Sequim-Dungeness Clean Water District Pollution Identification & Correction Plan Trends Monitoring Program 2020-2021 Report

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Introduction

In 2001, Clallam County established a shellfish protection district named the Sequim-Dungeness Clean Water District (District, or CWD) by adopting Chapter 27.16 of Clallam County Code (CCC). A map of the CWD is in in Appendix A. The boundaries of the District include "The Dungeness Watershed and those waters influenced by it through the irrigation system, and other independent tributaries to the Strait of Juan de Fuca, from Bagley Creek east to and including the Sequim Bay Watershed." (The boundaries of the District generally coincide with the boundaries of Clallam County's Marine Recovery Area, or MRA, where the County is also required to implement an enhanced Onsite Sewage Management Plan under RCW 70.118A).

State law (RCW 90.72) directs formation of shellfish protection districts where nonpoint pollution threatens water quality "…upon which the continuation or restoration of shellfish farming or harvesting is dependent." By 1997 water quality monitoring had begun to show increasing bacterial pollution in and around Dungeness Bay. In 2000, 2001, and 2003, the Washington State Department of Health downgraded portions of the Dungeness Bay shellfish growing area due to bacterial pollution caused by nonpoint sources within the watershed.

In May 2015, Clallam County Environmental Health, with the assistance of staff and volunteers from Streamkeepers of Clallam County, initiated a Baseline Trends Monitoring Program to track surface water quality in the Sequim-Dungeness Clean Water District. The Pollution Identification & Correction Plan called for this effort for the Sequim Bay-Dungeness Watershed Clean Water District (PIC Plan). Created by PIC Project Partners for the District in 2014, the PIC Plan is one element of the shellfish downgrade response plan for the Sequim-Dungeness Clean Water District. The Baseline Trends Monitoring study area includes major freshwater drainages within the District.

This PIC Trends Monitoring Report covers calendar years 2020 and 2021. The information gathered through PIC Trends monitoring and presented in annual reports helps guide Pollution Identification and Correction activities within the Clean Water District.

Sampling Approach and Results

The objective of the Baseline Trends Monitoring Program is to consistently monitor long-term water quality in order to evaluate trends at or near the mouths of waterways throughout the District. This information helps prioritize waterways for further targeted investigation and eventual pollution cleanup as described in the PIC Plan. Further, trends monitoring builds upon at least two decades of prior water quality studies. As in past investigations, water quality parameters associated with human sewage and animal waste such as fecal coliforms and nutrients were used to evaluate the water quality.

Sampling locations were selected as close to the discharge points of the streams as practical given ownership, access, and tidal conditions. Twelve streams were designated Tier 1 sites and nine streams were designated Tier 2 sites. Tier 1 sites were sampled monthly as for both fecal coliforms (fecal or FC) and nutrients (nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen/NH3), phosphate-phosphorous, silicate-silica, total nitrogen, and total phosphate). Tier 2 sites were sampled quarterly (January, April, August, November) for fecal coliforms only.
In addition to bacteria and nutrients sampling, water temperature and salinity data were recorded at all sample sites. Table 1 describes sites and sampling conducted while Figures 1-3 show sample site locations.

Barometric pressure, dissolved oxygen, pH, specific conductance, and turbidity data are readily recorded alongside standard in-situ measurements with a YSI Pro-DSS multi-parameter water quality meter. Stream stage is recorded where appropriate reference points exist and meters present on the Dungeness River and McDonald Creek provide readily accessible discharge data. This data is not presented in its entirety in this report, but all data produced from this project is available from the Clallam County Water Resources Database (http://www.clallam.net/SK/watersheds.html). Data collection not specifically called for in the Pollution Identification and Correction Quality Assurance Project Plan (QAPP, Bond et al. 2019) is performed following the Streamkeepers Program (SK QAPP, Chadd et al. 2019).

Streamkeepers volunteer Peggy McClure gets a water sample from Matriotti Creek for nutrient analysis.

Table 1: Site locations and type of sampling performed from January 2020 through December 2021. Tier 1 sites were sampled monthly s possible for fecal coliforms (F) and nutrients (N). Sampling sessions without a full complement of nutrient samples are marked as partial (P). Tier 2 sites were sampled quarterly for fecal coliforms only. Water temperature and salinity data were collected at all sites on every visit. Dung. Bay/R. = Dungeness Bay/River. Seq. Bay = Sequim Bay. SJF = Strait of Juan de Fuca. Cells highlighted in pink lack data for the sampling interval. Reasons for data gaps include: Meadowbrook Slough 0.23: landowner rescinded permission in Aug. 2020; Gierin 1.8: lost contact with landowner Aug 2020 – Jan. 2021; Dean 0.7: Site inaccessible due to failed bridge April 2020 – April 2021; No Name 0.03: ditch was dry in Aug. 2021.

	Stream/ Site Name	Re-ceiving Waters	YR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tier 1 Streams	Dun-geness 0.7	Dung. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Meadowbrook 0.2	Dung. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Meadowbrook Slough 0.23	Dung. Bay	20	F N	F	F N	F	F	F N	F N					
			21												
	Golden Sands Slough 0.0	Dung. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Cooper 0.1	Dung. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Cassalery 0.0/ 0.6*	Dung. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F	F P	F
			21	F	F	F N	F	F N	F	F N	F	F	F	F P	F
	Matriotti 0.3a	Dung. R.	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Lotz-gesell 0.1	Dung. R.	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Sequim Bay State Park Creek 0.0/0.1 *	Seq. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Bell 0.2	Seq. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F

	Stream/ Site Name	Re-ceiving Waters	YR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Johnson 0.0	Seq. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
	Jimmy-come-lately 0.15	Seq. Bay	20	F N	F	F N	F	F	F N	F N	F	F	F P	F P	F
			21	F	F	F N	F	F N	F	F N	F	F N	F	F N	F
Tier 2 Streams	Bagley 0.7a	SJF	20	F			F				F			F	
			21	F			F				F			F	
	Siebert 1.0	SJF	20	F			F				F			F	
			21	F			F				F			F	
	Agnew Creek/ Ditch 0.3	SJF	20	F			F				F			F	
			21	F			F				F			F	
	McDon-ald 01.6	SJF	20	F			F				F			F	
			21	F			F				F			F	
	Hurd 0.2	Dung. R.	20	F			F				F			F	
			21	F			F				F			F	
	Gierin 1.8	Dung. Bay	20	F			F								
			21				F				F			F	
	Dean 0.17	Seq. Bay	20	F											
			21								F			F	
	No Name 0.03	Seq. Bay	20	F			F				F			F	
			21	F			F							F	
	Chicken Coop 0.24	Seq. Bay	20	F			F				F			F	
			21	F			F				F			F	

* Tide Dependent

Figure 1: PIC Baseline Trends Monitoring sample sites, Dungeness Bay area (Washington State Department of Ecology real-time flow meter located at Dungeness 0.8)

