

Wild Fish Conservancy

N O R T H W E S T

S C I E N C E E D U C A T I O N A D V O C A C Y

Coho Prespawning Mortality Assessment in Washington and Oregon

EPA Assistance ID: X5-96007101-0

Final Report

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Introduction:

Prespawning mortality (PSM) occurs when adult salmon return to freshwater but die before they spawn. From 1999 to present, Wild Fish Conservancy has documented alarming rates of coho salmon (*Oncorhynchus kisutch*) prespawning mortality in Seattle area streams, ranging from 17-100%. In some urban watersheds, the majority of returning adult coho die before spawning, sometimes within hours of stream entry. Other salmonid species using the same watersheds do not seem to be affected to the same extent by this phenomenon. The NOAA Northwest Fisheries Science Center with assistance from Wild Fish Conservancy (WFC) and Seattle Public Utilities, is analyzing stream and storm water quality and performing ecotoxicology bioassays on a subsample of Seattle metropolitan area coho salmon body tissues to investigate potential mortality factors. Preliminary results suggest compromised water quality as a causal factor, but the specific mortality mechanism, relationship to land-use, and geographic scope of the phenomenon are as yet unknown.

Given the threatened or depressed status of trout, salmon, freshwater mussel, and other aquatic populations across the Pacific Northwest, water quality conditions so inhospitable as to kill fish within hours of initial exposure are ecologically intolerable. In 2003 and 2004, with EPA support, WFC examined coho PSM in Snoqualmie (King County, western Washington) and Skykomish (Snohomish County, western Washington) watershed tributaries to expand the geographic focus of our studies and to investigate coho PSM in rural residential/agricultural watersheds (WFC 2004). In 2005 and 2006, again with funding awarded by EPA, we expanded our geographic scope to further investigate coho PSM in heavily- and moderately-developed Seattle, Bellingham, and Olympia, Washington area streams. We also polled Pacific Northwest aquatic resource managers to better gauge the extent of coho PSM, and completed a coarse-scale GIS analysis to elucidate relationships between coho PSM, watershed characteristics, and land use. This report documents the results of the 2005-2006 effort.

Objectives:

The identification of coho salmon prespawning mortality is a recent phenomenon. A precise coho PSM causal mechanism has yet to be described, and little is known about the geographic extent of the problem. While NOAA Fisheries scientists continue to investigate causal mechanisms, WFC sought to better gauge the geographic extent of the phenomenon using both field surveys in urban streams and a survey distributed to Pacific Northwest aquatic managers. Finally, we examined the spatial patterns of watershed conditions and land use in study watersheds.

Our objectives were to:

1. Document the spatial and temporal extent of coho PSM in Bellingham, Seattle, and Olympia area streams during the 2005-6 spawning season utilizing field surveys.
2. Poll Pacific Northwest aquatic habitat managers to collect more extensive information on the geographic extent of coho PSM and to educate managers.
3. Complete a coarse-scale GIS analysis of coho PSM watersheds to better describe watershed characteristics where the phenomenon has been observed.

Methodology:

Field Surveys – Previous coho spawning success surveys in King and Snohomish County streams conducted by WFC documented high but variable rates of prespawning mortality in adult coho salmon. In this study, we performed field surveys to describe coho spawning success in urban and suburban streams in Puget Sound watersheds with intermediate levels of development. WFC coordinated with Bellingham- and Olympia-area project partners including the City of Bellingham, the Nooksack Salmon Enhancement Association (NSEA), the City of Olympia, and the WRIA 13 Technical Advisory Group, to select suitable survey streams representing intermediate levels of development (Table 1). In the north region (Bellingham area), WFC trained NSEA staff to perform coho PSM surveys. With NSEA's assistance, data from a greater number of streams were collected.

Table 1. Study streams by region.

North Puget Sound (Whatcom County)	Mid Puget Sound (King County)		South Puget Sound (Thurston County)
	Seattle	Rural King Co.	
Padden	Thornton	Cherry	Green Cove
Upper Fishtrap	Pipers	Weiss	Ellis
Squalicum-Baker	Longfellow		Indian
Upper Deer	Fauntleroy		Moxlie
Chuckanut	Taylor		Huston
McCauley			Schneider
Larabee Springs			
Mitchell			
Tass			
Tenmile			
Terrell			
Landingstrip			
Schell			
Silver Spring			
Smith			
Anderson			
Tinling			
Bertrand			
Lower Deer			

We used field protocols previously developed and tested in cooperation with Seattle Public Utilities. Two or three-person survey teams walked stream reaches searching for coho carcasses, examining and probing debris jams, boulders, cut banks, deep pools, and other channel cover in deeper water. In addition, riparian areas were inspected for coho carcasses that had been dragged ashore by scavengers.

The location of salmon carcasses and redds encountered were recorded using either GPS or by hand on field maps of survey reaches. For each carcass surveyors recorded species, sex, fork length, body cavity condition (intact or violated), approximate hours since death, and the presence of any tags fin clips, or marks. The body cavity of each recovered carcass was cut open and examined for the presence of residual eggs or milt. Sampled carcasses were also marked by removal of the lower jaw or caudal fin to enable their identification and exclusion from subsequent surveys. Where carcass deterioration precluded the identification or measurement of species, sex, fork length, body cavity condition, or marks/tag presence, “unknown” was recorded in the appropriate field on data forms.

For females, sign of death (predator wound, stranding, or unknown) was recorded. For all female carcasses, egg retention was scored as: none/low (spawned out with <25% egg retention), partial (25-75% retention), all/most (>75% retention), or unknown (carcass deteriorated or body cavity not intact). In female carcasses with intact body cavities, the number or volume (mL) of retained eggs was measured, and diameter of five randomly-selected eggs was measured. For

carcasses with <100 retained eggs, eggs were counted manually; when females retained more than 100 eggs, the volume of eggs was measured. For male carcasses, crews estimated spawning condition based on milt retention as: spawned (<25% retention), partial (25-75% retention), unspawned (>75% retention), or unknown. Field data were recorded on field forms, and later entered into Microsoft Excel for analysis. Single-factor analysis of variance (ANOVA) was used to test for differences in average carcass forklength and percentage of marked fish among regions.

Linear regressions were developed to describe coho egg volume-to-number, and length-to-fecundity relationships. Due to low escapement in the 2005-2006 spawning season, we included in the regressions females measured during the previous 2004-2005 spawning season to provide a larger sample and more robust estimates. To estimate the percentage of eggs retained by body-cavity-intact female coho we used the regressions to estimate the number of retained eggs and the expected fecundity.

Information Request and Interviews – In November 2006, Wild Fish Conservancy developed and distributed an online survey to state and local government, and conservation organizations in Washington and Oregon. Agencies contacted included state departments of Fish and Wildlife, Indian Tribes, conservation non-profits, as well as city and county governments, as well as select non-profit conservation organizations. We targeted agencies and groups working in urban or urbanizing landscapes in Washington and Oregon. A complete list of persons and entities contacted is included in the Appendix.

The online information request form distributed through SurveyMonkey.com allowed WFC to: characterize local salmon spawning survey efforts, document potential PSM occurrences, and identify a shortlist of contacts for follow-up interviews. A secondary goal of the survey was to familiarize local jurisdictions with the issue of salmon PSM and to establish government contacts for future information exchange.

The survey was distributed to 495 individuals representing organizations/agencies performing salmon spawning surveys in Washington and Oregon. Of the 495 polled, 109 responded by December 2006. WFC staff followed up with regional personnel where the initial email contact had failed, and an additional 20 survey responses were received.

Follow-up interviews were conducted with 17 survey respondents reporting observations of prespawning mortality in salmon. Through these phone or email interactions, we collected additional information on the species, sex, run component (e.g. hatchery vs. wild), location, number of years, and numbers of PSM fish observed. We also sought more detailed information on if and how respondents evaluated PSM in their surveys. Finally, we contacted five additional individuals with knowledge of salmon populations in the Portland-Vancouver and east Kitsap Peninsula urban areas to confirm the lack of PSM observations for these areas.

Spatial Analysis – WFC developed a coarse-scale GIS characterization of watersheds where PSM has been documented. Watersheds with observations of PSM in >3% of returning female salmon (identified from either WFC surveys or from the Information Request respondents) were mapped in relation to a regional GIS coverage of impervious cover (Washington Department of Ecology - Western Washington Land Cover Change Analysis project, <http://www.ecy.wa.gov/services/gis/data/impervious/basins.htm>). ArcHydro (ArcGIS 9.2) was

used to delineate watersheds, and the ArcGIS 9.2 Raster Calculator operation utilized to calculate levels of impervious surfaces by watershed (Figure 1).

We used Spearman's rank correlation to evaluate the relationship between percent impervious cover and reported PSM rates. Spearman's rank correlation does not require the assumption that the relationship between the variables is linear, or that the variables are normally distributed. In cases with multiple reported rates for different species we used the highest reported rate, except in one case (Thornton Creek) where we used the lower rate for coho salmon since PSM rates for sockeye and chinook salmon were reported as "up to 100%" (see Table 4, below).

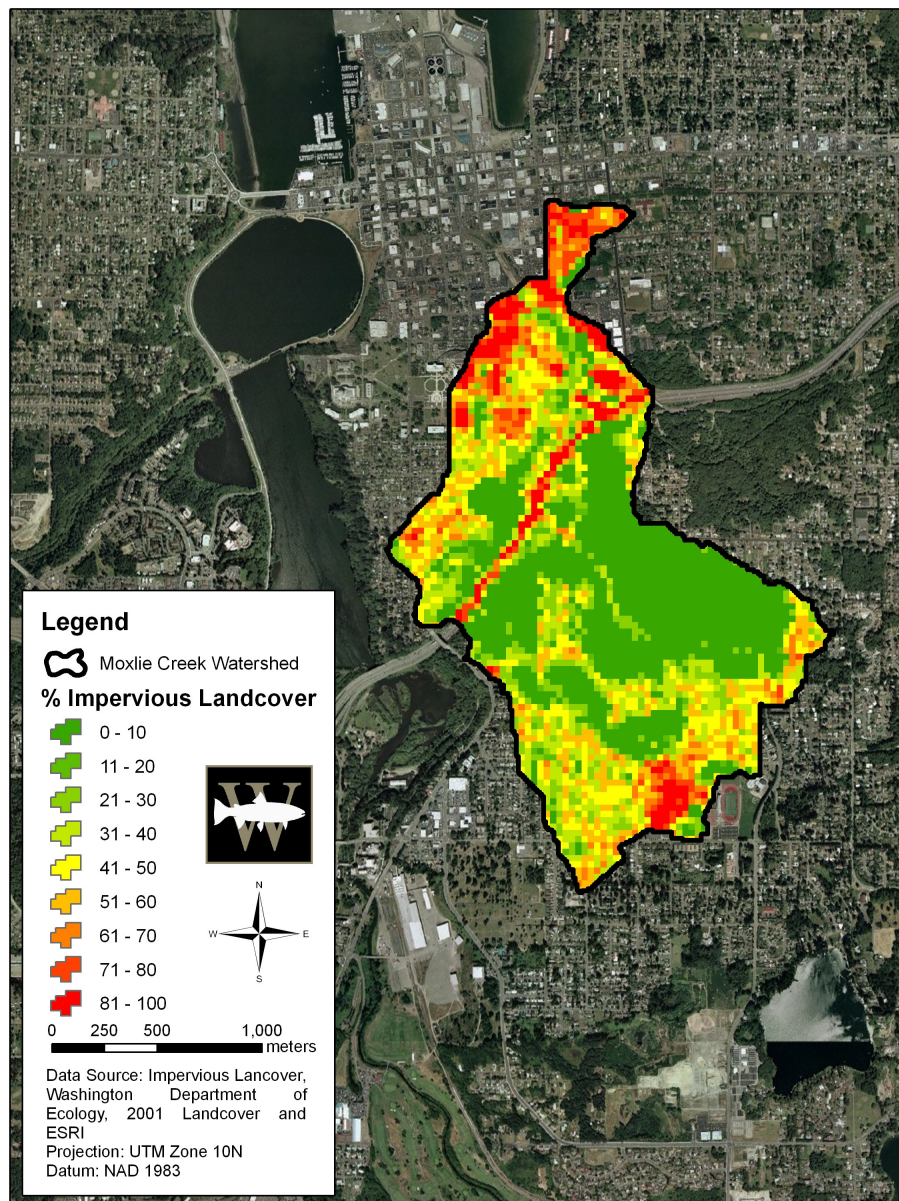


Figure 1. Percent impervious cover for Moxlie Creek in Olympia, Washington. ArcHydro (ArcGIS 9.2) was used to delineate watersheds, and the ArcGIS 9.2 Raster Calculator operation utilized to calculate levels of impervious surfaces by watershed.

