or both scientific and common name; or updated date prior to created date
qa_j101_Project_taxa_missing_or_illogical_info	critical	Missing taxon ID, project code, species code, category, record status, or both scientific and common name; or updated date prior to created date
qa_j111_Project_taxa_duplicate_sci_name	critical	Duplicates on scientific name
qa_j111_Project_taxa_duplicate_sci_name	critical	Duplicates on scientific name
qa_j121_Project_taxa_duplicate_species_code	critical	Duplicates on species code
qa_j121_Project_taxa_duplicate_species_code	critical	Duplicates on species code
qa_j131_Project_taxa_duplicate_TSN	critical	Duplicates on TSN
qa_j131_Project_taxa_duplicate_TSN	critical	Duplicates on TSN
qa_j202_Project_taxa_without_park_records	warning	Lookup taxa (excluding temporary and grouped taxa) that do not have an associated park record
qa_j202_Project_taxa_without_park_records	warning	Lookup taxa (excluding temporary and grouped taxa) that do not have an associated park record
qa_j211_Park_taxa_missing_or_illogical_info	critical	Missing taxon ID, park code, park status, park origin, or record status; or updated date prior to created date
qa_j211_Park_taxa_missing_or_illogical_info	critical	Missing taxon ID, park code, park status, park origin, or record status; or updated date prior to created date
qa_l101_Images_missing_critical_info	critical	Missing image ID or event ID
qa_l101_Images_missing_critical_info	critical	Missing image ID or event ID
qa_l113_Locations_wo_images	information	Sampling locations with no images
qa_l113_Locations_wo_images	information	Sampling locations with no images
qa_l122_Images_missing_values	warning	Image records missing both image label and image description, or frame number, or image filename
qa_l122_Images_missing_values	warning	Image records missing both image label and image description, or frame number, or image filename
qa_n101_Task_list_missing_critical_info	critical	Missing task description, request date, or status; or the completed date is before the request date; or the completed date is filled in but the status is not 'complete'
qa_n101_Task_list_missing_critical_info	critical	Missing task description, request date, or status; or the completed date is before the request date; or the completed date is filled in but the status is not 'complete'
qa_n113_Task_list_summary	information	Summary of task list items
qa_n113_Task_list_summary	information	Summary of task list items
qa_p103_Snorkel_summary_data	information	Summary of snorkel survey data by location, date and observer
qa_p103_Snorkel_summary_data	information	Summary of snorkel survey data by location, date and observer
qa_p121_Snorkel_data_missing_critical_info	critical	Missing event ID, river section, observer, taxon, fork length code, or tally; or the taxon is not in the species lookup table or is not an active taxon
qa_p121_Snorkel_data_missing_critical_info	critical	Missing event ID, river section, observer, taxon, fork length code, or tally; or the taxon is not in the species lookup table or is not an active taxon

Query name	Type	Returns records meeting the following criteria
qa_p132_Snorkel_data_duplicate_taxon_obs	warning	Duplicate records for event, river section, observer, fork length category, and taxon
qa_p132_Snorkel_data_duplicate_taxon_obs	warning	Duplicate records for event, river section, observer, fork length category, and taxon
qa_p142_Snorkel_data_values_not_in_lookup	warning	Observer name is not in the project crew lookup table, or the fork length category is not in the lookup table
qa_p142_Snorkel_data_values_not_in_lookup	warning	Observer name is not in the project crew lookup table, or the fork length category is not in the lookup table
qa_p153_Snorkel_data_maximum_tally	information	Maximum tally of individuals observed at once during snorkel surveys
qa_p153_Snorkel_data_maximum_tally	information	Maximum tally of individuals observed at once during snorkel surveys
qa_x101_Target_coord_errors	critical	For GIS review - target coordinates with incomplete UTMs, missing datum, or illogical created/updated dates
qa_x101_Target_coord_errors	critical	For GIS review - target coordinates with incomplete UTMs, missing datum, or illogical created/updated dates
qa_x112_Locations_without_target_coords	warning	For GIS review - locations missing target coordinate records
qa_x112_Locations_without_target_coords	warning	For GIS review - locations missing target coordinate records
qa_x203_Coordinates_distance_from_target	information	For GIS review - distance of field coordinates from target UTMs by sampling location
qa_x203_Coordinates_distance_from_target	information	For GIS review - distance of field coordinates from target UTMs by sampling location
qa_x902_Locations_no_best_coord_assigned	warning	For GIS review - locations without best coordinates
qa_x902_Locations_no_best_coord_assigned	warning	For GIS review - locations without best coordinates
qa_x912_Coordinates_without_final_coords	warning	For GIS review - records missing final UTMs that incorporate post-processing and offsets
qa_x912_Coordinates_without_final_coords	warning	For GIS review - records missing final UTMs that incorporate post-processing and offsets
qa_x922_Locations_without_public_coords	warning	For GIS review - locations missing public coordinates
qa_x922_Locations_without_public_coords	warning	For GIS review - locations missing public coordinates
qa_x931_Coordinates_final_UTM_inconsistencies	critical	Final UTM coordinates are incomplete; or they are present and the coordinate type or datum is missing; or coord type or an estimated error value is present and the final coordinates are missing
qa_x931_Coordinates_final_UTM_inconsistencies	critical	Final UTM coordinates are incomplete; or they are present and the coordinate type or datum is missing; or coord type or an estimated error value is present and the final coordinates are missing
qa_x941_Coordinates_public_UTM_inconsistencies	critical	Public UTM coordinates are incomplete; or they are present and the public offset is missing; or public offset is present and the public coordinates are missing
qa_x941_Coordinates_public_UTM_inconsistencies	critical	Public UTM coordinates are incomplete; or they are present and the public offset is missing; or public offset is present and the public coordinates are missing
qa_x942_Coordinates_duplicates_on_final_UTMs	warning	Returns instances where multiple records have the

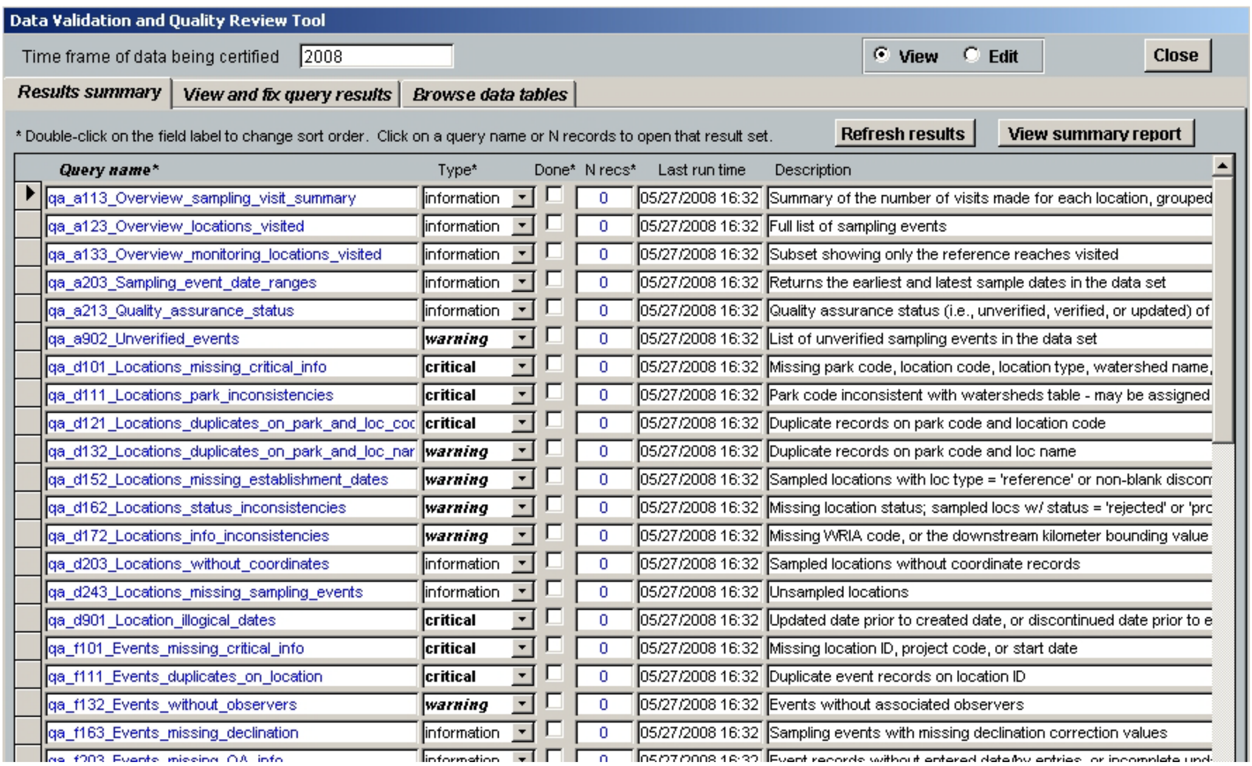
Query name	Type	Returns records meeting the following criteria
		same exact final UTMs
qa_x942_Coordinates_duplicates_on_final_UTMs	warning	Returns instances where multiple records have the same exact final UTMs

In addition to these automated checks, the person performing the quality review should remain vigilant for errors or omissions that may not be caught by the automated queries. Another task that cannot be automated is the process of making sure that all of the data for the current season are in fact entered into the database. This will often involve manual comparisons between field forms or other lists of the sites visited and the results of queries showing the sites for which data exist. The Data Manager also is available as needed to help construct new database queries or modify existing ones as needed.

Using the Database Quality Review Tools

Open the working copy of the database application and hit the button labeled “QA Checks”. This will open the quality review form. Upon opening, the quality review form automatically runs the validation queries and stores the results in a table built into the front-end database (tbl_QA_Results). Each time the queries results are refreshed, or the quality review form is re-opened, the number of records returned and the run times are rewritten so that the most recent result set is always available; any remedy description and the user name for the person making the edits is retained between runs of the queries. These results form the basis of documentation in the certification report output as shown below.

The first page of the quality review form has a results summary showing each query sorted by name, the number of records returned by the query, the most recent run time, and the description. There is also a button for refreshing the results, which may need to be done periodically as changes in one part of the data structure may change the number of records returned by other queries.


Data Validation and Quality Review Tool

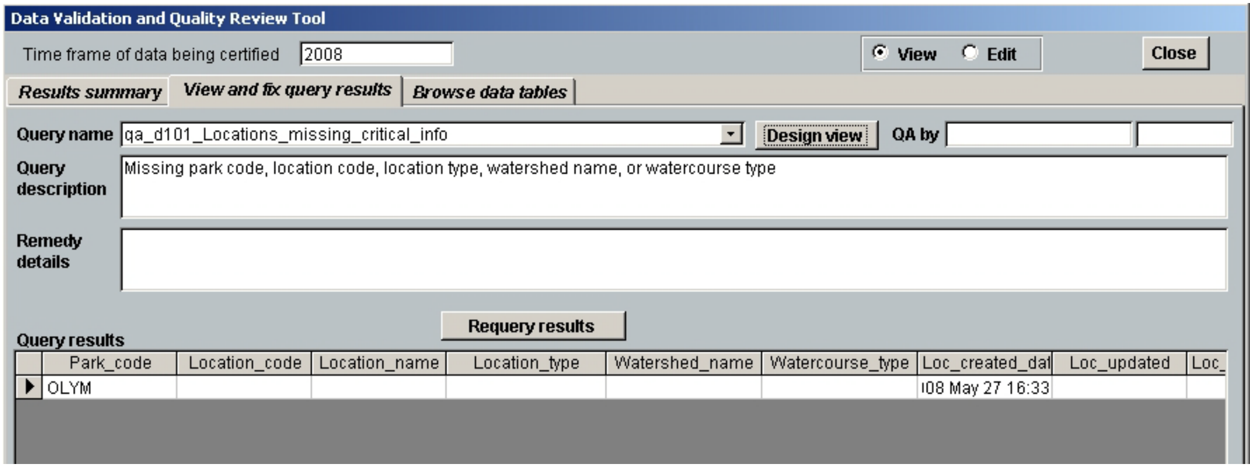
Time frame of data being certified 2008 | View | Edit | Close

Results summary | View and fix query results | Browse data tables

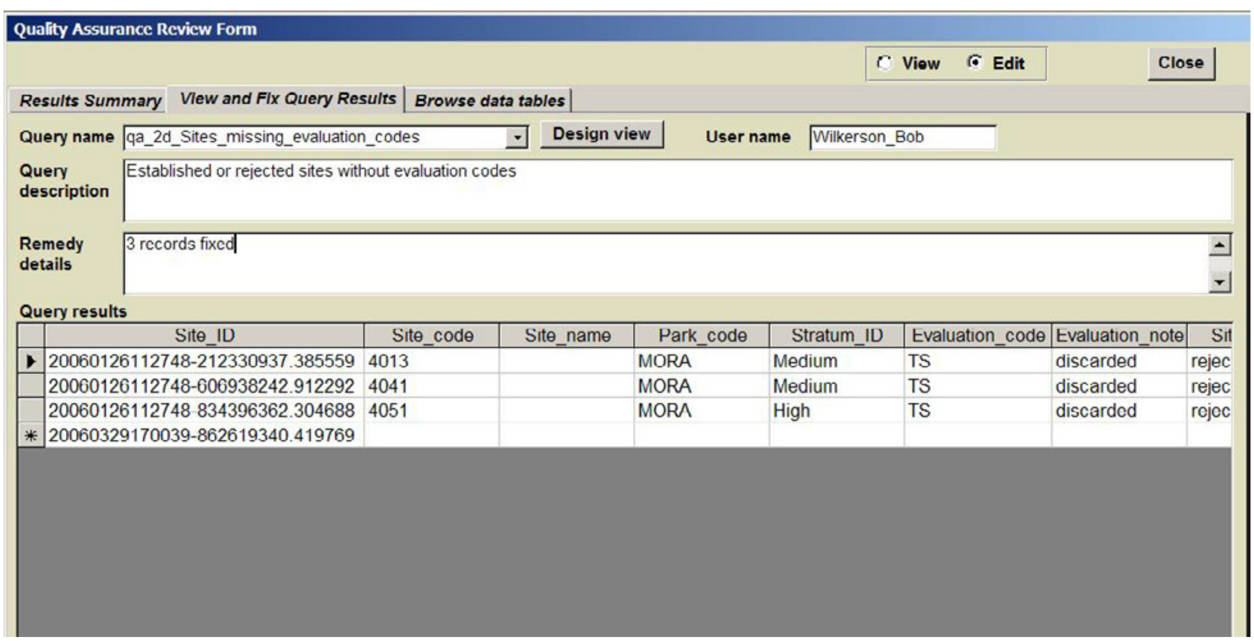
* Double-click on the field label to change sort order. Click on a query name or N records to open that result set. | Refresh results | View summary report