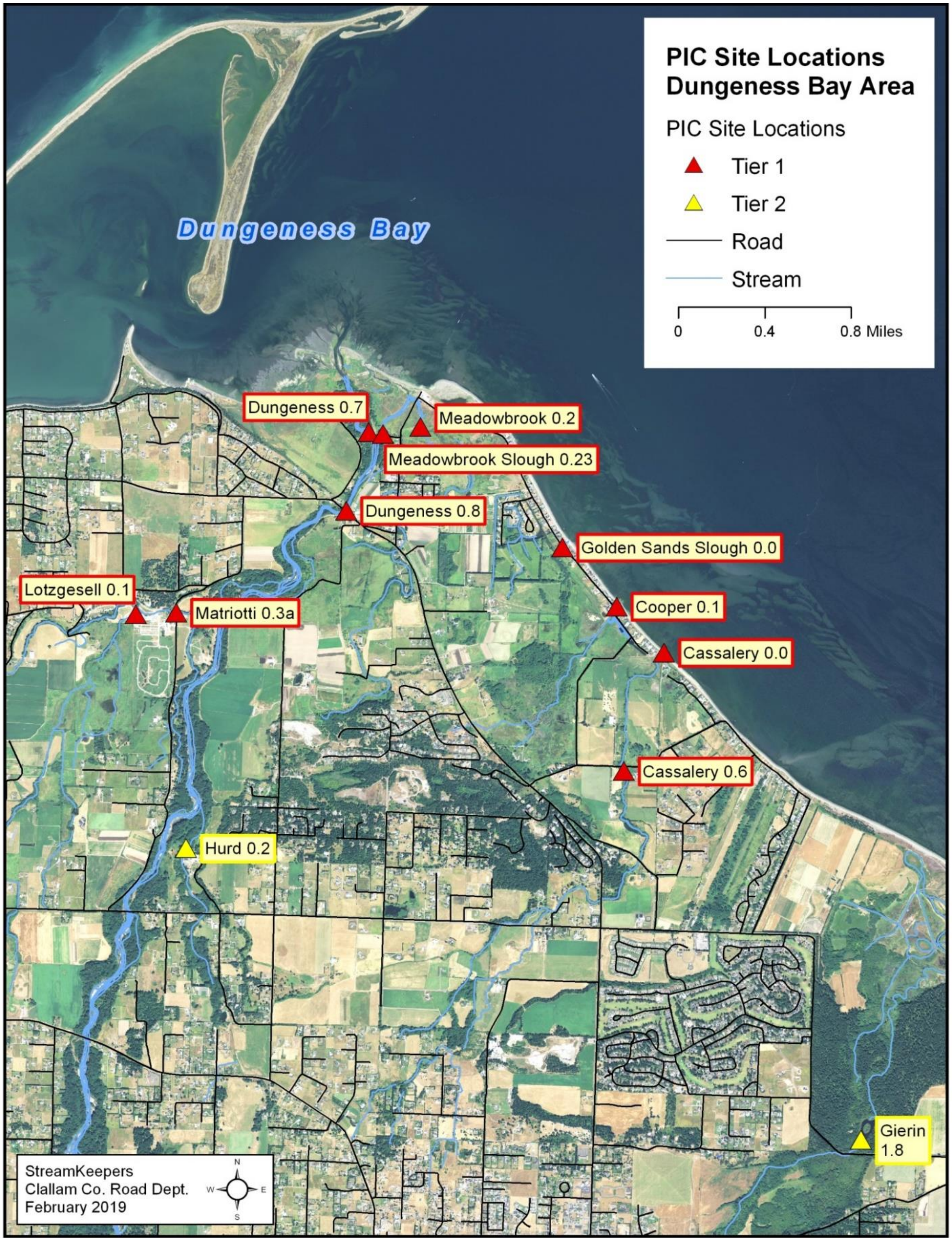


Figure 2: PIC Baseline Trends Monitoring sample sites, Sequim Bay area

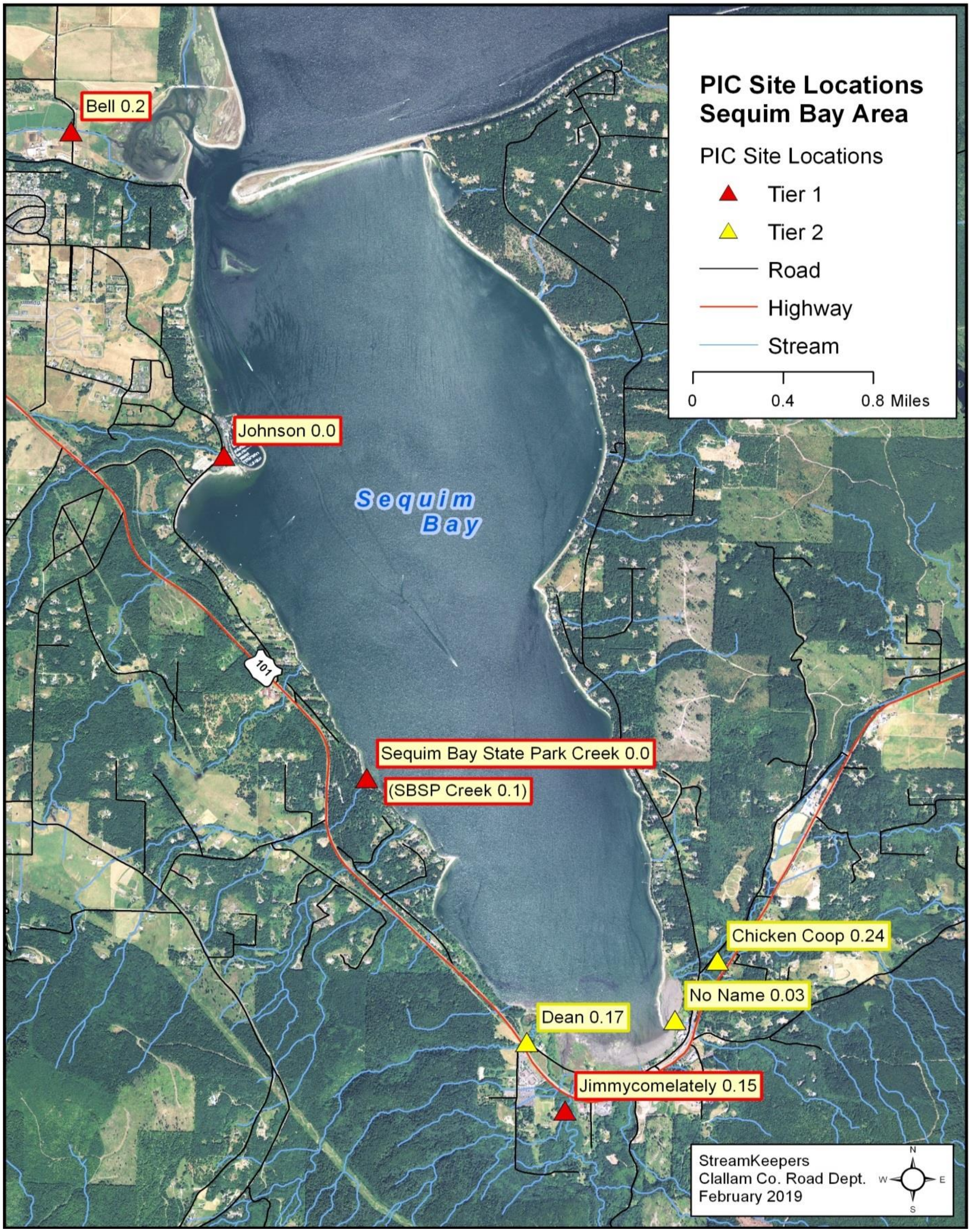
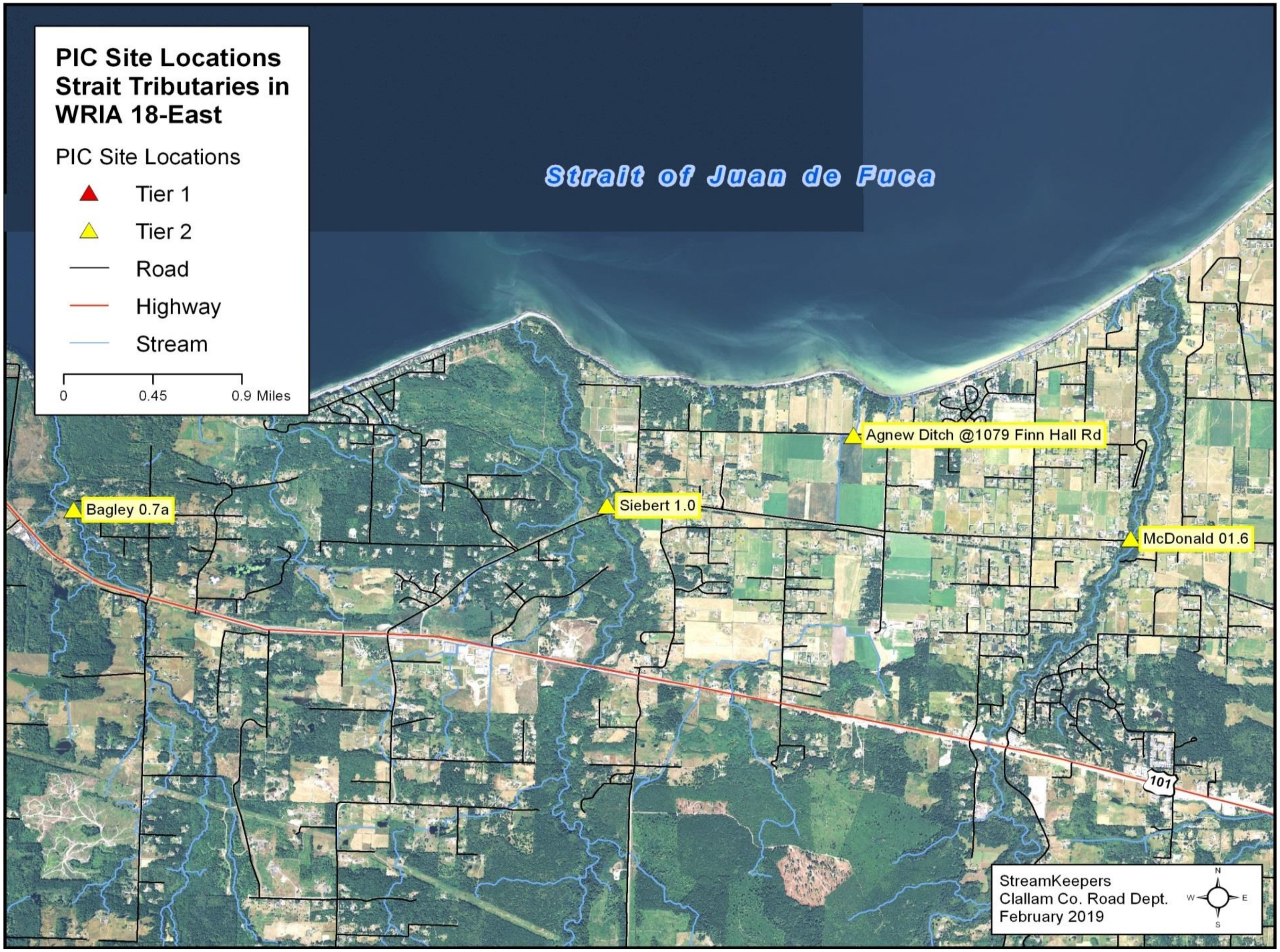


Figure 3: PIC Baseline Trends Monitoring sample sites, waters west of Dungeness Bay



Data Caveats

- Data qualifiers used are per Washington State Department of Ecology's (Ecology) Environmental Information Management (EIM) system.
- Rejected (REJ) data are not used in our analyses.
- Field replicates were averaged with primary samples.
- Field blanks were recorded and used for quality assurance (QA)/quality control (QC) analyses but were not used in this report to generate statistics or figures.
- Some sites are tidally influenced, as can be seen in the salinity data presented below. The sampling procedure dictates sampling during low-tide conditions, but this is not always possible. Alternate sites were sampled at Cassalery Creek and Sequim Bay State Park when tides prohibited collection of freshwater observations at the primary sample sites due to the lack of accessibility or impacts marine water has on the quality of the sample.