Results:

Field Surveys – On 55 days from September 27, 2005 to January 25, 2006, Wild Fish Conservancy and project partners conducted surveys in 33 different stream reaches in north, middle, and south Puget Sound watersheds. A total of 362 coho carcasses were examined, including 244 from Seattle area streams and 118 from all north, mid (rural King County), and south Puget Sound streams combined. During the 2005-6 spawning season, low coho spawner abundance resulted in few carcasses to sample for PSM.

Of the 362 coho carcasses recovered, 133 were male, 152 were female, and sex could not be determined for 77. Overall, 186 fish were adipose fin-clipped, 123 possessed adipose fins, and 54 were too deteriorated to determine adipose condition. The percentage of adipose-clipped fish varied significantly by region (Table 2; ANOVA F-statistic = 35.7, $p < 0.001$) with the highest percentage of clipped fish recovered in the south region and Seattle area streams (100% and 70%, respectively), and with lower rates of marked fish found in the north and mid - rural King County regions (46% and 3%, respectively). Forklength also varied significantly (ANOVA F-statistic = 5624.2, $p < 0.001$) by region with larger fish evident in the south region.

Table 2. Summary of findings by region. Body cavity condition was not explicitly recorded during Seattle surveys, but all fish recorded as PSM were body cavity intact. Numbers in parentheses are effective sample sizes for each category.

Region	N Coho Carcasses	Mean Forklength (cm)	Percent Female (N)	Percent Adipose Fin Clip (N)	N Female Body Cavity Intact
North	63	53.5	47% (57)	46% (61)	24
Mid - rural King Co.	35	53.6	50% (30)	3% (29)	12
Mid - Seattle	244	52.8	55% (186)	70% (206)	n/a
South	20	57.7	58% (12)	100% (13)	5

In total, 150 female coho carcasses were recovered, of which 49 were too scavenged or deteriorated to determine spawning condition. Of the remaining 101 body cavity-intact (BCI) female coho carcasses, 52 (51%) retained more than 75% of their eggs and were classified as “unspawned”. The proportion of unspawned carcasses varied by region, with high numbers of recovered intact females (60), and the highest proportion of unspawned carcasses (43, or 72%) from Seattle area streams (Table 3 and Figure 2). Though we recovered few coho carcasses from north, mid – rural King County, and south Puget Sound streams, the proportion of unspawned females was still high, with 5 of 12 (42%), 2 of 5 (40%), and 2 of 24 (8%) from mid – rural King County, south, and north Puget Sound streams, respectively.

The percentage of unspawned carcasses were calculated using only BCI females, and thus our findings likely underestimate actual rates of coho PSM, since carcasses with retained eggs may experience higher rates of animal scavenging on the energy- and nutritionally-rich eggs. Carcasses with “unknown” egg retention were too deteriorated or scavenged to accurately score and thus could not be included in the calculation of PSM rates.

Table 3. Summary of female (BCI) coho carcass spawning condition by region.

Region	Egg Retention				Total BCI	All/Most (% of BCI)
	None/Few <25%	Partial 25-75%	All/Most >75%	Unknown (no BCI)		
North	18	4	2	1	24	8%
Mid - rural King Co.	0	7	5	3	12	42%
Mid - Seattle	14	3	43	43	60	72%
South	2	1	2	2	5	40%
Total	34	15	52	49	101	51%

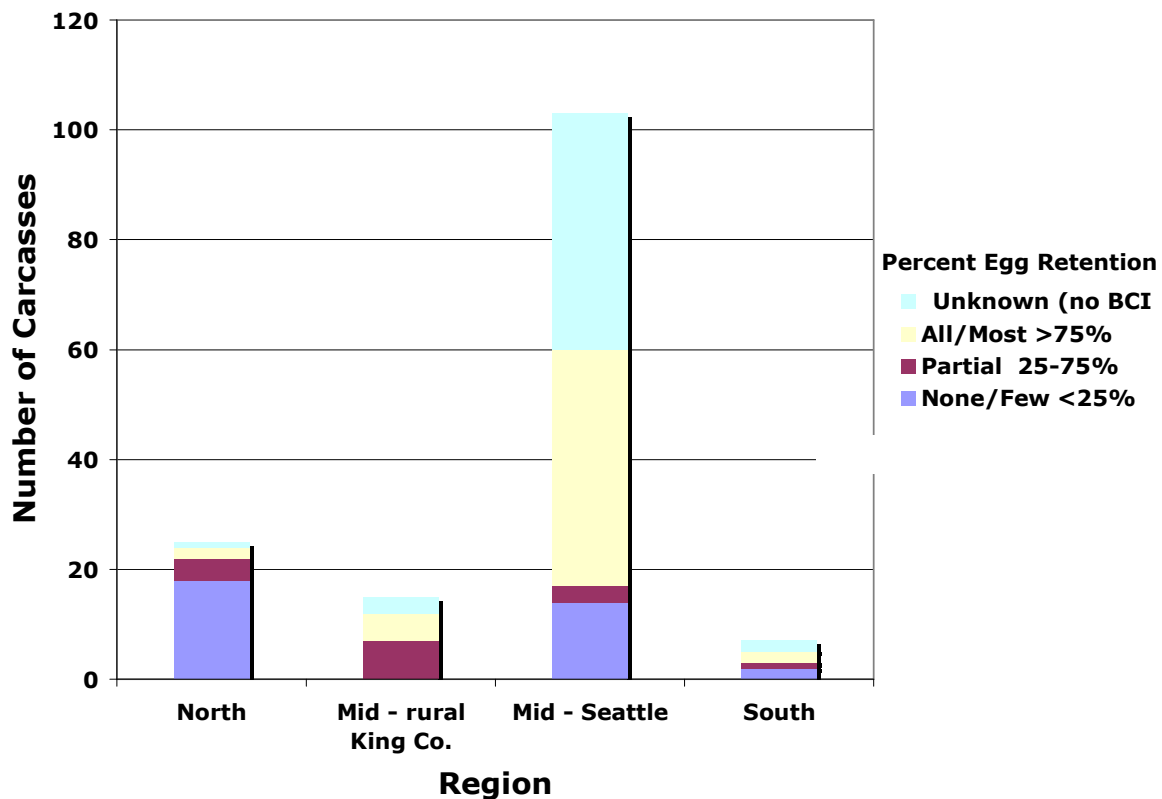


Figure 2. Number of recovered female coho carcasses by spawning condition (percent egg retention) and region.

Using data collected during the present study and 2004-5 coho spawning survey efforts (EPA Agreement ID: MM97061201-0, WT 2005), we regressed coho egg number vs. egg volume (Figure 3), as well as coho forklength vs. fecundity (Figure 4). We used these functions to estimate egg number for four BCI carcasses for which we lacked total egg counts, to estimate total fecundity for recovered BCI spawned and partially spawned carcasses, and finally to estimate percent egg retention for recovered female coho.

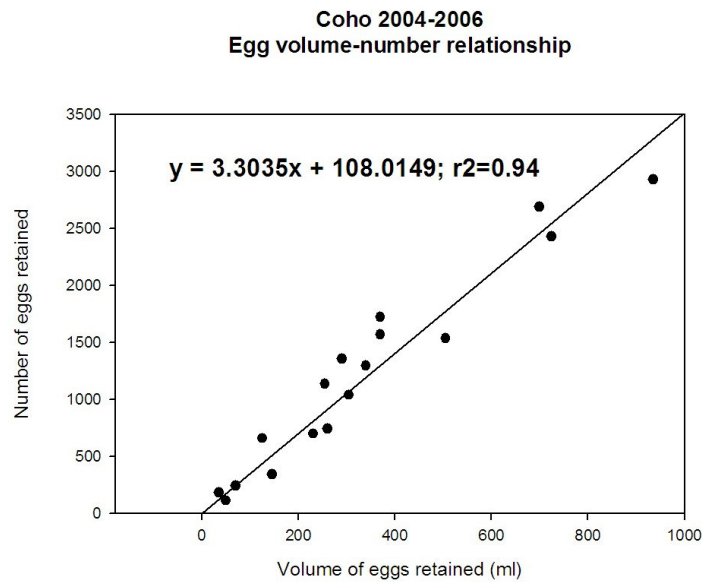


Figure 3. Regression of female coho egg volume to egg number (N = 17 carcasses).

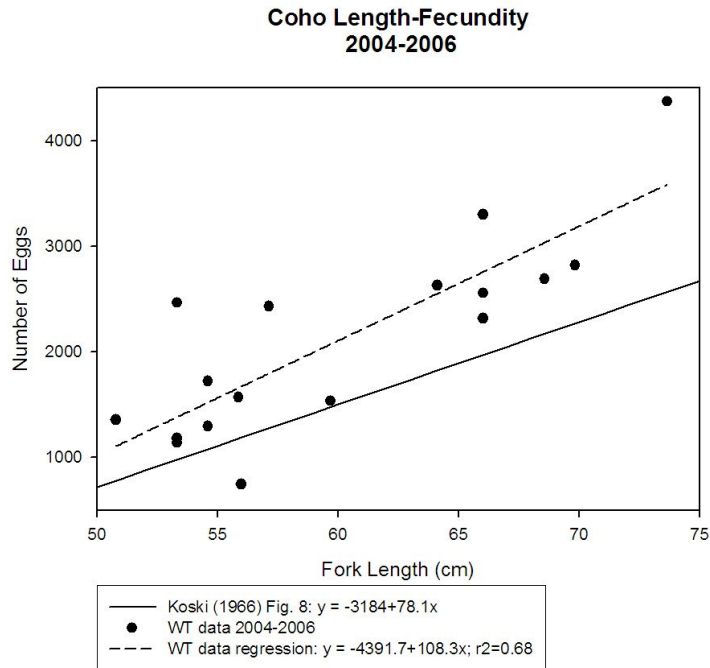


Figure 4. Female coho salmon forklength-fecundity regression (N = 17 carcasses). The WT regression represents data collected by Wild Fish Conservancy during 2004-2006. Data from Koski 1966 are included for comparison purposes.

For non Seattle-area streams, egg retention in 42 body cavity-intact female coho carcasses ranged from 0 to 2817 eggs, with 29 fish retaining ≥ 1 egg and a median of 3 eggs retained/carcass. Based on our fecundity estimates, egg retention rates indicated that most fish retained $<10\%$ or $>90\%$ of their eggs (Figure 5).