Query name*	Type*	Done*	N recs*	Last run time	Description
qa_a113_Overview_sampling_visit_summary	information		0	05/27/2008 16:32	Summary of the number of visits made for each location, grouped
qa_a123_Overview_locations_visited	information		0	05/27/2008 16:32	Full list of sampling events
qa_a133_Overview_monitoring_locations_visited	information		0	05/27/2008 16:32	Subset showing only the reference reaches visited
qa_a203_Sampling_event_date_ranges	information		0	05/27/2008 16:32	Returns the earliest and latest sample dates in the data set
qa_a213_Quality_assurance_status	information		0	05/27/2008 16:32	Quality assurance status (i.e., unverified, verified, or updated) of
qa_a902_Unverified_events	warning		0	05/27/2008 16:32	List of unverified sampling events in the data set
qa_d101_Locations_missing_critical_info	critical		0	05/27/2008 16:32	Missing park code, location code, location type, watershed name,
qa_d111_Locations_park_inconsistencies	critical		0	05/27/2008 16:32	Park code inconsistent with watersheds table - may be assigned
qa_d121_Locations_duplicates_on_park_and_loc_coc	critical		0	05/27/2008 16:32	Duplicate records on park code and location code
qa_d132_Locations_duplicates_on_park_and_loc_nar	warning		0	05/27/2008 16:32	Duplicate records on park code and loc name
qa_d152_Locations_missing_establishment_dates	warning		0	05/27/2008 16:32	Sampled locations with loc type = 'reference' or non-blank discon
qa_d162_Locations_status_inconsistencies	warning		0	05/27/2008 16:32	Missing location status; sampled locs w/ status = 'rejected' or 'pro
qa_d172_Locations_info_inconsistencies	warning		0	05/27/2008 16:32	Missing WRIA code, or the downstream kilometer bounding value
qa_d203_Locations_without_coordinates	information		0	05/27/2008 16:32	Sampled locations without coordinate records
qa_d243_Locations_missing_sampling_events	information		0	05/27/2008 16:32	Unsampled locations
qa_d901_Location_illogical_dates	critical		0	05/27/2008 16:32	Updated date prior to created date, or discontinued date prior to e
qa_f101_Events_missing_critical_info	critical		0	05/27/2008 16:32	Missing location ID, project code, or start date
qa_f111_Events_duplicates_on_location	critical		0	05/27/2008 16:32	Duplicate event records on location ID
qa_f132_Events_without_observers	warning		0	05/27/2008 16:32	Events without associated observers
qa_f163_Events_missing_declination	information		0	05/27/2008 16:32	Sampling events with missing declination correction values
qa_f203_Events_missing_QA_info	information		0	05/27/2008 16:32	Event records without entered date/by entries, or incomplete upd

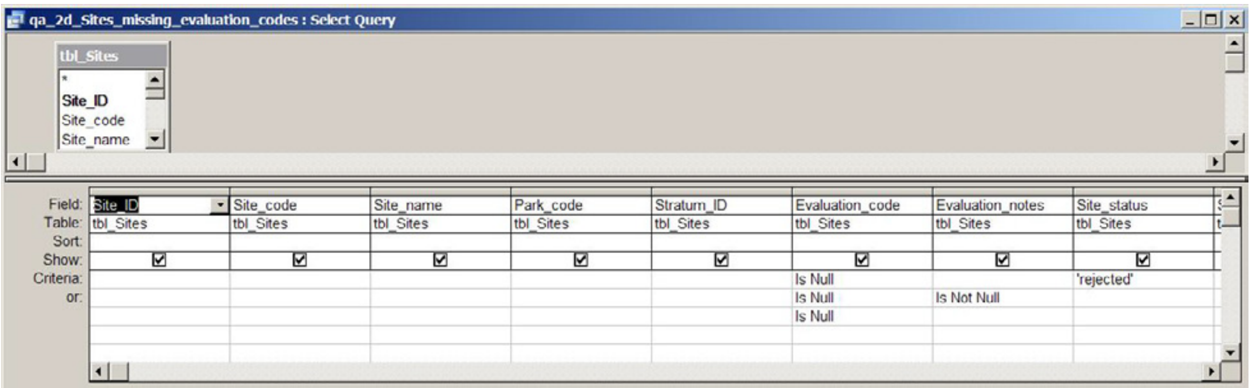
Upon double-clicking a particular query name, the second page will open up to show the results from that query.



In the upper-right is a switch that allows the user to put the form in either view mode (default) or edit mode. Upon changing to edit mode, the form changes color to provide a visual reminder that edits are possible. At this point the query results may be modified and the remedy details may be entered in the appropriate place. If certain records in a query result set are not to be fixed for whatever reason, this is also the place to document that. The user name is automatically filled in (if it was blank) once the user types in the remedy details.



The button labeled “Design view” also on this page will open the currently selected query in the design interface in Access. In this manner, the user can verify that the query is in fact filtering records appropriately. Note: Any desired changes to query structure or names should be discussed with the Data Manager prior to making these changes.



Certain queries, due to their structural complexity, cannot be edited directly. Other queries may not contain all of the fields the user may want to see in order to make the best decision about whether and how to edit a given record. In such cases, the user may opt to view and/or edit data directly in the data tables. To facilitate this process, the “Browse Data Tables” page on the form can be used to open the table directly for viewing and editing as needed.

Important: As with all edits performed during the quality review, these types of direct edits in the data tables should be made with extreme care as the validation checks that are built into the front-end data entry forms are not present in the tables themselves. It is possible, therefore, to make edits to the tables that may result in a loss of data integrity and quality. While the automated queries are intended to check for these, it is not possible to check for every possible error combination.

Note: Whenever making quality review edits – whether through a query or directly in a table – the user should remember to update the Updated_date and Updated_by fields to the current date and the current user name.

Generating Output for the Certification Report

The first page of the quality review form has a button labeled “View summary report”. This button opens the formatted information for each query, the last run time, the number of records returned at last run time, a description and any remedy details that were typed in by the user. This report can be exported from the database and included as an attachment to the certification report by either hitting File > Export on the Access menu, or by right clicking on the report object and selecting Export. Select ‘Rich Text Format (*.rtf)’ to retain formatting to facilitate importing it into the certification report in Word.

Quality Assurance and Data Validation Results Data season year/range 2008 Report run time 05/27/2008 16:34

	Query name	Type	N Records	Query description	Remedy details	QA by
1	qa_a113_Overview_sampling_visit_summary	information	0	Summary of the number of visits made for each location, grouped by location type and survey type		
2	qa_a123_Overview_locations_visited	information	0	Full list of sampling events		
3	qa_a133_Overview_monitoring_locations_visite	information	0	Subset showing only the reference reaches visited		
4	qa_a203_Sampling_event_date_ranges	information	0	Returns the earliest and latest sample dates in the data set		
5	qa_a213_Quality_assurance_status	information	0	Quality assurance status (i.e., unverified, verified, or updated) of all sampling events in the data set		
6	qa_a902_Unverified_events	warning	0	List of unverified sampling events in the data set		
7	qa_d101_Locations_missing_critical_info	critical	0	Missing park code, location code, location type, watershed name, or watercourse type		
8	qa_d111_Locations_park_inconsistencies	critical	0	Park code inconsistent with watersheds table - may be assigned to wrong watershed		
9	qa_d121_Locations_duplicates_on_park_and_lo	critical	0	Duplicate records on park code and location code		
10	qa_d132_Locations_duplicates_on_park_and_lo	warning	0	Duplicate records on park code and loc name		
11	qa_d152_Locations_missing_establishment_date	warning	0	Sampled locations with loc type = 'reference' or non-blank discontinued dates, but without establishment dates		
12	qa_d162_Locations_status_inconsistencies	warning	0	Missing location status; sampled locs w/ status = 'rejected' or 'proposed'; locs w/ establishment dates and status = 'proposed'; 'retired' locs w/o discont. dates; discont. dates w/ status other than 'retired' or 'rejected'		
13	qa_d172_Locations_info_inconsistencies	warning	0	Missing WRIA code, or the downstream kilometer bounding value is greater than the upstream value		
14	qa_d203_Locations_without_coordinates	information	0	Sampled locations without coordinate records		
15	qa_d243_Locations_missing_sampling_events	information	0	Unsampled locations		

Tuesday, May 27, 2008 Page 1 of 4

Completing Data Certification

Data certification is a benchmark in the project information management process that indicates that: (1) data are complete for the period of record; (2) they have undergone and passed the quality assurance checks; and (3) they are appropriately documented and in a condition for archiving, posting, and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies that may or may not have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. The Project Lead is primarily responsible for completing a NCCN Project Data Certification Form, available on the NCCN website. This brief form and the certified data should be submitted according to the timeline in **Appendix H: Yearly Project Task List**. Refer to the product delivery schedule in **Section 6J - Product Delivery, Posting, and Distribution** for delivery instructions.

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Appendix A. Photographs of Fish Species Commonly Observed in NCCN Rivers.

Photographs by Ernest Keeley used with permission.

A. Cutthroat trout (OLYM files).

B. Bull trout (photo credit: Jason Dunham, USGS, Corvallis)

C. Sockeye salmon (photo credit: Ernest Keeley)

D. Coho salmon (photo credit: Ernest Keeley).

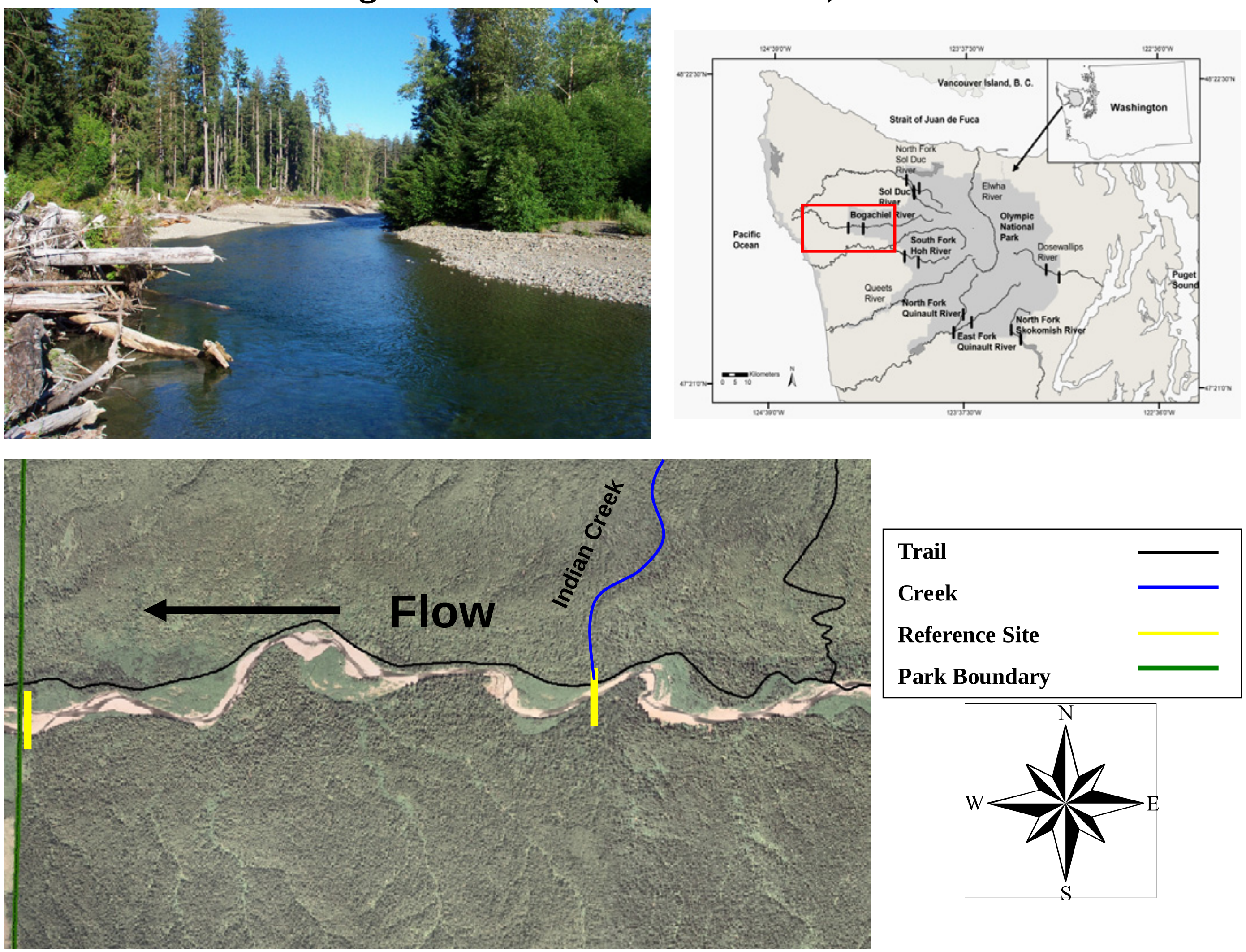
E. Summer steelhead trout (photo credit: Ernest Keeley)

F. Chinook salmon (photo credit: Ernest Keeley)

G. Mountain whitefish (photo credit: Ernest Keeley)

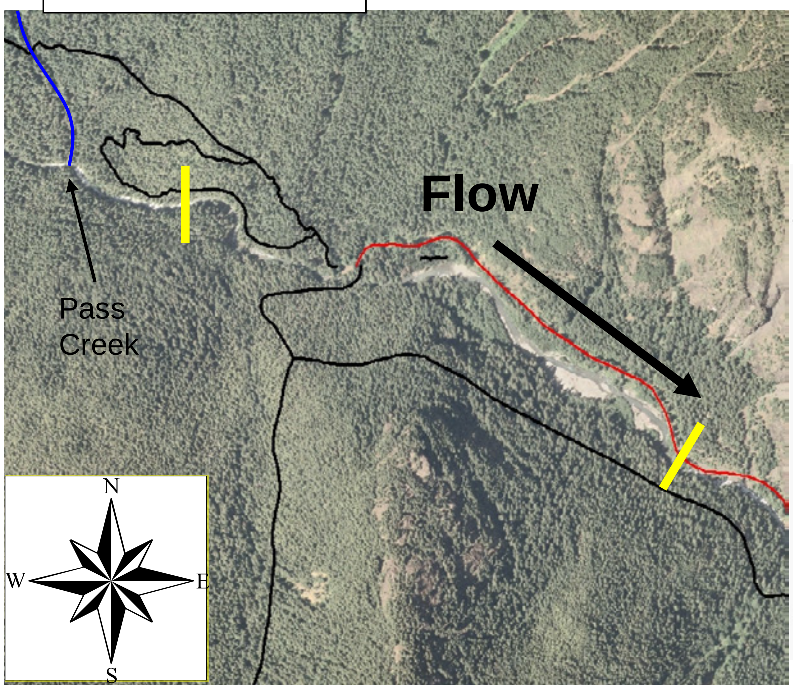
Appendix B. Photographs and Locations of Reference Sites for the Eight Rivers in the Olympic National Park.

