



Monitoring Riverine Fish Communities in the North Coast and Cascades Network

2010 Annual Report

Natural Resource Technical Report NPS/NCCN/NRTR—2012/530



ON THE COVER

Olympic National Park fisheries biologists count fish species in the North Fork Skokomish River.
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Natural Resource Technical Report NPS/NCCN/NRTR—2012/530

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Abstract

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. Fishery resources in many park rivers – particularly those that drain from Olympic National Park (OLYM) – are of high ecological and cultural importance, and significantly contribute to economically important recreational, commercial, and tribal fisheries.

This report summarizes the monitoring of fish communities in 2010 with reference to past years for context. Specific monitoring objectives were to determine seasonal trends in: 1) fish species composition; 2) relative abundance; and 3) the extent of nonnative and hatchery fish among rivers during summer months. We relied on repeated and consistent annual sampling at monitoring sites to insure that we accounted for the high interannual variability in fish movements and abundances in rivers. One underlying assumption is that the monitoring program for fish communities will occur annually in perpetuity, and consequently the capability to detect trends increases with time.

Fish communities were monitored via intensive snorkel surveys in ~ 5-km reference sites located immediately upstream of the park boundary in 10 OLYM Rivers from June to September. A total of 351 snorkel surveys covering ~1,400 river kilometers occurred from 2005 to 2010 and biologists observed 129,558 individual fish. The most surveys occurred in the North Fork Skokomish River (n=69 surveys). In 2010, 53 surveys occurred from June to September when biologists observed 28,600 individual fish and monitored 14 fish species. The maximum total number of fish observations occurred in the East Fork Quinault (n=8,059) and Bogachiel (n=6,499) Rivers, with the fewest in the Elwha River (n=473) in 2010.

Seasonal trends in fish species composition were reported as the mean percent of each fish species in a month in each river. In 2010, species compositions in the East and North Fork Quinault and South Fork Hoh Rivers exhibited similar patterns where mountain whitefish (*Prosopium williamsoni*), cutthroat/rainbow trout (*Oncorhynchus clarkii*/*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*) had the highest percentages, respectively. The Sol Duc, North Fork Sol Duc, and Dosewallips Rivers were dominated by trout during all summer months and mountain whitefish and trout comprised a majority of the assemblage in the Bogachiel, South Fork Calawah, and North Fork Skokomish Rivers. Species composition among all rivers in 2010 was generally consistent with overall patterns observed since 2005. There were no observations of nonnative fish, a relevant indicator river health, among the 10 rivers in 2010 (n=28,600 fish observations).

Analysis of annual peak counts of fish species provided a gauge of relative productivity among rivers. Peak counts of mountain whitefish were orders of magnitude higher than those for other fish species in 2010, and whitefish were the most abundant species in each river since 2005. Adult summer steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*) were at critically low levels of abundance in all rivers from 2005 to 2010.

Annual trends in proportions of hatchery (that is, fin clipped) versus wild salmonids were determined at each reference site. The extent of hatchery fish varied by river and species. In

2010, hatchery nonnative summer steelhead were detected in the Bogachiel, East and North Fork Quinault, and South Fork Hoh Rivers and hatchery Chinook were observed in the South Fork Hoh River. We did not detect hatchery coho (*Oncorhynchus kisutch*) salmon in any reference site in 2010 although they were observed in the South Fork Hoh in four of the last six years. This suggests that future monitoring should rely on annual sampling to account for interannual variability in presence of hatchery fish. The Sol Duc River contained all wild coho salmon based on 1,126 observations since 2005. Overall, the high numbers of observed stray hatchery summer coho, summer steelhead, and Chinook in the South Fork Hoh was surprising since the Hoh Basin does not receive hatchery plantings for those stocks.

The allocation of sampling effort represented a balance between ecological considerations, a sound monitoring approach, and practical limitations caused by logistical constraints and a limited annual budget. This protocol has allowed NPS fisheries managers to detect trends in high priority management species that are increasing or decreasing in abundance. Data from this project were used: 1) to develop annual fishing regulations at OLYM; 2) to meet in-park and ESA compliance requirements designed to minimize impacts to federally threatened fish during road repair projects; 3) to provide an understanding of the extent of nonnative and hatchery fish invasions in OLYM; 4) to leverage funds for additional monies from USFWS, NPS, and Washington National Park Fund; and 5) to communicate findings with diverse audiences including decision makers, park visitors, fishing groups, researchers and educators.

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Introduction

This annual report presents 2010 results from the monitoring of fish assemblages in the North Coast and Cascades Network (NCCN) as part of the Inventory and Monitoring Program. The Protocol for Monitoring Fish Assemblages in Pacific Northwest Parks was designed for rivers in the NCCN that have high water visibility and are conducive to snorkel methods from June through September each year (Brenkman and Connolly 2008). Although the 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, difficult logistics, and safety concerns. The sampling design in this protocol was designed to accommodate many of the challenges inherent in working in remote, roadless wilderness rivers.

From 2005 to present, we tested and implemented the protocol in OLYM rivers based on the high priority of fishery resources in that park. 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 over 130 species of aquatic and terrestrial wildlife species (Cederholm et al. 2001), and studies have shown that 20 to 40% of the phosphorus, nitrogen, and carbon in freshwater systems may be marine-derived through carcasses of spawned salmon (Kline et al. 1990, 1994, Bilby et al. 1996).

In OLYM Rivers, fishery resources are of high ecological and cultural importance, and contribute significantly to recreational, commercial, and tribal fisheries. Fish communities are focal resources of parks (see Jenkins et al. 2003) and represent critical components of biological integrity from ecosystem and public interest perspectives (Peck et al. 1999). Fish communities also serve as excellent indicators of ecological conditions because they integrate effects from lower trophic levels (e.g. fish being key predators and consumers in aquatic food webs), they integrate environmental variability at different spatial scales (Oberdorff et al. 2002), and they are reasonably easy to identify (Plafkin et al. 1989). At the temporal scale, the longevity of fishes helps to “register” environmental alterations across long time periods (Schmutz et al. 2000). The life histories of many fish species are well understood, and therefore the presence or absence of specific taxa or life stages can have large inferential meaning (Flotemersch et al. 2006). The decline in native fish species in western North America highlights the importance of understanding patterns observed in least-disturbed habitats such as rivers of OLYM.

Rivers that drain from OLYM have many key fish species that are commercially, ecologically, and recreationally important, with a necessary management emphasis on Pacific salmon and steelhead. Additionally, park rivers contain federally threatened fish populations (e.g. bull trout, *Salvelinus confluentus*) and non-commercial fish species such as mountain whitefish (*Prosopium williamsoni*). Mountain whitefish have received little attention despite being one of the most abundant fish species in many river systems (Northcote and Ennis 1994). Cutthroat trout (*Oncorhynchus clarkii*) and summer steelhead (*Oncorhynchus mykiss*) also are important species targeted by recreational anglers. Prior to the inception of this monitoring project there were no existing monitoring programs for non-commercial (e.g. Pacific salmonids) fish species in Olympic Peninsula rivers.

Sampling Design

There is a lack of widely accepted sampling protocols for monitoring trends in fish communities in river systems. Aquatic environments are inherently difficult to sample (Fausch et al. 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 (Peck et al. 1999, Flotemersch et al. 2006). However, many of the sampling techniques for wadeable streams are infeasible in river systems (Flotemersch et al. 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, Aquatic Riparian Effectiveness Monitoring Program, and National Water-Quality Assessment Program are existing aquatic protocols that focus on monitoring fish, macroinvertebrates, and water quality metrics (Meador et al. 1993, Peck et al. 1999, Moulton 2002). Additionally, there are existing protocols designed to monitor fish in national park units. Existing 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 et al. 2006, Petersen et al. 2008). For this report, we rely on the established protocol for monitoring fish assemblages in NCCN rivers (Brenkman and Connolly 2008).

The fundamental sampling entity in this monitoring plan is the fish community, which will serve as an indicator of ecological integrity. One underlying assumption was that annual monitoring would occur in perpetuity, and consequently the capability to detect trends increases with time (McDonald 2006). The primary goal of this monitoring program is to determine seasonal and annual trends in fish communities throughout reference sites of 10 rivers during summer months. Trends are identified as continuing directional change in value of an indicator, generally up or down within season or among years (Larsen et al. 2004). Specific monitoring objectives for this report were to determine seasonal trends in: 1) fish species composition; 2) relative abundance; and 3) extent of nonnative and hatchery fish among rivers during summer months.

Study Area

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 protects 373,133 ha (922,000 acres) including the upper portions of 12 major river basins and 5,600 km of streams (Figure 1). The park is 96% designated wilderness, with roads, campgrounds, and structures comprising less than 1% of the total area of the park (Jenkins et al. 2003). The western portion of the park receives the greatest precipitation in the conterminous United States with annual precipitation that ranges from 180 to 250 cm to greater than 600 cm on Mount Olympus (Jenkins et al. 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 are generally 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.

Watersheds that drain the west side of the park contain anadromous and non-anadromous species, whereas watersheds that drain the eastside of the park are inhabited strictly by potamodromous (e.g., migrate entirely within freshwater) fish species because of natural barriers and dams that prevent upstream migration of anadromous fish. A summary of watershed characteristics can be found in Table 1.

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 (Houston and Contor 1984, OLYM files). A total of 31 native and 5 non-native freshwater fish species from 11 different families have been documented in OLYM waters. Both native wild populations and hatchery stocks of Pacific salmonids occur in OLYM.

OLYM has exclusive federal jurisdiction of recreational fishing regulations in the park, where fishing is generally permitted 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 nonnative fish. Tribal gill-net fisheries occur in coastal rivers most weeks of the year.