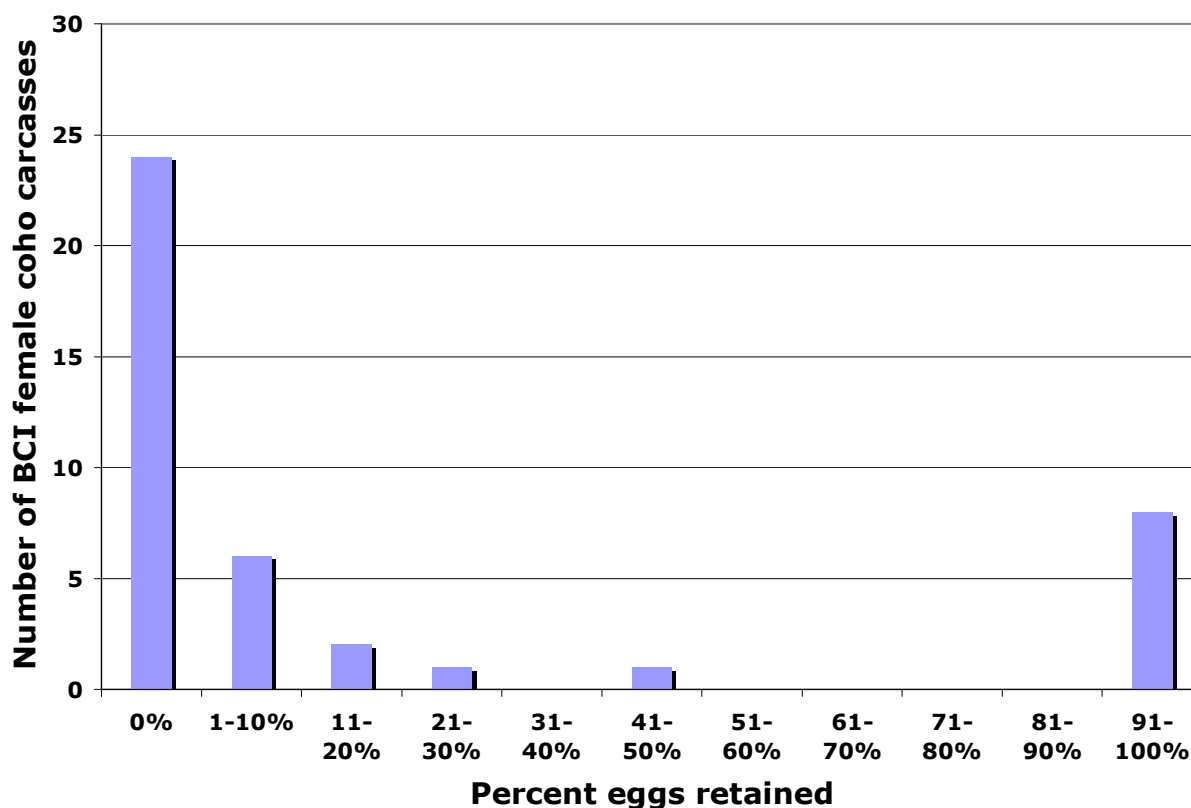


Figure 5. Egg retention in body cavity intact female coho (N = 42 carcasses sampled in non-Seattle area streams). In four cases, egg number was estimated from egg volume using the egg volume-egg number relationship shown in Figure 3.



Figure 6. A prespawn mortality coho, Moxlie Creek, City of Olympia.

Information Request and Interviews – Of the 495 managers queried (see Appendix), 129 responded to our online information request form, providing an overall response rate of 26%.

Respondents represented a broad array of organization types, with strong representation from cities (33%), nonprofits (21%), and counties (16%, Table 4). In the following summary, reported response numbers may not sum as a result of several incomplete surveys.

Table 4. Distribution of organization types and response rate from online information request.

Organization Type	N Respondents	Percent of Respondents	N Initial Contacts	Response Rate
City	43	33%	187	23%
County	21	16%	60	35%
Special District	10	8%	73	14%
Nonprofit	27	21%	92	29%
Tribe	6	5%	21	29%
State Agency	10	8%	40	25%
Federal Agency	11	9%	17	65%
Academic/Business	1	1%	5	20%
Total	129		495	

Eighty-seven of 126 respondents (69%) claimed to be familiar with the issue of coho salmon prespawning mortality prior to receiving the WFC information request. Fifty-nine of 123 respondents (48%) reported that their organization had performed salmon or trout spawning surveys within the last ten years. Target fish species for these surveys included: coho (48 respondents), chinook (44), chum (26), sockeye/kokanee (13), and pink salmon (9), as well as steelhead (31), rainbow (2), cutthroat (13), and bull trout (4) (Figure 7).

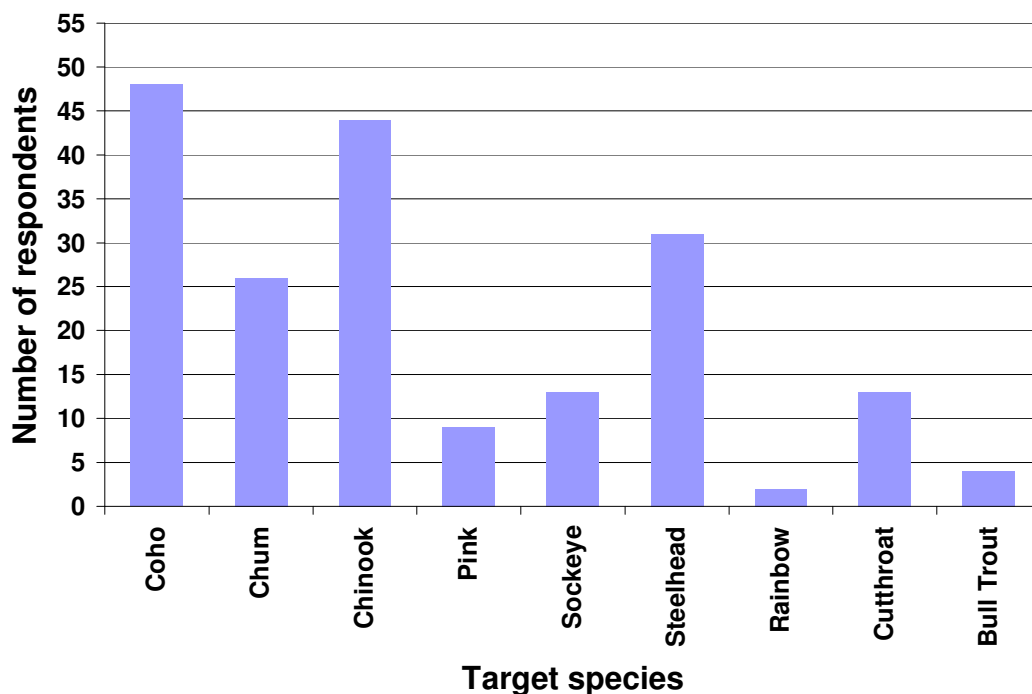


Figure 7. Target spawning ground survey species reported by information request respondents. Many respondents recorded surveying for more than one species (N = 59 respondents).

Respondents reported typical survey frequencies of: daily (1), twice weekly (3), weekly (19), every 10-12 days (6), every two weeks (10), variable/as frequently as possible (18), or annually/sporadic (8), (Figure 8). The duration of reported spawning surveys ranged from 1 to

94 years, with 11 (26%) covering 1-3 years, 16 (37%) spanning 4-9 years, 9 (21%) covering 10-19 years, and 7 (16%) covering 20 or more years in duration. Thirty-eight of the 43 reported spawning survey data sets (88%) included current or recent years (2005 or 2006).

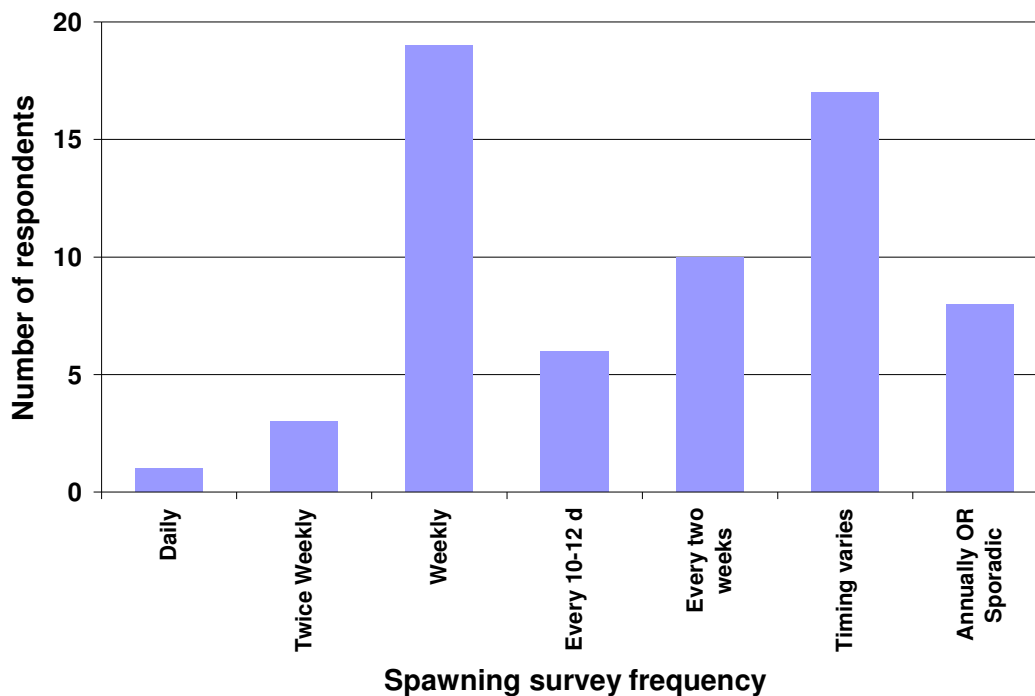


Figure 8. Spawning survey frequencies reported by information request respondents (N = 64).

Fifty of 129 respondents (39%) described the data collected during spawning surveys. Survey data recorded included: live fish counts (48), live fish locations (30), redd counts (40), redd locations (29), carcass counts (43), carcass locations (22), and other (16; e.g. fish sex, length, carcass tags/fin clips, scale/otolith/genetic samples).

Seventeen of 46 respondents (37%) had observed “significant egg retention (>200 eggs) in a female salmon or trout carcass”, and six of 38 surveyed (16%) indicated observations of “live salmon that had recently entered freshwater but were disoriented, gaping or struggling to remain upright.” However, only 11 of 47 respondents (23%) reported systematically checking carcasses for egg/milt retention (Figure 9). Among respondents who conduct spawning surveys for coho salmon, rates of PSM observations were similar. Fourteen of 28 (33%) had observed egg retention, 5 of 29 (15%) observed disoriented adults, and only 10 of 43 (23%) reported systematically checking carcasses for egg/milt retention.

Follow up phone interviews with respondents helped clarify and pinpoint locations for individual reports of salmon PSM. Ten respondents reported PSM in salmon populations from non-urban watersheds. These cases of PSM were associated by the surveyors with fish stranding, disease, warm stream temperatures, poaching, lack of passage at culverts or dams, and/or low water conditions. Many of the reported PSM observations were for species other than coho salmon. Through these inquiries we collected information on affected streams, species, and rates of PSM.

Based on interviews with staff from King County and the cities of Bothell and Bellevue, we verified reports of salmon prespawning mortality from twelve additional King County area urban streams: Big Bear, Little Bear, Cottage Lake, Issaquah, Kelsey, May, North, Taylor (Cedar River tributary), Lewis, Ebright, Laughing Jacobs, and Pine Lake creeks. Staff from the Suquamish Tribe confirmed PSM observations in four east Kitsap County urbanizing streams: Chico, Gorst, Dogfish, and Ross creeks. In addition, reports of PSM in coho were documented in two non-urban watersheds, the Pysht River (Clallam County, WA) and Lambert Creek (Lewis County, WA). A WDFW biologist (Bryce Glaser, SW region) reported PSM in Chinook populations from Abernathy Creek, Elochoman River, Germany Creek, Grays River, and Mill Creek. Cowlitz, Toutle, Lewis, Kalama, and White Salmon rivers.

These reports included observations of PSM in coho, chinook, sockeye/kokanee, and chum salmon, as well as cutthroat trout. Lacking few reports of documented salmon PSM in Oregon watersheds from our information request response, we conducted additional phone and email inquiries with Oregon aquatic resource managers from the ODFW, and the City of Portland. In spite of this additional effort, we did not confirm any additional reports of PSM in Oregon watersheds. Based on our field surveys and information request form feedback, we confirmed reports of PSM from 37 Washington and Oregon watersheds (Table 4).