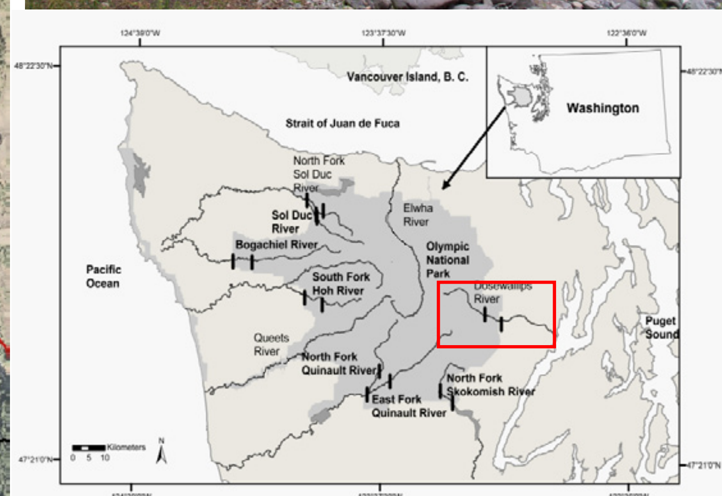
Bogachiel River (rkm 40.5-35.6)



Dosewallips River (rkm 25.9 – 23.5)

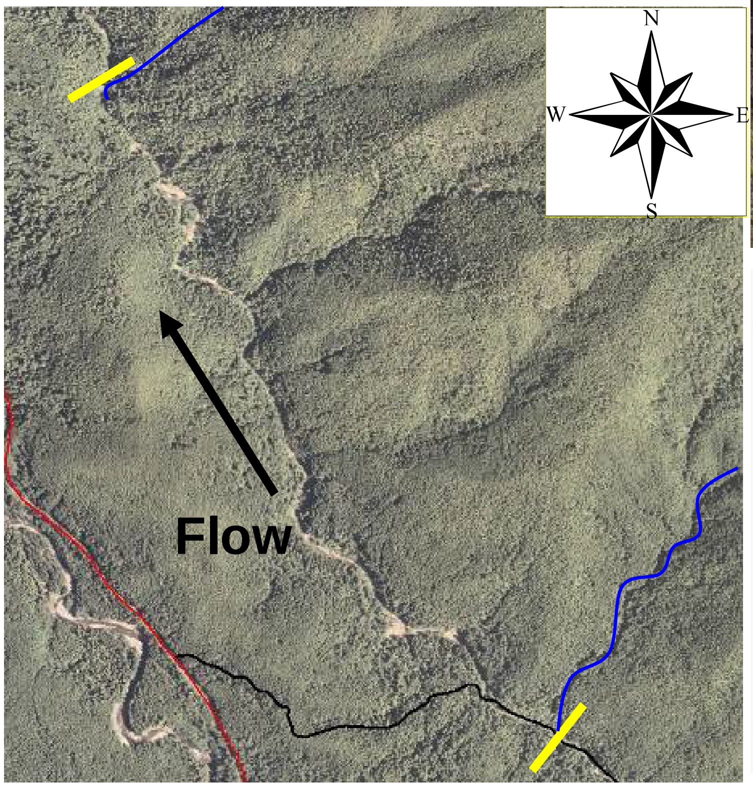
Trail	
Road	
Creek	
Reference Site	

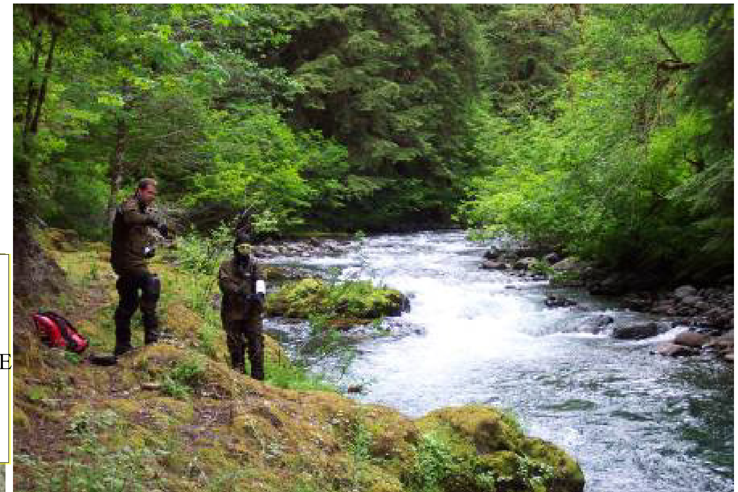


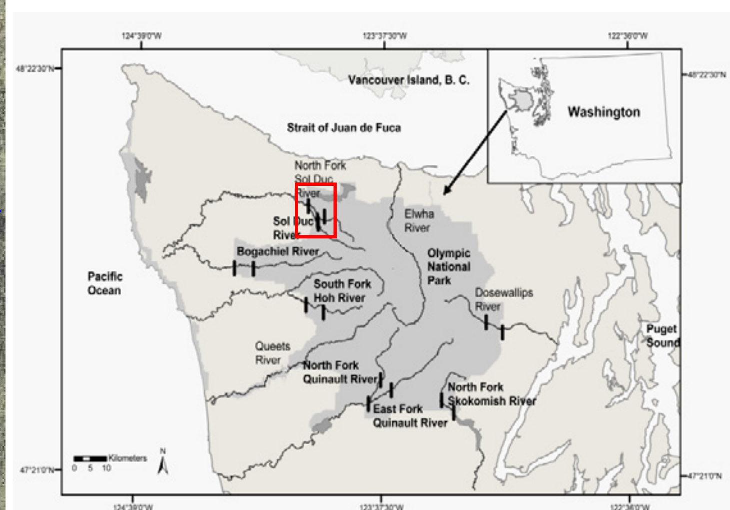


North Fork Sol Duc River (rkm 7.1 – 3.6)

Trail/Road	red line
Unnamed Creek	blue line
Reference Site	yellow line

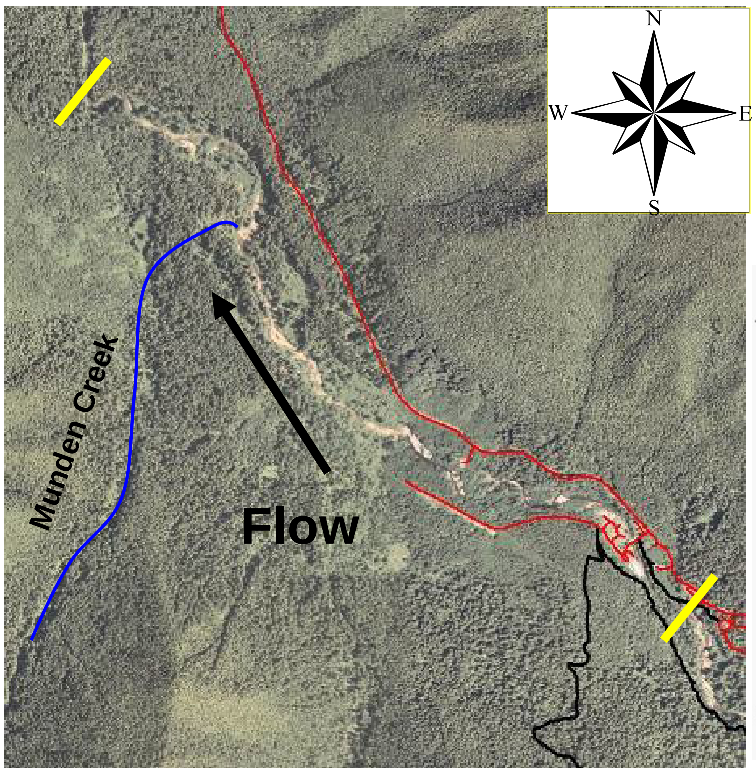


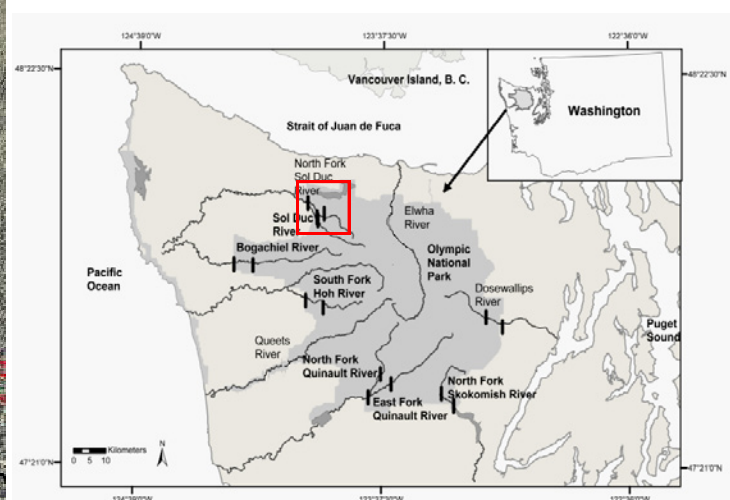




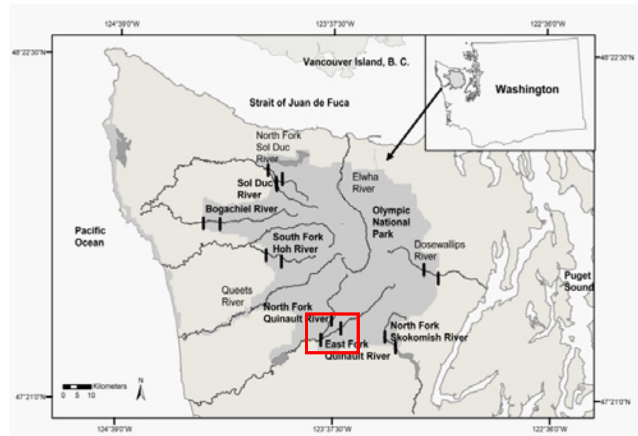
Sol Duc River (rkm 101.6 – 97.2)

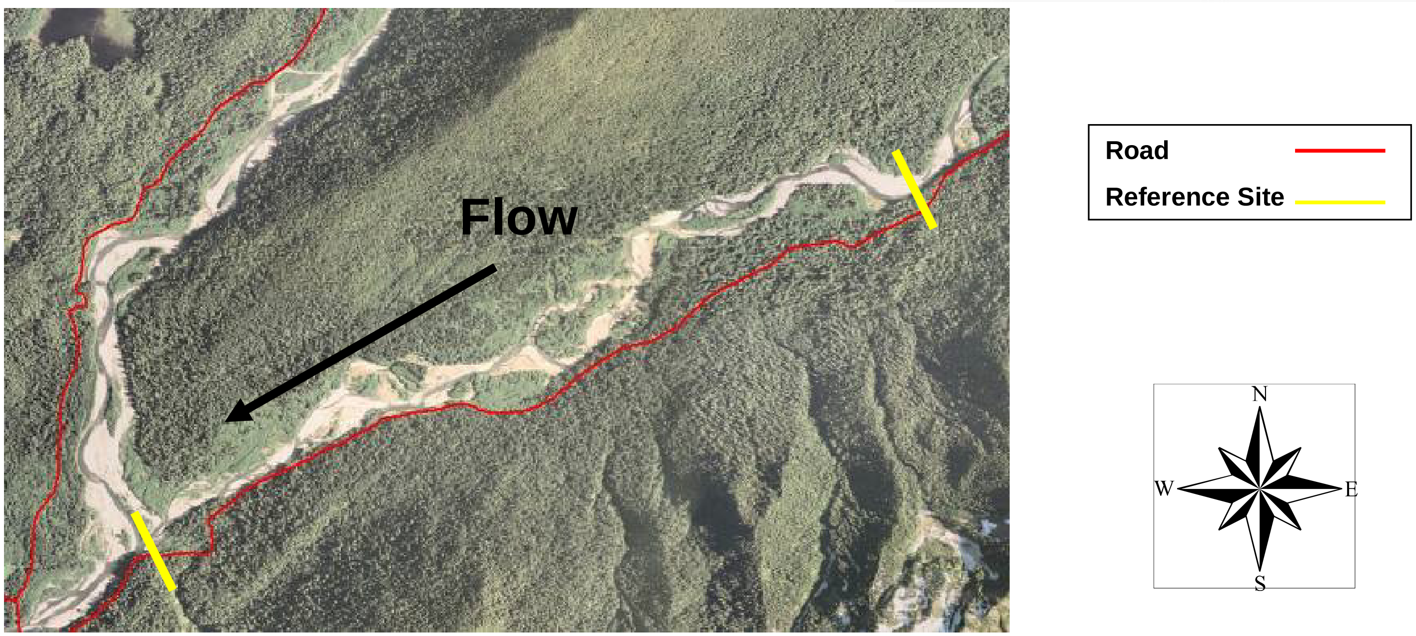
Trail/Road	red line
Reference Site	yellow line
Creek	blue line