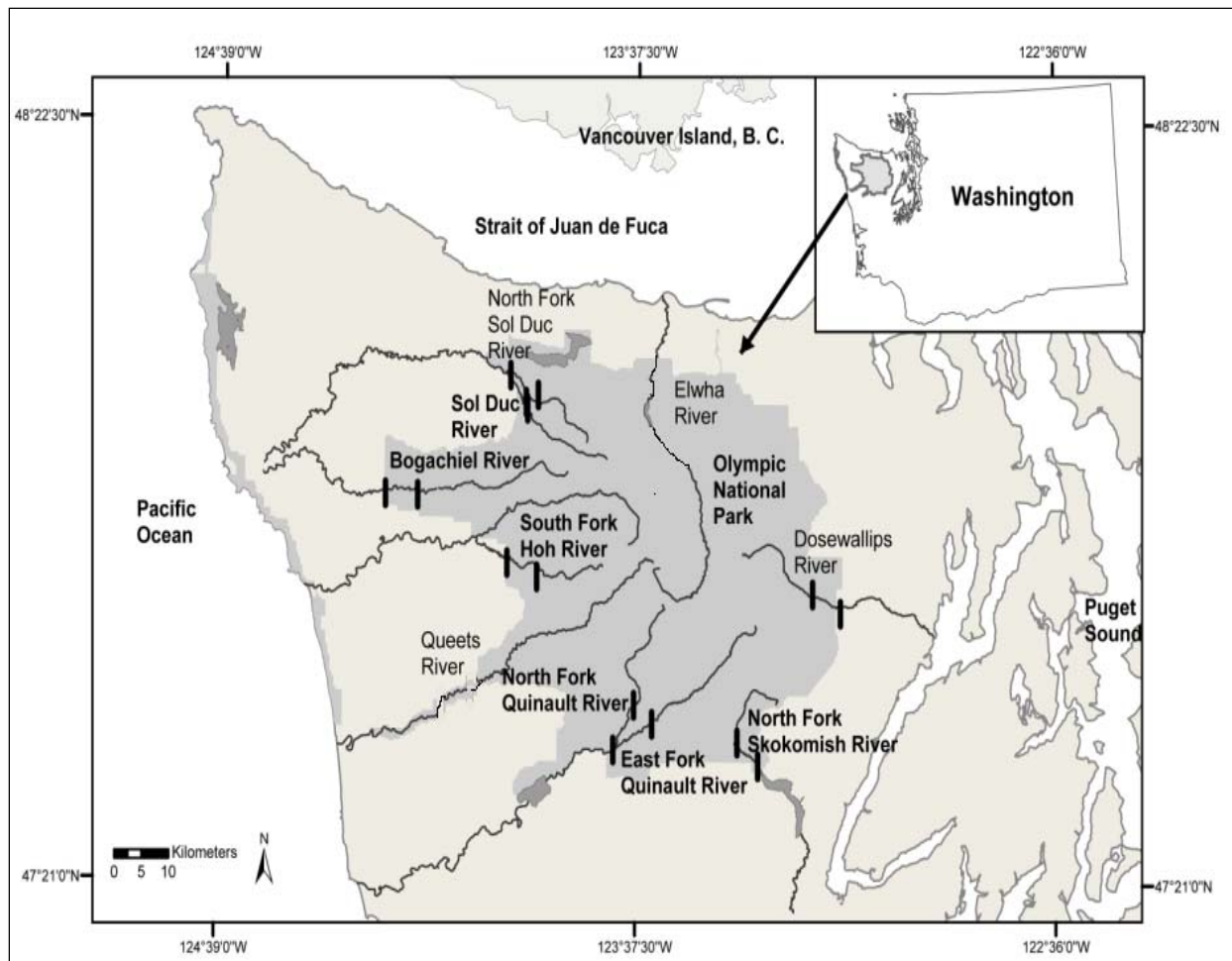


Figure 1. Location of reference sites for long-term monitoring of fish communities in OLYM rivers. Bars depict general location of reference sites that extend upstream from the park boundary.

Table 1. Watershed characteristics of OLYM rivers being monitored for seasonal and annual trends in fish communities.

River	Watershed Area (ha)	% Watershed Area in Park	Elevation at Park Boundary/ Headwater (m)	Total River Length (km)	Total River Length in Park (km)	Mean Summer Flow (cfs)	Anadromous Fish/ Hatchery Present	Drains into Where
Bogachiel (BOGA)	32,849	64	103/1,288	75.3	42.1	193	Yes/Yes	Quillayute River
Dosewallips (DOSE)	30,091	63	326/1,872	45.8	25.9	Not gaged	No/No	Hood Canal
East Fork Quinault (EFQU)	23,278	100	117/2,245	21.4	21.4	Not gaged	Yes/Yes	Quinault River
Elwha (ELWH)	83,300	82	262/1,372	72	60+	Not gaged	Yes/Yes	Strait of Juan de Fuca
North Fork Quinault (NFQU)	20,837	100	115/1,238	30.8	30.8	Not gaged	Yes/Yes	Quinault River
North Fork Skokomish (NFSK)	31,081	48	225/1,622	51.8 (includes reservoirs)	22.7	306	No/Yes	Lake Cushman
South Fork Hoh (SFHO)	11,338	79	244/1,318	31	24.3	287	Yes/No	Hoh River
Sol Duc (SOLD)	19,442	29	318/1,440	105.6	25.9	134	Yes/Yes	Quillayute River
North Fork Sol Duc (NFSO)	7,965	100	329/1,520	24.3	24.3	91	Yes/Yes	Sol Duc River

Methods

The seasonal movements, assemblage structure, and relative abundances of fish species were determined by intensive, weekly snorkel counts in reference sites of each river. The objective of repeated snorkel surveys in relatively long sample sites (2.6 to 5.7 km) was to examine seasonal and annual changes in abundances of each of the primary species. The general rationale for intensive sampling (e.g., up to 10 surveys per river per year) of reference sites was to account for the high seasonal variability in fish movements and abundances in rivers. To detect seasonal and annual trends in fish communities in reference sites, we relied on repeated (e.g. multiple surveys) and consistent annual sampling using the same methods at each monitoring location.

Number and Location of Sampling Sites

Fish communities were monitored in reference sites located immediately upstream of the park boundary (Figure 1, Table 1). We monitored portions of rivers immediately upstream of the park boundary as these reference sites typically minimize challenges to access. Specific locations of reference sites, travel times and duration of surveys are included in Tables 2a-b. The reference sites were comprised of main-stem and side-channel habitats with multiple types of habitat units (e.g., 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. These river reference sites were generally 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 2a. Approximate drive time (round trip from Port Angeles), hiking duration, and duration of snorkel survey at each reference site.

River/Park Region	Drive Time	Hike Time	Snorkel Time
Bogachiel, Quillayute System	3.0hrs	2.0hrs	2.0-3.5hrs
Dosewallips, Hood Canal	3.0hrs	3.5hrs	1.0-1.5hrs
East Fork Quinault, Pacific Coast	5.5hrs	0.5hrs	2.0-3.75hrs
Elwha River, Strait of Juan de Fuca	0.5hrs	1.0hrs	1.0-1.5hrs
North Fork Quinault, Pacific Coast	5.5hrs	0.5hrs	2.0-3.75hrs
North Fork Skokomish, Hood Canal	5.0hrs	0.5hrs	1.5-2.5hrs
South Fork Calawah River, Quillayute System	1.5hrs	0.3hrs	3.0hrs
S. Fk. Hoh, Pacific Coast	4.5hrs	1.75hrs	1.5-3.0hrs
Sol Duc, Quillayute System	2.0hrs	0.75hrs	2.25-3.5hrs
N. Fk. Sol Duc, Quillayute System	2.0hrs	1.0hrs	2.5-4.0hrs

Table 2b. Specific locations of river reference sites in OLYM based on GPS.

River/Park Region	Downstream Boundary		Upstream Boundary		Location (rm)
	Latitude	Longitude	Latitude	Longitude	
Bogachiel, Quillayute System	47.8788972	124.2472417	47.8830556	124.18972	25.0-22.0
Dosewallips, Hood Canal	47.7325709	123.1542179	47.7377778	123.17083	16.0-14.5
East Fork Quinault, Pacific Coast	47.5375	123.6708333	47.5575	123.61139	51.0-47.4
Elwha River, Strait of Juan de Fuca	NA	NA	NA	NA	17.1-15.1
North Fork Quinault, Pacific Coast	47.5375	123.6708333	47.5689143	123.64873	2.7-0.0
North Fork Skokomish, Hood Canal	47.5022222	123.3175	47.5196182	123.33442	29.7-28.1
South Fork Calawah River, Quillayute System	47.9633333	124.2938889	47.9519444	124.24444	15.8-13.1
South Fork Hoh, Pacific Coast	47.7902778	123.9352778	47.7782956	123.90696	6.5-4.8
Sol Duc, Quillayute System	47.9872222	123.8938889	47.9669444	123.85972	62.7-60.4
North Fork Sol Duc, Quillayute System	48.025	123.9094444	48.007486	123.89154	4.2-2.2

Two experienced divers, one on each side of the river (Figure 2), proceeded downstream counting each species of fish greater than 15 cm in fork length. When fish were observed in large aggregations, divers commonly made two passes in their respective lanes and averaged the counts. Because of the difficulty in distinguishing between cutthroat trout and rainbow trout underwater, counts of these two species were combined as cutthroat/rainbow trout. Seasonal and annual trends of proportions of hatchery (e.g., fin clipped) versus wild salmonids were determined by observations of marked and unmarked fish at reference site each survey. The observations of marked fish provide a relative gage of the extent of hatchery fish invasions in park rivers. These observations only apply to adult salmonids. Divers made frequent stops to compare and minimize duplication of counts. The sampling procedure of snorkel counts was consistent within and among years and consistent among rivers.