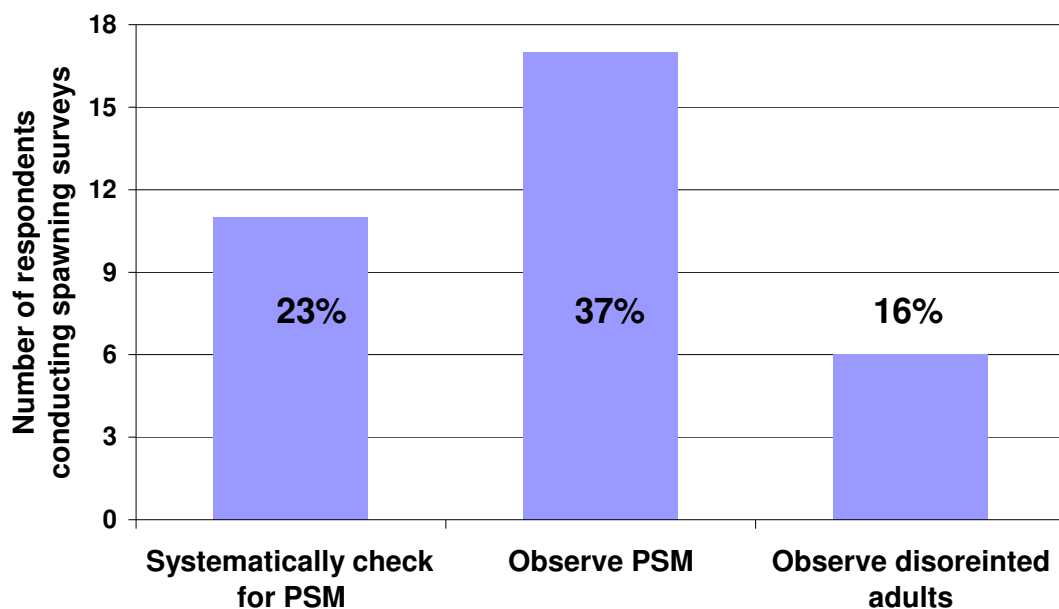


Figure 9. Number and percentage of survey respondents conducting salmon spawning surveys who reported checking for PSM, observing PSM, and observing disoriented adult salmon (N = 47, 46, and 38 respondents, respectively).

Spatial Analysis – We consolidated all observations and reports of PSM for all salmon species, then computed percent impervious cover for each watershed from a regional impervious cover data set. Percent impervious cover in PSM-affected watersheds ranged from 0-85%, with no apparent direct relationship to percent impervious cover (Table 4). Spearman’s rank correlation results indicated that reported PSM rates were not correlated with percent impervious cover ($R=0.251$, $p=0.19$). However, all affected watersheds except two had $>4\%$ impervious cover,

and 22 of 27 had >10% impervious cover. Also, in many cases the PSM sample sizes were inadequate to allow a more robust analysis.

Table 4. Impervious cover and rates of observed salmon prespawning mortality in affected Washington watersheds.

Stream	County	Source	% Impervious Cover	PSM rate (N)	Species
Landingstrip Cr	Whatcom WA	WFC-NSEA	0.0	50% (2)	coho
Taylor Cr (trib to Cedar R)	King WA	KCDNR	1.0	100% (1)	chinook
Cherry Cr	King WA	WFC	4.2	40% (10)	coho
Gorst Cr	Kitsap WA	Suquamish Tribe	7.0	10-15%	chinook
Weiss Cr	King WA	WFC	8.8	50% (2)	coho
Issaquah Cr	King WA	KCDNR	10.7	23%	chinook
				4-8%	sockeye
Laughing Jacobs Cr	King WA	KCDNR	11.6	~20%	kokanee
Dogfish Cr	Kitsap WA	Suquamish Tribe	13.9	10-15%	chinook
Ross Cr	Kitsap WA	Suquamish Tribe	17.6	10-15%	chum
Pine Lake Cr	King WA	KCDNR	18.4	~10%	kokanee
Chico Cr	Kitsap WA	Suquamish Tribe	23.9	0-60%	coho
Big Bear Cr	King WA	KCDNR	23.9	4-8%	chinook
				1-3%	coho
Ebright Cr	King WA	KCDNR	25.7	~25%	kokanee
Cottage Lake Cr	King WA	KCDNR	28.4	4-8%	chinook
				1-3%	coho
Little Bear Cr	King WA	KCDNR	32.3	4-8%	chinook
				1-3%	coho
May Cr	King WA	KCDNR	32.3	4-8%	chinook
Lewis Cr	King WA	KCDNR	50.0	50% (2)	cutthroat
				~35%	kokanee
North Cr	King WA	KCDNR	54.9	4-8%	chinook
Longfellow Cr	King WA	WFC	54.4	76% (46)	coho
Taylor Cr (Seattle)	King WA	WFC	54.9	33%	sockeye
Indian Cr	Thurston WA	WFC	58.6	100% (1)	coho
Moxlie Cr	Thurston WA	WFC	62.1	33% (3)	coho
Kelsey Cr	King WA	City of Bellevue	65.6	0-68%	coho
				7%	chinook
Padden Cr	Whatcom WA	WFC-NSEA	76.0	100% (1)	coho
Thornton Cr	King WA	WFC	83.2	44% (9)	coho
				up to 100%	chinook
				up to 100%	sockeye
Pipers Cr	King WA	WFC	84.6	75% (4)	coho
Fauntleroy Cr	King WA	WFC	84.8	100% (1)	coho

We report PSM observations from several non-urban, forested watersheds in Table 5 below, separately. The individuals that reported the observations presented in Table 5 qualified their data by providing some explanation of why they believe the observed PSM occurred (stranding, water temperature, early run timing, etc.).

Table 5. Observed salmon pre-spawning mortality in Oregon and Washington watersheds lacking urban development and where individuals providing the data provided some explanation of why they believe the observed PSM occurred (stranding, water temperature, early run timing, etc.). In addition to those listed below, a few observations of prespawning mortality were reported for chinook salmon in the Coweeman (Cowlitz Co) and East Fork Lewis (Clark Co) rivers, as well as for coho salmon in the Pysht River (Clallam Co) but spawning success was not systematically recorded and PSM rates are not available.

Stream	County	Source	PSM rate (N)	Species
Mollala R	Clackamas OR	Native Fish Society	5% (125)	chinook
Lambert Cr	Lewis WA	Lewis PUD	60%	coho
Abernathy Cr	Cowlitz WA	WDFW ¹	~37%	chinook
Elochoman R	Wahkiakum WA	WDFW ¹	~20-36%	chinook
Germany Cr	Cowlitz WA	WDFW ¹	~11-32%	chinook
Grays R	Wahkiakum/Pacific WA	WDFW ¹	~0-12%	chinook
Mill Cr	Cowlitz/Wahkiakum WA	WDFW ¹	~12-17%	chinook

¹ WDFW identified female spawners with $\geq 50\%$ egg retention as prespawning mortalities, salmon egg retention assessments were sometimes biased towards bright/bulging females, and prespawning mortality was not systematically recorded for all carcasses so reported rates are approximate.

One challenge for the spatial analysis was the lack of a GIS coverage delineating small watersheds. For this analysis small watersheds were delineated individually utilizing a digital elevation model (DEM). The Pacific Northwest Hydrography Framework has developed coarse-scale GIS watershed delineations, but no fine-scale (e.g. 7th field HUCs) coverage is available for the Puget Sound lowlands. Once such a coverage becomes available, it could be combined with regional impervious cover data sets to identify watersheds with a high risk for PSM.

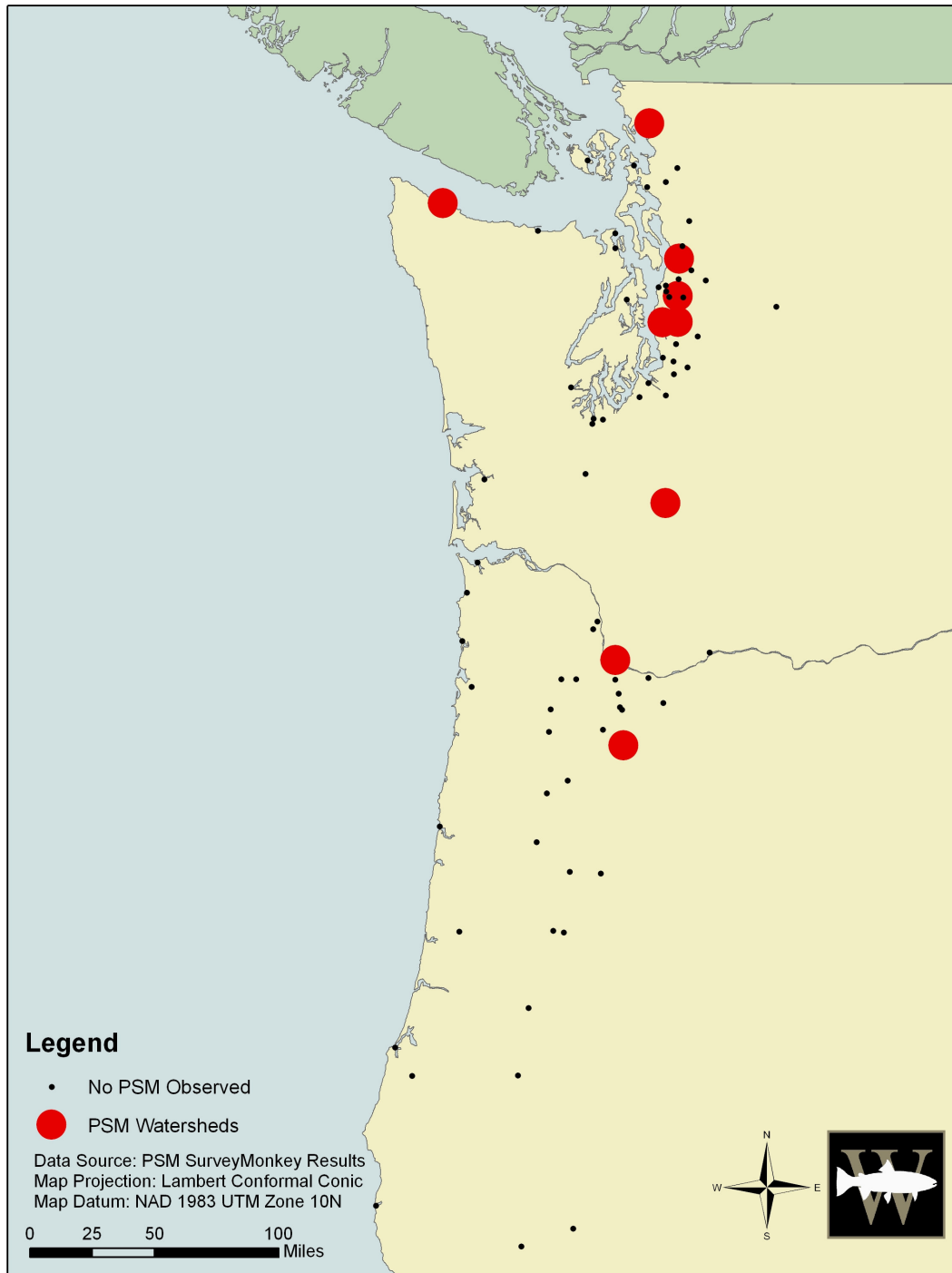


Figure 10. Distribution of information request respondents and PSM observations. Note that this map shows the location of information request form respondents, not the locations of the actual watersheds.