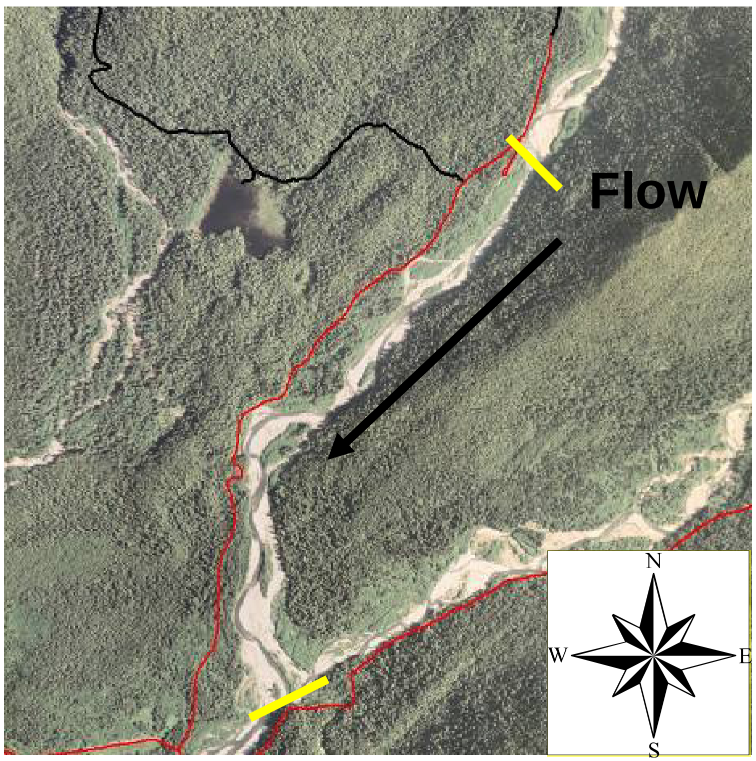
East Fork Quinault River (rkm 82.6 – 76.9)

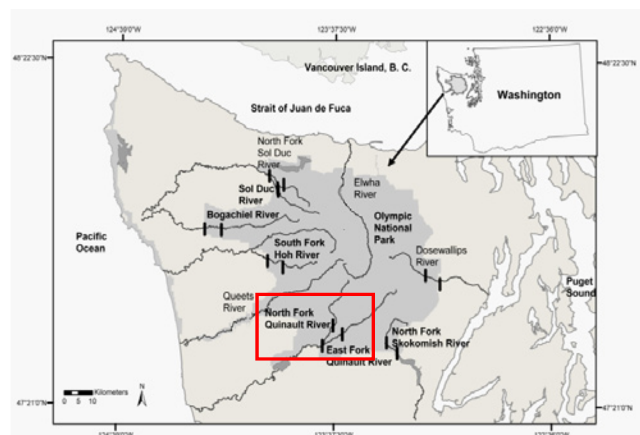


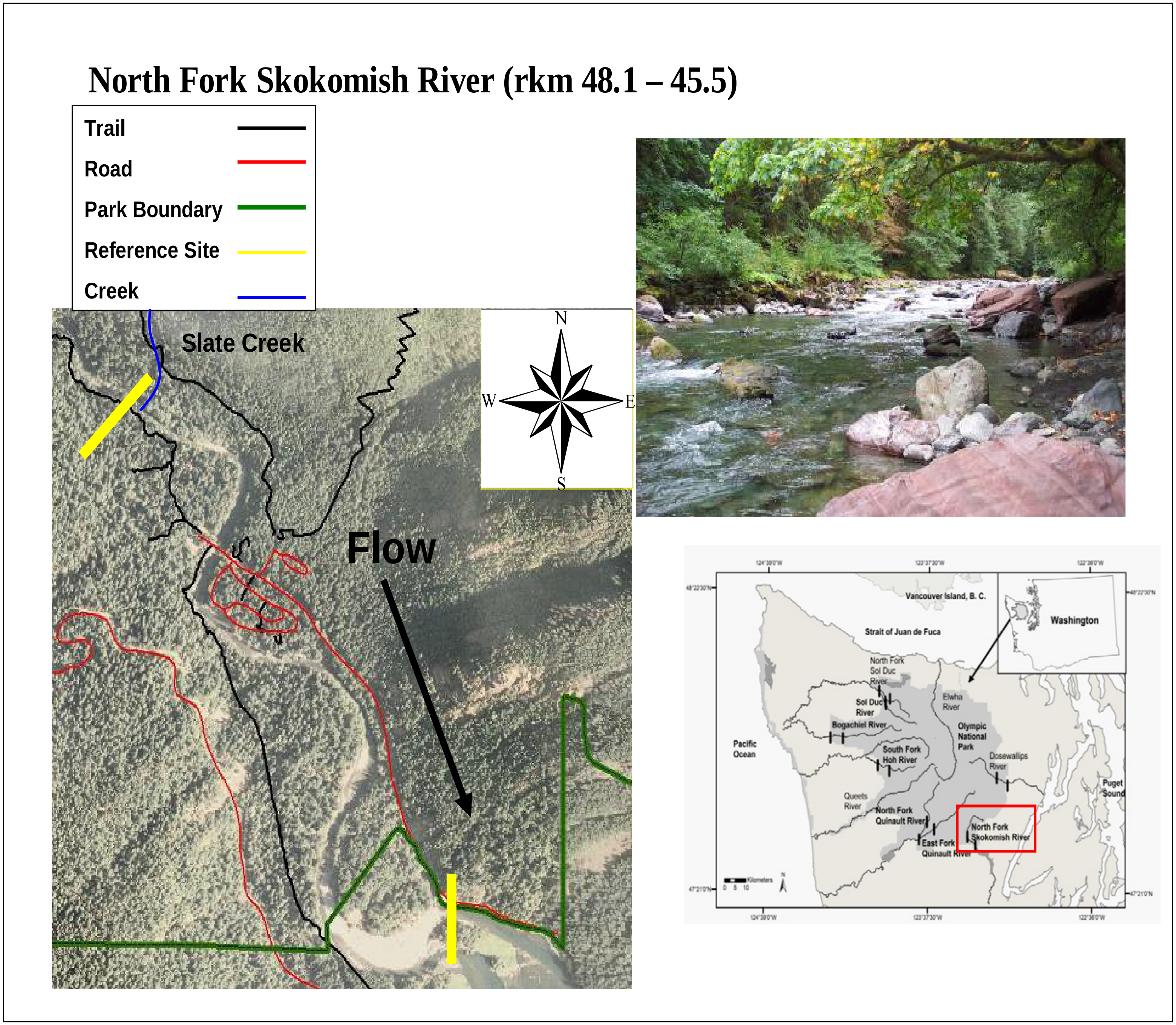


North Fork Quinault River (rkm 4.4 – 0.0)

Trail	(black line)
Road	(red line)
Reference Site	(yellow line)

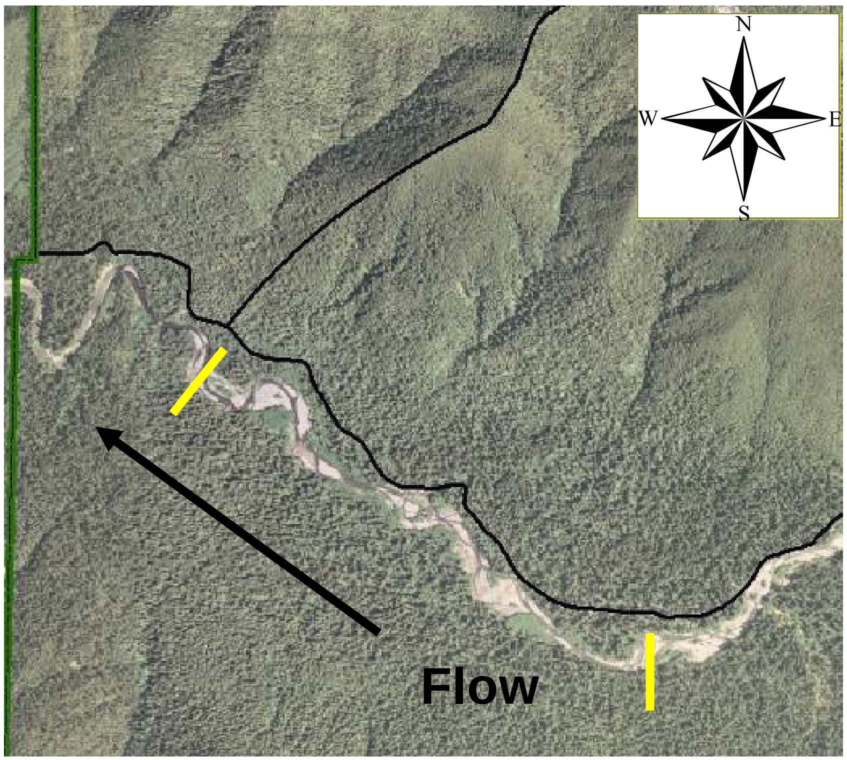


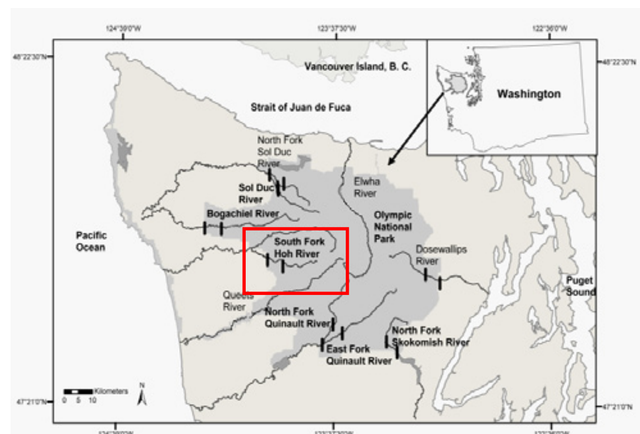



North Fork Skokomish River (rkm 48.1 – 45.5)
Trail
Road
Park Boundary
Reference Site
Creek
Slate Creek
Flow
N
W
E
S
Vancouver Island, B. C.
Washington
Strait of Juan de Fuca
North Fork Sol Duc River
Sol Duc River
Bogachiel River
Elwha River
Olympic National Park
Pacific Ocean
South Fork Hoh River
Dosewallips River
Queets River
North Fork Quinault River
East Fork Quinault River
North Fork Skokomish River
Puget Sound
Kilometers
0 5 10

South Fork Hoh River (rkm 48.1–45.5)

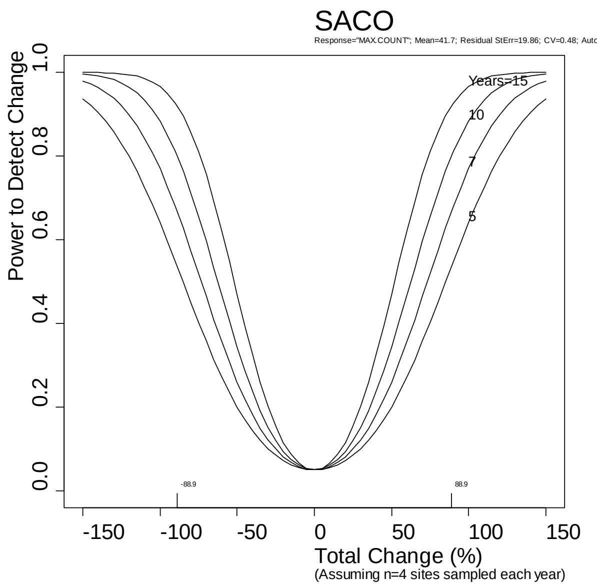
Trail	
Reference Site	
Park Boundary	



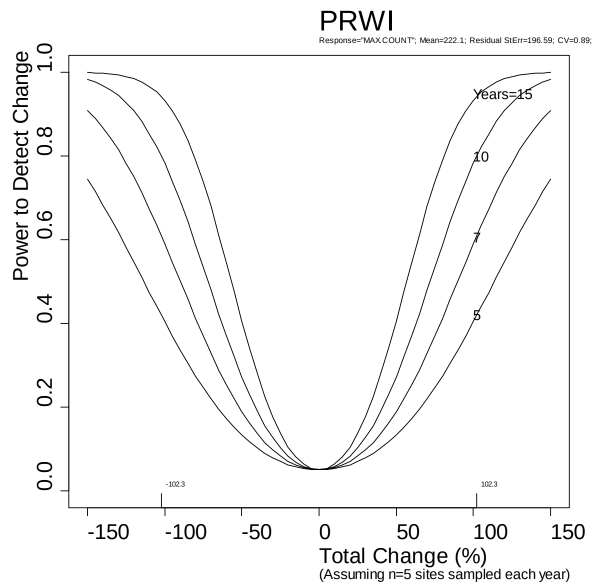


Appendix C. Power to Detect *Regional* Trends in Run Size Using the Maximum Count After T=5, 7, 10, and 15 Years of Multiple Annual Snorkel Surveys in Each of n=5 Rivers.

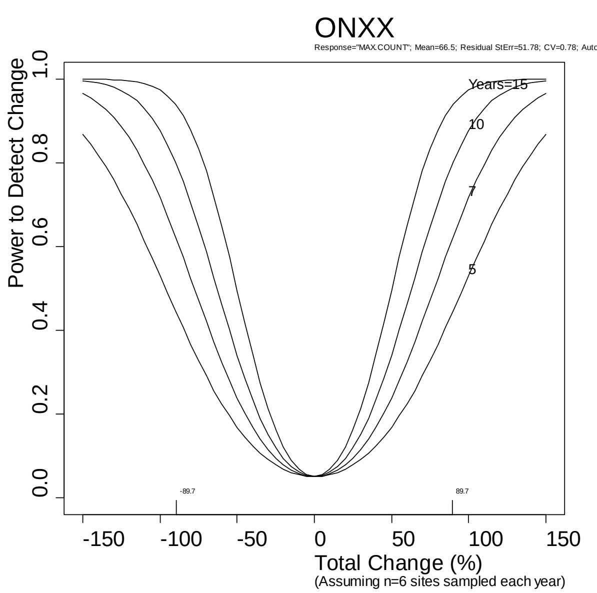
SACO, bull trout; PRWI, mountain whitefish; ONXX, cutthroat/rainbow trout; ONTS, Chinook salmon. Total percent change=(run size year 1 – run size year *T*)/(run size year 1). Equivalent annual percent changes are total percent change / *T*. Tick marks along the bottom axis in the plot area delineate the percent change detectable with 80 percent power after 10 years. Adopted from McDonald (2006).