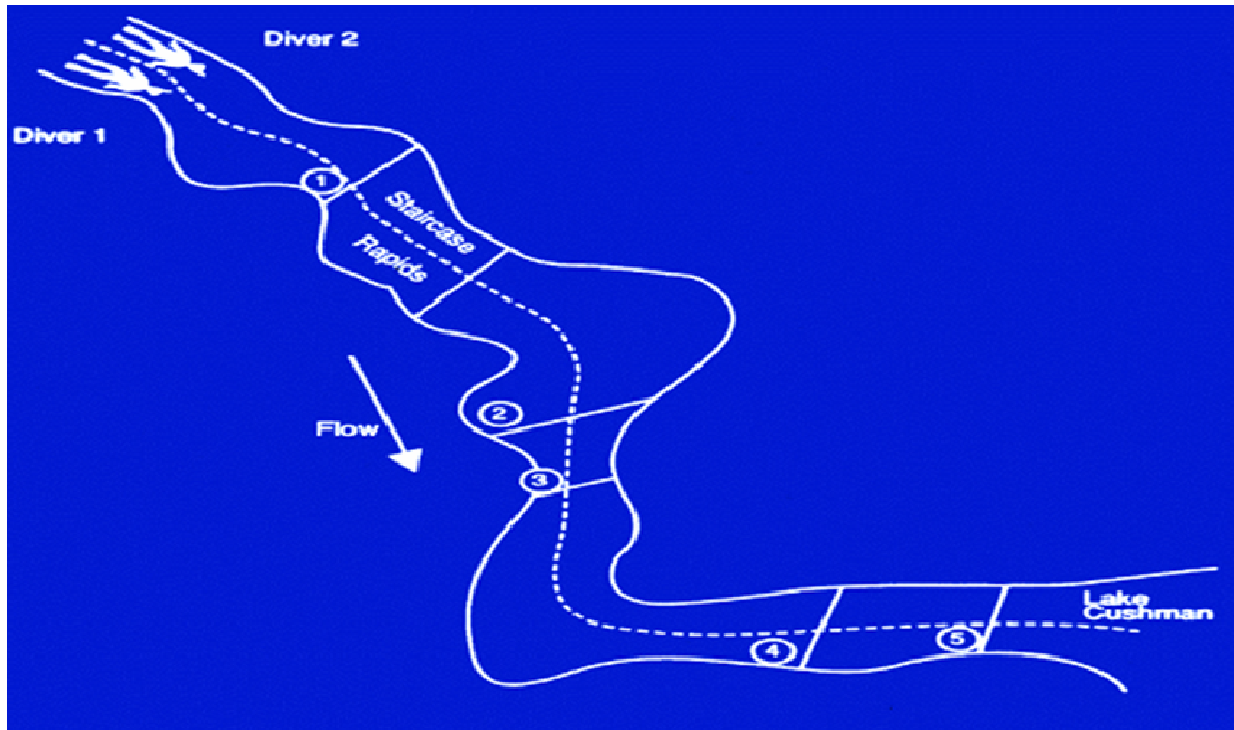


Figure 2. Schematic diagram that depicts two divers snorkeling downstream to count fish species in the reference site in the North Fork Skokomish River, OLYM.

Results

Snorkel Survey Effort Within and Among Rivers

Fisheries biologists conducted the most intensive monitoring efforts to date of fish communities in NCCN rivers with $n=351$ snorkel surveys from 2005 to 2010 (Figure 3). Fisheries crews snorkeled ~1,400 river kilometers in 10 rivers during those years. The maximum number of surveys occurred in the North Fork Skokomish River (69 surveys) and the minimum number of surveys occurred in the Dosewallips (12 surveys) and South Fork Calawah (4 surveys; 2010 only) (Figure 3). Biologists made 129,558 individual fish observations from 2005 to 2010. The number of fish observed per river in a given year ranged from 1,936 in the Elwha to 34,999 in the East Fork Quinault (Figure 4). In total, we monitored 14 fish species across the 10 rivers. Eleven of the 14 fish species were in the family Salmonidae (Table 3).

In 2010, 53 surveys occurred from June to September, 2010 with most occurring in August and September (Table 4). In 2010, biologists made 28,600 individual fish observations (Figure 5), with the maximum number of fish observations occurred in the East Fork Quinault ($n=8,059$) and Bogachiel ($n=6,499$) Rivers and the least number of observations in the Elwha River ($n=473$).

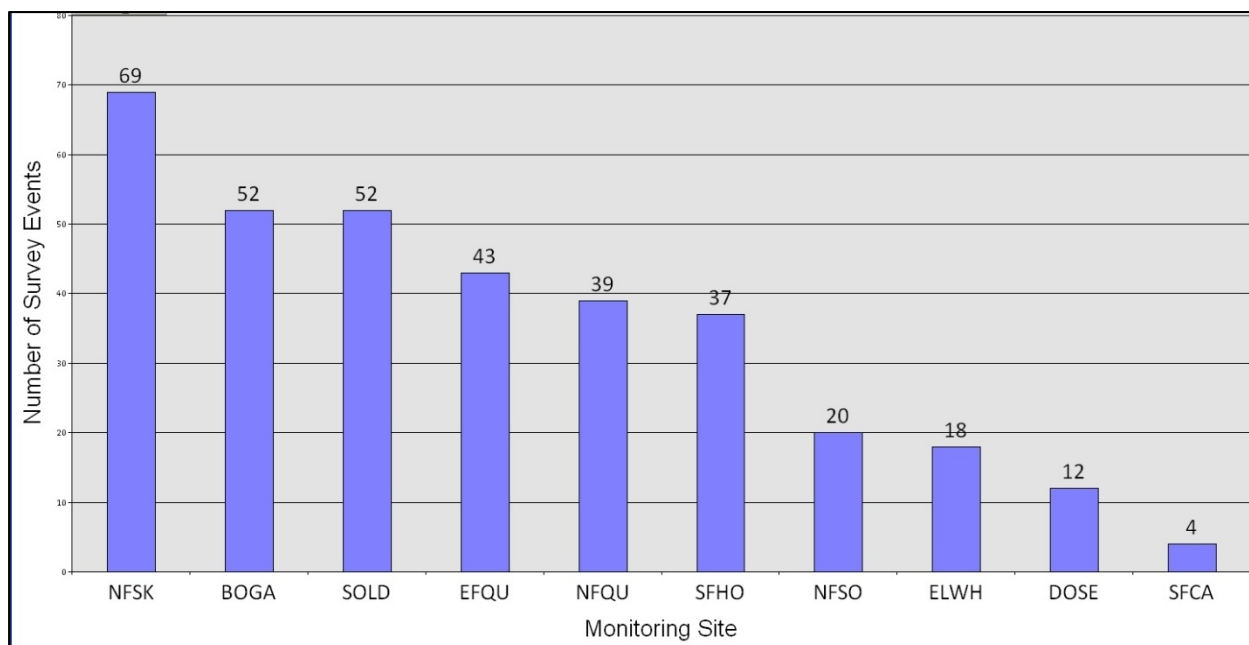


Figure 3. Number of snorkel surveys in reference sites of OLYM rivers from 2005 to 2010 as part of the monitoring program for fish communities during summer months.

Table 3. Fish species that were annually monitored in OLYM rivers during snorkel surveys from 2005 to 2010.

Common Name	Family	Genus species	River(s)
Largescale sucker	Catostomidae	<i>Catostomus macrocheilus</i>	EFQU
Dace	Cyprinidae	<i>Rhynchithys spp.</i>	BOGA
Pacific lamprey	Petromyzontidae	<i>Lampetra tridentata</i>	BOGA
Chinook salmon	Salmonidae	<i>Oncorhynchus tshawytscha</i>	#NFSK; BOGA; EFQU; NFQU; SOLD; SFHO
Pink salmon	Salmonidae	<i>O. gorbuscha</i>	BOGA
Chum salmon	Salmonidae	<i>O. keta</i>	BOGA; SFHO
Sockeye salmon	Salmonidae	<i>O. nerka</i>	BOGA; EFQU; SFHO
Coho salmon	Salmonidae	<i>O. kisutch</i>	BOGA; EFQU; NFQU; SOLD; NFSO; SFHO
Steelhead trout	Salmonidae	<i>O. mykiss</i>	BOGA; EFQU; NFQU; SOLD; NFSO; SFHO; SFCA
+Rainbow trout	Salmonidae	<i>O. mykiss</i>	DOSE; ELWH; BOGA; EFQU; NFQU; SOLD; NFSO; SFHO; SFCA; NFSK
Cutthroat trout	Salmonidae	<i>O. clarkii</i>	ELWH; BOGA; EFQU; NFQU; SOLD; NFSO; SFHO; SFCA; NFSK
Bull trout	Salmonidae	<i>Salvelinus confluentus</i>	ELWH; EFQU; NFQU; SFHO; NFSK
*Eastern brook trout	Salmonidae	<i>S. fontinalis</i>	DOSE
Mountain whitefish	Salmonidae	<i>Prosopium williamsoni</i>	SFCA; BOGA; EFQU; NFQU; NFSO; SFHO; SFCA; NFSK

*Non-native fish species; #Landlocked Chinook salmon; +Landlocked rainbow trout.

Table 4. Weekly distribution of snorkel surveys among ten OLYM rivers from June to September, 2010.

