Puget Sound Benthos Biomonitoring Methods: Summary of Field Collection, Sampling Design, Taxonomy, and Data

2014[1]

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With input and assistance from project stewards from Puget Sound agencies and Tribes

Introduction and Objectives

Numerous Puget Sound agencies and tribes collect benthic macroinvertebrate samples from Puget Sound streams and rivers as part of their biological monitoring programs. Some methods are fairly consistent across agencies and projects, whereas others are carried out using a variety of methods. This document and the Puget Sound region methods matrix table (Table 1) provides a snapshot and summary of the field collection methods, sampling design considerations, taxonomic resolution, and data in the Puget Sound Stream Benthos (PSSB) data management system to serve as a regional reference[2].

Complete standardization of methods across the region is not a goal. The purpose and study questions associated with each monitoring project, in addition to the available resources, ultimately dictate why certain methods are used. However, data are increasingly being rolled up to a regional level to establish baseline conditions, detect trends over time, make stream impairment decisions (e.g., 303(d) list), and evaluate Puget Sound Partnership ecosystem recovery targets. It is imperative to understand which data are comparable across the region to assess stream condition. As new programs emerge or existing programs are modified, there could be utility in adopting regionally standardized methods.

Current best available science suggests that some methodological differences have an influence on the outcome of stream condition assessments while others do not. For example, the level of taxonomic effort influences benthic index of biotic integrity (B-IBI) scores. However, different effort levels are accounted for in B-IBI scoring by the PSSB to ensure data comparability across projects and years as long as the taxonomic effort is correctly assigned (King County 2014a). Net mesh size is an important variable because it establishes the smallest sized organisms likely to be collected. Puget Sound agencies are united in using collection devices with 500 µm nets. In contrast, the type of net (D-frame kicknet, Surber sampler, etc.) is not likely to impact assessment results (Cao et al. 2005).

[1] Methods matrix table (Table 1) updated and accurate as of December 2013; Scorable site visit information (Table 3) updated and accurate as of July 2014.
[2] Both this document and the methods matrix table are downloadable from the PSSB at http://www.pugetsoundstreambenthos.org/Projects/BIBI-Recalibration-Documentation.aspx.

Table 1. **Methods matrix table compiled to represent collection methods, sampling design, taxonomy, and data aspects of Puget Sound region macroinvertebrate monitoring programs. Accurate as of December 2013. Also downloadable from http://www.pugetsoundstreambenthos.org/Projects/BIBI-Recalibration-Documentation.aspx as an Excel spreadsheet with supporting tabs that describe the column headings and abbreviations.**