Data Quality Analysis

The following data quality analyses help PIC Project Partners decide where Measurement Quality Objectives (MQO) have been met.

Blanks Analysis—Fecal Coliforms

In general, one fecal coliform field blank is prepared each sampling tour. From January 2020 through November 2021, all fecal coliform field blanks were "non-detects" since the analyte was not detected at or above the detection limit of 2 CFU/100ml. This indicates proper handling of grab samples. In December 2021, the blank had a measured value of 4 CFU/100 ml. Therefore, for December 2021, all fecal coliform measurements were qualified as estimates (EST).

In addition to field blanks, the Clallam County Water Laboratory prepares and analyzes a lab blank 1) before running samples, 2) after every ten samples, and 3) after running all samples. Lab blank results are not reported to the PIC Baseline Trends Monitoring Program. Rather, these blanks serve as an internal control for the laboratory. For the period of this report no fecal coliform data were rejected or qualified due to laboratory blanks. Clallam County Environmental Health Laboratory is accredited by Ecology and follows Membrane Filter Standardized Method SM9222D.

Blanks Analysis—Nutrients

At least one nutrient field blank (FB) is prepared for each PIC Baseline Trends Monitoring tour. Table 2 summarizes nutrient field blank results. UW Marine Chemistry Laboratory provides annual Minimum Detection Limits (MDL). Synthesized Reporting Limit (RL) is calculated as 3.18 × Annual MDL *or* FB mean + 1 Standard Deviation (SD), per QAPP (Bond et al. 2019).

For 2020 and 2021, the reporting limits were calculated as the average MDL for both years, and the synthetic RL determined using this value. For most nutrients, the synthetic RL was defined by the MDLs multiplied by the factor 3.18, as previously recommended by Ecology. Total phosphate and total nitrogen synthetic RL was determined by FB mean + 1 SD. The fraction of field blanks exceeding the reporting limit was <5% for 2020 and 2021.

Beyond field blanks, UW Marine Chemistry Laboratory internal QA/QC involves nutrient lab blank preparation and analysis. These analyses are not presented here, as the lab only reports data that have passed internal controls. To date, laboratory nutrient blanks have never prompted data qualification or corrective action.

Table 2: Nutrients field blank (FB) results and synthetic reporting limit (RL) calculations. All values in [µg/L]. Field blank outliers (shaded in pink) were excluded from mean, standard deviation (SD), and RL calculations. RL is calculated as the max of (3.18 × MDL, FB Mean + 1 SD), per QAPP (Bond et al., 2019). Field blanks greater than the synthetic RL are highlighted in red.

Arrival date	[PO_4-P]	[SiO_4-Si]	[NO_3-N]	[NO_2-N]	[NH_4-N]	TP	TN
21-Jan-20	0.0	4.5	0.0	0.000	0.2	0.0	10.1
10-Mar-20	0.3	5.2	0.6	0.000	0.0	2.6	80.9
20-Jun-20	0.8	2.7	0.0	0.000	0.5	1.4	16.9
14-Jul-20	0.5	4.2	0.4	0.008	1.3	2.7	67.0
12-Oct-20	0.8	8.4	0.0	-0.004	1.3		
16-Nov-20	1.4	0.0	0.1	0.000	0.0		
8-Mar-21	1.6	0.5	3.9	0.000	11.1	31.6	367.7
10-May-21	0.6	7.2	73.3	0.000	2.0	1.3	126.7
21-Jul-21	1.0	0.0	1.2	0.028	0.0	0.0	19.4
13-Sep-21	1.1	2.0	1.4	-0.043	1.4	1.7	94.3
21-Nov-21	1.5	3.0	0.6	0.000	0.0	3.0	108.9
2020 MDL	0.6	13.5	14.3	2.1	2.1	1.0	46.0
2021 MDL	0.9	30.0	4.0	0.4	1.0	0.2	4.0
2020-21 FB mean	0.9	3.4	0.8	-0.001	0.7	1.6	65.5
2020-21 SD	0.5	2.8	1.2	0.017	0.7	1.2	45.1
3.18 × Average MDL	2.4	69.2	29.1	4.0	4.9	1.9	79.5
2020-21 synthetic RL	**2.4**	**69.2**	**29.1**	**4.0**	**4.9**	**2.8**	**110.6**

Field Replicate Analysis—Fecal Coliforms

Field replicates of fecal coliform grab samples are collected at the rate of one for every 5% of sites or at least one per sampling event. Field replicates help assess precision and confidence in sampling procedures.

Primary samples and replicates from each sampling event are compared in terms of relative standard deviation (RSD). In general, Clallam County Water Laboratory analyzes the field replicate and a laboratory duplicate of the field replicate; the mean of these two values is reported as “replicate” in Table 3, below.

QAPP section 6.2 describes the desired level of agreement between qualifying pairs of primary FC samples and field replicates (after pairs with averages below 20 CFU/100mL have been excluded). Half of all pairs should have less than or equal to 20% RSD, ninety percent of qualifying pairs should have less than or equal to 50% RSD, and all qualifying pairs should have less than 85% RSD. Table 4, below, compares observed results against these criteria for the reporting period.

No fecal coliform data were qualified based on field replicate analyses, as replicate pairs met measurement quality objectives described in QAPP section 6.2 (Bond et al. 2019).

Table 3: Fecal coliform field replicate results. Here each field replicate and a laboratory duplicate of the field replicate are averaged and reported as a single, composite value called "replicate."

Date	Type	FC CFU	Mean	%RSD
01/22/20	Primary	120	115.5	5.5%
	Replicate	111		
04/20/20	Primary	28	31.5	15.7%
	Replicate	35		
8/18/2020	Primary	258	267.0	4.8%
	Replicate	276		
11/17/202	Primary	192	168.0	20.2%
	Replicate	144		
04/20/21	Primary	12	9.0	N/A Excluded
	Replicate	6		
08/10/21	Primary	28	34.5	26.6%
	Replicate	41		
11/16/21	Primary	196	183.0	10.0%
	Replicate	170		
01/21/20	Primary	220	224.5	2.8%
	Replicate	229		
02/11/20	Primary	76	91.0	23.3%
	Replicate	106		
03/10/20	Primary	66	65.7	0.7%
	Replicate	65		
04/12/20	Primary	64	70.5	13.0%
	Replicate	77		
05/12/20	Primary	120	119.5	0.6%
	Replicate	119		
06/15/20	Primary	210	211.5	1.0%
	Replicate	213		
07/14/20	Primary	280	273.0	3.6%
	Replicate	266		
08/12/20	Primary	172	165.0	6.0%
	Replicate	158		
09/28/20	Primary	72	76.0	7.4%
	Replicate	80		
10/12/20	Primary	64	70.5	13.0%
	Replicate	77		
11/16/20	Primary	486	493.0	2.0%
	Replicate	500		
12/07/20	Primary	4	3.5	N/A Excluded
	Replicate	3		
01/11/21	Primary	68	69.5	3.1%
	Replicate	71		

Date	Type	FC CFU	Mean	%RSD
02/09/21	Primary Replicate	56 59	57.5	3.7%
03/08/21	Primary Replicate	96 100	98.0	2.9%
04/19/21	Primary Replicate	102 1061	581.5	N/A Excluded, TNTC
05/10/21	Primary Replicate	416 354	385.0	11.4%
06/14/21	Primary Replicate	180 170	175.0	4.0%
07/12/21	Primary Replicate	292 224	258.0	18.6%
08/09/21	Primary Replicate	360 456	408.0	16.6%
09/13/21	Primary Replicate	999 999	999.0	N/A Excluded
10/11/21	Primary Replicate	60 48	54.0	15.7%
11/08/21	Primary Replicate	12 12	12.0	N/A Excluded
12/13/21	Primary Replicate	368 336	352.0	6.4%
				Total pairs: 31 Excluded pairs: 5 Qualifying pairs: 26

Primary/replicate pairs with means less than 20 CFU are excluded from MQO analysis.

Table 4: Fecal coliform data Measurement Quality Objectives

QC tiers	Pairs in Tier	% Pairs in Tier	% Pairs Required	MQO Met?
Pairs <= 20% RSD	23	88.5%	50.0%	YES
Pairs <= 50% RSD	26	100.0%	90.0%	YES
Pairs <= 85% RSD	26	100.0%	100.0%	YES

Field Replicate Analysis—Nutrients

Nutrient field replicates are also collected alongside 5% of all samples (or at least one replicate each sampling event). These replicates are again compared against their primary samples to calculate Relative Standard Deviation. Primary/replicate pairs with means less than five times the reporting limit are excluded from RSD calculation. QAPP Table 1 (Bond et al. 2019) describes acceptable annual median RSD values, and sampling results are compared against the criteria below.