River	Jun 20	Jun 27	Jul 4	Jul 11	Jul 18	Jul 25	Aug 1	Aug 8	Aug 15	Aug 22	Aug 29	Sep 5	Sep 12	Sep 19
NF Skokomish							X	X	X	X	X	X	X	X
Bogachiel		X	X	X	X		X	X	X	X			X	
Sol Duc	X	X		X	X		X	X					X	
EF Quinault							X	X	X	X	X	X	X	
NF Quinault								X	X	X		X	X	
SF Hoh					X	X		X		X			X	
NF Sol Duc		X			X							X		
Elwha												X	X	X
Dosewallips										X			X	
SF Calawah				X			X	X	X					

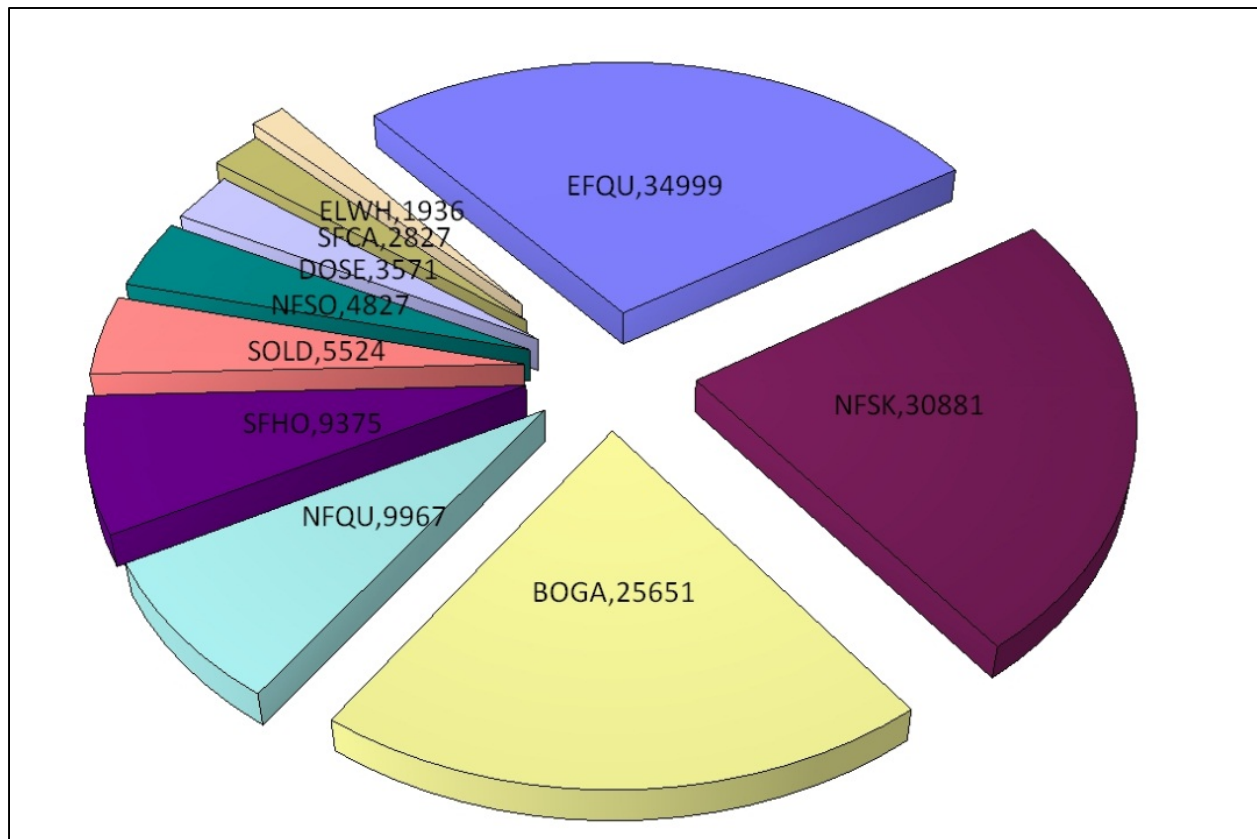


Figure 4. Total number of fish observations among rivers from 2005 to 2010.

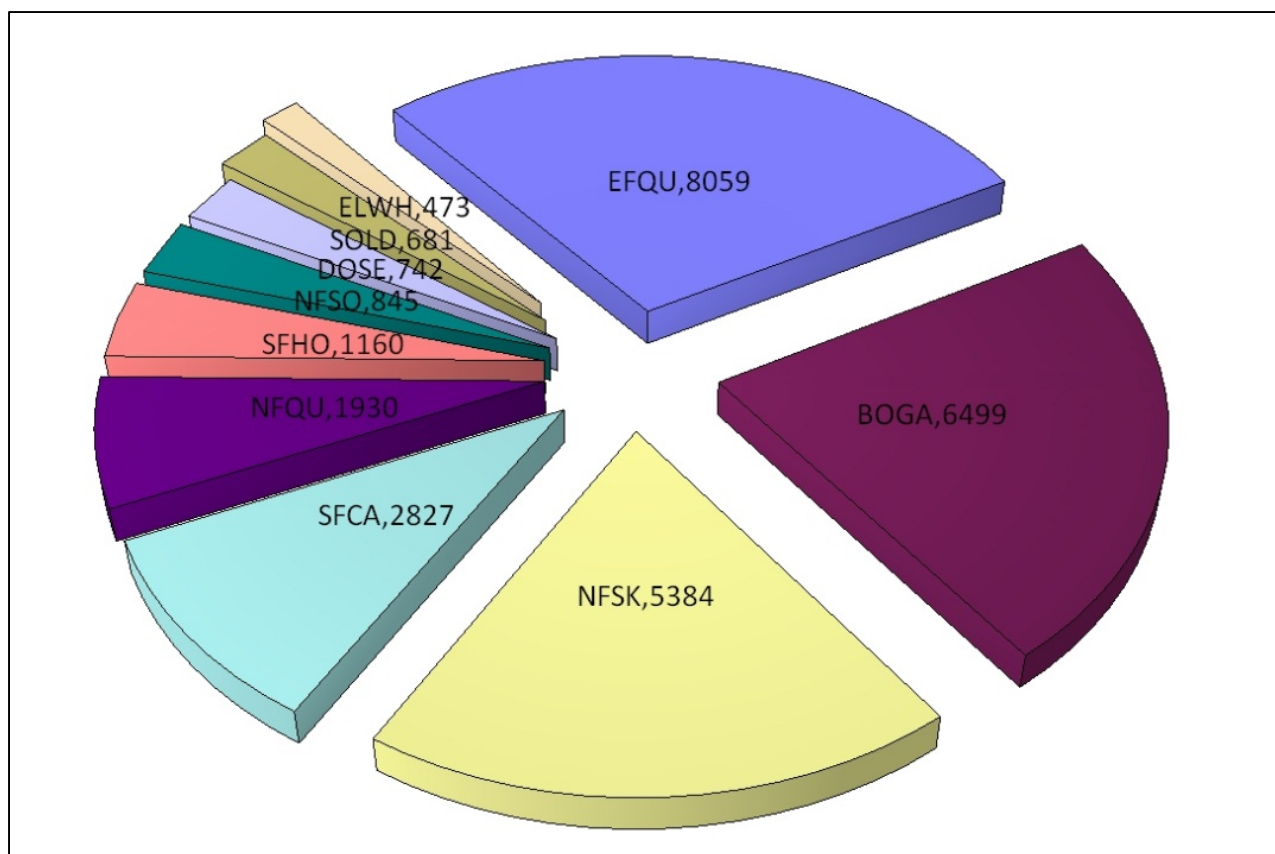


Figure 5. Total number of fish observations among rivers in 2010.

Comparisons of Seasonal Fish Species Composition Within and Among Rivers

The relative seasonal composition of fish species was determined within each river in 2010 (Figures 6 to 8). Seasonal trends in fish species composition were reported as the mean percent of each fish species in a given month in each river.

Species compositions in the East Fork Quinault, North Fork Quinault, and South Fork Hoh Rivers exhibited similar patterns during summer months in 2010. Mountain whitefish, trout, and bull trout had the highest percentages, respectively in those rivers (Figure 6 with EFQU, NFQU, SFHO). The Sol Duc, North Fork Sol Duc, and Dosewallips Rivers were dominated by trout during all summer months in 2010 (Figures 7 and 8). Mountain whitefish and trout comprised a majority of the fish communities in the Bogachiel, South Fork Calawah, and North Fork Skokomish Rivers (Figures 7 and 8). Adult Pacific salmon and steelhead trout comprised low percentages of reference sites among all rivers in 2010.

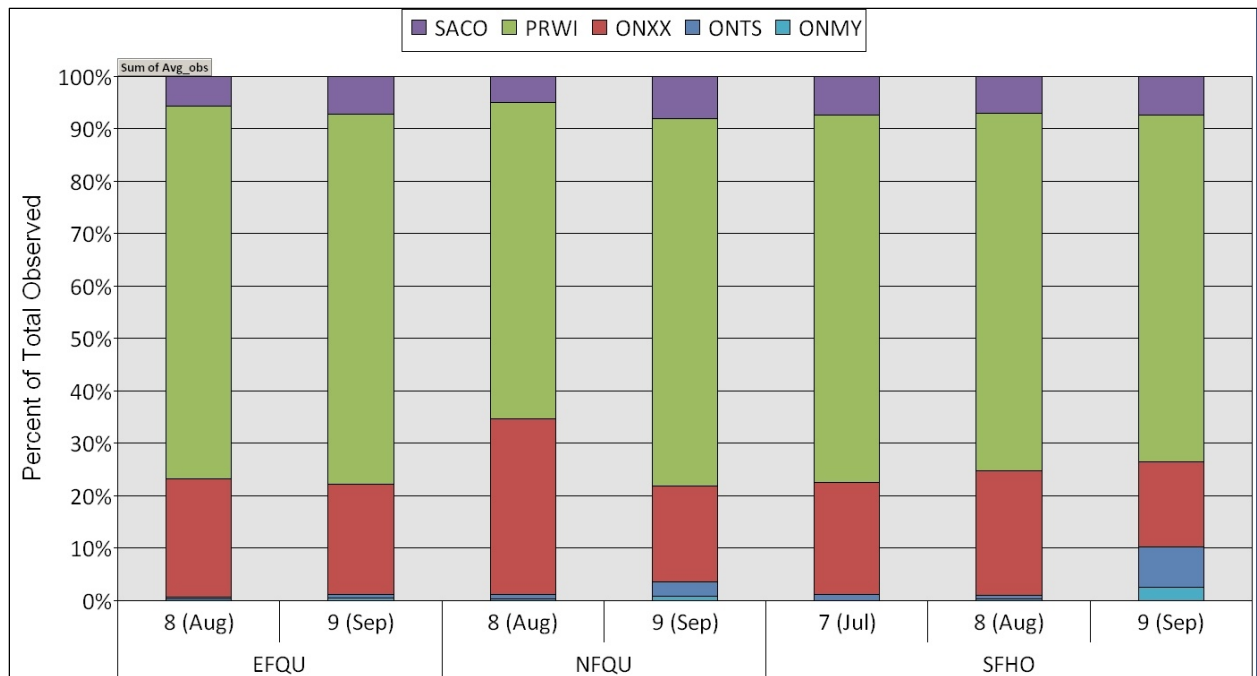


Figure 6. Mean monthly composition of primary fish species in the East Fork Quinault River, North Fork Quinault River, and South Fork Hoh River in 2010. Surveys were limited to the months below based on high riverflows in June and July. SACO=bull trout; PRWI=mountain whitefish; ONXX=cutthroat/rainbow trout; ONTS=adult Chinook salmon; and ONMY=adult summer steelhead.