Contact Info		Field Collection Methods											Sampling Design						Taxonomy						Data	
Contact Info	**Primary Contact**	**Total Sampled Area (sq ft)**	**Each Rep Area (sq ft)**	**# Reps**	**Rep Treatment**	**Sampling Device**	**Mesh Size (micron)**	**Disturbance Time (seconds)**	**Disturbance Device**	**Rock Protocol**	**Habitat Data Collection**	**Other Data**	**Habitat Sampled**	**QC Rep %**	**QC Rep - Timing**	**Random Sample Design?**	**Sampling Window**	**Sites/Year**	**Samp Schedule**	**Taxonomic Lab**	**Chironomid Resolution**	**Acari Resolution**	**Oligochaete Resolution**	**Closest STE**	**Subsampling Target**	**Data in PSSB**	**Analysis Tool**
Adopt-A-Stream	Tom Murdoch	3	1	3	composite	1' x 1' Surber	500	info not available	info not available	info not available	info not available	info not available	info not available	10%	same day	no	late June	10	1 time	Rhithron	LPL	Acari	Oligo	fine	500	2008	B-IBI
Bainbridge Island	Cami Apfelbeck	9	3	3	separate	1' x 1' Surber	500	60	weed tool or screwdriver	rinse in front of net; second cleaning in dishpan on stream bank	substrate, wetted and bankfull width, riffle dimensions, bank instability, riparian zone vegetation, % canopy cover	flow, physiochemical	3 riffles	none	N/A	no	mid Aug - mid Sept	6 to 8	annually	Rhithron	LPL	Acari	Oligo	fine	500	2008	B-IBI
Bellevue	Kit Paulsen	usually 9, rarely 8	usually 3	usually 3	generally 3 separate; but composite 8 if previous samples at site < 500 organisms	1' x 1' Surber	500	info not available	info not available	info not available	info not available	info not available	3 riffles	none	N/A	no	Aug - mid Sept	2 to 13	various	Rhithron	LPL 98,01,10-12; family 02-07	Acari	Oligo 98-07; LPL >2010	fine	500 since 2003; 700 before	1998-2012 except '00, '04, '08-09	B-IBI
Bellingham	Sara Brooke Benjamin or Renee LaCroix	8	2	4	separate	1' x 2' Surber/D-net combo on a stick	500	60 scrub rocks, 60 agitate	hands/ brush to scrub, tool to agitate	rinse in front of net in stream	substrate, canopy cover (densiometer) measurements	WQ (Temp, DO, SpC, pH), stream reach profile	4 riffles	none	N/A	no	mid to late Sept	2 to 13	various	2001-03 WWU; 2007-09 R2; 2011 & 2013 Rhithron	LPL, Subfamily ≤2009	LPL, Acari ≤2009	LPL, Oligo ≤2009	fine	500 since 2007; 'all' 2001 -2003	2001-03, '07, '09, '11	B-IBI
Clallam County after adoption of standard PS protocols (2011-)	Ed Chadd	8	1	8	composite	1' x 1' Surber	500	remove big rocks, dig 60, time-out if more big rocks found underneath	weed tool or similar, big enough for two hands	rinse in front of net in stream &/or collect for further inspection	photos, noxious weeds, gradient, temperature	WQ & flow at some sites	4 riffles or best available habitat	10%	usually same day	no	Aug - Sept	5 to 35	per funding & advisory group	ES&C including A.J. Frost	Family	LPL (genus)	LPL	fine	500	2011	B-IBI
Clallam County prior to adoption of standard PS protocols (1999-2011)	Ed Chadd	9	3	3	separate	1' x 1' Surber	500	remove big rocks, dig 60, time-out if more big rocks found underneath	weed tool or similar, big enough for two hands	rinse in front of net in stream & collect for further inspection	photos, noxious weeds, gradient; from 1999-2005, also substrate, densiometer, canopy type, conifer stems, LWD, pools, cross-section, bank stability, erosion/ revetment	WQ, flow	best riffle habitat, 3 riffles if possible	none	N/A	no	Sept 1 - Oct 15	5 to 35	per funding & advisory group	A.J. Frost, except Aq Ent 2001-02 & '07, ES&C + A.J. Frost 2011	Family	Acari	Oligo	coarse	500 or all till 2003, then generally 500	1999-2011, no '09; * all private	B-IBI
Ecology - Ambient	Chad Larson	8	1	1 composite of 8 kicks	composite	1' wide D-frame kicknet	500	30 sec	kick with feet	rinse in front of net in stream	Ecology, Watershed Health	periphyton assemblage in situ water chemistry, sediment chemistry	reach-wide (transect)	10% per survey	within index period	no, targets least disturbed contitions	July 1 - mid Sept	20-30	rotating by region	presently Rhithron	LPL	Genus for adults, “Acari” for indeterminate specimens	LPL	fine	500	2002-04, 2010-12	O/E, MMI
Ecology – TMDL/Effectiveness Monitoring	Scott Collyard	8	1	1 composit of 8 kicks	composite	1' wide D-frame kicknet	500	30 sec	kick with feet	rinse in front of net in stream	Ecology, Watershed Health	periphyton assesmblage, metals, TOC, Chla, water and sediment chemistry	4 riffles	10% per study/yr	same day	targeted and random	July 1-Oct 15	~5-30 statewide	various	presently Rhithron	LPL	LPL (Acari 02-04)	LPL	fine	500	2009, 2010, 2011	O/E, MMI, other