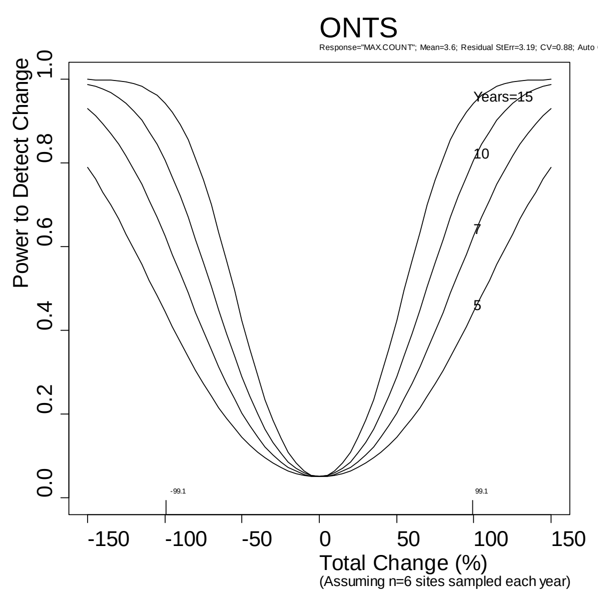
East Fork Quinault, North Fork Quinault, North Fork Skokomish, and South Fork Hoh Rivers.



Bogachiel, East Fork Quinault, North Fork Quinault, North Fork Skokomish, and South Fork Hoh Rivers.

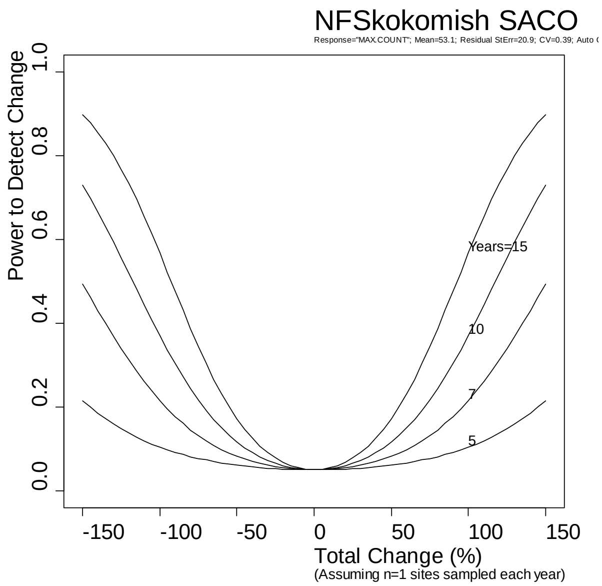


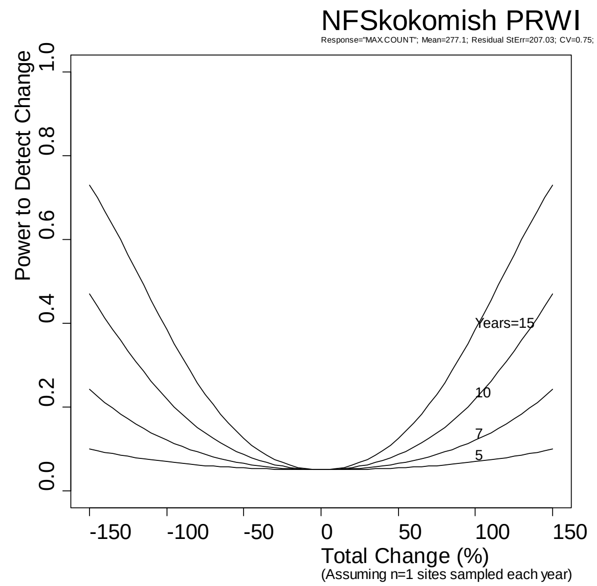
Bogachiel, East Fork Quinault, North Fork Quinault, North Fork Skokomish, Sol Duc, and South Fork Hoh Rivers.

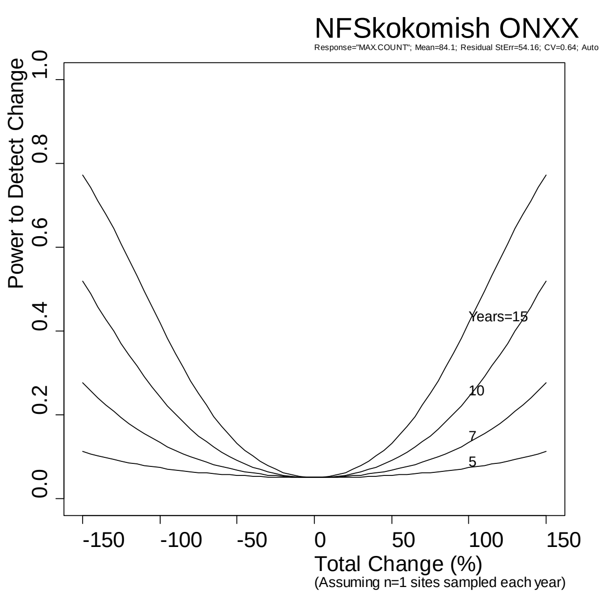


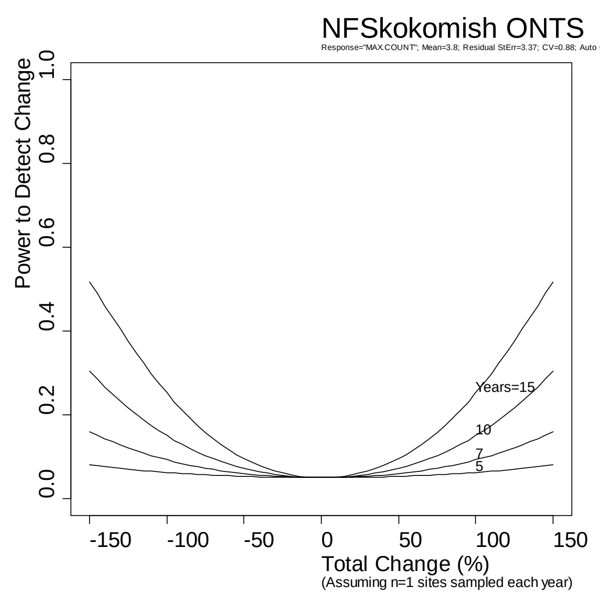
Appendix D. Power to Detect Trends on *Individual* Rivers in Run Size Using the Maximum Count After T=5, 7, 10, and 15 Years of Multiple Annual Snorkel Surveys in a Single River.

SACO, bull trout; PRWI, mountain whitefish; ONXX, cutthroat/rainbow trout; ONTS, Chinook salmon. Single river is the North Fork Skokomish River. Total percent change = (run size year 1 – run size year T)/(run size year 1). Equivalent annual percent changes are total percent change / T. Tick marks along the bottom axis in the plot area delineate the percent change detectable with 80 percent power after 10 years. Adopted from McDonald (2006).









Appendix E. Example of Snorkel Data Form Used in River Surveys.

Olympic National Park Snorkel Survey Form

River /Creek:_________________________ **Species:** ___________ **Date:** ____/_____

WRIA #: __ __. __ __ __ __ Time of Survey: Begin _______ End _______

Survey Type: Index Supl. Other:________ Observer/s & Agency: _____________________

Flow: LOW MOD. LOW MOD. MOD. HIGH HIGH Water Temp (C^{o}) = ______at ______

Water Visibility: EXC. V. GD. GOOD FAIR POOR

Location (river mile): _________ to ____________

Comments

Summary

Species	Mean FL (mm)	Fork Length Range	Species Count

FISH COUNTS AND ESTIMATED LENGTHS

	DIVER _______						DIVER _______					
Sectio (RM X -	Sp	< 5 (<	5 – (2	15 – (6 -	30 – (12 -	> 5 (>	Sp	< 5 (<	5 – (2	15 – (6 -	30 – (12 -	> 5 (>

Species Codes

ONK	Coho salmo	O	Unidentified salr	C	Sculpin spp		
ONTS	Chinook salm	S	Bull trout	CA	Longnose suc		
ONMY	Rainbow/Stealh	S	Brook trout	Rl	Longnose da		
ONN	Sockeye/Koka	R	Speckled dac				
ONG	Pink salmor	CA	Largescale suc				
PRW	Mountain white	L	River lampre				
ONCl	Cutthroat tro	L	Pacific lampr				
ONKl	Chum salmo	L	Brook lampr				

Appendix F. Example of Electrofishing Data Form Used in River and Stream Surveys.

Page ____ of _____

Olympic National Park Electrofishing Survey Form

River /Creek:__________________________ **Species:** ___________ **Date:** ____/_____/____

WRIA #: __ __. __ __ __ __ Time of Survey: Begin _______ End _______

Survey Type: Index Supl. Other:________ Observer/s & Agency: ______________________

Survey Method: Walk Snorkel Air Boat Elect. Other: __________

Flow: LOW MOD. LOW MOD. MOD. HIGH HIGH Water Temp (C^o) = ______at ______

Water Visibility: EXC. V. GD. GOOD FAIR POOR

Location (river mile): _________ to ____________

Shocker Settings and Information

Shocker Setting: _________________

Voltage Range: ________________

Time Counter Beginning: __________

Time Counter Ending: ___________

Conductivity (ms/cm): _____________

Summary

Species	Mean FL (mm)	Length Range	Species Count

Species	Fork Length (mm)	Weight (g)	Species	Fork Length (mm)	Weight (g)	Comments

Species Codes

ONKI	Coho salmon	ONXX	Unidentified salmonid	CACA	Longnose sucker	ONCL	Cutthroat trout
ONTS	Chinook salmon	SACO	Bull trout	RHOS	Speckled dace	ONKE	Chum salmon
ONMY	Rainbow/Stealhead	SAFO	Brook trout	RHCA	Longnose dace		
ONNE	Sockeye/Kokanee	SAMA	Dolly Varden	LARI	Brook lamprey		
ONGO	Pink salmon	COXX	Sculpin spp.	LAAY	River Lamprey		
PRWI	Mountain whitefish	RIBA	Redside Shiner	LATR	Pacific Lamprey		

Appendix G. Existing Section 10A1a Permit Issued by NOAA Fisheries (cover letter) for Sampling in MORA That Is Valid Through December 31, 2011.

UNITED STATE DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, Oregon 97232-1274

November 29, 2006 F/NWR3

Mr. Steve Corbett
U.S. National Park Service, Olympic National Park
600 East Park Avenue
Port Angeles, Washington 98362

Re: Permit 1565

Dear Mr. Corbett:

Enclosed is Scientific Research Permit 1565 issued to the U.S. National Park Service, Olympic National Park (ONP) under the authority of Section 10(a)(1)(A) of the Endangered Species Act. The permit authorizes the ONP to annually take listed salmonids while conducting Mt. Rainier National Park Inventory and Monitoring Program.

The National Marine Fisheries Service (NMFS) requires that the individuals acting under the authority of Permit 1565 review the permit before engaging in the permitted activities. Please sign and date the last page then fax a copy of it (or mail a photocopy) to our office to the attention of Gary Rule. Our fax number is (503) 230-5441. Please note that you are not authorized to conduct activities under Permit 1565 until our office receives a signed copy of the signature page.

Your attention is directed to Section B(19) and the attached annual report form that describe annual authorization requirements. Permit 1565 is subject to annual authorization based on your reported annual take and compliance with the authorization requirements. Annual reports are due by January 31 each year. Permit 1565 expires on December 31, 2011.

If you have any questions concerning the permit, please contact Gary Rule at (503) 230-5424.

Sincerely,

for D. Robert Lohn
Regional Administrator

Appendix H. Yearly Project Task List.

This table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution. Protocol sections and SOPs are referred to as appropriate.

Project Stage	Task Description	Responsibility	Timing
Preparation (*Chapter 6b*)	Notify Data Manager and GIS Specialist of needs (field maps, GPS support, training)	Project Lead	by Dec 1
	Initiate announcement for seasonal field crew positions	Project Lead	Feb
	Ensure all project compliance needs are completed for the coming season	Project Lead	Mar
	Hire seasonal field crew positions	Project Lead	by Mar 15
	Inform GIS Specialist and Data Manager of specific needs for upcoming field season	Project Lead	by Mar 31
	Plan schedule and logistics, including ordering any needed equipment and supplies	Project Lead	Apr
	Update and load data dictionary and target coordinates into GPS units	GIS Specialist	by Apr 15
	Prepare and print field maps	GIS Specialist	by Apr 15
	Purchase equipment (temp. loggers, snorkel gear, etc.)	Project Lead	Apr
	Ensure that project workspace is ready for use and GPS download software is loaded at each park	Project Lead, Data Manager and GIS Specialist	by May 1
	Initiate computer access and key requests (may need park-specific dates)	Project Lead or Field Lead	May
	Provide field crew email addresses and user logins to Data Manager	Project Lead	May
	Generate pre-printed data forms	Project Lead	May
	Implement working database copy	Data Manager	by May 15
	Provide database/GPS training as needed	Data Manager and GIS Specialist	May-June
	Train field crew in fish identification, use of equipment, field sampling protocols, safety, vehicle use, and backcountry travel	Project Lead	May-June
Data Acquisition (*Chapter 3a-e*)	Collect field data during field trips	Technicians	May-Sep
	Review data forms after each day	Technicians	daily
	Regular review of field forms for completeness and accuracy	Field Crew Lead	weekly
	De-brief crew on operations, field methods, gear needs	Project Lead	weekly
Data Entry and Processing (*Chapter 6d*)	Download GPS data and email files to GIS Specialist for correction	Technicians	as soon as possible after data collection, usually in Sept
	Download and process digital images	Technicians	as needed
	Enter data into working copy of the database	Technicians	weekly
	Verification of accurate transcription as data are entered	Technicians	weekly