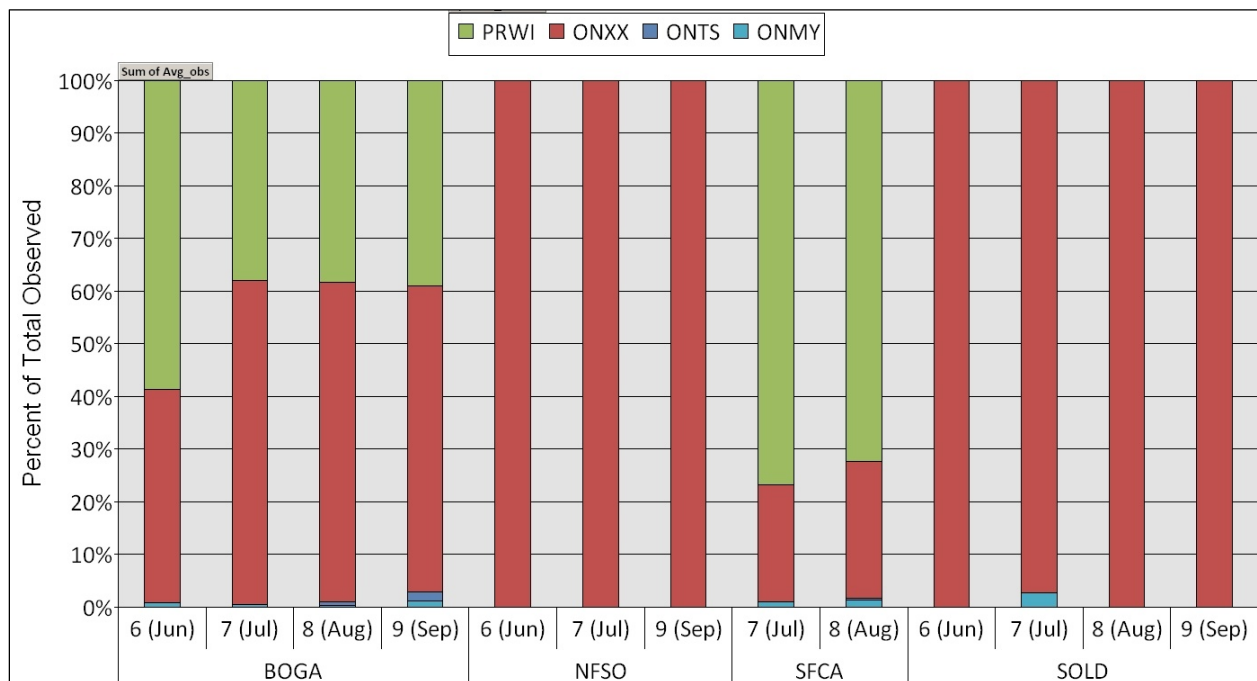


Figure 7. Mean monthly composition of primary fish species in the Bogachiel, North Fork Sol Duc, South Fork Calawah, and Sol Duc Rivers in 2010.

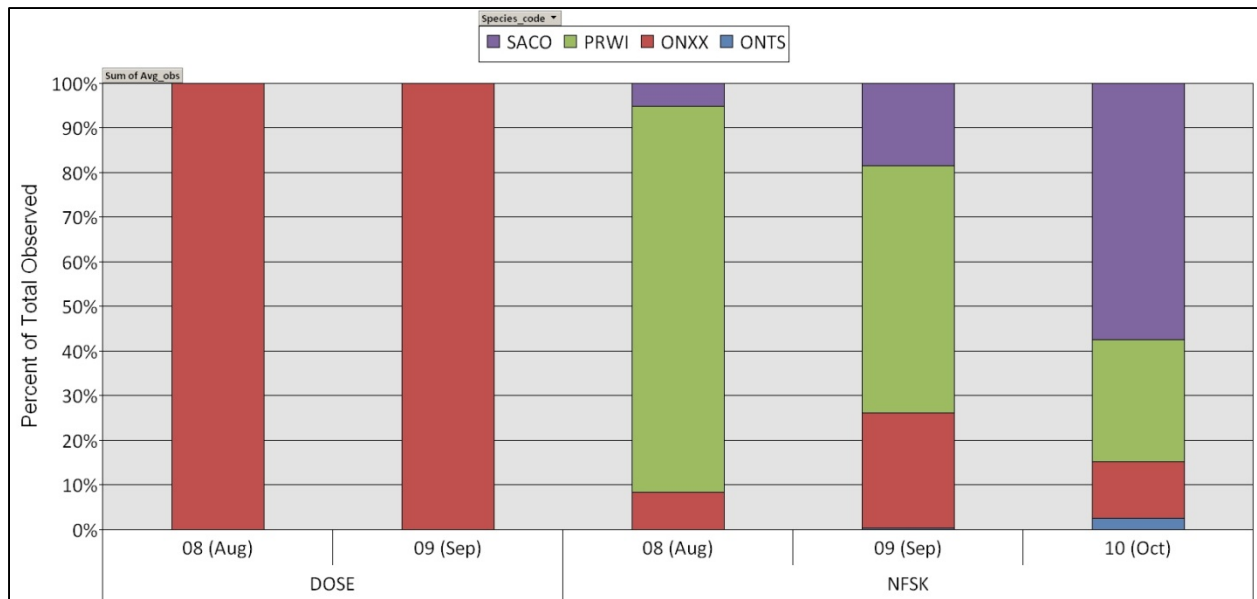


Figure 8. Mean monthly composition of primary fish species in the Dosewallips and North Fork Skokomish Rivers in 2010.

The patterns of mean percent species composition observed among all rivers in 2010 was generally consistent with overall patterns based on means of monthly surveys conducted since 2005 (Figures 9a-c). Missing bar graphs for certain months reflect no surveys during that time.

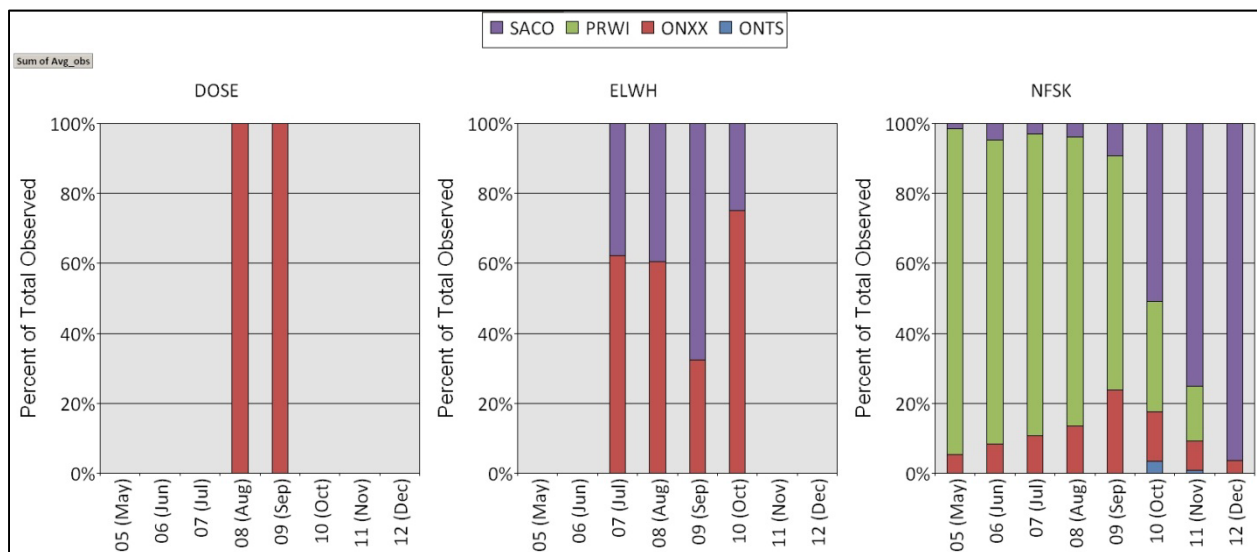


Figure 9a. Mean monthly composition of primary fish species in the Dosewallips, Elwha, and North Fork Skokomish Rivers from 2005 to 2010.

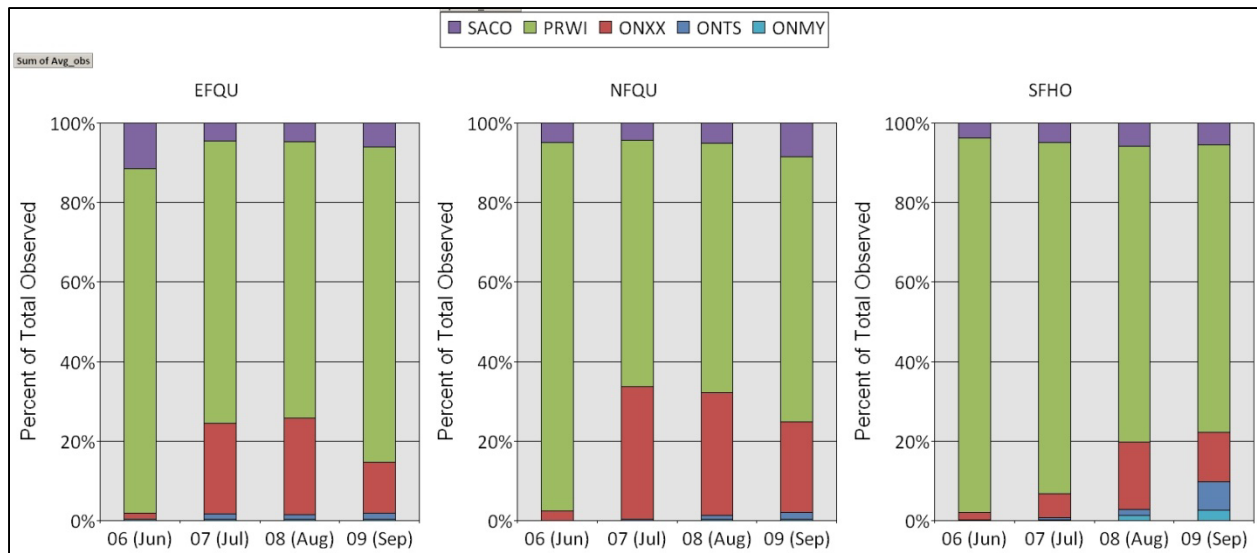


Figure 9b. Mean monthly composition of primary fish species in the East Fork Quinault, North Fork Quinault, and South Fork Hoh Rivers from 2005 to 2010.