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Contact Info	Primary Contact	Total Sampled Area (sq ft)	Each Rep Area (sq ft)	# Reps	Rep Treatment	Sampling Device	Mesh Size (micron)	Disturbance Time (seconds)	Disturbance Device	Rock Protocol	Habitat Data Collection	Other Data	Habitat Sampled	QC Rep %	QC Rep - Timing	Random Sample Design?	Sampling Window	Sites/Year	Samp Schedule	Taxonomic Lab	Chironomid Resolution	Acari Resolution	Oligochaete Resolution	Closest STE	Subsampling Target	Data in PSSB	Analysis Tool
Ecology - Watershed Health	Glenn Merritt	8	1	1 composit of 8 kicks	composite	1' wide D-frame kicknet	500	30 sec	kick with feet	rinse in front of net in stream	Ecology, Watershed Health	vertebrate assemblage, in situ water chemistry, sediment chemistry	reach-wide (transect)	10% per survey	within index period	yes (GRTS)	July 1 - Oct 15	50 or 100 (random) sites annually +16 sentinel sites	rotating by region; revisit PS every 4th yr (2009, 2013, 2017…)	presently Rhithron	LPL	Genus for adults, "Acari" for indeterminate specimens	LPL	fine	500	2009-2012	O/E, MMI
Everett	Heather Kibbey or Mike Papa	3	1	3	composite	1' x 1' Surber	500	60	screw driver	rinse in front of net in stream	info not available	info not available	3 riffles	none	N/A	no	v. late July - mid Sept	9	annually	ABA	LPL	Acari	Oligo	fine	all	2008-2012	B-IBI
Federal Way	Dan Smith	9 ≥2004, 3≤2003	3≥'04, 1≤03	3	separate	1' x 1' Surber	500	60	weed tool	rinse in front of net in stream	some qualitative habitat	info not available	3 riffles	none	N/A	no	mid Aug - late Sept	~ 12	annually	Rhithron	LPL (2001 family)	Acari	Oligo (1999-2000 to family)	fine (coarse in 2001)	all	1998-2012	B-IBI
Issaquah	Micah Bonkowski	3	1	3	composite	1' x 1' Surber	500	60 sec rub rocks, 60 sec	weed tool	rinse in front of net in stream	info not available	info not available	3 riffles	none	N/A	no	Aug - late Sept	3 to 8	annually	Rhithron	LPL	Acari	Oligo	fine	all	2002-2008,	B-IBI
King County DNRP, Ambient	Jo Wilhelm	3 ≤2011, 8 ≥2012	1	3 < 2011, 8>2012	composite	1' x 1' Surber	500	60	weed tool	rinse in front of net in stream	mix of qualitative & quantitative habitat	flow & WQ at some collected separately from B-IBI	3 riffles <2011, 4 riffles>2012	10%	same day	yes	Aug - mid Sept	120 to 147	annually	Rhithron 2002-2005, 2010-13; ABR 2006-09	LPL, Family ≤2011	LPL, Acari ≤2011	LPL, Oligo ≤2011	fine (coarse < 2011)	500	1999-2012 except 2004	B-IBI
King County Roads, ESA WQ	Brent Dhoore	3	1	3	composite since 2003; separate 1999-2002	1'x1' Surber	500	60	screw driver or weed tool	scrub in front of net in stream	mix of qualitative & quantitative habitat	road/stream crossing structure type	3 riffles	~ 5% (1 to 5/yr)	same day preferably but usually different day as close to original as possible	no	Aug - Sept (Oct in '00-01)	23 to 74	ESA baseline study annually; 2010 last yr	Rhithron 1999-2005, 2010-13; ABR 2006-09	family	Acari	Oligo	coarse	500	1999-2010	B-IBI