Nutrient sample replicate analysis generally showed a high degree of precision among primary/replicate pairs and no data were qualified as a result of this analysis.

Table 5: Nutrients field replicate results and QC analysis for data pairs with mean > 5 RL

Analyte	Data Pairs	Median RSD	RSD Criterion	Data Qualified
Ammonia	2	2.20%	15%	none
Nitrate	11	0.40%	10%	none
Nitrite	0		10%	none
Phosphate	11	0.60%	10%	none
Silicate	11	0.60%	10%	none
Total N	9	1.20%	10%	none
Total P	9	1.50%	10%	none

Field Replicate Analysis—Physical and Chemical Parameters

The PIC Baseline Trends Water Quality Monitoring Program calls for in situ measurements of water temperature and salinity at all sample sites.

Barometric pressure (BP), dissolved oxygen (DO), pH, specific conductance (SpC), and turbidity measurements are also collected (though not required), given the ease of data collection with multiparameter water quality meters. These data are collected in accordance with the Streamkeepers Program QAPP (Chadd et al. 2019). The quality of these data are reported here, though results are not included in the below discussion. Again, all data are available from the Clallam County Water Resources Database.

Measurement quality objectives of physical and chemical data are described in terms of maximum allowable percent relative standard deviation and/or maximum allowable difference between primary samples and replicates. Where two criteria are provided, at least one must be met for data to pass unqualified and avoid corrective action. Table 6, below, summarizes comparison of environmental data against MQO criteria. Salinity and temperature criteria were described in the PIC Project QAPP (Bond et al. 2019) while measuring and reporting methods for other criteria were described in the Streamkeepers Program QAPP (Chadd et al. 2019).

Table 6. Physical/chemical water quality field replicate QC analysis

Parameter	Units	Data Pairs	Max RSD (by pairs)	RSD Criterion	Max Difference Observed	Difference Criteria	Data Qualified
BP	Hg	22			0.02	0.05	None
DO	mg/L	26		1% per pair	0.1	0.2	None
pH	N/A	26			0.1	0.2	None
Salinity	PSU (ppt)	25		5% per pair	0.00	0.2	None
Sp Cond	µs/cm	26	1.8%	5% per pair			None
Water T	◦C	26			0.1	0.2	None
Turbidity	FNU	26	131.0%	7% per pair		1	Yes 1/22/20

Laboratory Standards Checks—Nutrients

In addition to internal controls metioned previously, UW Marine Chemistry Laboratory uses check standards to assess bias stemming from analytical methods. Wherever standards are not met, analyses are repeated. Data reported by the lab have passed all internal QA/QC screening. To date no nutrient data have required qualification or corrective action following laboratory data quality analyses.

Compliance with Project QAPP and SOPs

In compliance with the project QAPP (Bond et al. 2019), environmental data were collected following standard operating procedures (SOP).

Water samples for the purpose of fecal coliform testing were collected in sterile polypropylene (PP) bottes, stored in coolers with ice packs for less than 8 hours, and analyzed at Clallam County Water Laboratory.

Meanwhile, samples for nutrients testing were collected in either acid-washed PP or acid-washed high-density polyethylene (HDPE) bottles, chilled with ice packs in coolers, and shipped overnight to UW Marine Chemistry Laboratory in Seattle, WA.

In situ physical and chemical water quality measurements (water temperature, dissolved oxygen concentration, pH, specific conductance, salinity, turbidity) were collected using a YSI ProDSS field meter which was calibrated prior to sampling events and checked afterward.

Where necessary, data have been flagged with appropriate qualifiers based on QA/QC measures.

Environmental Data Summary

PIC Baseline Trends Monitoring environmental data collected between January 1, 2020 and December 31, 2021 are given in Appendix B. These data are presented visually in the charts to follow and explored in the Discussion section of this report. Rejected data have been excluded. Additional data for parameters not described in the PIC Quality Assurance Project Plan (dissolved oxygen, pH, turbidity, conductivity), collected according to the Streamkeepers QAPP, are presented in Appendix C.

Fecal Coliforms

All PIC Baseline Trends Monitoring streams fecal coliform data for the reporting period are summarized in the charts below.

Streamkeepers volunteer Sarah Miller collecting data using a multiparameter waer quality meter at Lotzgesell Creek next to the Olympic Game Farm, while an interested grizzly bear looks on.

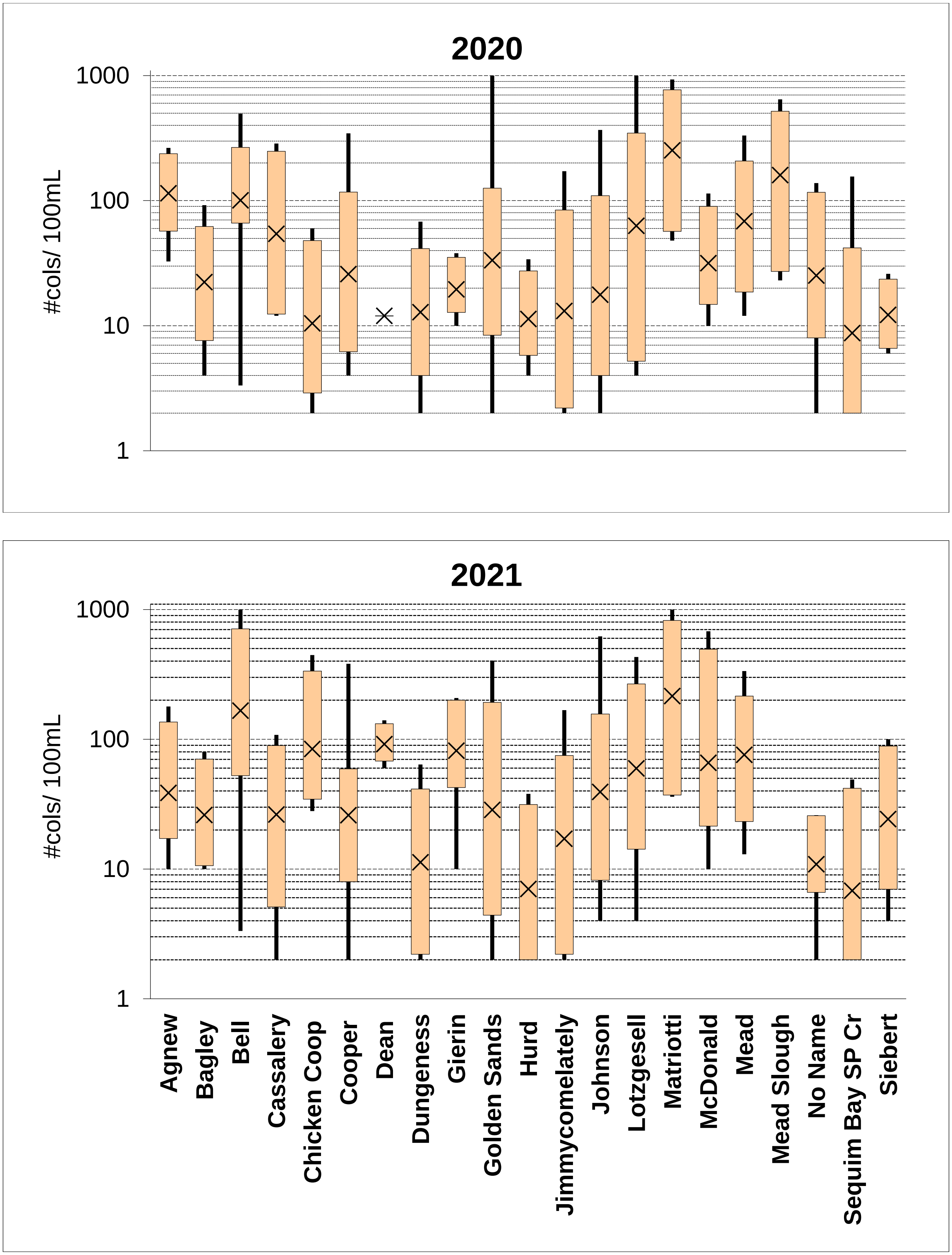


Figure 4: Fecal Coliforms, all CWD streams. Note log scale. X marks geometric mean; bottom and top of box represent observed 10th and 90th percentiles; ends of whiskers represent extremes.

Site	Tier	2015		2016		2017		2018		2019		2020		2021	
		Geo Mean > 50	Geo Mean > 100	Geo Mean > 50	Geo Mean > 100	Geo Mean > 50	Geo Mean > 100	Geo Mean > 50	Geo Mean > 100	Geo Mean > 50	Geo Mean > 100	Geo Mean > 50	Geo Mean > 100	Geo Mean > 50	Geo Mean > 100
Agnew	2			X						X		X	X		
Bagley	2														
Bell	1											X	X	X	X
Cassalery	1									X		X			
Chicken Coop	2													X	
Cooper	2														
Dean	2														
Dungeness	1														
Gierin	2													X	
Golden Sands	1	X		X						X					
Hurd	2														
Jimmycomelately	1														
Johnson	1														
Lotzgesell	1									X		X		X	
Matriotti	1	X		X		X		X		X	X	X	X	X	X
McDonald	2											X		X	
Meadowbrook	1											X		X	
Meadowbr. Slough	1							X	X	X	X	X	X		
No Name	2														
Sequim Bay SP Cr	1														
Siebert	2														

Figure 5. Trends in bacterial pollution in monitored streams, 2015-2021. Monitored streams are shown in the left column. Tier 1 streams were monitored monthly, Tier 2 streams quarterly. For each year, the following fecal coliform metrics are reported for each stream: 1) geometric mean fecal coliform > 50 CFU/100 ml, and 2) geometric mean fecal coliform > 100 CFU/100 ml. If neither threshold is exceeded, blocks are green. If the lower threshold is exceeded, blocks are orange; if the higher is exceeded, blocks are red. Due to small sample size (usually 4 per year, sometimes 3), results for Tier 2 streams should not be considered definitive. When less than three samples were collected in a year, data were considered insufficient to report here, and blocks are white.