Project Stage	Task Description	Responsibility	Timing
	Periodic review of database entries for completeness and accuracy	Field Crew Lead	weekly
	Correct GPS data and send screen capture to Field Lead and Project Lead for review	GIS Specialist	as needed, usually in Sept
	Scan field forms as PDF documents	Field Crew Lead	by Sept 30
	Merge, correct, and export GPS data. Upload processed and verified coordinates to database. Complete stream routing analysis, update reach lengths in database.	GIS Specialist	Oct
Product Development (*Chapter 6i*)	Complete field season report	Field Crew Lead	by Sept 30
Product Delivery (*Chapter 6j*)	Send field season report to Project Lead, Data Manager, and GIS Specialist	Field Crew Lead	by Sept 30
Quality Review (*Chapter 6e*)	Quality review and data validation using database tools	Project Lead	Oct-Nov
	Prepare coordinate summaries and/or GIS layers and data sets as needed for spatial data review	GIS Specialist	by Oct 15
	Joint quality review of GIS data, determine best coordinates for subsequent mapping and field work	Project Lead and GIS Specialist	late Oct
Metadata (*Chapter 6f*)	Identify any sensitive information contained in the data set (see **Section 6i, Reporting and Product Development** for a definition)	Project Lead	by Nov 30
	Update the project metadata interview form	Project Lead	by Nov 30
Data Certification and Delivery (*Chapter 6g*)	Certify the season's data and complete the certification report	Project Lead	Nov
	Deliver certification report, certified data, and updated metadata interview form to Data Manager (and GIS Specialist as applicable)	Project Lead	by Nov 30
	Update project GIS data sets, layers and associated metadata records	GIS Specialist	Dec-Jan
	Upload certified data into master project database, store data files in NCCN Digital Library[1]	Data Manager	Dec-Jan
	Submit certified water temperature data WRD for merging with WRD STORET[2] and EPA STORET[2]	Data Manager	Dec-Jan
	Notify Project Lead of uploaded data ready for analysis and reporting	Data Manager	by Jan 15
	Finalize and parse metadata records, store in NCCN Digital Library[1]	Data Manager and GIS Specialist	by Mar 15
Data Analysis (*Chapter 6h*)	To be decided after analysis SOPs are written	Data Analyst	Jan-Feb
Reporting and Product Development (*Chapter 6i*)	Export automated summary queries and reports from database	Data Analyst	Jan-Feb
	Generate report-quality map output for reports	GIS Specialist	Feb-Mar, as needed
	Acquire the proper report template from the *NPS website*, create annual report	Data Analyst and Project Lead	Feb-Apr
	Screen all reports and data products for sensitive information	Project Lead	Feb-Apr

Project Stage	Task Description	Responsibility	Timing
	Prepare draft report	Project Lead	Feb-Apr
Product Delivery (*Chapter 6j*)	Submit draft I&M report to Network Coordinator for review	Project Lead	by May 1
	Review report for formatting and completeness, notify Project Lead of approval or need for changes	Network Coordinator	May
	Upload completed report to NCCN Digital Library[1] submissions folder, notify Data Manager	Project Lead	upon approval
	Deliver other products according to the delivery schedule and instructions	Project Lead	upon completion
	Product check-in	Data Manager	upon receipt
Posting and Distribution (*Chapter 6j*)	Submit metadata to NPS Data Store[3]	Data Manager	by Mar 15
	Create NatureBib[4] record, post reports to NPS clearinghouse	Data Manager	upon receipt
	Update NPSpecies[5] records according to data observations	Data Manager	Jan-Mar
	Submit certified data and GIS data sets to NPS Data Store[3]	Data Manager	Jun (after 2-year hold)
Archival and Records Management (*Chapter 6k*)	Store finished products in NCCN Digital Library[1]	Data Manager	upon receipt
	Review, clean up and store and/or dispose of project files according to NPS Director's Order #19[6]	Project Lead	Jan
	Move hard-copy data forms to park collections	Project Lead	Jan
Season Close-out (*Chapter 6l*)	Inventory equipment and supplies, store gear for winter	Field Crew Lead	by Sept 30
	De-brief field crew concerning safety, logistics, and data concerns	Project Lead, Technicians	by Sept 30
	Meet to discuss the recent field season, and document any needed changes to field sampling protocols or the working database	Project Lead, Data Manager, and GIS Specialist	by Nov 30 of the same year
	Discuss and document needed changes to analysis and reporting procedures	Project Lead, Data Analyst, and Data Manager	by Mar 31

[1] The NCCN Digital Library is a hierarchical digital filing system stored on the NCCN file servers (Boetsch and others, 2005). Network users have read-only access to these files, except where information sensitivity may preclude general access.

[2] NPSTORET (*http://www.nature.nps.gov/water/infoanddata*) and EPA STORET (*http://www.epa.gov/storet/*) are, respectively, the NPS and national enterprise data warehouses for water quality data. NPSTORET is maintained by NPS-Water Resources Division (WRD) and is synchronized with EPA STORET on a regular basis.

[3] NPS Data Store is a clearinghouse for natural resource data and metadata (*http://science.nature.nps.gov/nrdata*). Only non-sensitive information is posted to NPS Data Store. Refer to the section on sensitive information in **Section 6J, Product Delivery, Posting, and Distribution** for details.

[4] NatureBib is the NPS bibliographic database (*http://www.nature.nps.gov/nrbib/index.htm*). This application has the capability of storing and providing public access to image data (for example, PDF files) associated with each record.

[5] NPSpecies is the NPS database and application for maintaining park-specific species lists and observation data (*http://science.nature.nps.gov/im/apps/npspp/index.htm*).

[6] NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: *http://data2.itc.nps.gov/npspolicy/DOrders.cfm*.

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Appendix I. Database Documentation.

The database for this project consists of three types of tables: core tables describing the "who, where, and when" of data collection, project-specific tables, and lookup tables that contain domain constraints for other tables. Although core tables are based on NCCN standards, they may contain fields, domains, or descriptions that have been added or altered to meet project objectives.

The database includes the following standard tables:

tbl_Locations	Sample locations – river reaches and temperature data observation points
tbl_Target_Coords	Target coordinates for sample locations
tbl_Events	Data collection event for a given location
tbl_Coordinates	Coordinate data collected during sampling events
tbl_GPS_Info	GPS information associated with sampling event coordinates
tbl_Observers	Observers for each sampling event
tbl_Task_List	Checklist of tasks to be completed at sampling locations
tbl_Images	Images associated with sampling events
tbl_QA_Results	Quality assurance query results for the working data set
tbl_Edit_Log	Edit log for changes made to data after certification

The following are project-specific data tables:

tbl_Electro_Data	Electroshocking survey observation data
tbl_Snorkel_Data	Snorkel survey observation data
tbl_Temp_Data	Temperature data from data loggers
tbl_Temp_Files	Temperature data log files

The following are a few of the more prominent, standard lookup tables:

tlu_Project_Crew	List of personnel associated with a project
tlu_Project_Taxa	List of species associated with project observations
tlu_Park_Taxa	Park-specific attributes for taxa

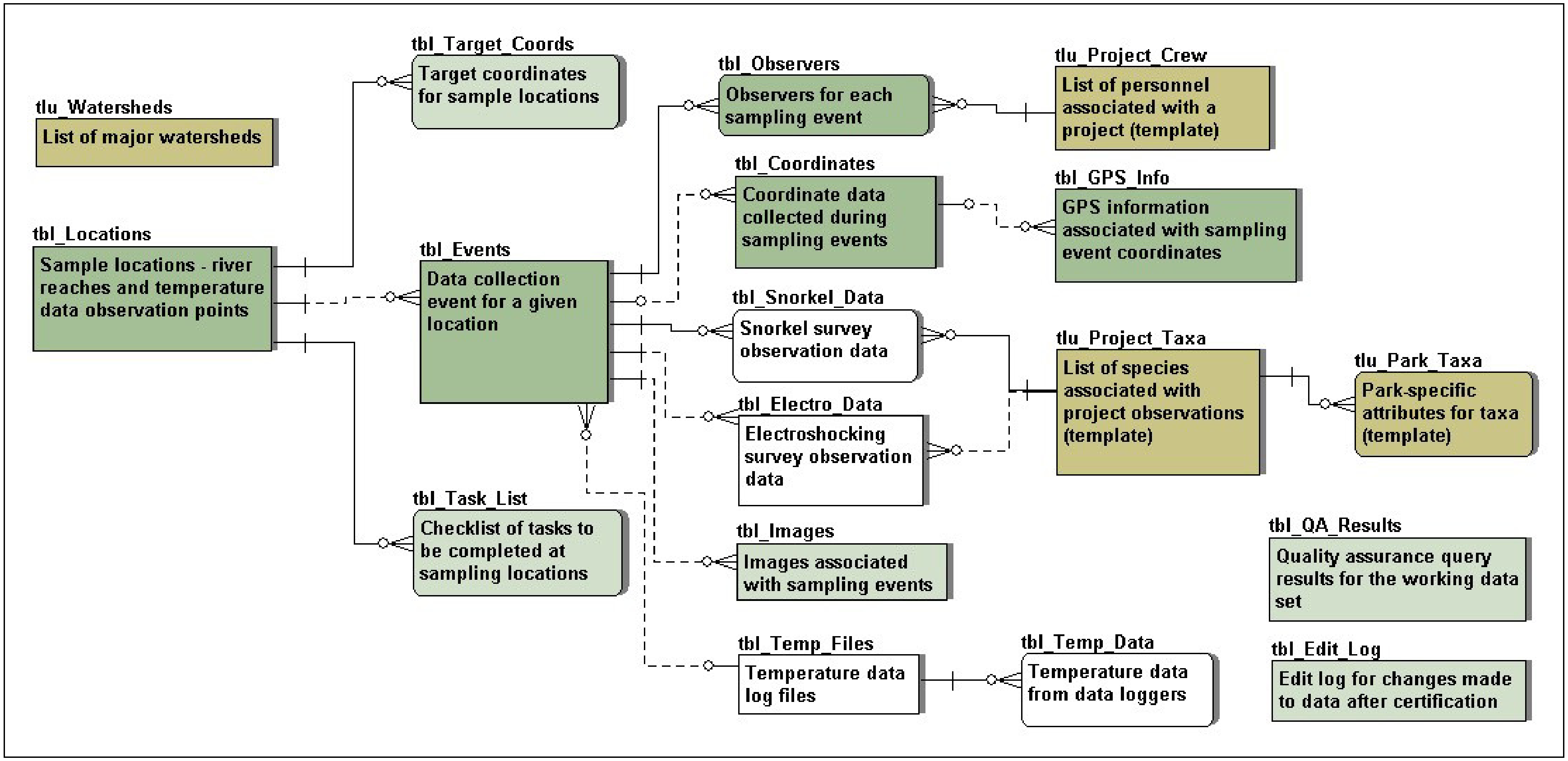

Figure I1. Entity relationship diagram of the project database. Relationships between tables are represented by lines. Dark green tables represent core standard tables; light green represents extended standard tables; light brown are standard lookup tables. Project-specific tables are unshaded.

Data Dictionary

Note: Required fields are denoted with an asterisk (*).

File name: Fish_Assemblages_FIa10.DM1
Model name: Physical
Platform: Microsoft Access
Report date: 1/10/2008 11:45:53 AM

tbl_Coordinates - Coordinate data collected during sampling events

Index	*Index columns*
Coord_label	Coord_label
Coord_type	Coord_type
Coord_updated	Coord_updated
Datum	Datum
Event_ID	Event_ID
Field_coord_source	Field_coord_source
GIS_loc_ID	GIS_loc_ID
pk_tbl_Coordinates (primary)	Coord_ID

Field name	*Index/key*	*Data type*	*Description*
Coord_ID	primary *	text (50)	Unique identifier for each coordinate record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
GIS_loc_ID	indexed	text (50)	GIS feature ID for each set of coordinates, to link with geospatial layers
Event_ID	indexed (FK)	text (50)	Sampling event of coordinate data collection
Coord_label	indexed	text (25)	Name of the coordinate feature (for example, plot center, NW corner)
Is_best		bit	Indicates whether this set of coordinates is the best available for this location
UTM_east		decimal (9,3)	Final UTM easting (zone 10N, meters), including any offsets and corrections
UTM_north		decimal (10,3)	Final UTM northing (zone 10N, meters), including any offsets and corrections
Coord_type	indexed	text (20)	Coordinate type stored in UTM_east and UTM_north: target, field, post-processed
Datum	indexed	text (5)	Datum of UTM_east and UTM_north
	Default: "NAD83"		
Est_horiz_error		decimal (9,3)	Estimated horizontal error (meters) of UTM_east and UTM_north
Field_UTME		decimal (9,3)	UTM easting (zone 10N) as recorded in the field

Field_UTMN		decimal (10,3)	UTM northing (zone 10N) as recorded in the field
Field_datum		text (5)	Datum of field coordinates
Field_horiz_error		decimal (9,3)	Field coordinate horizontal error (m)
Field_offset_m		decimal (6,2)	Distance (meters) from the field coordinates to the target
	Constraint: Is Null Or >=0		
Field_offset_azimuth		smallint	Azimuth (degrees, declination corrected) from the coordinates to the target
	Constraint: Is Null Or (>=0 And <=360)		
Field_coord_source	indexed	text (12)	Field coordinate data source
GPS_file_name		text (50)	GPS rover file used for data downloads
GPS_model		text (25)	Make and model of GPS unit used to collect field coordinates
Source_map_scale		text (16)	Approximate scale of the source map
Source_citation		text (250)	Name and date of the source map
Coordinate_notes		memo	Notes about this set of coordinates
Coord_created_date		datetime	Time stamp for record creation
	Default: Now()		
Coord_updated	indexed	datetime	Date of the last update to this record
Coord_updated_by		text (50)	Person who made the most recent edits

tbl_Edit_Log - Edit log for changes made to data after certification

Index	*Index columns*
Edit_date	Edit_date
Edit_type	Edit_type
pk_tbl_Edit_Log (primary)	Data_edit_ID
Project_code	Project_code
Table_affected	Table_affected
User_name	User_name