Kirkland	Ryean-Marie Tuomisto	3	1	3	separate until 2010; composite since 2011	1' x 1' Surber	500	60	weed tool	rinse in front of net in stream & put in to bucket	riffle length, width, average depth	air & water temp, pH	3 riffles	none	N/A	no	Aug- late Sept	6 to 10	annually	Rhithron	LPL	Acari	Oligo	fine	500 (/rep)	2001-2013 except 2004	B-IBI
Kitsap County, Stream Team	Mauro Heine	3 ≤ 2001; 9 2002-06	1	3 (2000-01); 9 (2002-06)	composite 2002-05; separate 2000-01, 06	1' x 1' Surber	500	30	trowel	rinse in front of net in stream, double check in bucket	some qualitative habitat	surface flow, temp	1 riffle (2000-01), 3 riffles (2002-06)	20% (4 2001-2003)	same day	no	mid Aug - mid Oct	7 to 26	annually; project complete	ABA	LPL	Acari	Oligo	fine	500 (/rep)	2000-2006	B-IBI
Kitsap County, Navy's Envvest	Mauro Heine	3	1	3	separate 2000; composite 2002 & 03	1' x 1' Surber	500	info not available	info not available	info not available	info not available	info not available	1 riffles	3 sites in 2003	same day	no	late Aug - mid Oct	33 to 46	annually; project complete	ABA	LPL	Acari	Oligo	fine	all?	2000, 2002-03	B-IBI
Kitsap County, SSWM	Mauro Heine	3	1	3	separate, many composited by lab for IBI calc	1' x 1' Surber	500	30	trowel	rinse in front of net in stream, double check in bucket	some qualitative habitat	surface flow, temp	1 riffles	none	N/A	no	mid Aug - mid Oct	1 to 6	annually; project complete	ABA	LPL	Acari	Oligo	fine	all?	1998 to 2003	B-IBI
Kitsap County, Watershed Health	Mauro Heine or Renee Scherdnik	8	1	8	composite	1' x 1' Surber	500	≥ 30 <60	trowel	rinse in front of net in stream, double check in bucket	some qualitative habitat on all. EMAP>2012 (a few each yr)	surface flow, DO, pH, SpC, temp	≥ 4 riffles	20% (5 sites) in 2011	same day	no	mid Aug - mid Oct	22 to 25	every 1 to 3 yrs 3-tiered approach	ABA	LPL	Acari	Oligo	fine	500	2010-2012	B-IBI
Lake Forest Park	Mark Phillips	3	1	3	separate	1' x 1' Surber	500	60	crow bar or weed tool	double check + rinse into bucket	no habitat	DO, temp, pH > 20 yrs	1 riffle	none	N/A	no	late Sept - mid Oct	4	annually	Aq Ent	Family	Acari	Oligo	coarse	all	2006-2010, 2012-2013	B-IBI
Pierce County	Carla Vincent	3	1	3	separate	1' x 1' Surber	500	60	crow bar or weed tool	double check + rinse into bucket	some qualitative habitat	air temp, water temp, pH, SpC	1 riffle	none	N/A	no	late June - mid Oct	20-30	at least once every 5 yrs	Aq Ent	Family	Acari	Oligo	coarse	all	1999-2012	B-IBI
Port Glallam Skallam Tribe	Abigail Welch	3	1	3	composite	1' x 1' Surber	500	60	kick with feet	rinse in front of net in stream	yes	WQ, flow, WDFW snorkel surveys	3 riffles	none	N/A	no, Dosewallips River	info not available	info not available	info not available	info not available	info not available	info not available	info not available	info not available	info not available	No	info not available