Nutrients

Nutrients results are summarized in the charts below. Nutrients data were collected monthly at CWD Tier 1 streams only.

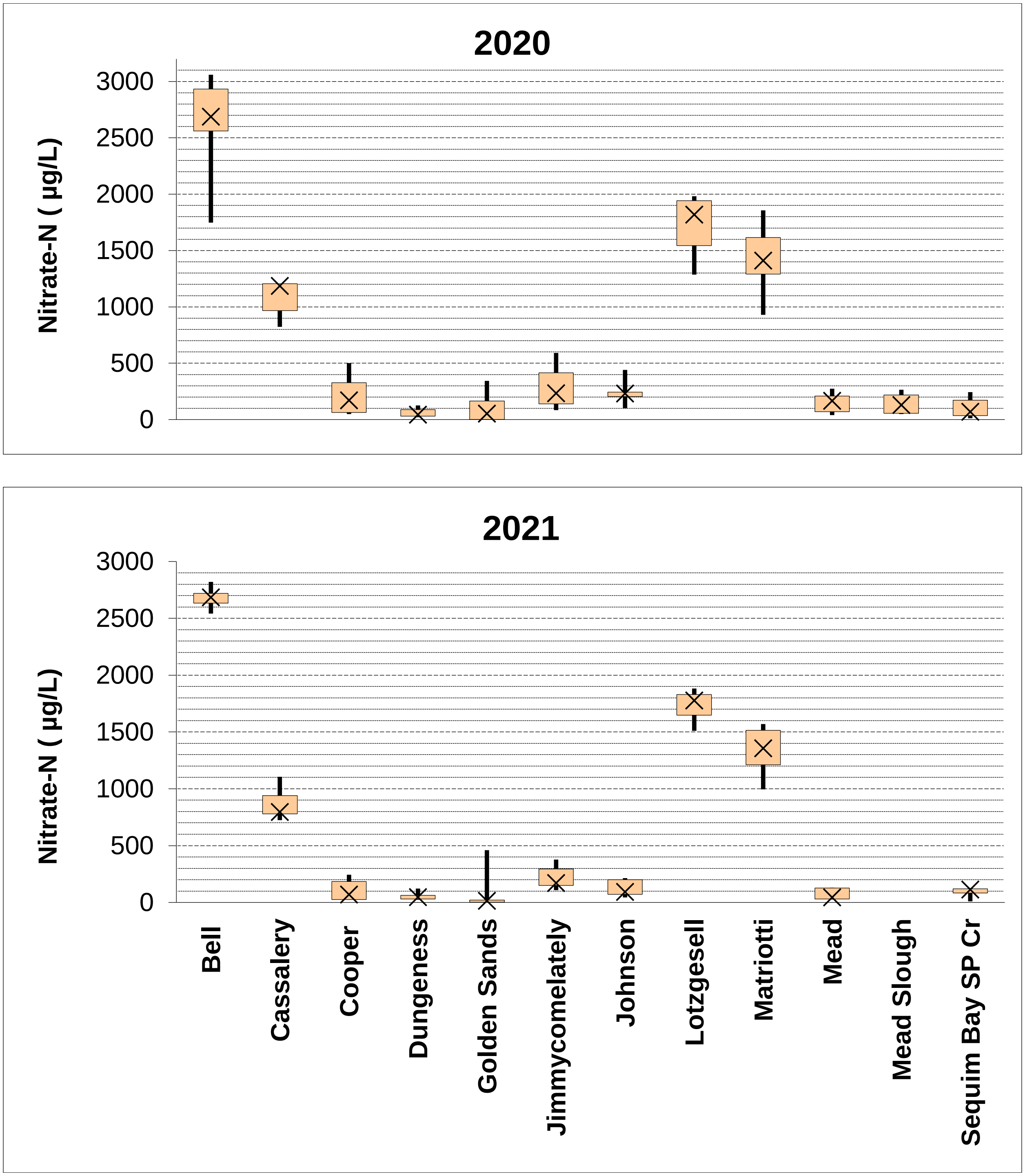


Figure 5. Nitrate as N, Tier 1 streams. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

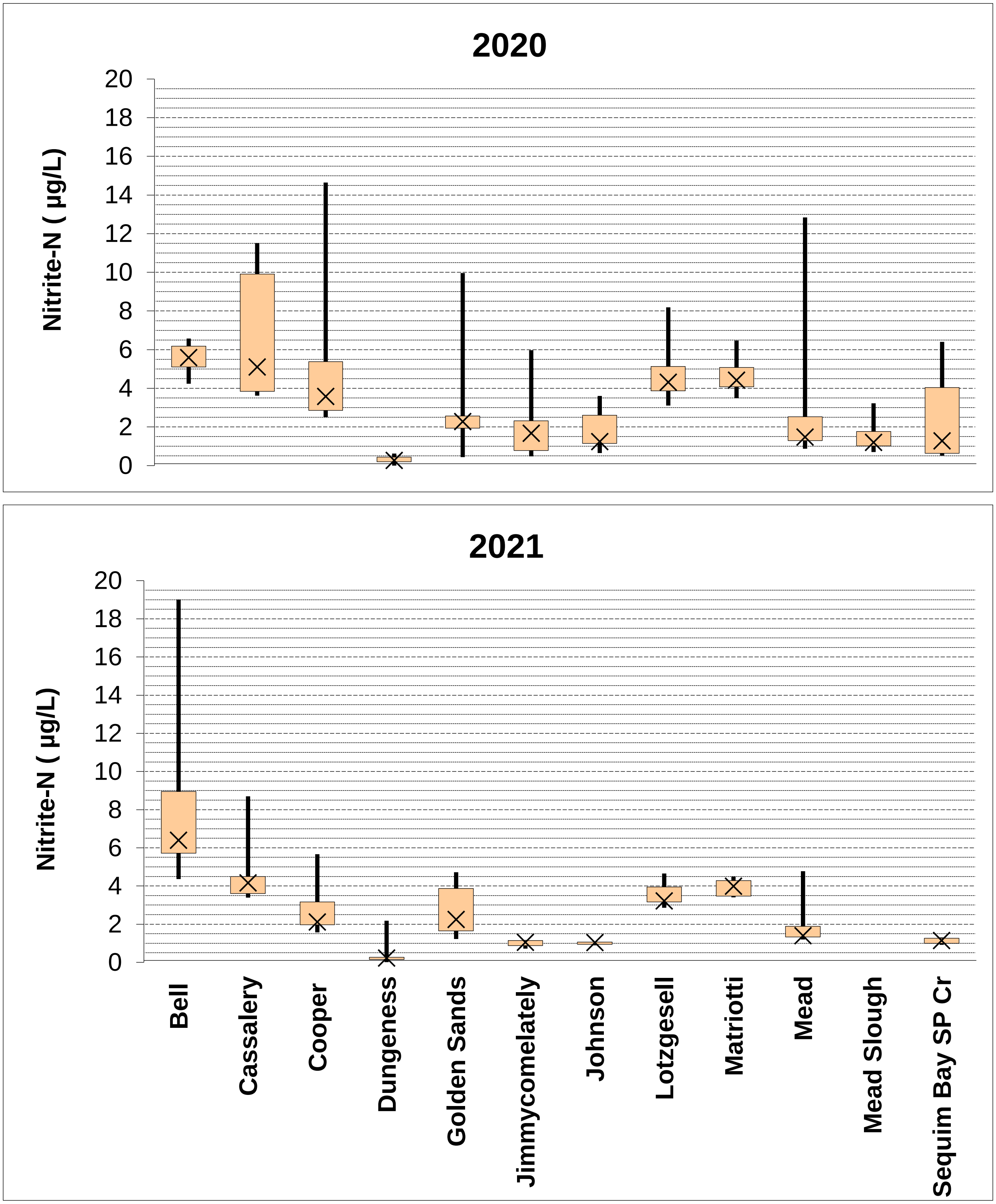


Figure 6. Nitrite as N, Tier 1 streams. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