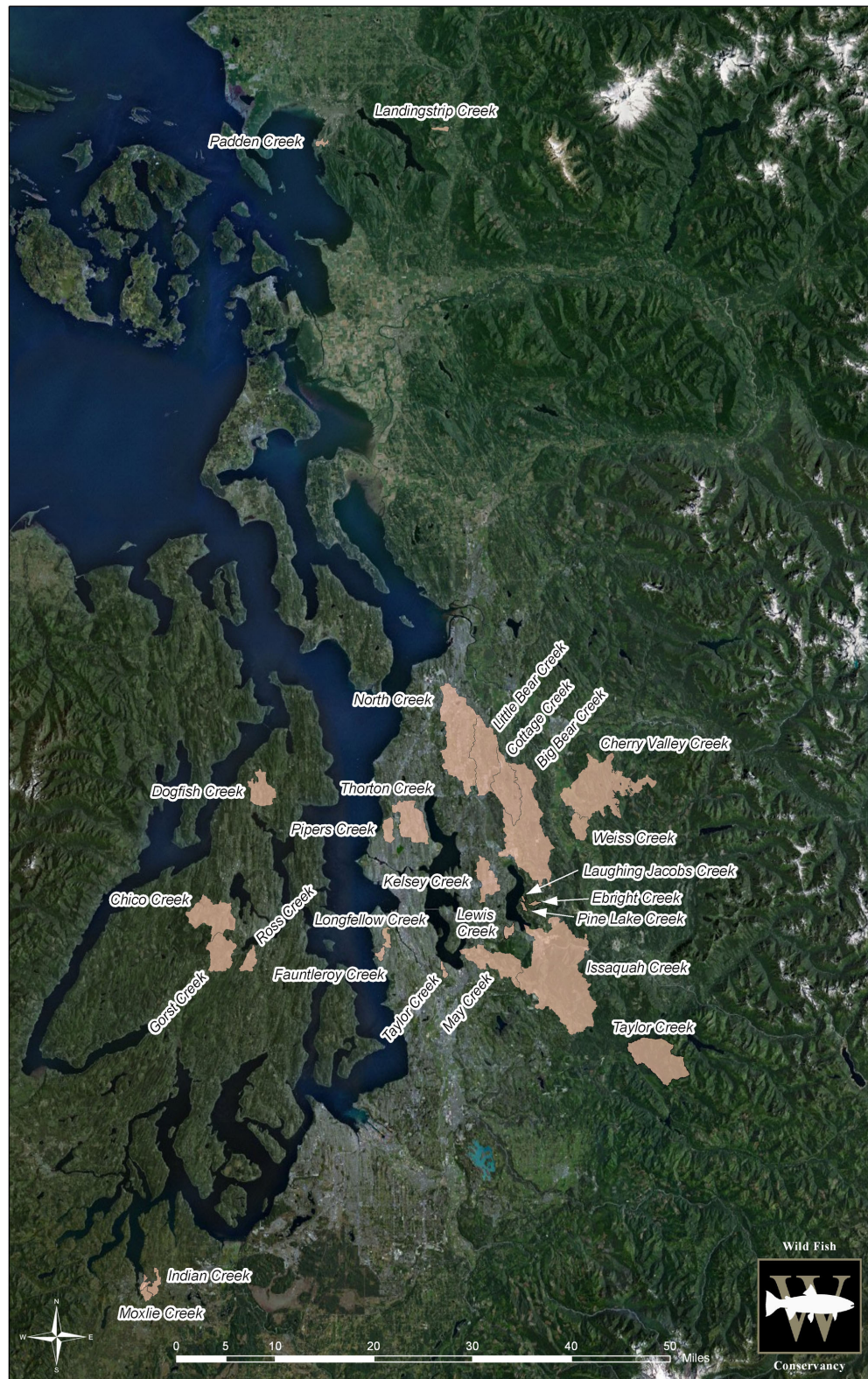


Figure 11. Map of watersheds with documented PSM observations. There were anecdotal reports of PSM occurring in Squalicum and Baker Creek watersheds within the City of Bellingham, but despite multiple requests we were not able to obtain those data.

Discussion:

Low spawner abundance in 2005-2006 limited our ability to recover coho carcasses and evaluate PSM in the north, mid, and south Puget Sound streams we surveyed. Nonetheless, we observed PSM in coho populations from three additional streams where it had not been previously documented, and developed length-fecundity and egg volume-number relationships useful for assessing egg retention and PSM in future survey efforts. Our field surveys revealed differences in mortality rates across regions, with Seattle area streams showing the highest numbers and rates of prespawning mortality, as compared streams from all other Puget Sound regions. We also documented regional trends in coho forklength and adipose fin presence.

Since carcasses with eggs retained are likely preferentially scavenged, and scavenged carcasses (i.e. with body cavity violated) were excluded from our analyses, our field survey results likely underestimate the actual occurrence of coho PSM. In addition, we were constrained to carcass sampling every week-to-ten days due to study logistics and likely missed carcasses that were scavenged or flushed from survey reaches during interim periods. From comparisons of daily NOAA Fisheries and weekly WFC spawning surveys conducted synchronously over four years in Seattle's Longfellow Creek, we know that weekly counts typically miss 13-58% of spawning salmon, as compared to daily counts (WFC 2005). In addition, our field survey methodology could not account for carcasses flushed into or out of target reaches. As a result, we report approximate estimates of PSM, to be updated with data from future surveys over time.

From our PSM information request, we collected reports of PSM in other salmon species, and from watersheds where we were not able to survey. We learned that there are few spawner surveys being conducted in vulnerable urban watersheds outside the mid Puget Sound region (where survey effort is good). Lack of surveys in urban watersheds compounded by the lack of surveyors systematically checking carcasses for PSM where surveys are conducted demonstrate that more information must be collected before we can reliably chart the extent of PSM in Pacific Northwest watersheds.

Traditionally, salmon spawning ground surveys have been conducted by fish management agencies for use in estimating escapement from fisheries and natural production. Because egg retention and PSM issues have only recently been identified and have not yet been deemed important in fish management decision-making, these parameters have not been systematically recorded. To develop a more comprehensive understanding of the impact of PSM on salmon populations, more surveys in urban watersheds are needed, in concert with systematic sampling for egg retention and PSM in non-urban streams.

Other barriers to evaluation of PSM include the lack of a standardized field methodology and a lack of a means to systematically document PSM in the statewide spawning survey database maintained by WDFW. In Oregon, the ODFW spawning survey database enables users to identify prespawning mortality carcasses (Mark Lewis, ODFW, personal communication September 24, 2007), and ODFW has published a standardized spawning survey protocol to ensure consistent data collection procedures by department staff and cooperators (ODFW 2005). We attempted but failed to contact the ODFW spawning survey database manager to query this database for PSM observations. The ODFW spawning survey database should be investigated for use in estimating reported rates of PSM in Oregon.

Many streams with a high incidence of PSM also have salmon populations dominated by hatchery fish. Though our field survey data are too sparse to systematically evaluate this pattern,

KCDNR has documented higher rates of PSM in hatchery vs. wild chinook populations of east King County (Berge et al. 2006). This pattern could indicate a greater vulnerability of hatchery fish to PSM, lower natural salmon production in hatchery-dominated urban streams, low or no natural salmon production where PSM occurs, or some combination of these and other factors. In addition, certain agencies conducting spawning surveys have noted vulnerability of chinook, sockeye, and chum salmon to PSM (COB 2007, KCDNR 2006). Future investigations of PSM should evaluate differences in PSM between hatchery vs. wild fish, and entities conducting surveys should be aware of the potential vulnerability of salmon species other than coho.

The distribution of our online information request form served as an educational tool, useful as much to inform aquatic resource managers of the salmon PSM phenomenon as to gather observations. Feedback from the information request combined with our own field survey results provides the first-ever list of streams in the Pacific Northwest with observations of PSM. However, additional survey and education efforts are needed to fully document PSM and inform aquatic resource managers in vulnerable watersheds.

Recommendations:

The potential implications of elevated rates of coho prespawning mortality as they relate to Pacific salmon recovery are immense. Most fisheries management agencies and the sustainable yield models they rely on incorporate estimates of salmon escapement to set harvest goals; these escapement estimates come, in part, from surveys conducted to enumerate adult salmon returning to spawn. It is known (and sometimes measured) that each life history stage of the salmon is subjected to some level of mortality (survival to emergence, egg-to-fry, survival to smolt, etc.); however, the status-quo assumption is that the adult salmon returning to spawn do so successfully. Even with the low coho escapement that we observed in fall 2005, the data we present here suggest otherwise; in 21 streams that we surveyed that had coho salmon return, eleven of them experienced some level of coho PSM. In some urban watersheds, almost all the coho died before spawning. Given the rates at which it's being observed, we believe that the coho PSM phenomenon should be taken into consideration by fisheries managers charged with evaluating the risk and uncertainty surrounding harvest and sustainability models.

Depending ultimately on the mechanisms responsible for the phenomenon, it is possible that the solution to the problem will require drastic changes in urban/suburban stormwater management, changes in pesticide and herbicide regulations, or other wholesale changes to our urban/suburban lifestyles. In the meantime, we feel it is now appropriate to include some consideration of PSM when assessing salmon harvest levels, and when identifying and prioritizing salmon habitat restoration projects in areas known or suspected to be susceptible to PSM.

Though the mechanism for salmon PSM has still not been elucidated, work to chart the full extent of this phenomenon should continue. In particular, we recommend the following actions:

- WDFW should modify their statewide spawning survey database to include a field or code to identify female carcasses with prespawn mortality in order to support the systematic recording of this data in spawning ground surveys.
- The ODFW statewide spawning survey database should be queried to quantify rates of reported PSM in Oregon watersheds.
- WDFW should develop a statewide spawning survey protocol manual, and offer training in conducting spawning ground surveys to cooperators with local governments, nonprofit organizations, and the general public to ensure consistent data collection for the

documentation of spawning salmon abundance. The ODFW protocol could serve as a model for such work (<http://nrimp.dfw.state.or.us/crl/Reports/OASIS/05SSmanual.pdf>).

- WDFW and ODFW should coordinate salmon spawning surveys with all Tribes, nonprofit organizations, cities, counties, and federal agencies, in order to implement a uniform protocol for documenting salmon spawning condition. The methodology developed by WFC could serve as a model for such work.
- When possible, spawning ground surveyors should modify their protocols to record data on female spawning condition. This practice should occur in both urban and non-urban watersheds so that we can better quantify PSM frequency across different land use conditions.
- Spawning surveys in urban/urbanizing watersheds should continue where established, and be initiated in other vulnerable watersheds with high impervious cover. This work should be used to refine our estimates of PSM and better document the extent of the phenomenon, even in streams with low spawner abundance. As part of this work, a high priority should be identification of vulnerable urban watersheds that lack surveys, as well as qualified local entities that could conduct surveys.

References:

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Berge, H., M.L. Hammer, and S.R. Foley. 2006. Timing, abundance, and population characteristics of spawning chinook salmon in the Cedar/Sammamish watershed. King County Department of Natural Resources and Washington Department of Fish and Wildlife. 33 pp.

Oregon Department of Fish and Wildlife (ODFW). 2005. Coastal salmon spawning survey procedures manual. Coastal Salmon Inventory Project, Corvallis, OR.

The Watershed Company (TWC). 2007. Salmon spawner survey 2006: Kelsey Creek and tributaries. Prepared for the City of Bellevue, Utilities Department, Bellevue, Washington. 58 pp. + appendices.

Washington Trout. 2004. Land use and coho prespawning mortality in coho in the Snohomish watershed, Washington. EPA agreement ID MM97061201-0 final report. 15 pp.