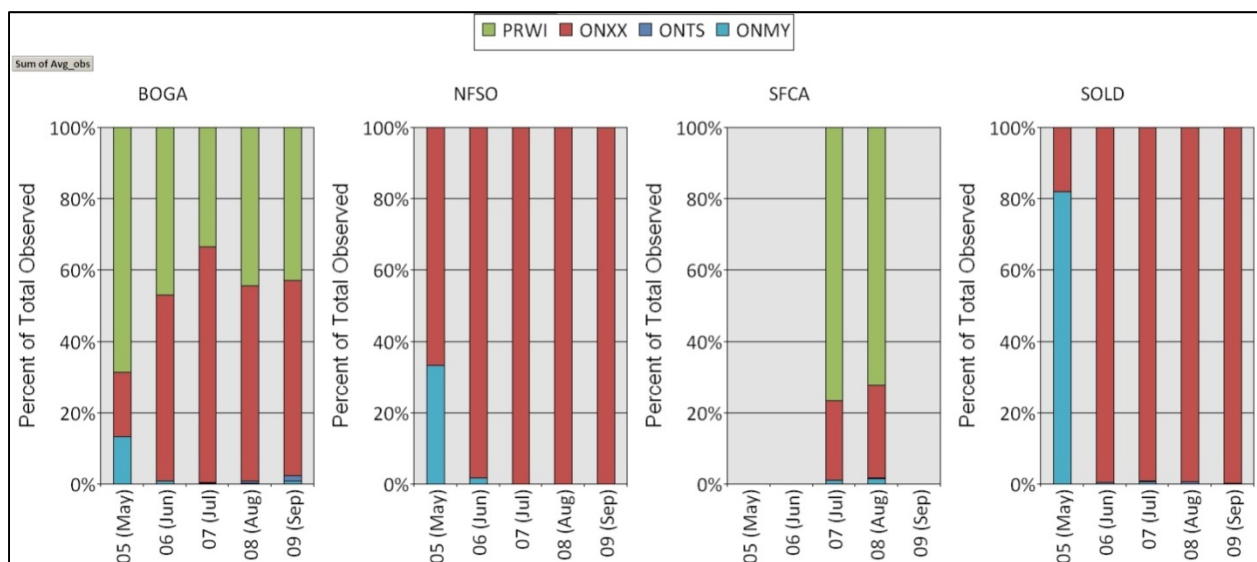


Figure 9c. Mean monthly composition of primary fish species in the Bogachiel, North Fork Sol Duc, South Fork Calawah, and Sol Duc Rivers from 2005 to 2010.

Annual Abundances of Fish Species within and Among Rivers

We determined annual peak counts of primary fish species among rivers in 2010 (Figures 10 and 11) as a gage of relative productivity for different species among park rivers. Annual peak counts of mountain whitefish were orders of magnitude greater than other fish species, and were highest in the East Fork Quinault and North Fork Skokomish Rivers (Figure 10). Peak counts of rainbow/cutthroat trout were highest in the Bogachiel River and bull trout were highest in the North Fork Skokomish River.

In 2010, peak counts of adult Chinook and summer steelhead were exceptionally low across rivers and ranged from 3 to 32 and 3 to 13 adults, respectively (Figure 11). The South Fork Calawah had the highest number of summer steelhead and the South Fork Hoh contained the most adult Chinook salmon in 2010.

For context, trends in annual peak counts were also determined for summer steelhead, bull trout, and mountain whitefish in coastal rivers since 2005 (Table 5). Adult summer steelhead were in relatively low abundances in all rivers when compared to bull trout and mountain whitefish (Table 5). Mountain whitefish were the most abundant fish species in all rivers in each of the six years. The North Fork Skokomish River had the highest annual peak counts for bull trout and mountain whitefish.

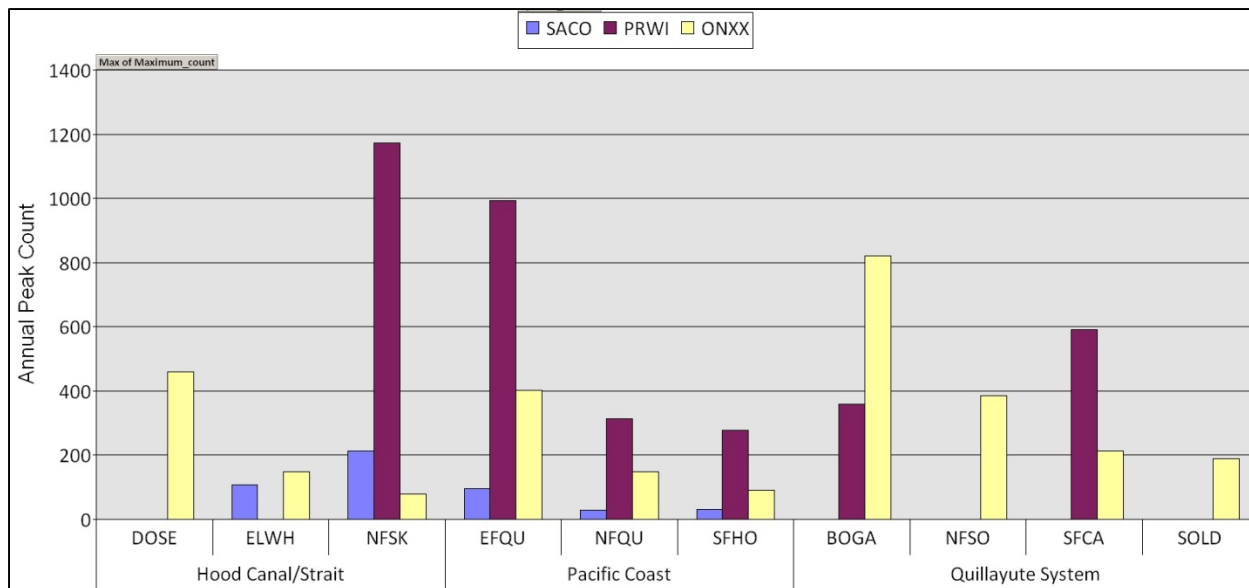


Figure 10. Annual peak counts of bull trout, mountain whitefish, and rainbow/cutthroat trout across ten OLYM rivers in summer, 2010.

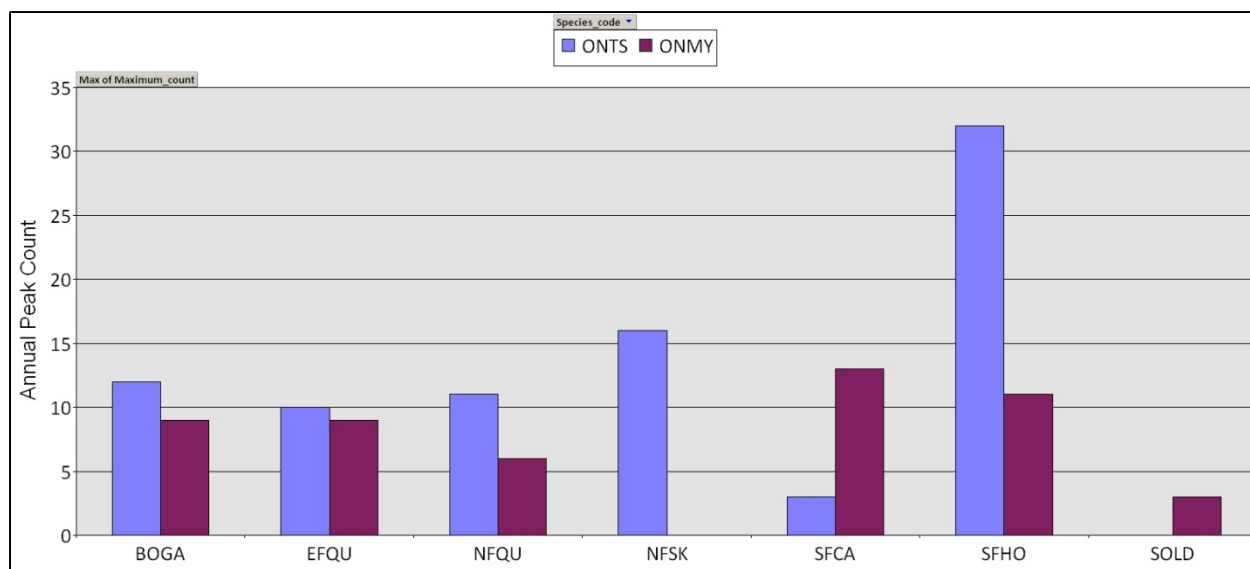


Figure 11. Annual peak counts of adult Chinook salmon and adult summer steelhead in seven rivers in summer, 2010. Chinook and steelhead do not occur in some rivers.

Table 5. Comparisons of annual peak counts for adult summer steelhead, bull trout and mountain whitefish among river systems from 2005 to 2010.