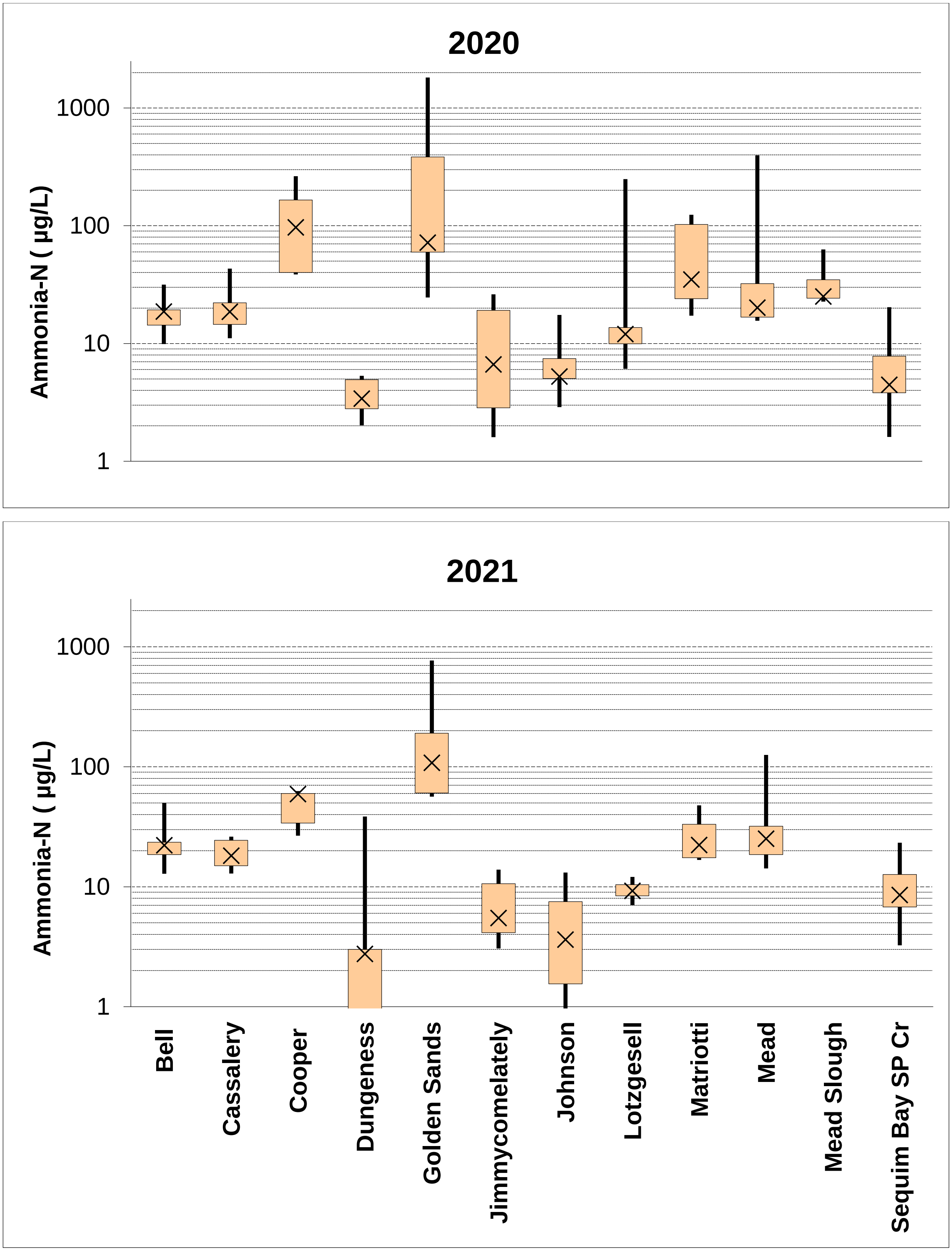


Figure 7. Ammonia as N, Tier 1 streams. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

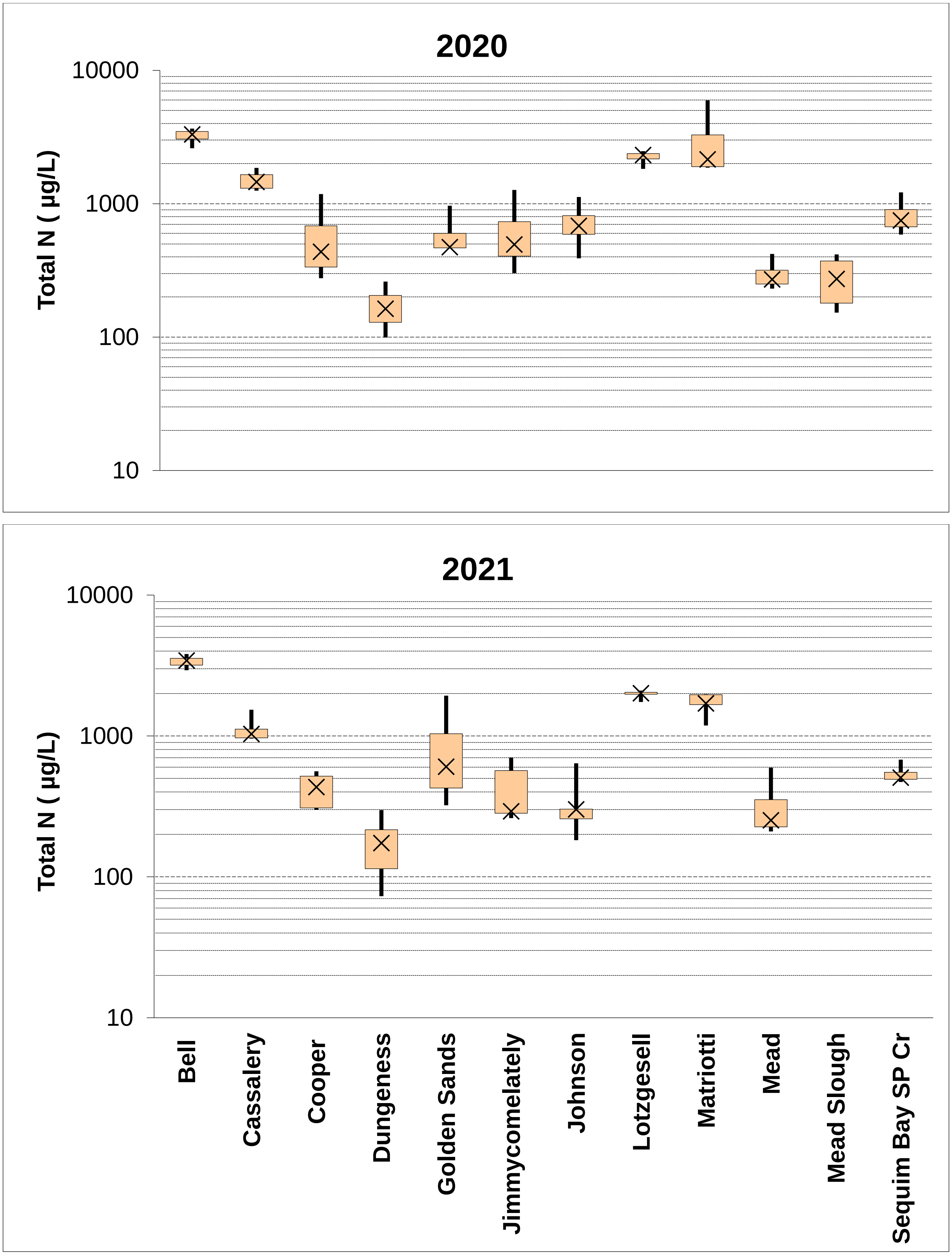


Figure 8. Total nitrogen, Tier 1 streams. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