Acronyms:

ANOVA	analysis of variance
BCI	body cavity intact
CEDC	Clallam Economic Development Council
COB	City of Bellevue
DEM	digital elevation model
EPA	Environmental Protection Agency
FL	fork length
FWS	U.S. Fish and Wildlife Service
GIS	geographic information system
GPS	global positioning system
HUC	hydrologic unit code
KCDNR	King County Department of Natural Resources
N	number OR sample size
NOAA	National Oceanic and Atmospheric Agency
NPS	National Park Service
NSEA	Nooksack Salmon Enhancement Association
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODSL	Oregon Department of State Lands
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
PSM	prespawning mortality
PUD	Public Utility Department
SPU	Seattle Public Utilities
USDA	U.S. Department of Agriculture
USDI	U.S. Department of Interior
WDOE	Washington Department of Ecology
WDFW	Washington Department of Fish and Wildlife
WFC	Wild Fish Conservancy
WT	Washington Trout

Appendix: PSM Information Request Contacts

State of Washington

Agency or Entity	Contact Person	Type
WSU Extension Whatcom County	Cheryl Niles - Watershed Masters coordinator	Academic
WWU - Huxley College - Institute of Watershed Studies	Robin Matthews - Director	Academic
Pacific Power (PacificCorp)	Frank Schrier	Business
Puget Sound Energy	Cary Feldman - ESA compliance	Business
City of Aberdeen	Larry Bledsoe - Public Works director	City
City of Anacortes	Fred Buckenmeyer - Public Works director	City
City of Arlington	Bill Blake - Natural Resources	City
City of Auburn	Aaron Nix - Environment coordinator	City
City of Bainbridge Island	Peter Best - city planner	City
City of Battle Ground	Brian Carrico - Community Development director	City
City of Bellevue Storm & Surface Water	Kit Paulson - environmental scientist	City
City of Bellevue Storm & Surface Water	Laurie Devereaux - Stream Team coordinator	City
City of Bellingham	Renee LaCroix - environmental resources coordinator	City
City of Bellingham	Chris Spens - senior city planner	City
City of Bonney Lake	Gary Leaf - Community Services director	City
City of Bothell	Andy Loch - salmon watchers coordinator	City
City of Bremerton	Bill McKinney - Forestry manager	City
City of Burien	Dan Bath - Planning engineer (surface water)	City
City of Burlington	Margaret Fleek - Planning director	City
City of Camas	Monte Brachman - Public Works director	City
City of Centralia	Dick Southworth - Utilities director	City
City of Chehalis	Tim Grochowski - Public Works director	City
City of Covington/Black Diamond	David Delph - Public Works director	City
City of Des Moines	Lauren Reinhold	City
City of Edmonds	Noel Miller - Public Works director	City
City of Enumclaw	Mike Thomas - Community Development director	City
City of Everett	Jim Miller - Stormwater Program manager	City
City of Federal Way	Don Robinett - ESA Coordinator	City
City of Ferndale	Bob Cecile - Public Works director	City
City of Ferndale	Tom Black - Planning director	City
City of Gig Harbor	David Breerton - Public Works director	City
City of Hoquiam	Brian Shay - Public Works director	City
City of Issaquah	Jennifer Kauffman - Stream Team coordinator	City
City of Kenmore	Emily Wicker - senior planner	City
City of Kent	Kelly Peterson - Environmental Engineering	City
City of Kirkland	John Morrow - Surface Water engineer	City
City of Lacey	Tim Wilson - Water Resources	City
City of Lake Forest Park	Mamie Bolender - Stewardship	City
City of Lake Forest Park	Mark Phillips - Streamkeepers	City
City of Lake Forest Park	Sarah Phillips - Communications Director - Streamkeeper	City
City of Lake Stevens	Becky Ableman - Planning director	City
City of Lakewood	Greg Vigoren - Surface Water Management	City
City of Longview	Josh Johnson - Stormwater manager	City
City of Lynden	Mark Sandal - environmental coordinator	City
City of Lynden	Duane Huskey - Public Works director	City
City of Lynnwood	Jared Bond - environmental coordinator	City
City of Maple Valley	Diana Pistoll - Public Works Program coordinator	City
City of Marysville	Paul Roberts - Public Works director	City
City of Mercer Island	Jeff Thomas - principal planner	City
City of Mill Creek	Tim Burns - Public Works director	City
City of Monroe	Kate Galloway - senior city planner	City
City of Montesano	Mike Wincewicz - Public Works director	City
City of Mount Vernon	Christopher Hagedom - Stormwater Program coordinator	City
City of Mountlake Terrace	Paula Schwartz - city planner	City
City of Mountlake Terrace	Mike Shaw - Stormwater Program manager	City
City of Mukilteo	Jim Pemberton - Public Works director	City
City of Newcastle	Maiya Andrews - Public Works director	City
City of Oak Harbor	Howard Thomas - Environmental Working Group	City
City of Olympia	Patricia Pyle - Stream Team coordinator	City
City of Olympia Public Works	Roy Iwai - Stormwater Division - research analyst	City
City of Port Angeles	Glenn Cuttler - Public Works director	City
City of Port Orchard	Maher Abed - Public Works director	City
City of Port Townsend	Kenneth Clow - Public Works director	City
City of Poulsbo	Barry Berezowsky - Planning director	City

Appendix: PSM Information Request Contacts

State of Washington

Agency or Entity	Contact Person	Type
City of Poulsbo	Jeff Bauman - Public Works director	City
City of Puyallup	Mark Higginson - Stormwater	City
City of Redmond	Keith MacDonald - CAPNR	City
City of Renton	Gary Fink - Surface Water Utilities/Salmon Watchers coordinator	City
City of Sammamish/Inglewood	John Cunningham - Public Works director	City
City of Sea-Tac	Dale Schroeder - Public Works director	City
Seattle City Light	Dave Pflug - fish biologist	City
Seattle Public Utilities	Rand Little - Water Management - senior fish biologist	City
City of Sedro-Wooley	John Coleman - SEPA coordinator	City
City of Sequim	James Bay - Public Works director	City
City of Shelton	Chuck Roy - Stormwater	City
City of Shoreline	Jessica Williams - Surface Water Management.	City
City of Snohomish	Tim Heydon - Public Works director	City
City of Stevenson	[No specific contact person]	City
City of Sumner	Lee Anderson - Parks & Facilities manager.	City
City of Tacoma	Cathy Petty - Environmental Services	City
City of Tukwila	Ryan Partee - fish biologist	City
City of Tumwater	Debbie Smith - Stream Team coordinator	City
City of Tumwater	Dan Smith - Water Resources program manager	City
City of University Place	David Swindale - Development Services director	City
City of Vancouver	Marion Lahav - Long Range Planning	City
City of Vancouver	Annette Griffy - Stormwater	City
City of Washougal	Mitch Kneipp - Planning Department	City
City of Woodinville	Mick Monken - Public Works director	City
City of Woodinville	Debra Crawford - Development Services	City
Clallam County	Andy Brastad - WRIA 20 LE	County
Clallam County	Salinda Barkhuis - WRIA 20 LE	County
Clallam County	Cathy Lear - Natural Resources coordinator	County
Clark County	Joel Rupley - ESA Program Coordinator	County
Grays Harbor County - Utilities & Development Division	Lee Napier - WRIA 22,23,24 LE	County
Island County Planning & Community Development	Kim Brendensteiner - WRIA 6 LE	County
Island County Water Resources Advisory Committee	Jill Wood - WRAC	County
Jefferson County Environmental Health Dept.	Neil Harrington - Natural Resources - WRIA 17 LE	County
King County	Jennifer Vanderhoof - Salmon Watch Coordinator	County
King County Dept. of Natural Resources & Parks	Mary Maier - Bear Creek/Issaquah Creek watershed steward	County
King County Dept. of Natural Resources & Parks	Doug Osterman - WRIA 9 watershed coordinator	County
King County Dept. of Natural Resources & Parks	Tom Beavers - Cedar River watershed steward	County
King County Dept. of Natural Resources & Parks	Kirk Anderson - Snoqualmie River watershed steward	County
King County Dept. of Natural Resources & Parks	Lori Larkin - Vashon & Maury Island watershed steward	County
King County Dept. of Natural Resources & Parks	Mary Jorgensen - WRIA 8 watershed coordinator	County
King County Dept. of Natural Resources & Parks	Jane Lamensdorf-Bucher - WRIA 8 watershed coordinator	County
King County Dept. of Natural Resources & Parks	Josh Kaham - Green/Duwamish watershed steward	County
King County Dept. of Natural Resources & Parks	Yvette Lizee-Smith - WRIA 7 watershed coordinator	County
Kitsap County Department of Community Development	Kathleen Peters - East Kitsap LE	County
Kitsap County Department of Community Development	Val Koehler - Stream Team coordinator	County
Kitsap County Natural Resources	Keith Folkerts - WRIA 15 LE	County
Lewis County	Kernen Lien -	County
Lewis County	Mark Cook - Public Works director	County
Mason County Department of Community Development	Pam Bennett-Cumming - WRIA 14,16 LE	County
Pierce County	Roy Huberd	County
Pierce County Health Dept.	Ray Hanowell - WRIA 12 LE	County
San Juan County Dept. of Health & Community Services	Mark Tompkins - WRIA 2 LE	County
San Juan County Marine Resources Council	Barbara Rosenkotter	County
Skagit County Public Works	Jeff McGowan	County
Skamania County	Todd Lefevre - Public Works director	County
Snohomish County Public Works	Janet Carrol - Snohomish watershed steward	County
Snohomish County Public Works	Bob Aldrich - Principal watershed steward	County
Snohomish County Public Works	Tim Walls - Snohomish LE	County
Snohomish County Public Works	Sean Edwards - Stillaguamish LE	County
Snohomish County Public Works	Jake Jacobson - Stillaguamish watershed steward	County
Snohomish County Public Works	Suzi Swint - Salmon Watchers coordinator	County
Snohomish County Public Works	Craig Young - South County watershed steward	County
Snohomish County Public Works	John Engel - Supervisor habitat & rivers	County
Thurston County	Mark Swartou - Natural Resources Coordinator	County

Appendix: PSM Information Request Contacts

State of Washington

Agency or Entity	Contact Person	Type
Wahkiakum County	Chuck Byer – Planning coordinator	County
Whatcom County Planning Dept.	Jeff Chalfant - WRIA 1 LE	County
Whatcom County Public Works	John Thompson - ESA coordinator	County
FWS - Nisqually National Wildlife Refuge	Christopher Ellings	Federal agency
Gifford Pinchot National Forest	Diane Perez - lead fish biologist	Federal agency
Mount Baker-Snoqualmie National Forest	Scott Lentz	Federal agency
North Cascades National Park	Reed Glesne	Federal agency
NPS - Mount Rainier National Park	- lead fish biologist	Federal agency
Olympic National Forest	Larry Ogg - lead fish biologist	Federal agency
Olympic National Park	Sam Brenkman - lead fish biologist	Federal agency
US Army - Fort Lewis	Paul Steucke - Environmental director	Federal agency
Chehalis Basin Fisheries Taskforce	Dave Hamilton - president	Nonprofit
Chehalis River Council	Margaret Raider	Nonprofit
Columbia River Estuary Study Taskforce	Peter Heltzel - fish biologist	Nonprofit
Friends of Des Moines Creek	Laura Hartema - FODMC coordinator	Nonprofit
Friends of the Hylebos	Hillary??? - Stream Team coordinator	Nonprofit
Hood Canal Coordinating Council	Richard Brocksmith - LE coordinator	Nonprofit
Hood Canal Coordinating Council	Scott Brewer - Salmon Recovery program manager	Nonprofit
Hood Canal Salmon Enhancement Group	Nate Ackley - Salmon Project supervisor	Nonprofit
Lower Columbia Fish Enhancement Group	Tony Meyer - executive director	Nonprofit
Mid Puget Sound Fish Enhancement Group	Troy Fields - executive director	Nonprofit
Nooksack Salmon Enhancement	Wendy Scherrer - executive director	Nonprofit
North Olympic Salmon Coalition	Rebecca Benjamin	Nonprofit
Pacific Coast Salmon Coalition	No contact person	Nonprofit
Skagit Fish Enhancement Group	Alison Studley - executive director	Nonprofit
Skagit Watershed Council/Long Live the Kings	Shirley Solomon - president	Nonprofit
South Puget Sound Salmon Enhancement Group	Lance Winecka	Nonprofit
Stilly-Snohomish Fisheries Taskforce	Ann Boyce - executive director	Nonprofit
StreamKeepers of Clallam County	Ed Chadd/Hannah Merrill - co-managers	Nonprofit
Willapa Bay Fish Enhancement Group	Ron & Leta	Nonprofit
Clallam Conservaton District	Joe Holtrop - district manager	Special district
Clallam PUD	Carol Biss	Special district
Clark Conservation District	Denise Smee - district manager	Special district
Clark PUD	Jeff Wittler - Environmental Services manager	Special district
Cowlitz Conservation District	Darin Houpt - district manager	Special district
Grays Harbor Conservation District	Terry Nielsen - office manager	Special district
Jefferson Conservation District	Al Latham -district manager	Special district
Jefferson County PUD	James Parker - district manager	Special district
King Conservation District	Geoff Reed - district watershed coordinator	Special district
Kitsap Conservation District	Joy Garitone - District Resource coordinator	Special district
Kitsap PUD	Debbie Thomas - salmon education/outreach	Special district
Lewis County Conservation District	Bob Amrine - district manager	Special district
Lewis PUD	Mike Kohn - fish biologist	Special district
Lower Columbia Fish Recovery Board	Steve Manlow - Salmon Recovery manager	Special district
Lower Columbia Fish Recovery Board	Phil Trask - WRIA 25,26,27,28 LE	Special district
Mason Conservation District	John Bolender - district manager	Special district
Mason County PUD	Dick W. - district manager	Special district
Pacific County Conservation District	Michael Johnson - WRIA 24 LE	Special district
Pacific County PUD	Douglas Miller - general manager	Special district
Pierce Conservation District	Monty Mahan - district manager	Special district
Pierce Conservation District	Jayne Gordon - Stream Team coordinator	Special district
San Juan Conservation District	Ron Zee - district manager	Special district
Skagit Conservation District	Carolyn Kelley - district manager	Special district
Skagit Conservation District	Kristi Carpenter - Stream Team coordinator	Special district
Skagit Council of Governments	Kelley Moldstad - WRIA 3,4 LE	Special district
Skagit County PUD	Kenneth Kukuk - general manager	Special district
Skamania PUD	[No specific contact person]	Special district
Snohomish Conservation District	Kim Levesque - District Manager	Special district
Snohomish PUD	Cristoff Enderlien - environmental affairs	Special district
Snohomish PUD	Keith Binkley - fish biologist	Special district
Tacoma PUD	Debbie Young - Natural Resources director	Special district
Thurston Conservation District	Amy Hatch-Winecka - WRIA 13 LE coordinator	Special district
Thurston County Stream Team	Susie Vanderburg - Stream Team coordinator	Special district
Thurston PUD	Herta Ingram - assistant manager	Special district