Field name	*Index/key*	*Data type*	*Description*
Data_edit_ID	primary *	text (50)	Unique identifier for each data edit record
		Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())	
Project_code	indexed *	text (10)	Project code, for linking information with other data sets and applications
		Default: "FIa10"	
Edit_date	indexed *	datetime	Date on which the edits took place
		Default: Date()	
Edit_type	indexed *	text (12)	Type of edits made: deletion, update, append, reformat, tbl design
Edit_reason		text (100)	Brief description of the reason for edits
User_name	indexed	text (50)	Name of the person making data edits
Table_affected	indexed	text (50)	Table affected by edits
Fields_affected		text (200)	Description of the fields affected
Records_affected		text (200)	Description of the records affected
Data_edit_notes		memo	Comments about the data edits

tbl_Electro_Data - Electroshocking survey observation data

Index	*Index columns*
Condition	Condition
Event_ID	Event_ID
pk_tbl_Electro_Data (primary)	Observation_ID
River_section	River_section
Taxon_ID	Taxon_ID

Field name	*Index/key*	*Data type*	*Description*
Observation_ID	primary *	int	Unique identifier for each record
Event_ID	indexed (FK)*	text (50)	Sampling event
River_section	indexed *	text (10)	Section of the river to which the observation applies ('index' indicates the entire reach)
	Default: "index"		
Taxon_ID	indexed (FK)*	text (50)	Taxon observed
Fork_length_mm		smallint	Measured fork length, in millimeters
	Constraint: >=10 And <=900		
Condition	indexed *	text (1)	Condition observed
	Default: "U"		
Mark_type		text (10)	Type of marking observed (for example, adipose clip)
Obs_notes		text (50)	Comments about the observation

tbl_Events - Data collection event for a given location

Constraints: : [Counter_end] Is Null Or [Counter_end] Is Null Or [Counter_end]>=[Counter_start]

Index	*Index columns*
Certified_date	Certified_date
Entered_date	Entered_date
Location_ID	Location_ID
pk_tbl_Events (primary)	Event_ID
Start_date	Start_date
Survey_type	Survey_type
Temp_file (unique)	Temp_file
Updated_date	Updated_date
Verified_date	Verified_date

Field name	*Index/key*	*Data type*	*Description*
Temp_file	unique (FK)	text (25)	Name of the temperature data log file
Event_ID	primary *	text (50)	Unique identifier for each sampling event
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Location_ID	indexed (FK)*	text (50)	Sampling location for this event
Project_code	*	text (10)	Project code, for linking information with other data sets and applications
	Default: "FIa10"		
Start_date	indexed *	datetime	Start date of the sampling event
Start_time		datetime	Start time of the sampling event
End_date		datetime	End date of the sampling event (optional)
End_time		datetime	End time of the sampling event
Survey_type	indexed *	text (25)	Survey method
Survey_extent		text (25)	Description of the extent of the reach surveyed
Km_surveyed		decimal (6,3)	Number of kilometers surveyed, updated from GIS after routing GPS data
	Constraint: Is Null Or (>=0 And <=6)		
Target_species		text (20)	Target species code, if applicable
Water_temp_C		single	Water temperature observed, in Celsius
	Constraint: Is Null Or (>=0 And <=25)		
Water_obs_time		datetime	Time at which the water temperature was observed
Flow_est		text (10)	Flow conditions during the survey
Visibility		text (10)	Water visibility conditions during the survey
Weather		text (10)	Weather conditions during the survey
Shocker_setting		text (25)	Shocker setting
Voltage_range		text (25)	Shocker voltage range used
Counter_start		smallint	Shocker counter start value
	Constraint: Is Null Or (>=0 And <=10000)		

Counter_end		smallint	Shocker counter end value (indicator of the number of seconds the shocker was used)
	Constraint: Is Null Or (>=0 And <=10000)		
Conductivity_mscm		text (25)	Conductivity setting, in ms/cm
Event_notes		memo	Comments about the sampling event
Entered_by		text (50)	Person who entered the data for this event
Entered_date	indexed	datetime	Date on which data entry occurred
	Default: Now()		
Updated_by		text (50)	Person who made the most recent updates
Updated_date	indexed	datetime	Date of the most recent edits
Verified_by		text (50)	Person who verified accurate data transcription
Verified_date	indexed	datetime	Date on which data were verified
Certified_by		text (50)	Person who certified data for accuracy and completeness
Certified_date	indexed	datetime	Date on which data were certified
QA_notes		memo	Quality assurance comments for the selected sampling event

tbl_GPS_Info - GPS information associated with sampling event coordinates

Index	*Index columns*
Coord_ID	Coord_ID
Corr_type	Corr_type
Datum	GPS_datum
Feat_name	Feat_name
Feat_type	Feat_type
GPS_date	GPS_date
GPS_file	GPS_file
Location_ID	Location_ID
pk_tbl_GPS_Info (primary)	GPS_ID

Field name	*Index/key*	*Data type*	*Description*
GPS_ID	primary *	text (50)	Unique identifier for the GPS record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Coord_ID	indexed (FK)	text (50)	Coordinate identifier
Location_ID	indexed	text (50)	Sample location, used for temporary links
Feat_type	indexed	text (20)	Feature type (point, line, or polygon) collected with GPS
Data_dict_name		text (50)	Data dictionary name used to collect feature
Feat_name	indexed	text (50)	Feature name in data dictionary
GPS_file	indexed	text (50)	GPS file name
GPS_date	indexed	datetime	Date GPS file was collected
GPS_time		datetime	Time GPS file was collected
AM_or_PM		text (2)	Ante-meridian or post-meridian (a.m. or p.m.) if a 12 hour clock was used
Corr_type	indexed	text (50)	GPS file correction type
GPS_UTME		decimal (9,3)	UTM easting in GPS unit
GPS_UTMN		decimal (10,3)	UTM northing in GPS unit
UTM_zone		text (5)	UTM projection system zone
	Default: "10N"		
GPS_datum	indexed	text (5)	Datum of GPS coordinates
Elev_m		decimal (9,3)	Elevation (meters) in GPS unit
Num_sat		int	Number of satellites tracked by GPS unit during data collection
GPS_duration		text (25)	Length of time GPS file was open
Filt_pos		int	Number of GPS positions exported from GPS file
PDOP		decimal (9,3)	Position dilution of precision scale
HDOP		decimal (9,3)	Horizontal dilution of precision scale
H_err_m		decimal (9,3)	Horizontal error (meters)
V_err_m		decimal (9,3)	Vertical error (meters)
Std_dev_m		decimal (9,3)	Standard deviation (meters)
GPS_process_notes		text (255)	GPS file processing notes

tbl_Images - Images associated with sampling events

Index	*Index columns*
Event_ID	Event_ID
Image_label	Image_label
Image_quality	Image_quality
Image_type	Image_type
pk_tbl_Images (primary)	Image_ID

Field name	*Index/key*	*Data type*	*Description*
Image_ID	primary *	text (50)	Unique identifier for each image record
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Event_ID	indexed (FK)*	text (50)	Sampling event
Image_type	indexed	text (20)	Type of image
	Default: "ground photo"		
Image_label	indexed	text (25)	Image caption or label
Image_desc		text (255)	Brief description of the image bearing, perspective, etc.
Frame_number		text (10)	Frame number for photographic images
Image_date		datetime	Date on which the image was created, if different from the sampling event date
Image_source		text (50)	Name of the person or organization that created the image
Image_quality	indexed	tinyint	Quality of the image
Is_edited_version		bit	Indicates whether this version of the image is the edited (originals = False)
Object_format		text (20)	Format of the image
Orig_format		text (20)	Format of the original image
Image_edit_notes		text (200)	Comments about the editing or processing performed on the image
Image_is_active		bit	Indicates whether the image is still being used for navigation or interpretation
	Default: True		
Image_root_path		text (100)	Drive space location of the main project folder or image library
Image_project_path		text (100)	Location of the image from the main project folder or image library
	Default: "images\"		
Image_filename		text (100)	Name of the image including extention (.jpg) but without the image path
Image_notes		memo	Comments about the image
Sort_order	indexed *	int	Sort order for displaying records in the order they were entered

tbl_Locations - Sample locations - river reaches and temperature data observation points

Constraints: : [Upstream_km] Is Null Or [Downstream_km] Is Null Or [Upstream_km]>[Downstream_km]

Index	*Index columns*
Loc_updated	Loc_updated
Location_code	Location_code
Location_status	Location_status
Location_type	Location_type
Park_code	Park_code
pk_tbl_Locations (primary)	Location_ID
Public_offset	Public_offset
udx_tbl_Locations	Location_code
Watercourse_type	Watercourse_type
Watershed_name	Watershed_name

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary *	text (50)	Unique identifier for each sample location
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Park_code	indexed *	text (4)	Park code
	Default: "OLYM"		
Watershed_name	indexed *	text (50)	Watershed in which the sample location is found
Location_code	indexed *	text (10)	Alphanumeric code for the sample location
Location_type	indexed *	text (20)	Indicates the type of sample location
Watercourse_type	indexed *	text (10)	Type of watercourse (stream, river)
Location_name		text (50)	Brief colloquial name of the sample location (optional)
Upstream_km		single	Kilometer mark associated with the upstream boundary of the reach
	Constraint: Is Null Or (>0 And <=120)		
Downstream_km		single	Kilometer mark associated with the downstream boundary of the reach
	Constraint: Is Null Or (0 And <=120)		
WRIA_code		text (50)	Water Resource Inventory Area code associated with the reach
UTME_public		decimal (9,3)	UTM easting (zone 10N, meters). Note: in addition to any measurement error, these coordinates may have been offset up to 2 km from their actual position.

UTMN_public		decimal (10,3)	UTM northing (zone 10N, meters). **Note:** In addition to any measurement error, these coordinates may have been offset up to 2 km from their actual position.
Public_offset	indexed	text (50)	Type of processing performed to make coordinates publishable
Location_status	indexed	text (10)	Status of the sample location
Travel_notes		memo	Directions for relocating the sample location
Location_notes		memo	Other notes about the sample location
Loc_established		datetime	Date the sample location was established
Loc_discontinued		datetime	Date the sample location was discontinued
Loc_created_date	*Default*: Now()	datetime	Time stamp for record creation
Loc_updated	indexed	datetime	Date of the last update to this record
Loc_updated_by		text (50)	Person who made the most recent edits

<u>**tbl_Observers** - Observers for each sampling event</u>

Index	*Index columns*
Contact_ID	Contact_ID
Event_ID	Event_ID
Observer_role	Observer_role
pk_tbl_Observers (primary)	Event_ID, Contact_ID

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event identifier
Contact_ID	primary (FK)*	text (50)	Observer identifier
Observer_role	indexed	text (25)	Role of the observer during data collection (optional)
Observer_notes		text (200)	Comments about the observer specific to this sampling event

tbl_QA_Results - Quality assurance query results for the working data set

Index	*Index columns*
pk_tbl_QA_Results (primary)	Query_name, Time_frame
Query_name	Query_name
Query_result	Query_result
Query_type	Query_type
Time_frame	Time_frame

Field name	*Index/key*	*Data type*	*Description*
Query_name	primary *	text (100)	Name of the quality assurance query
Time_frame	primary *	text (30)	Field season year or range of dates for the data being passed through quality assurance checks
Query_type	indexed	text (20)	Severity of data errors being trapped: 1=critical, 2=warning, 3=information
Query_result	indexed	text (50)	Query result as the number of records returned the last time the query was run
Query_run_time		datetime	Run time of the query results
Query_description		memo	Description of the query
Query_expression		memo	Evaluation expression built into the query
Remedy_desc		memo	Details about actions taken and/or not taken to resolve errors
Remedy_date		datetime	When the remedy description was last edited
QA_user		text (50)	Name of the person doing quality assurance
Is_done	*	bit	Temporary flag to indicate that the user is done reviewing this query even if some records remain

tbl_Snorkel_Data - Snorkel survey observation data

Index	*Index columns*
Event_ID	Event_ID
Observer	Observer
pk_tbl_Snorkel_Data (primary)	Event_ID, River_section, Observer, Taxon_ID, Fork_length_code
River_section	River_section

Field name	*Index/key*	*Data type*	*Description*
Event_ID	primary (FK)*	text (50)	Sampling event
River_section	primary *	text (10)	Section of the river for which the species tally applies ('index' indicates the entire reach)
	Default: "index"		
Observer	primary *	text (50)	Observer name
Taxon_ID	primary (FK)*	text (50)	Taxon observed
Fork_length_code	primary *	text (10)	Fork length category
Tally	*	smallint	Number of individuals observed
	Constraint: >0 And <=500		

tbl_Target_Coords - Target coordinates for sample locations

Index	*Index columns*
Location_ID	Location_ID
pk_tbl_Target_Coords (primary)	Location_ID, Target_type
Target_updated	Target_updated

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary (FK)*	text (50)	Sample location
Target_type	primary *	text (10)	Type of target (e.g., upstream or downstream boundary)
Target_UTME		decimal (9,3)	Target UTM easting (zone 10N)
Target_UTMN		decimal (10,3)	Target UTM northing (zone 10N)
Target_datum		text (5)	Target coordinate datum
	Default: "NAD83"		
Target_notes		memo	Notes about the target coordinates
Target_created_date		datetime	Time stamp for record creation
	Default: Now()		
Target_updated	indexed	datetime	Date of the last update to this record
Target_updated_by		text (50)	Person who made the most recent edits

tbl_Task_List - Checklist of tasks to be completed at sampling locations

Index	*Index columns*
Date_completed	Date_completed
pk_tbl_Task_List (primary)	Location_ID, Request_date, Task_desc
Task_status	Task_status

Field name	*Index/key*	*Data type*	*Description*
Location_ID	primary (FK)*	text (50)	Sampling location
Request_date	primary *	datetime	Date of the task request
	Default: Now()		
Task_desc	primary *	text (100)	Brief description of the task
Requested_by		text (50)	Name of the person making the initial request
Task_status	indexed	text (50)	Status of the task
	Default: "active"		
Date_completed	indexed	datetime	Date the task was completed
Followup_by		text (50)	Name of the person following up on or completing the task
Task_notes		memo	Notes about the task
Followup_notes		memo	Comments regarding what was done to follow-up on or complete this task

tbl_Temp_Data - Temperature data from data loggers

Index	*Index columns*
pk_tbl_Temp_Data (primary)	Log_date, Log_time, Temp_file
Temp_file	Temp_file