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Redmond	Tanya McFarlane	9	3	3	composite	2' x 1.5' D-net	500 (900 2010 and before)	60	shovel	rinse in front of net in stream	no habitat	info not available	3 riffles	none	N/A	no	mid Aug-late Sept	10 to 18	annually	Rhithron	LPL	Acari	Oligo (genus 2002-2004)	fine	500	2002-2012	B-IBI, O/E
Seattle, Project Evaluation	Katherine Lynch	9	1	9	composite	1' x 1' Surber	500	60	weed tool	don't rub rocks, process in bins	some qualitative habitat	info not available	3 riffles	none	N/A	no	mid Aug - early Sept	3 to 10	annually	ABA	LPL	Acari	Oligo	fine	all (2005-'08); 500 (2009-present)	2005-2013; missing '06, '10, '11	B-IBI
Seattle, Status & Trends	Katherine Lynch	9 (≥2003), 3 (≤2001); ? 2002	1	9 (≥2003), 3 (≤2001); ? 2002	composite 9 sf (≥2003); separate 3 sf (<2001); ? 2002	1' x 1' Surber	500	60	weed tool	don't rub rocks, process in bins	some qualitative habitat	info not available	3 riffles	none	N/A	no	mid-Aug - mid-Oct	10 to 23	annually	ABA	LPL	Acari	Oligo	fine	all (2005-'08); 500 (2009-present)	1994-2013 (missing '97, '11, '12)	B-IBI
Shoreline	Jennifer Adams	4	1	4	composite	1' x 1' Surber	500	unknown	unknown	hand scrub all handable-sized rocks, then agitate substrate to depth of 10cm	NW Indian Fishery Commission 1997 protocols	pebble counts, flow, morphology, canopy	4 riffles	none	N/A	no	late Aug - early Sept	7	intermittent	EcoAnalysts	LPL	Acari	Oligo	fine	500	2002	B-IBI
Skokomish Tribal Nation	Ron Figlar Barnes	8	1	8	composite or separate	1' wide D-frame kicknet	500	60	kick with feet	don't rub rocks, process in bins	no habitat	info not available	13 riffles	none	N/A	no	late Aug - mid Oct	31	one period	ABA	LPL	Acari	Oligo	fine	all	2006	B-IBI
Snohomish County, Ambient 2005-2012	Steve Britsch or Jen Oden	generally 3 (except 6 in '08 & 4 in '09 are 9)	1 (3 for exceptions)	3	generally composite (except 6 in '08 & 4 in '09 separate)	1' x 1' Surber	500	60	screw driver	rinse in front of net in stream	no habitat	info not available	riffles	none	N/A	yes	early Aug - late Sept	5 to 36	rotating panel ~ every 3rd yr	Rhithron	LPL	Acari	Oligo	fine	500	2006-2013 (no 2007)	B-IBI
Snohomish County, Ambient 2013-present	Steve Britsch or Jen Oden	8	1	1	composite	1' x 1' Surber	500	60	screw driver	rinse in front of net in stream	no habitat	info not available	riffles	none	N/A	yes	early Aug - late Sept	5 to 36	rotating panel ~ every 3rd yr	Rhithron	LPL	Acari	Oligo	fine	500	2013	B-IBI
Snohomish County, Critical Area Regulations	Frank Leonetti or Jen Oden	3	1	3	composite	1' x 1' Surber	500	60	screw driver	rinse in front of net in stream	some qualitative habitat	info not available	3 riffles	none	N/A	no, paired catchment study	early Aug - early Sept	7 to 23	annually	Rhithron	LPL	Acari	Oligo	fine	500	2008-2010	B-IBI
Snoqualmie Tribe	Matt Baerwalde	3, 5, or 7 (minimum 3, performed additional reps until confident exceeded 500 organisms)	1	3 or more	composite	1' x 1' Surber	500	60	weed tool	scrub in front of net in stream	info not available	info not available	riffles	none	N/A	no	early Aug - early Sept	6	intermittent	EcoAnalysts	LPL	LPL	LPL	fine	500	2010	B-IBI
Stillaguamish Tribe	Jody Brown	8	1	8	8	D-frame kicknet	500	60	kick with feet	scrub in front of net in stream	no habitat	DO, temp, conductivity	4 riffles	none	N/A	no	mid July - Aug 1	2 to 3	annually	EcoAnalysts/ Stillaguamish Tribe	family	LPL (genus or suborder)	Oligo	coarse	all	2009-2011	B-IBI
Thurston County	Ann Marie Pearce	9	3	3	separate	1' x 1' Surber	500	60	weed tool	rinse in front of net in stream	no habitat	info not available	3 riffles	none	N/A	no	late June-mid August	6 to 15	annually	ABA	LPL	Acari	Oligo	fine	all	2002-2008	B-IBI
WRIA 8	Hans Berge	8	1	8	composite	1' x 1' Surber	500	60	disturbance to 10 cm depth using garden weed puller and hands	scrub in net outside of stream	Ecology's wadeable streams protocol (modified EMAP)	flow at some; fish; temperature	4 riffles	10% (5/yr)	same day	yes	July - August	30 to 62	annually 2009-2013	W. Aq Ent; Rhithron	sub-family (2010 family)	Acari (2011 LPL)	Oligo	medium	600	2009-2013	B-IBI, EPT, other diversity indices, guilds