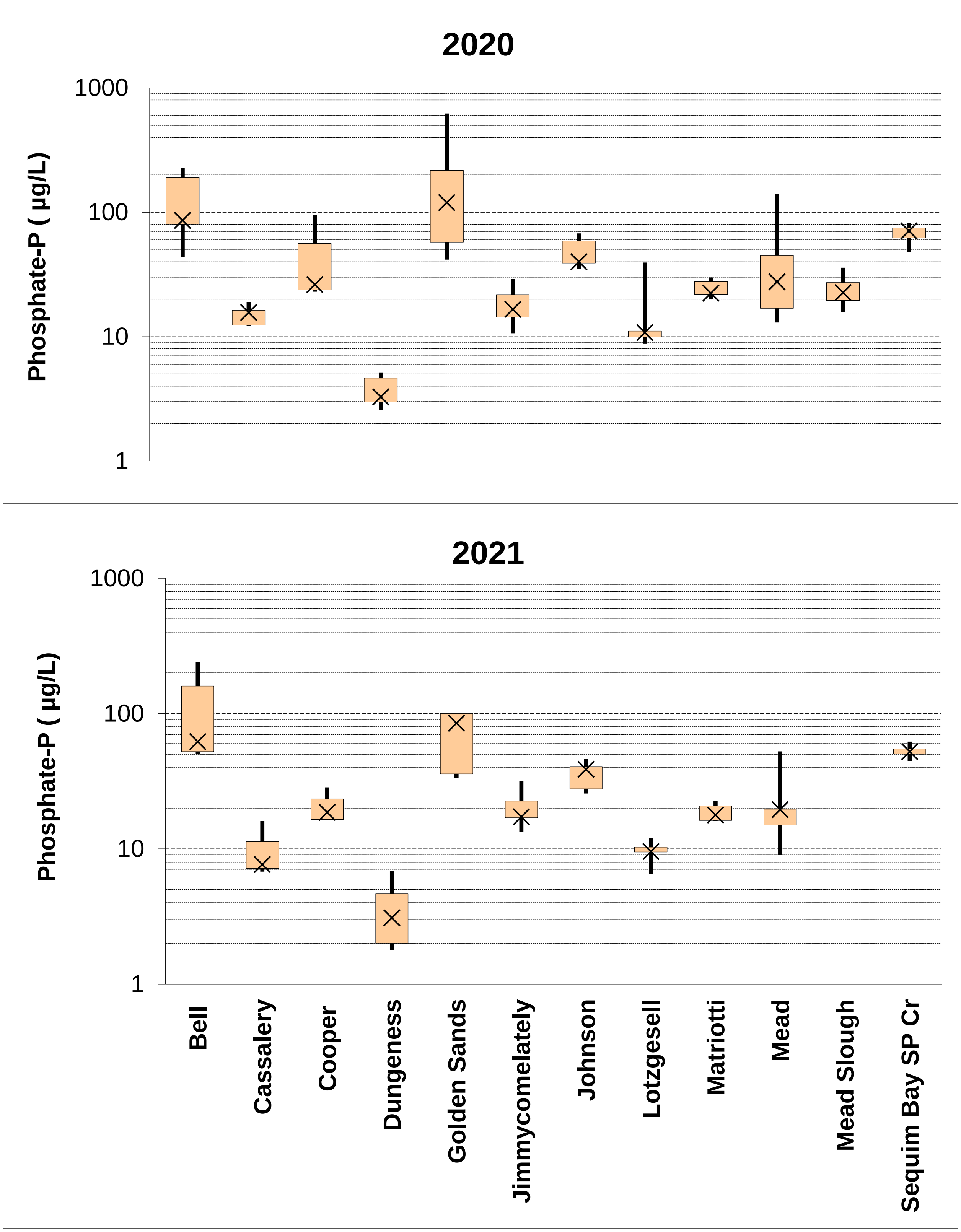


Figure 9. Phosphate as P, Tier 1 streams. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

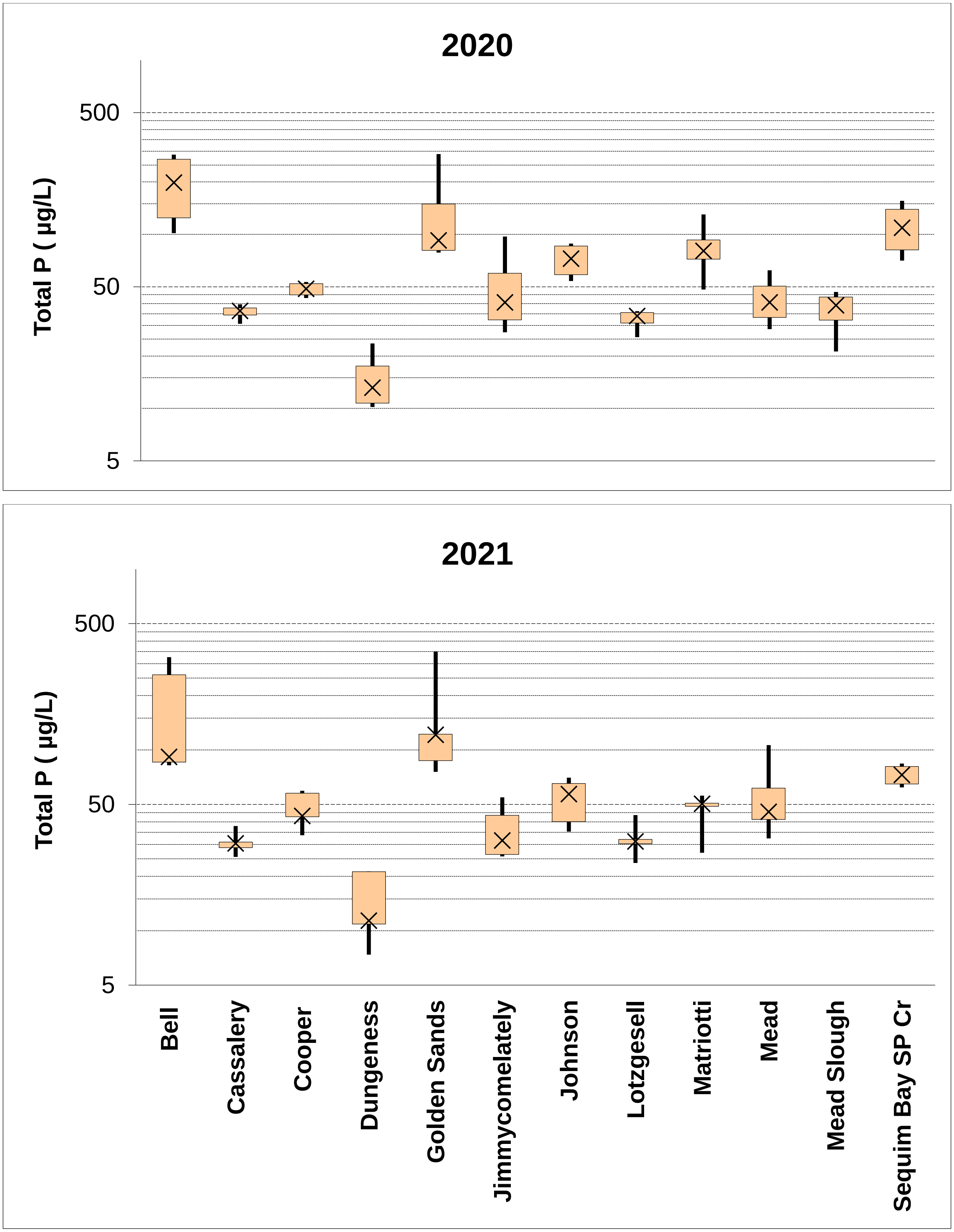


Figure 10. Total Phosphorus, Tier 1 streams. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

Water Temperature and Salinity

Summaries of water temperature and salinity data covering the reporting period follow. Physical and chemical data are collected monthly at Tier I streams and quarterly at Tier II streams. Additional measurements collected following the Streamkeepers program QAPP include barometric pressure, dissolved oxygen, pH, specific conductance, and turbidity data. These measurements are not specifically required by the PIC QAPP and are not discussed here, though they are available from the Clallam County Water Resources Database. Data summaries are presented in Appendix C.

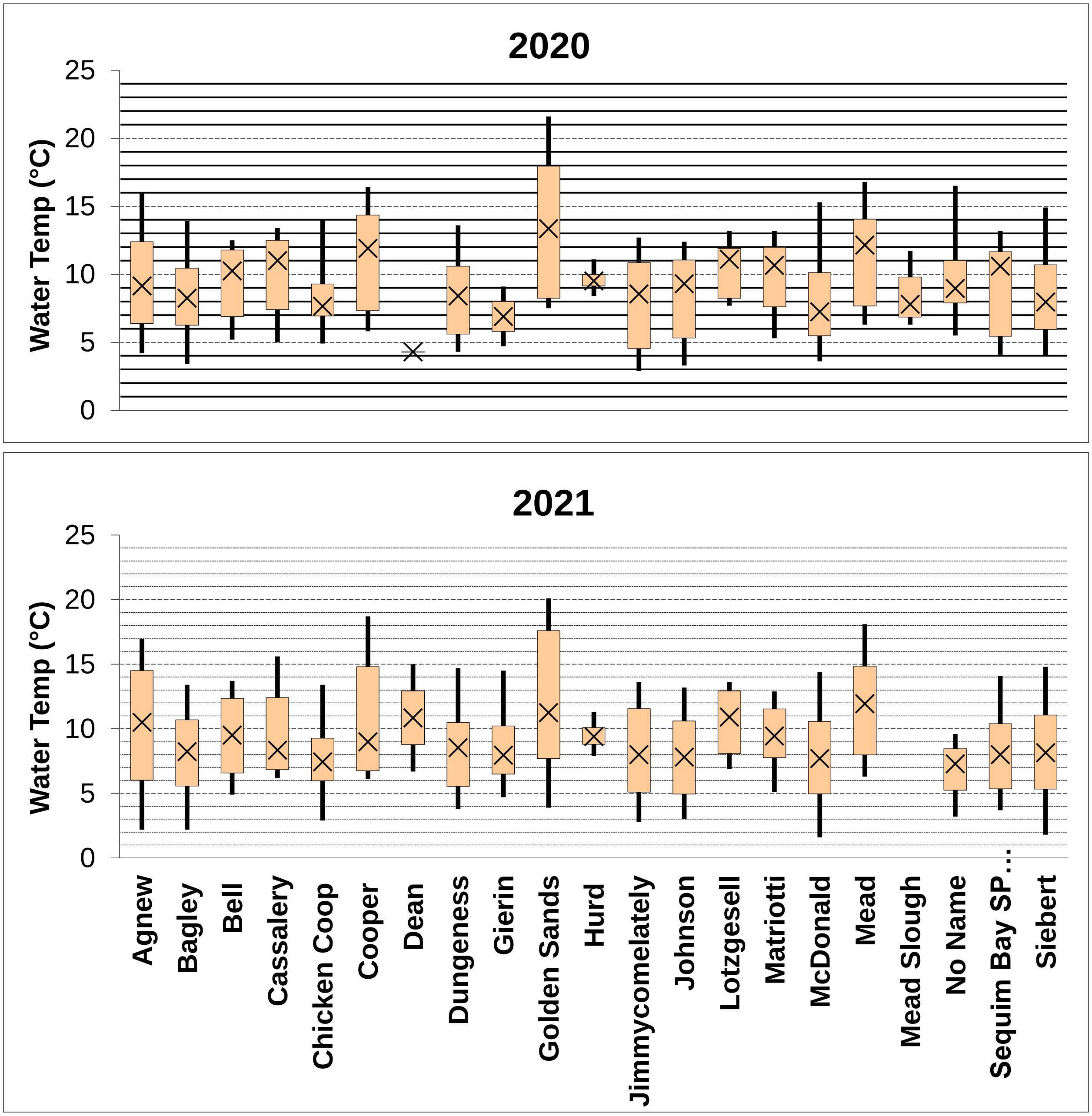


Figure 11. Water Temperature, all CWD streams. X marks median; bottom and top of box represent 1st & 3rd quartiles; ends of whiskers represent min. and max. values. For evaluative purposes, the State's maximum 7-day average of daily maxima for salmonid core summer habitat (the designated use for all sites) is 16°C (WAC 173-201A-200, 2019).