Field name	*Index/key*	*Data type*	*Description*
Log_date	primary *	datetime	Start date of the log file
Log_time	primary *	datetime	End date of the log file
Temp_C		single	Temperature in Celsius
QA_flag		text (3)	Data quality flag
Temp_file	primary (FK)*	text (25)	Name of the temperature data log file

tbl_Temp_Files - Temperature data log files

Field name	*Index/key*	*Data type*	*Description*
Temp_file	primary *	text (25)	Name of the temperature data log file
Log_start_date	*	datetime	Start date of the log file
Log_end_date		datetime	End date of the log file
File_path		text (100)	Path and file name of the log file
File_notes		text (200)	Comments about this log file

tlu_Condition_Code - List of fish condition codes

Field name	*Index/key*	*Data type*	*Description*
Condition_code	primary *	text (1)	
Condition_desc		text (100)	
Sort_order		tinyint	

tlu_Coord_Label - List of project-specific coordinate labels (template)

Field name	*Index/key*	*Data type*	*Description*
Coord_label	primary *	text (25)	
Coord_label_desc		text (100)	
Sort_order		tinyint	

tlu_Coord_Source - List of coordinate data sources (standard)

Field name	*Index/key*	*Data type*	*Description*
Coord_source	primary *	text (12)	
Coord_source_desc		text (100)	
Sort_order		tinyint	

tlu_Coord_Type - List of coordinate types (standard)

Field name	*Index/key*	*Data type*	*Description*
Coord_type	primary *	text (20)	
Coord_type_desc		text (100)	
Sort_order		tinyint	

tlu_Datum - List of coordinate datum codes (standard)

Field name	*Index/key*	*Data type*	*Description*
Datum	primary *	text (5)	
Datum_desc		text (50)	
Sort_order		tinyint	

tlu_Edit_Type - List of the types of post-certification edits made to data (standard)

Field name	*Index/key*	*Data type*	*Description*
Edit_type	primary *	text (12)	
Edit_type_desc		text (100)	
Sort_order		tinyint	

tlu_Flow_Code - List of water flow condition codes

Field name	*Index/key*	*Data type*	*Description*
Flow_code	primary *	text (10)	
Flow_desc		text (100)	
Sort_order		tinyint	

tlu_Fork_Length_Code - List of fork length observation categories
Constraints: : [Length_min_cm]<[Length_max_cm]

Field name	*Index/key*	*Data type*	*Description*
Fork_length_code	primary *	text (10)	
Midpoint_cm		single	
Length_min_cm		tinyint	
Length_max_cm		tinyint	
Sort_order		tinyint	

tlu_GPS_Model - List of GPS devices used to collect coordinate data (template)

Field name	*Index/key*	*Data type*	*Description*
GPS_model	primary *	text (25)	
Sort_order		tinyint	

tlu_Image_Format - List of image, map, and photographic formats (template)

Field name	*Index/key*	*Data type*	*Description*
Image_format	primary *	text (12)	
Image_format_desc		text (100)	
Sort_order		tinyint	

tlu_Image_Quality - List of quality ranks for images (template)

Field name	*Index/key*	*Data type*	*Description*
Quality_code	primary *	tinyint	
Image_quality	*	text (20)	
Image_quality_desc		text (100)	

tlu_Image_Type - List of image types (template)

Field name	*Index/key*	*Data type*	*Description*
Image_type	primary *	text (12)	
Image_type_desc		text (100)	
Sort_order		tinyint	

tlu_Location_Type - List of location type codes (template)

Field name	*Index/key*	*Data type*	*Description*
Location_type	primary *	text (20)	
Loc_type_desc		text (200)	
Sort_order		tinyint	

tlu_Observer_Role - List of observer role assignments (template)

Field name	*Index/key*	*Data type*	*Description*
Observer_role	primary *	text (25)	
Role_desc		text (100)	
Sort_order		tinyint	

tlu_Origin_Code - List of origin codes for park taxa (standard)

Field name	*Index/key*	*Data type*	*Description*
Origin_code	primary *	text (16)	
Origin_desc		text (100)	
NPSpp_ID		smallint	
Sort_order		tinyint	

tlu_Parks - List of NCCN parks and park codes (standard)

Field name	*Index/key*	*Data type*	*Description*
Park_code	primary *	text (4)	
Park_name		text (50)	

tlu_Park_Taxa - Park-specific attributes for taxa (template)

Index	*Index columns*
Park_origin	Park_origin
Park_status	Park_status
pk_tlu_Park_Taxa (primary)	Taxon_ID, Park_code
Record_status	Record_status

Field name	*Index/key*	*Data type*	*Description*
Taxon_ID	primary (FK)*	text (50)	Taxon identifier
Park_code	primary *	text (4)	Park code
Park_status	indexed	text (16)	Status of the taxon in this park (from NPSpecies)
	Default: "unknown"		
Park_origin	indexed	text (16)	Origin of the taxon in this park (from NPSpecies)
	Default: "unspecified"		
Local_list		bit	Indicates that the taxon is the preferred one for use at the park (from NPSpecies)
Local_accepted_TSN		int	Taxonomic serial number of the local preferred taxon (from NPSpecies)
Preferred_sci_name		text (255)	Preferred scientific name of the taxon at the park (from NPSpecies)
Park_taxon_notes		memo	Comments about the taxon specific to this park
Record_status	indexed	text (16)	Indicates the status of the record in terms of synchrony with master databases
	Default: "new record"		
Created_date		datetime	Time stamp for record creation
	Default: Now()		
Updated_date		datetime	Date of the last update to this record
Updated_by		text (50)	Person who made the most recent edits

tlu_Park_Taxon_Status - List of codes for park species occurrence (standard)

Field name	*Index/key*	*Data type*	*Description*
Taxon_status_code	primary *	text (16)	
Taxon_status_desc		text (250)	
NPSpp_ID		smallint	
Sort_order		tinyint	

tlu_Project_Crew - List of personnel associated with a project (template)

Index	*Index columns*
Contact_location	Contact_location
Contact_updated	Contact_updated
First_name	First_name
Last_name	Last_name
Organization	Organization
pk_tlu_Project_Crew (primary)	Contact_ID
Project_code	Project_code

Field name	*Index/key*	*Data type*	*Description*
Contact_ID	primary *	text (50)	Unique identifier for the individual (Lastname_Firstname_MI)
Project_code	indexed *	text (10)	Project code, for linking information with other data sets and applications
Last_name	indexed *	text (24)	Last name
First_name	indexed	text (20)	First name
Middle_init		text (4)	Middle initials
Organization	indexed	text (50)	Employer (for example, NPS-MORA)
Position_title		text (50)	Position title held by the individual
Email		text (50)	Email address
Work_voice		text (25)	Work phone number
Work_ext		text (5)	Work extension number
Mobile_voice		text (25)	Mobile phone number
Home_voice		text (25)	Home phone number
Fax		text (25)	Fax number
Contact_location	indexed	text (255)	Where the individual is located
NPS_login		text (50)	NPS network login
Contact_notes		memo	Notes about the contact
Contact_created		datetime	Time stamp for record creation
	Default: Now()		
Contact_updated	indexed	datetime	Date of the last update to this record
Contact_updated_by		text (50)	Person who made the most recent edits
Contact_is_active		bit	Indicates that the contact record is currently available for data entry pick lists
	Default: True		

tlu_Project_Taxa - List of species associated with project observations (template)

Index	*Index columns*
Accepted_TSN	Accepted_TSN
Category	Category
pk_tlu_Project_Taxa (primary)	Taxon_ID
Project_code	Project_code
Record_status	Record_status
Scientific_name (unique)	Scientific_name
Species_code (unique)	Species_code
Subcategory	Subcategory
Taxon_type	Taxon_type
TSN	TSN

Field name	*Index/key*	*Data type*	*Description*
Taxon_ID	primary *	text (50)	Unique identifier for each taxon
	Default: =Format(Now(),"yyyymmddhhnnss") & '-' & 1000000000*Rnd(Now())		
Project_code	indexed *	text (10)	Project code, for linking information with other data sets and applications
	Default: "FIa10"		
Species_code	unique *	text (20)	Unique field code for each project taxon
Scientific_name	unique *	text (100)	Scientific name of the taxon (from ITIS/NPSpecies)
Common_name		text (100)	Common name for the taxon (from ITIS/NPSpecies)
Pref_com_name		text (100)	Preferred common name for this project
TSN	indexed	int	ITIS taxonomic serial number or a provisional number (from NPSpecies)
Accepted_TSN	indexed	int	ITIS taxonomic serial number of the accepted name for this taxon (from NPSpecies)
Category	indexed	text (20)	General category of the taxon (from NPSpecies)
	Default: "unspecified"		
Subcategory	indexed	text (20)	Subcategory specific to the needs of each taxonomic discipline (from NPSpecies)
Authority		text (60)	Taxonomic authority (from ITIS)
Authority_subsp		text (60)	Taxonomic authority for subspecific taxa (from ITIS)
Family		text (60)	Taxonomic family (from ITIS)
Taxon_type	indexed	text (12)	Indicates the taxonomic resolution and certainty represented by this record
	Default: "specific"		
Taxon_notes		memo	General notes about the taxon
Created_date		datetime	Time stamp for record creation

	Default: Now()		
Updated_date		datetime	Date of the last update to this record
Updated_by		text (50)	Person who made the most recent edits
Taxon_is_active		bit	Indicates that the record is currently available for data entry pick lists
	Default: True		
Record_status	indexed	text (16)	Indicates the status of the record in terms of synchrony with master databases
	Default: "new record"		
Rec_status_notes		text (255)	Notes about the disposition of the record
Project_taxon_notes		memo	Project-specific comments about the taxon

tlu_QA_Flag - List of temperature data quality flag codes

Field name	*Index/key*	*Data type*	*Description*
QA_flag	primary *	text (3)	
Flag_desc		text (100)	
Sort_order		tinyint	

tlu_Site_Status - List of status codes for sampling stations (standard)

Field name	*Index/key*	*Data type*	*Description*
Site_status	primary *	text (10)	
Site_status_desc		text (200)	
Sort_order		tinyint	

tlu_Source_Scale - List of common map scales associated with maps and imagery (standard)

Field name	*Index/key*	*Data type*	*Description*
Source_scale	primary *	text (16)	
Source_scale_desc		text (100)	
Sort_order		tinyint	

tlu_Survey_Type - List of survey method types

Field name	*Index/key*	*Data type*	*Description*
Survey_type	primary *	text (25)	
Survey_desc		text (100)	
Sort_order		tinyint	

tlu_Taxon_Category - List of taxonomic categories (standard)

Field name	*Index/key*	*Data type*	*Description*
Category	primary *	text (20)	
Category_desc		text (100)	
NPSpp_ID		smallint	
Sort_order		tinyint	

tlu_Taxon_Rec_Status - List of status codes for taxon records (standard)

Field name	*Index/key*	*Data type*	*Description*
Record_status_code	primary *	text (16)	
Record_status_desc		text (200)	
Sort_order		tinyint	

tlu_Taxon_Type - List of taxon resolution codes (standard)

Field name	*Index/key*	*Data type*	*Description*
Taxon_type	primary *	text (12)	
Taxon_type_desc		text (200)	
Sort_order		tinyint	

tlu_Visibility_Code - List of water visibility condition codes

Field name	*Index/key*	*Data type*	*Description*
Visibility_code	primary *	text (10)	
Visibility_desc		text (100)	
Sort_order		tinyint	

tlu_Watercourse_Type - List of watercourse types

Field name	*Index/key*	*Data type*	*Description*
Watercourse_type	primary *	text (10)	
Type_desc		text (100)	
Sort_order		tinyint	

tlu_Watersheds - List of major watersheds

Constraints: : [Total_length_km] Is Null Or [Park_length_km] Is Null Or [Total_length_km]>=[Park_length_km]

Index	*Index columns*
Has_anadromous_fish	Has_anadromous_fish
Has_hatchery	Has_hatchery
Park_code	Park_code
pk_tlu_Watersheds (primary)	Watershed_name
Watershed_GIS	Watershed_GIS
Watershed_name	Watershed_name
WRIAID	WRIA_ID

Field name	*Index/key*	*Data type*	*Description*
Watershed_name	primary *	text (25)	Name of the watershed
Park_code	indexed *	text (4)	Park in which the watershed is found
	Default: "OLYM"		
Area_ha		int	Watershed area, in hectares
	Constraint: Is Null Or >0 And <1000000		
Percent_in_park		smallint	Percent of the watershed found within the NPS boundary
	Constraint: Is Null Or (>=0 And <=100)		
Elev_boundary_m		smallint	Elevation at the park boundary, in meters
	Constraint: Is Null Or (>=0 And <10000)		
Elev_headwaters_m		smallint	Elevation at the headwaters, in meters
	Constraint: Is Null Or (>=0 And <10000)		
Total_length_km		decimal (5,2)	Total length, in kilometers
	Constraint: Is Null Or (>0 And <=100)		
Park_length_km		decimal (5,2)	Length within the NPS boundary, in kilometers
	Constraint: Is Null Or (>0 And <=100)		
Gradient_perc		text (25)	River gradient, percent
Summer_flow_cms		text (50)	Estimated mean summer flow, in cubic meters per second
Max_safe_flow_cms		text (50)	Maximum flow for safe sampling, in cubic meters per second
Has_anadromous_fish	indexed	text (3)	Indicates whether or not anadromous fish are known for this watershed
Has_hatchery	indexed	text (1)	Whether or not a hatchery is present inside this watershed
Drains_to		text (50)	The watershed into which this watershed drains
Larger_basin		text (25)	The larger watershed basin in which this watershed is found
Huc4_basin		text (25)	Crosslink field for the Hydrologic Universal Code 4th field names

WRIA_ID	indexed	smallint	Crosslink field for the Water Resource Inventory Area number of the watershed
On_park_list		bit	Indicates that the watershed is normally part of the park pick list
Is_grouped		bit	Indicates that the watershed represents a grouping of natural watersheds, typically of small coastal streams that drain to salt water
Watershed_notes		text (255)	Comments regarding this watershed record
Watershed_GIS	indexed	smallint	GIS ID code for the watershed

tlu_Weather_Code - List of weather condition codes

Field name	*Index/key*	*Data type*	*Description*
Weather_code	primary *	text (10)	
Weather_desc		text (100)	
Sort_order		tinyint	

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Brenkman and others— **Protocol for Monitoring Fish Assemblages in Pacific Northwest National Parks**—Techniques and Methods 2–A7