Results from experimental studies have verified the comparability of samples collected from different surface areas (King County 2014b) or habitats (i.e., riffle versus reach-wide transects; Gerth and Herlihy 2006 and Rehn et al. 2007). Subsampling procedures and replicate handling (i.e., whether to composite individual collections or keep them separate) can influence B-IBI scores. However, these two variables can be standardized using the "criteria boxes" available in the PSSB which promotes regional data comparability.

Field Collection Methods

There is a fair amount of standardization across the region when it comes to how benthic macroinvertebrates are collected in the field. An individual collection (most commonly 1 ft^2 as dictated by the frame of the sampling net) typically involves cleaning off individual pieces of large substrate (coarse gravel and larger) within the stream flow in front of the sampling net before agitating the substrate by kicking or with a disturbance tool such as a shovel, robust screwdriver, or weed tool for 30-60 seconds (60 seconds is most common). There are several agencies that also set aside the large substrate into bins for visual inspection outside the stream. All agencies are currently using collection nets with 500 µm mesh size. The 1 ft. x1 ft. Surber sampler is the most commonly used sampling device followed by a 1 ft. wide D-frame kick net.

Total collection area and handling of sample replicates is variable across the region, and also represents a progression of methods over time. Early collection efforts (e.g., 1990s) seemed to most closely follow the methods outlined by Karr and Chu (1999) which called for collecting three separate 1-ft^2 samples from a single riffle resulting in a 3 ft^2 sampled area. This methodology seemed to evolve into sample collection from multiple riffles to characterize a slightly longer reach in one of two ways. In cases where minimum abundance targets (e.g., <300 organisms) were not consistently being met, the method was essentially tripled resulting in three-1 ft^2 samples from three riffles for a total sample area of 9 ft^2. These samples were either composited into one-9 ft^2 sample or kept as three-3 ft^2 samples. The larger sample area increased the likelihood of reaching abundance targets while still allowing the option of maintaining separate replicates at a site. In other cases the original method seemed to evolve into collecting three 1-ft^2 samples from multiple riffles and compositing them into one sample for subsequent taxonomic identification. By compositing the replicates, this method reduced processing costs for a single site while also increasing the likelihood that the 3 ft^2 sample exceeded the organism abundance targets relative to individual 1 ft^2 samples. However, by only having a single sample from each site, microhabitat patchiness and within site variability are not explicitly measured. Meanwhile, the Region 10 EPA (Hayslip 2007) recommends sample collection from 8 ft^2 based on collection methods typically used by national efforts [e.g., NAWQA (Moulton et al. 2002), EMAP (Lazorchak et al. 1998), and EPA's rapid bioassessment program Barbour et al. 1999)]. These samples are collected either from targeted riffles or transect-based sampling designs, typically with one composited sample per site. As a result of this sampling history, there are examples of programs across the Puget Sound region that apply each of these methods (Table 2). However, recommendations by the Region 10 EPA (Hayslip 2007) to adopt 8 ft^2 collection methods and the requirement by the Washington State Department of Ecology (Ecology) to collect from at least an 8 ft^2 area for consideration for the state water

quality assessment have led to some agencies switching to the 8 ft^2 method (Clallam, King, Kitsap, and Snohomish Counties have all transitioned to 8 ft^2 in recent years). The results from a 2011 side-by-side sample collection experiment comparing 3, 8, and 9 ft^2 sample areas suggests that there isn't a consistent shift in biological index scores (e.g., B-IBI when a 500 count subsampling count is used (King County 2014b). Similarly, Gerth and Herlihy (2006) and Rehn and others (2007) demonstrated that riffle targeted sampling compared to reach scale transect methods are not significantly different.

Table 2. Summary of macroinvertebrate collection methods used by Puget Sound agencies.