Appendix: PSM Information Request Contacts

State of Washington

Agency or Entity	Contact Person	Type
Wahkiakum Conservation District	Darin Houpt - district manager	Special district
Wahkiakum PUD	Dave Trambly - district manager	Special district
Whatcom Conservation District	Andrea Hood - salmon recovery coordinator	Special district
Whatcom PUD	Steve Jilk - general manager	Special district
Whidbey Island Conservation District	Karen Lennon	Special district
Whatcom Conservation District	Beth Chisolm - stream team coordinator	Special district
Governor's Salmon Recovery Office	Chris Drivdahl - Salmon Recovery team leader	State agency
Governor's Salmon Recovery Office	Phil Miller - Columbia & Coastal Recovery coordinator	State agency
Governor's Salmon Recovery Office	Lloyd Moody - Puget Sound/Hood Canal Recovery coordinator	State agency
Washington Dept. of Ecology	Doug Allen - WRIA 1 lead	State agency
Washington Dept. of Ecology	Phil Wiatrak - WRIA 14,16,17 lead	State agency
Washington Dept. of Ecology	Scott McKinney - WRIA 25,26,27,28 lead	State agency
Washington Dept. of Ecology	Cynthia Nelson - WRIA 18 lead	State agency
Washington Dept. of Ecology	Kahle Jennings - WRIA 22,23 watershed lead	State agency
Washington Dept. of Ecology	Jacque Klug - WRIA 2,3,4,5,6,7,15 lead	State agency
Washington Dept. of Ecology	Steve Craig - WRIA 11,13,22,23 lead	State agency
Washington Dept. of Ecology	Bob Duffy - WRIA 12,19,20 lead	State agency
Washington Dept. of Fish & Wildlife	Pat Frazier - Fish Program manager	State agency
Washington Dept. of Fish & Wildlife	Craig Burley - Fish Program manager	State agency
Washington Dept. of Fish & Wildlife	Ron Warren - Fish Program manager	State agency
Washington Dept. of Natural Resources	Jason Stuart	State agency
Washington Dept. of Natural Resources	Scott Horton - regional biologist	State agency
Washington Dept. of Natural Resources	Alan Estep - regional biologist	State agency
Washington Dept. of Natural Resources	Alan Mainwaring - regional biologist	State agency
Elwha Klallam Tribe	Doug Morrill - fisheries manager	Tribe
Jamestown S'Klallam Tribe	Scott Chitwood - Natural Resources director	Tribe
Lummi Tribe	Alan Chapman - WRIA 1 LE	Tribe
Makah Tribe	Russel Svec - fisheries m	Tribe
Nisqually Tribe	David Troutt - Natural Resources director	Tribe
Noocksack Tribe	Robert "Bob" Kelly - Natural Resources director	Tribe
Port Gamble S'Klallam Tribe	Cindy Gray - finfish manager	Tribe
Port Gamble S'Klallam Tribe	Sharon Purser - Natural Resources director	Tribe
Port Gamble S'Klallam Tribe	Ted Labbe - habitat biologist	Tribe
Quileute Tribe	Roger Lien - fisheries services chief	Tribe
Quinalt Indian Nation	Jon Sims - WRIA 21 LE	Tribe
Samish Tribe	Christine Woodward	Tribe
Skagit Systems Cooperative	Eric Beamer - Research director	Tribe
Skagit Systems Cooperative	Stan Walsh - Environmental Services fish biologist	Tribe
Skokomish Tribe	Keith Dublanica - Natural Resources director	Tribe
Squaxin Island Tribe	Joe Peters - fish biologist	Tribe
Stillaguamish Tribe	John Drotts - Natural Resource manager	Tribe
Suquamish Tribe	Rob Purser - fisheries	Tribe
Suquamish Tribe	Dee Williams - Natural Resources	Tribe
Tulalip Tribe	Kit Rawson - Fisheries Program manager	Tribe
Tulalip Tribe	Terry Williams - WRIA 7 LE	Tribe

Appendix: PSM Information Request Contacts

State of Oregon

Agency or Entity	Contact Person	Type
OSU Extension	Guillermo Giannico - OSU Extension Fisheries	Academic
City of Albany	Jeff Kinney - Stormwater supervisor	City
City of Ashland	Robbin Pearce - Conservation division	City
City of Ashland	Paula Brown - Public Works director	City
City of Astoria	Ken Cook - Public Works director	City
City of Astoria	Todd Scott - Community Development director	City
City of Aurora	Bob Southard - Public Works director	City
City of Bandon	Michelle Hampton - City Planner	City
City of Beaverton	Paula Moore	City
City of Beaverton	David Winship - Utilities Engineer	City
City of Beaverton	Hal Bergsma	City
City of Brookings	Diane Snow - Planning director	City
City of Brookings	John Cowan - Public Works director	City
City of Canby	Beth Saul - Library & Parks director	City
City of Canby	Roy Hester - Public Works director	City
City of Cannon Beach	Rainmar Bartl - City planner	City
City of Cannon Beach	Kruz Flores - Public Works foreman	City
City of Central Point	Karen Roeber - Public Works	City
City of Central Point	Didi Thomas - Planning	City
City of Columbia City	Micah Olson - Public Works superint.	City
City of Coos Bay	Jim Hossley - Public Works & Development director	City
City of Coquille	Terence O'Connor - City manager	City
City of Cornelius	Richard Meyer - Development director	City
City of Corvallis	Tom Penpraze - Public Works - Utilities manager	City
City of Cottage Grove	Ron Bradsbury - Public Works director	City
City of Cottage Grove	Howard Schesser - Community Development director	City
City of Dallas	Fred Braun - director	City
City of Eugene	Kurt Corey - Public Works director	City
City of Fairview	Bob Cochran - Public Works director	City
City of Fairview	John Gessner - Community Development - Senior planner	City
City of Forest Grove	Jon Holan	City
City of Gladstone	Larry Canfield - Public Works director	City
City of Gold Beach	Jeff Denney - Public Works director	City
City of Grants Pass	Jim Huber - Community Development director	City
City of Gresham	Environmental Services - Watershed Management	City
City of Hillsboro	Karla Antonini	City
City of Independence	Michael Danko - Community Development director	City
City of Independence	Kenneth Perkins - Public Works director	City
City of Kaiser	Rob Kissler - Public Works director	City
City of Kaiser	Nate Brown - Planning director	City
City of Lake Oswego	Lisa HammerlynckNatural Resources coordinator	City
City of Lake Oswego	Jonna Papaefthimiou – Natural Resources	City
City of Lebanon	Jim Ruef - Public Works director	City
City of Lincoln City	Lila Bradley - Public Works director	City
City of Lincoln City	Richard Townsend - Planning director	City
City of McMinnville	Laura Johnson - Public Works	City
City of Medford	Planning Department	City
City of Medford	Cory Crebbin - Public Works director	City
City of Milwaukie	Jack Perry - Stormwater operations supervisor	City
City of Monmouth	Craig Johns - Public Works director	City
City of Myrtle Creek	Steve Johnson - Public Works director	City
City of Newberg	Dan Danicic - Public Works director	City
City of Newport	Lee Ritzman - Public Works director	City
City of Newport	James Bassingthwaite - Community Development director	City
City of North Bend	Barb Dunham - Visitor Services	City
City of North Bend	City Planner	City
City of Oakridge	Kevin Urban - Public Works director	City
City of Oregon City	Tom Morisette - Stormwater manager	City
City of Philomath	Beau Vencill - Public Works director	City
City of Portland	Joan Saroka - Environmental Services communications division	City
City of Portland	Dean Marriot - Environmental Services director	City
City of Reedsport	Floyd Dollar - Public Works superint.	City
City of Roseburg	Clay Baumgartner - Public Works director	City

Appendix: PSM Information Request Contacts

State of Oregon

Agency or Entity	Contact Person	Type
City of Roseburg	Allie Cyr - Planning	City
City of Salem	Ken Roley - stormwater	City
City of Salem	Patricia Farrel - Public Works	City
City of Salem	Sam Kidd - stormwater	City
City of Sandy	Tracy Brown - Planning director	City
City of Sandy	Mike Walker - Public Works director	City
City of Scappoose	Brian Varricchione - Community Development manager	City
City of Scappoose	Terry Andrews - Public Works supervisor	City
City of Seaside	Neal Wallace - Public Works director	City
City of Shady Cove	George Bostic - Public Works director	City
City of Silverton	Linda Sarnoff - Community Development director	City
City of Silverton	Rich Barstad - Public Works director	City
City of Springfield	Public Works - Environmental Services	City
City of St. Helens	Skip Baker - Planning administrator	City
City of St. Helens	Neal Sheppard - Public Works supervisor	City
City of Stayton	Mike Faught - Public Works director	City
City of Sweet Home	Craig Martin - City Manager	City
City of Sweet Home	Michael Adams - Public Works	City
City of Tigard	Eric Hand - Stormwater supervisor	City
City of Tigard	Denver Igarta - City planner	City
City of Tillamook	Mark Gervasi - City Manager	City
City of Tillamook	Arley Sullivan - Public Works director	City
City of Toledo	Pete Wall - City manager	City
City of Toledo	Public Works director	City
City of Troutdale	James Galloway - Public Works director	City
City of Troutdale	Rich Faith - Community Development director	City
City of Tualatin	Elizabeth Stepp	City
City of Tualatin	Dan Boss - Public Works director	City
City of Tualatin	Doug Rux - Community Development director	City
City of Waldport	Nancy Leonard - City manager	City
City of Waldport	Rick McClung - Public Works superint.	City
City of Warrenton	Edward Madere - City manager	City
City of West Linn	Mike Cardwell - Public Works director	City
City of Wilsonville	Luke Bushman - Stormwater manager	City
City of Wilsonville	Kerry Rappold - Natural Resources manager	City
City of Woodburn	Curtis Stultz - Public Works assistant superint.	City
City of Yachats	John McClintock - Public Works director	City
City of Yachats	Larry Lewis - City Planner	City
City of Yamhill	Kim Steele - City clerk	City
City of Yamhill	Richard Howard - Public Works superint.	City
Benton County	Laurel Byers	County
Clackamas County - Water Environment Services	Bob Storer - Environmental Policy specialist	County
Clatsop County	CEDC - Fisheries Project (propagation)	County
Columbia County	Todd Dugdale - Land Planning director	County
Coos County	Bob Laport - County forester	County
Curry County	David Pratt - Public Services - Environmental Services director	County
Douglas County	Tim Manton - Public Works - Natural Resources Division	County
Jackson County	Kelly Madding - Development Services director	County
Josephine County	Forestry Dept. [No specific contact person]	County
Lane County	Ollie Snowden - Public Works director	County
Lincoln County	Public Works director	County
Linn County	Steve Michaels - Planning director	County
Marion County	Public Works	County
Multnomah County	Kim Peoples - Environmental Compliance Program manager	County
Polk County	Austin McGuigan - Planning director	County
Polk County	Aaron Geisler - Public Works director	County
Tillamook County	Bill Campbell - Community Development director	County
Washington County	Steve Kelley - County planning	County
USDI Bureau of Land Management - Coos Bay District	Bill Hudson - Fish biologist	Federal agency
USDI Bureau of Land Management - Eugene District	Leo Poole - fish biologist	Federal agency
USDI Bureau of Land Management - Medford District	Dale Johnson - Fish biologist	Federal agency
USDI Bureau of Land Management - Roseburg District	Scott Lightcap - Fish biologist	Federal agency
USDI Bureau of Land Management - Salem District	Bob Ruediger - fish biologist	Federal agency