	2005	2006	2007	2008	2009	2010
Summer Steelhead						
Bogachiel	1	14	5	6	12	9
EF Quinault	8	13	3	2	5	9
NF Quinault	1	2	1	0	4	6
SF Hoh	13	11	5	7	6	11
Sol Duc	15	13	0	1	3	3
Bull Trout						
EF Quinault	50	62	51	58	79	96
NF Quinault	17	22	31	22	22	29
NF Skokomish	150	71	243	202	73	212
SF Hoh	24	17	24	18	14	31
Mountain Whitefish						
Bogachiel	211	251	165	173	447	358
EF Quinault	814	851	652	793	1084	994
NF Quinault	193	142	156	282	502	313
NF Skokomish	1294	744	791	810	664	1173
SF Hoh	353	313	312	322	209	278

Proportions of Hatchery and Wild Fish in Rivers

Annual trends in proportions of hatchery (fin clipped) versus wild salmonids were determined by observations of marked and unmarked fish at each reference site. Annual observations of

hatchery and wild fish (for each species) in a given river were summed to determine the proportion of hatchery to wild salmonids in 2010 (Figure 12). These observations apply only to adult salmonids and do not include observations recorded as “unknown” where snorkelers failed to identify whether an individual fish was wild or hatchery.

In 2010, hatchery, nonnative summer steelhead were detected in the Bogachiel, East Fork Quinault, North Fork Quinault, and South Fork Hoh Rivers (Figure 12). The South Fork Hoh had the highest percentage of hatchery summer steelhead (69%) that year. In 2010, hatchery Chinook salmon were only detected in the South Fork Hoh River (Figure 12; right panel). We did not detect hatchery coho salmon in any reference site in 2010.

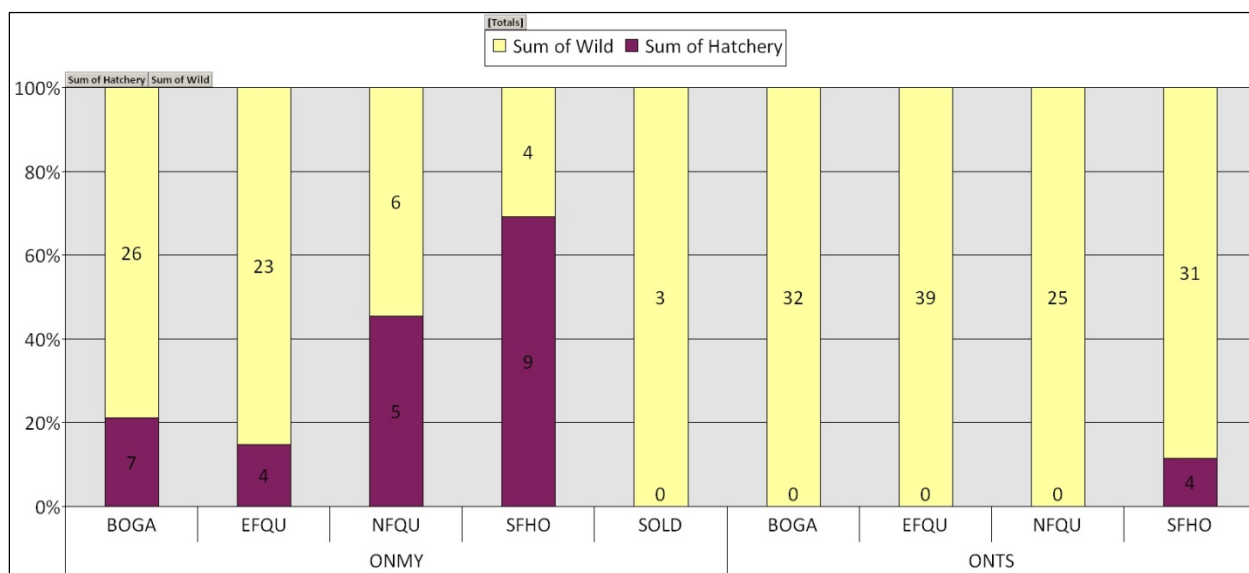


Figure 12. Summary of the relative proportions of hatchery (purple) and wild (yellow) adult steelhead and Chinook salmon among Bogachiel, East and North Fork Quinault, South Fork Hoh, and Sol Duc Rivers in 2010. The relative number of marked versus unmarked fish is based on the total number of observations from June through September that year.

To place 2010 hatchery versus wild fish observations in context, we evaluated the relative proportions of hatchery coho, summer steelhead, and Chinook salmon among coastal rivers from 2005 to 2010 (Figure 13). Hatchery coho salmon were only observed in the South Fork Hoh River (Figure 13; left panel) where they were found in four of six years (Figure 14). The Sol Duc River contained all wild coho in the reference site based on 1,126 observations since 2005 (Figures 13 and 14).

From 2005 to 2010, hatchery Chinook salmon were detected in the Bogachiel (2 out of 6 years), East Fork Quinault (4 out of 6 years), North Fork Quinault (2 out of six years), and South Fork Hoh (5 out of 6 years) Rivers (Figure 15). The percent of hatchery Chinook salmon ranged from 0 to 44 percent of the total observations in any given year in the South Fork Hoh River.

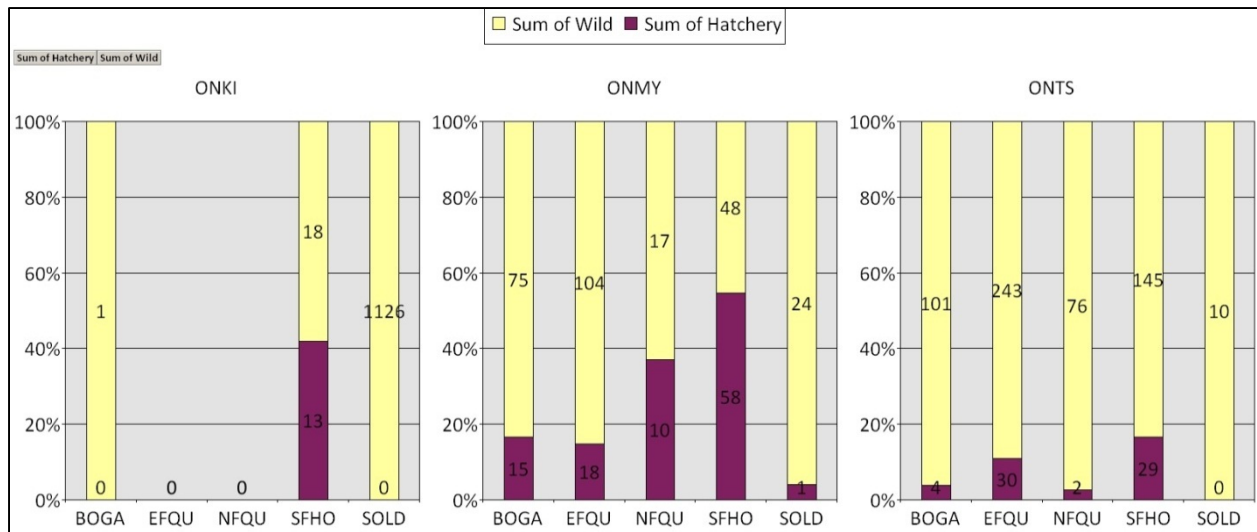


Figure 13. Summary of the relative proportions of hatchery (purple) and wild (yellow) adult coho, summer steelhead, and Chinook in the Bogachiel, East Fork Quinault, North Fork Quinault, South Fork Hoh, and Sol Duc Rivers based on total observations from 2005 to 2010.

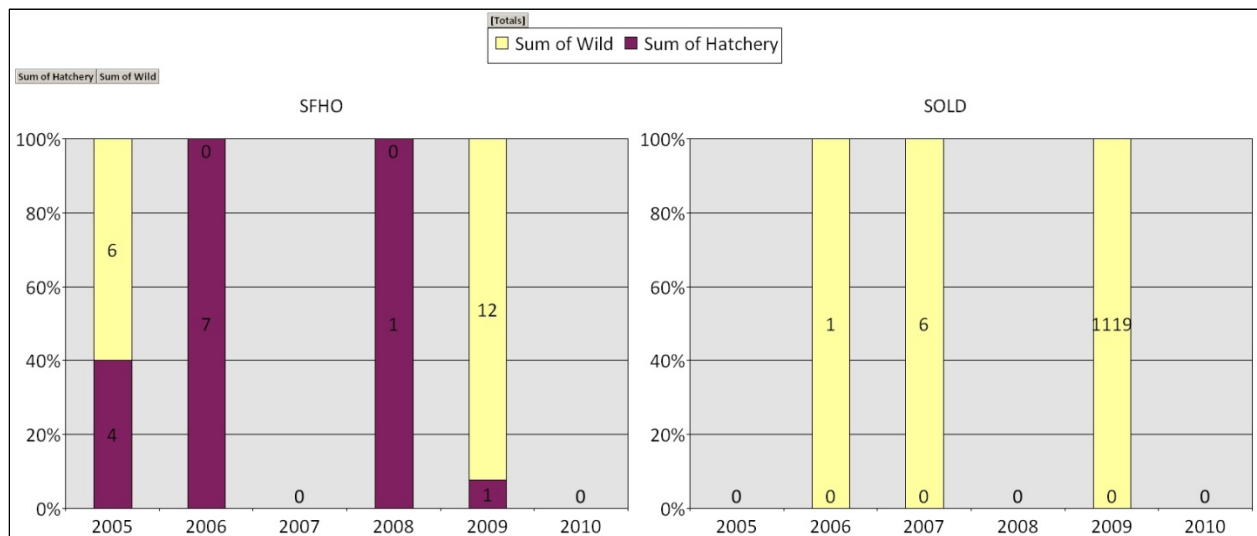


Figure 14. Summary of the relative proportions of hatchery (purple) and wild (yellow) adult coho salmon in the South Fork Hoh and Sol Duc Rivers from 2005 to 2010. The relative number of marked versus unmarked fish is based on the total number of observations from June through September each year.