Method	Agencies Currently Using	Agencies Previously Using
3 sf, composite, riffles (3: 3x1)	Everett Issaquah King Co. Roads (since 2003) Kirkland (since 2011)	Snohomish Co. (pre 2013) Kitsap Co. Navy Envvest (2002-03) King Co. Ambient (pre 2012) Federal Way (pre 2004) Adopt-A-Stream (2008) Port Glallam Skallam Tribe
3 sf, separate, riffles (3: 1-1-1)	Lake Forest Park Pierce Co.	Kitsap Co.: Navy Envvest (2000), Stream Team (pre 2002), SSWM (pre 2004) Kirkland (pre 2011) Seattle Status & Trends (pre 2002)
8 sf, composite, riffles (8:8x1)	Snohomish Co. (since 2013) Stillaguamish Tribe WRIA 8 Clallam Co. (since 2011) Bellingham (4-2sf samples) King Co. Ambient (since 2012)	
8 sf, composite, reach (8:8x1)	Ecology: Watershed Health and Ambient	
9 sf, composite, riffle (9:9x1)	Seattle: Project Evaluation, Status &Trends (since 2003)	Kitsap Stream Team (2002-2006)
9 sf, separate, riffle (9:3-3-3)	Redmond Bainbridge Thurston Co. Federal Way (since 2004) Bellevue	Clallam Co. (pre 2012)
Other methods not described above	Shoreline (4 sf) Skokomish Tribal Nation (8 sf, 8x1 and 4x2) Snoqualmie Tribe (variable sf)	

Ancillary data collected as a component of regional benthic macroinvertebrate programs ranges from no additional data, to some qualitative habitat, to extensive physical habitat, water chemistry, and flow data collection.

Sampling Design

Site selection is often driven by the overall purpose of the monitoring and it was beyond the scope of this summary to understand the background and details of each individual project. Instead, a few elements of sampling design were summarized. Three biomonitoring projects throughout the Puget Sound region are based on a random sampling design (King County ambient, Snohomish County ambient, and Ecology's watershed health). Six agencies conduct quality control (QC) replicate sampling at 5 to 20 percent of sites annually (5% King County Roads; 10% Adopt-A-Stream, Clallam County, Ecology, King County DNRP; 20% Kitsap County). These QC data allow within site variability to be assessed. The sample collection window in the Puget Sound region generally ranges from June through October, with most projects and programs focused on sample collection in August and September. Some programs collect samples annually at the same locations, while others employ a rotating sampling design (e.g., certain sites are visited every 3rd or 4th year). Other sampling efforts have a variable sampling schedule that may not follow a predictable pattern.

Taxonomy

Taxonomic effort influences biological index scoring and has evolved over time. Historically, midges (Chironomidae) were often identified to family or sub-family level and mites (Acari) and segmented worms (Oligochaeta) were often identified to subclass. Over time taxonomic identification skills have improved, laboratory costs for identification of challenging taxa groups have decreased, and there is a growing desire to link specific taxa with anthropogenic stressors. As a result, more agencies are requesting increased taxonomic effort (e.g., finer taxonomic resolution) for these same groups. Since 2011, all but 6 agencies identify midges to lowest practical level, typically species or genus. Of the remaining agencies, 5 identify midges to family level and 1 to subfamily level. Many agencies still identify mites and segmented worms to subclass, but 5 agencies identify both groups to lowest practical level (typically genus for mites and subfamily or genus for segmented worms) and a sixth agency identifies just mites to lowest practical level.

The Puget Lowland B-IBI$_{0\text{-}100}$ is calibrated to three levels of taxonomic effort or resolution (fine, medium, and coarse). Taxonomic resolution can also be specified when calculating the B-IBI using the PSSB. More details about taxonomic resolution and effort are available online[3] and in King County 2014a. Of the projects summarized in Table 1, 27 are classified as using "fine" resolution, 1 as "medium" resolution, and 5 as "coarse" resolution for the data stored in the PSSB. When data do not fit exactly into one of the pre-determined resolution levels, the taxonomic effort for midges is given the most weight because of the typically high species richness of this group and its influence on B-IBI scoring (King County 2014a).

[3] Taxonomic effort information is described online at http://pugetsoundstreambenthos.org/Standard-Taxonomic-Effort.aspx.

Data

This memo and accompanying matrix table is focused on monitoring programs with data stored in the PSSB. Benthic macroinvertebrate data collected between 1994 and 2013 are stored in the PSSB with over 300 site visits every year but one since 2002 (Table 3). In 2014, efforts were made by King County to help Puget Sound agencies enter historical data into the PSSB. The majority of Puget Sound agencies rely on B-IBI as the primary analysis or evaluation tool for benthic macroinvertebrate data. Ecology and the City of Redmond also evaluate biological integrity using observed versus expected models.