Appendix: PSM Information Request Contacts

State of Oregon

Agency or Entity	Contact Person	Type
NOAA Fisheries	Jeff Lockwood - NOAA Fisheries	Federal agency
US Environmental Protection Agency	Phil Larson - EPA	Federal agency
USDA Forest Service	Scott Peets - USFS Region 6 Fish Program	Federal agency
USDI Bureau of Land Management	Al Doelker - BLM	Federal agency
Alsea Watershed Council	Linda Johnston	Nonprofit
Applegate River Watershed Council	Zach Stevenson - coordinator	Nonprofit
Bear Creek Watershed Council	Beth Franklin - coordinator	Nonprofit
Calapooia Watershed Council	Tara Putney	Nonprofit
Cedar Mill Creek Watershed Watch	Gretchen Vadnais	Nonprofit
Chetco Watershed Council	Roger Thompson - coordinator	Nonprofit
Chetco Watershed Council	Bill Yocum	Nonprofit
Clackamas River Basin Council	Cheryl McGinnis - executive director	Nonprofit
Claggett Creek Watershed Council	Jon Falk	Nonprofit
Claggett Creek Watershed Council	Jane Keppinger	Nonprofit
Coast Fork Willamette Watershed Council	Pamela Reber - coordinator	Nonprofit
Columbia Slough Watershed Council	Jane Van Dyke - executive director	Nonprofit
Coos Watershed Association	Jon Souder - coordinator	Nonprofit
Coquille Watershed Association	Jennifer Hampel - coordinator	Nonprofit
Corvallis Environmental Center	Rachel O'Neal	Nonprofit
Ecola Creek Watershed Council	Jerome Arnold	Nonprofit
Elk Creek Watershed Council	Lee Russell - coordinator	Nonprofit
Elk-Sixes River Watershed Council	Joe Marsh	Nonprofit
Friends of Beaverton Creek	Amanda Legernes	Nonprofit
Friends of Beaverton's Johnson Creek	Mark Hereim -	Nonprofit
Friends of Mill Creek	Mark Wieprecht - coordinator	Nonprofit
Friends of Rock, Bronson & Willow Creek	Virginia Bruce	Nonprofit
Glenn Gibson Watershed Council	Charles Redon - coordinator	Nonprofit
Greater Oregon City Watershed Council	Anna McKinney - coordinator	Nonprofit
Hunter Creek-Pistol River Watershed Council	Clayton Barber	Nonprofit
Illinois Valley Watershed Council	Kevin O'Brian - Council coordinator	Nonprofit
Johnson Creek Watershed Council	Michelle Bussard - executive director	Nonprofit
Little Butte Watershed Council	Tim Weaver - coordinator	Nonprofit
Long Tom Watershed Council	Dana Erickson - coordinator	Nonprofit
Lower Columbia Watershed Council	Margaret Magruder - coordinator	Nonprofit
Lower Nehalem-Necanicum Watershed Council	Dave Godsney	Nonprofit
Lower Rogue Watershed Council	Dana Hicks - coordinator	Nonprofit
Luckiamute Watershed Council	Michael Cairns - coordinator	Nonprofit
Marys River Watershed Council	Sandra Coveny - coordinator	Nonprofit
McKenzie River Watershed Council	Megan Finnessy	Nonprofit
Midcoast Watersheds Council	Wayne Hoffman	Nonprofit
Middle Fork Willamette Watershed Council	Eve Montanero - coordinator	Nonprofit
Middle Rogue Watershed Council	Brad Carlson - coordinator	Nonprofit
Nestucca-Neskowin Watershed Council	Alex Sifford - coordinator	Nonprofit
North Santiam Watershed Council	Liz Redon - coordinator	Nonprofit
Partnership for Umpqua Rivers	Bob Kinyon - coordinator	Nonprofit
Port Orford Watershed Council	John Leuthe - coordinator	Nonprofit
Pringle Creek Watershed Council	Victor Dodier - coordinator	Nonprofit
Pudding River Watershed Council	Jamison Cavallaro - coordinator	Nonprofit
Rickreall Watershed Council	Charles Redon - coordinator	Nonprofit
Rock Creek Watershed Partners	Amanda Wilson - coordinator	Nonprofit
Rogue Basin Coordinating Council	Janelle McFarland - president	Nonprofit
Rogue Basin Fish Access Team	Steve Mason - Program manager	Nonprofit
Rogue Basin Technical Team	Jon Lange - Team facilitator	Nonprofit
Salem-Keizer Urban Watershed Council's Association	Watershed Enhancement Team	Nonprofit
Salmon-Drift Watershed Council	Katie McKenzie - coordinator	Nonprofit
Sandy River Basin Watershed Council	Russ Plaeger - coordinator	Nonprofit
Scappoose Bay Watershed Council	Janelle St. Pierre - coordinator	Nonprofit
Seven Basins Watershed Council	Gail Perrotti	Nonprofit
Siletz Watershed Group	Parker Ogburn	Nonprofit
Siuslaw Watershed Council	Todd Miller - coordinator	Nonprofit
Skipanon Watershed Council	Jim Scheller	Nonprofit
Skyline Ridge Neighbors - Natural Resources Committee	Rich Edwards	Nonprofit
South Coast Watersheds Council	Harry Hoogesteger - coordinator	Nonprofit

Appendix: PSM Information Request Contacts

State of Oregon

Agency or Entity	Contact Person	Type
South Santiam Watershed Council	Eric Hartstein - coordinator	Nonprofit
Tenmile Lakes Basin Partnership	Mike Mader	Nonprofit
Tillamook Bay Watershed Council	Denise Lofman - coordinator	Nonprofit
Tryon Creek Watershed Council	Terry Preeg Rigsby	Nonprofit
Tryon Creek Watershed Council	Catherine Sherraden	Nonprofit
Tualatin Watershed Council	April Olbrich	Nonprofit
Upper Nehalem Watershed Council	Maggie Peyton - coordinator	Nonprofit
Upper Rogue Watershed Council	Don Nelson - coordinator	Nonprofit
US Bureau of Land Management - Tillamook District	Matt Walker - fish biologist	Nonprofit
Williams Creek Watershed Council	Evelyn Roether	Nonprofit
Winchuck Watershed Council	Terry Hanscam	Nonprofit
Yamhill Basin Council	Jamie Sheahan - Watershed Coordinator	Nonprofit
Yaquina Basin Planning Team	Katie Lantz Phillips	Nonprofit
Youngs Bay Watershed Council	Mike Seppa	Nonprofit
Benton Soil & Water Conservation District	Gordon Cumming - district manager	Special district
Clackamas Soil & Water Conservation District	Rick Gruen - district manager	Special district
Clatsop Soil & Water Conservation District	David Ambrose - district manager	Special district
Clean Water Services	Kendra Smith – Water Resources Program manager	Special district
Clean Water Services	Mark Jockers - media relations	Special district
Clean Water Services	Sherry Wantland	Special district
Clean Water Services	Darrell Hedin - Watermaster	Special district
Columbia River Estuary Study Taskforce	Lori Lilly - North Coast Watershed Councils coordinator	Special district
Columbia River Estuary Study Taskforce	Peter Heltzel - fish biologist	Special district
Columbia Soil & Water Conservation District	[No specific contact person]	Special district
Coos Soil & Water Conservation District	Nancy Diaz	Special district
Curry Soil & Water Conservation District	Liesl Coleman	Special district
Douglas Soil & Water Conservation District	Walt Barton	Special district
East Lane Soil & Water Conservation District	[No specific contact person]	Special district
East Multnomah Soil & Water Conservation District	Eann Rains	Special district
Illinois Valley Soil & Water Conservation District	[No specific contact person]	Special district
Jackson Soil & Water Conservation District	Linda Town	Special district
Josephine Soil & Water Conservation District	[No specific contact person]	Special district
Lincoln Soil & Water Conservation District	[No specific contact person]	Special district
Linn Soil & Water Conservation District	Kevin Seifert - Watershed coordinator	Special district
Marion Soil & Water Conservation District	[No specific contact person]	Special district
METRO	Jim Morgan - Science & Stewardship manager	Special district
METRO	Regional Parks & Greenspaces	Special district
METRO	Karen Kane - Media coord	Special district
METRO	Jim Lind - Regional Parks Supervisor (Sandy River chinook)	Special district
Polk Soil & Water Conservation District	Jacki Hastings - district manager	Special district
Siuslaw Soil & Water Conservation District	[No specific contact person]	Special district
Tillamook Soil & Water Conservation District	[No specific contact person]	Special district
Tualatin Hills Park & Rec District	Sarah Cleek	Special district
Tualatin Soil & Water Conservation District	Kristi Turner - public relations	Special district
Umpqua Soil & Water Conservation District	[No specific contact person]	Special district
West Multnomah Soil & Water Conservation District	[No specific contact person]	Special district
Yamhill Soil & Water Conservation District	Tim Steiber - district manager	Special district
ODFW Corvallis Research Lab	Mark Lewis - OASIS Project leader	State agency
ODFW Natural Resources Information Management Program	Cedric Cooney - program leader	State agency
Oregon Dept. of Agriculture	Paul Measeles - ODA Hydrologist	State agency
Oregon Dept. of Environmental Quality	Greg Pettit - ODEQ Water Quality Program manager	State agency
Oregon Dept. of Environmental Quality	Steve Hanson ODEQ Volunteer Monitoring coordinator	State agency
Oregon Dept. of Fish and Wildlife	David Jepsen - Salmonid Life-Cycle/WORP Project leader	State agency
Oregon Dept. of Fish and Wildlife	Dan Knoll - ODFW Outreach coordinator	State agency
Oregon Dept. of Fish and Wildlife	Kirk Schroeder - Willamette Spring Chinook Project leader	State agency
Oregon Dept. of Fish and Wildlife	Kara Anlauf - assistant AI project lead	State agency
Oregon Dept. of Fish and Wildlife	Charlie Stein - assistant AI project lead	State agency
Oregon Dept. of Fish and Wildlife	Jeff Rodgers - ODFW Monitoring coordinator	State agency
Oregon Dept. of Fish and Wildlife	Trevan Cornwell - AI project biologist	State agency
Oregon Dept. of Fish and Wildlife	Kim Jones - AI project lead	State agency
Oregon Dept. of Fish and Wildlife	Jeremy Romer - AI project biologist	State agency
Oregon Dept. of Fish and Wildlife	Brianna Sounheim - Coastal Coho project leader	State agency
Oregon Dept. of Fish and Wildlife	Audrey Hatch - ODFW Conservation Planner	State agency

Appendix: PSM Information Request Contacts

State of Oregon

Agency or Entity

Oregon Dept. of Fish and Wildlife
Oregon Dept. of Fish and Wildlife
Oregon Dept. of Forestry
Oregon Dept. of Forestry
Oregon Division of State Lands
Oregon Watershed Enhancement Board

Contact Person

David Hering - AI project biologist
Brian Bangs - AI project biologist
Jim Cathcart - ODF Forest Health Monitoring manager
Andrew Yost - ODF Ecologist
Eric Metz - ODSL Essential Habitats
Greg Sieglitz - OWEB Monitoring Program manager

Type

State agency
State agency
State agency
State agency
State agency
State agency