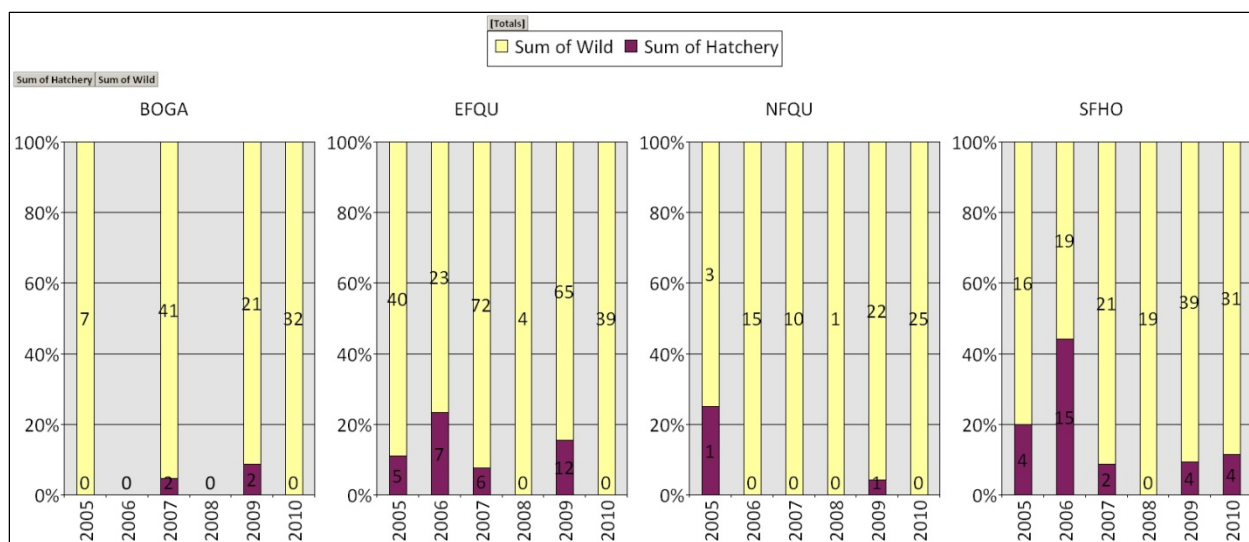


Figure 15. Summary of the relative proportions of hatchery (purple) and wild (yellow) adult Chinook salmon in the Bogachiel, East Fork Quinault, North Fork Quinault, and South Fork Hoh Rivers from 2005 to 2010. The relative number of marked versus unmarked fish is based on the total number of observations from June through September each year.

From 2005 to 2010, hatchery summer steelhead were observed in all coastal rivers, and were detected in the Bogachiel (4 out of 6 years), East Fork Quinault (5 out of 6 years), North Fork Quinault (4 out of 6 years), and South Fork Hoh all six years (Figure 15). A total of 55% of all observed summer steelhead in the South Fork Hoh were of hatchery origin during those years (Figures 13 and 16).

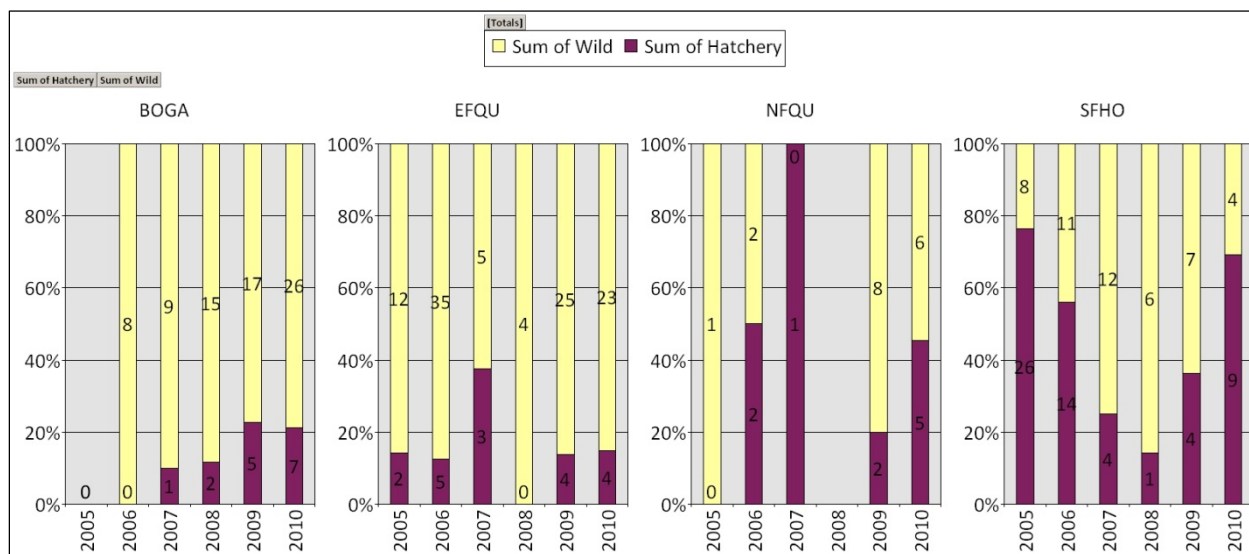


Figure 16. Summary of the relative proportions of hatchery (purple) and wild (yellow) adult summer steelhead in the Bogachiel, East Fork Quinault, North Fork Quinault, and South Fork Hoh Rivers from 2005 to 2010. The relative number of marked versus unmarked fish is based on the total number of observations from June through September each year.

Discussion

Fish communities that inhabit park rivers serve as important benchmarks that define natural limits of variation and monitoring can identify where management actions are necessary. A key to understanding fish communities in NCCN rivers is the collection of temporally consistent information on an annual basis. In OLYM rivers, no previous work has relied on an intensive approach to monitor fish communities across years and rivers. As a consequence, this effort – with over 350 surveys in 10 rivers across six years and comprising over 1400 kilometers surveyed – provides a novel and invaluable information asset for understanding and managing these resources.

Although conducted in wilderness rivers, the monitoring approach of repeated and intensive sampling of reference sites proved to be logistically feasible in the ten selected rivers. Surveys occurred at frequent intervals (i.e., every 7 to 10 days) to minimize the effects of fish movements within each river. The summer timeframe provided a seasonal snapshot of river fish communities, abundances, and hatchery and wild fish during low flows.

Fish Species Composition and Annual Peak Counts

Snorkel surveys revealed the magnitude of abundance of each fish species within reference sites of each river and provided some of the only information on federally threatened bull trout on the Olympic Peninsula. The presence and relatively high proportions of hatchery summer coho, summer steelhead, and spring Chinook in the South Fork Hoh was surprising since the Hoh River Basin does not receive hatchery plantings for any of those stocks. Mountain whitefish and trout typically exhibited the highest mean percentages of the fish assemblage during summer months followed by bull trout. Adult summer steelhead and Chinook salmon were in extremely low numbers in all coastal rivers that drain from OLYM and in lower numbers than federally threatened bull trout. Steelhead trout are a sea-run form of the rainbow trout that have declined from historic levels throughout the Pacific West.

Because sampling occurred only during summer low flows, key salmonid species such as adult coho, Chinook, and winter steelhead were missed since they typically enter the river in the autumn and winter. The snorkel methods also were ineffective at sampling benthic species (e.g. sculpins) and juvenile bull trout that are typically observed more at night. Despite these limitations, the approach to date has been a relatively cost effective (\$45,000 per year) approach to monitoring multiple species across park rivers.

Hatchery, Non-native, and Wild Fish in OLYM Rivers

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 OLYM boundaries. Hatchery fish, through interbreeding with wild fish, genetically alter wild populations, reduce fitness, and reduce genetic differentiation among stocks (Reisenbichler and McIntyre 1977, Chilcote et al. 1986).

The observations of marked fish provided a relative gage of the extent of hatchery fish invasions in OLYM rivers. The detection of hatchery salmonids in reference sites relied on multiple years

of surveys to account for interannual variability in hatchery returns. For instance, if one only looked in a reference site for one year, they may not detect hatchery fish. Therefore, it is critical to rely on repeated sampling across years in the reference sites.

Hatchery origin adult summer steelhead, summer coho salmon, and Chinook salmon were detected in OLYM rivers. Summer steelhead exhibited the highest proportions of hatchery fish across coastal rivers and were more abundant than wild steelhead in most years in the South Fork Hoh River (up to 76% in a given year). Recent estimates of the proportion of hatchery winter steelhead on natural spawning grounds in Olympic Peninsula rivers ranged from 16% (Quillayute River) to 44% (Quinault River) (Busby et al. 1996).

Adult hatchery Chinook salmon were detected in some years across rivers and hatchery coho salmon were only observed in the Sol Duc River in 2010. A total of 31% (n=319) of the adult salmonids observed in the South Fork Hoh River were of hatchery origin based on observations from 2005 to 2010. We did not detect non-native brook trout in any reference site from 2005 to 2010 although populations exist in headwater areas of many rivers that are being monitored.

Management Implications

We assessed high priority management species (e.g. economically important and threatened fish species) with information on the numbers of each fish species, the extent of non-native and hatchery fish invasions, and seasonal and annual trends in federally threatened fish species (e.g., bull trout). From a fish assemblage perspective, this program tracks changes in fish species composition within a river and allows general comparisons and correlations of trends in fish communities among rivers. This will be of particular value during detailed trend analyses to be conducted every five years.

There are multiple instances where data collected as part of this monitoring project were used to inform park managements:

- 1) Knowledge of the presence, timing, and numbers of threatened fish species within a reference site were used for compliance purposes and to establish work windows for road management projects along river corridors in 2010;
- 2) Information about migratory timing and relative abundance of fish species within reference sites was used to develop appropriate fishing regulations to protect federally threatened North Fork Skokomish River bull trout. In that river, the fishing season (June to September) provided recreational opportunity during summer months while protecting bull trout during their spawning migration from late September to December (e.g. river closed).
- 3) Information on the relative numbers of hatchery fish in reference sites is critical to the successful management of wild fish. The information on proportions of hatchery and wild salmonids from this monitoring was recently used to obtain funding to address hatchery origins of those fish. 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.

4) The detection of non-native fish (e.g. brook trout) in reference sites of rivers was designed to provide an early warning signal for alien fish invasions in OLYM rivers. Fortunately, we did not detect any nonnative fish in the reference sites in 2010. With annual sampling over the next years, any future detection of nonnative fish (e.g. brook trout) would prompt management actions that address the control of these nonnative fish in park rivers.

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