Table 3. Summary of scorable site visits in the Puget Sound Stream Benthos data management system by agency and project as of July 3, 2014.

Agency: Project Name	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Adopt-A-Stream															9					
Bainbridge Island															6					
Bellevue					13			12	12	2		9	7	5			8	5	5	6
Bellingham: Macroinv								10	8	13				3				2		
Bellingham: Whatcom Ck														3		3		3		3
Ecology: Ambient									5	3	16									
Ecology: Ambient Bio																	10	28	26	
Ecology: Boundary Ck									3											
Ecology: Clover Ck																				6
Ecology: Deschutes Effect																9	8	7	11	
Ecology: Muckleshoot										2										
Ecology: Sentinel																	8	12	16	
Ecology: Status & Tr																55	129	109	110	
Ecology: TMDL																			12	
Everett															8	8	8	8	8	
Federal Way					3	5	5	5	5	8	8	8	10	7	11	9	12	10	11	
Issaquah									8	6		5		6	7					
King-DNRP: Ambient									147	127		129	139	143	145	128	140	137	120	124
King-DNRP: Biosolids						8	10	9	10	10	10	10	10							
King-DNRP: Des Moines										1	4	4	4	4	4	4	4	4	2	
King-DNRP: DMPh3																	3			
King-DNRP: L. Boise Ck																	1	2	2	3
King-DNRP: Mercer Isl						3	3	4	5	4		3	3		3					
King-DNRP: Miller-Walk										1	4	10	11	8	9	8	8	10	3	3
King-DNRP: Reg Effect															9	9	9	9	9	
King-DNRP: Rivers																				20
King-DNRP: UPD				5		7	7	7				2	7	2	6	2	6			
King-DNRP: Vashon												3	3	3	2	3	3	3	3	3
King-DNRP: WRIA08																30	57	57	57	56
King-Roads: CIP Support													6	6	5	10	10	10	6	
King-Roads: ESA WQ						37	39	23	47	45	84	77	70	73	76	66	74			
Kirkland								7	7	6		7	7	7	7	7	7	10	10	
Kitsap: Envvest							33		35	46										
Kitsap: SSWM					5	6	6	6	6	1										
Kitsap: Stream Team							15	20	20	21	26	17	7							
Kitsap: Watershed Hlth																	25	25	22	
Lake Forest Park													4	4	4	4		1	4	

Agency: Project Name	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Pierce						2	8	16	12	11	11	19	18	15	18	8	18	19	31	31
Redmond: Annual Mon.									10	11	10	11	10	10	15	16	12			
Redmond: Benthos																		17	18	16
Seattle: Project Eval														4	7	10			8	
Seattle: Status & Trends	5	1	9		14	23	24						11	18	12	11	9			
Shoreline									7											
Skokomish													13							
Snohomish: Ambient													31		36	5	30	30	29	26
Snohomish: CAR Monit															7	22	23			
SnoqTribe																	6			
Stillaguamish: Stilly WQ																3	2	3		
Thurston									6	10	13	14	15	15	15					
VNC: Vashon Benthos																				3
Total	**5**	**1**	**9**	**5**	**35**	**91**	**150**	**119**	**353**	**328**	**186**	**328**	**386**	**336**	**421**	**430**	**630**	**521**	**523**	**300**

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Agency	Name
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Bellevue	Kit Paulsen
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Clallam Streamkeepers	Ed Chadd
Ecology	Chad Larson, Glenn Merritt, Scott Collyard
Everett	Mike Papa
Federal Way	Dan Smith
Issaquah	Micah Bonkowski
KC Roads	Brent Dhoore
Kirkland	Ryean-Marie Tuomisto
Kitsap County	Renee Scherdnik
Lake Forest Park	Mark Phillips
Pierce County	Carla Vincent
Port Gamble Skallam Tribe	Abigail Welch
Redmond	Tanya MacFarlane
Seattle	Katherine Lynch
Shoreline	Jennifer Adams
Skokomish Tribal Nation	Ron Figlar Barnes
Snohomish County	Jen Oden
Snoqualmie Nation	Matt Baerwalde
Stillaguamish Tribe	Jody Brown
Thurston County	Ann Marie Pearce
WRIA 8	Hans Berge, Scott Stolnack

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