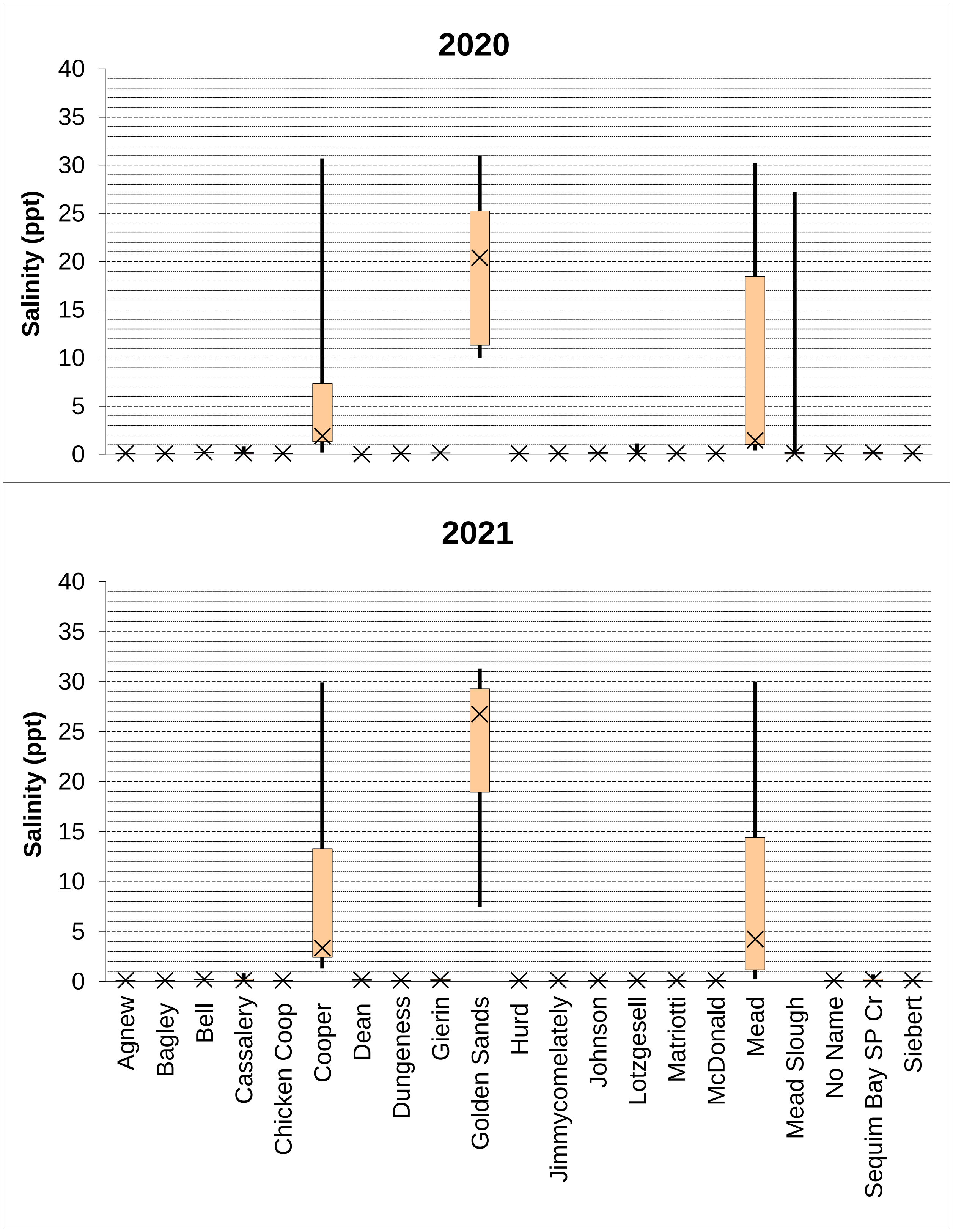


Figure 12. Salinity, all CWD streams. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

Availability of Data to the Public

Data is stored in Clallam County's Water Resources Database, and is available upon request (email to streamkeepers@clallamcountywa.gov). Data is submitted to Washington Dept. of Ecology's Environmental Information Management (EIM) database, and following Ecology's review, is posted and available to government agency personnel, nongovernmental organizations, and the public at https://ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database and at EPA's WQX database (https://www.epa.gov/waterdata/water-quality-data-wqx).

Discussion

Fecal Coliforms

Pollution Identifican and Correction work involves seeking and correcting upland sources of bacterial pollution that impact streams and receiving marine waters—especially where shellfish harvest activities exist. Baseline Trends Water Quality Monitoring helps highlight sub-watersheds for selection as PIC Focus Areas for further targeted investigation and pollution control. To date, Baseline Trends data have helped select Golden Sands and Meadowbrook Slough (2015-2017 PIC Focus Area), lower Matriotti and Lotzgesell Creeks (2017-2019 PIC Focus Area), and, most recently, upper Matriotti and lower Bell Creeks (2019-2022 PIC Focus Area).

Based on monitoring results for 2015-2021, fecal coliform metrics were higher in recent years (2019-2021) than in the first three years of monitoring in Bell Creek, Lotzgesell Creek, Matriotti Creek, McDonald Creek, Meadowbrook Creek, and Meadowbrook Slough (Figure 5). This may be related to increased residential development in these watersheds, as well as deteriorating older septic systems.

In both 2020 and 2021, geometric mean fecal coliform levels in Bell and Matriotti Creeks were higher than 100 CFU/100mL (Figures 4 and 5). As in previous years, these two creeks had higher levels of fecal coliform than most other creeks being monitored. Though these creeks have been a focus for pollution identification and correction, and progress is being made, these results demonstrate that continued effort is needed in these watersheds. As in 2018 and 2019, geometric mean fecal coliform in Meadowbrook Slough in 2020 was over 100 CFU/100mL. Unfortunately, sampling permission was lost and there is no data to compare for 2021.

PIC Project Partners elected to include lower Bell Creek as part of the 2019-2022 PIC Focus Area in an effort to seek and eliminate any potential sources of bacterial pollution and avoid taking steps backward from gains in shellfish growing area upgrades that occurred in 2018. Initial work began in the 2019-2022 Focus Area in December 2019. PIC Baseline Trends Monitoring data from Bell Creek were used as a line of evidence to justify the shellfish growing area upgrade (along with many other reasons including good marine water quality).

Between 2018 and 2019, three key septic system installations appeared to largely eliminate various pollution problems in the Golden Sands Slough area. As the first PIC Focus Area (2015-2017), many problematic wastewater disposal problems were found, including holding tanks, direct discharges, and other non-conforming wastewater systems. Still, caution should be applied when interpreting Golden Sands Baseline Trends Monitoring data, as periodic high salinity measurements indicate marine water influence. Marine water may have a dilution effect, reducing fecal coliform and/or nutrient concentrations of collected water samples.

While improvements have been made in the monitored watersheds in regards to individual landowner practices as a result of this PIC project, more work is needed to reduce bacterial pollution inputs and achieve improved water quality in Dungeness Bay and Sequim Bay, which would allow for opening more shellfish growning areas. In Dungeness Bay in 2021, there were no upgrades or downgrades for shellfish growning areas by Washington Dept. of Health. However nine of the sites monitored by Dept. of Health in Dungeness Bay had higher measured fecal coliform levels in November 2021 vs. November 2020, based on estimated 90th percentiles of 30 samples at each sample site (Trevor Swanson's report to the Clean Water Work Group, 12/15/2021) . Both PIC Trends data and Dept. of Health data highlights the need for continued water quality monitoring and followup landowner outreach efforts.

Nutrients

As seen in Figures 6-7, Bell, Cassalery, Lotzgesell, and Matriotti creeks continue to have the highest mean levels of nitrogen as nitrate and nitrite, with remaining creeks in the CWD having relatively low levels. The mean ammonia values in both 2020 and 2021 were highest at Bell, Cassalery, Cooper, Golden Sands, Matriotti, Meadowbrook, and Meadowbrook Slough, and relatively low at Dungeness, Jimmycomelately, Johnson, Lotzgesell, and Sequim Bay State Park Creek (Fig. 8). Bell, Cassalery, Lotzgesell, and Matriotti creeks continued to have mean total nitrogen levels above 1000 µg/L in both 2020 and 2021 (Fig. 9). The fact that these same creeks had relatively high levels of fecal coliform suggests common causes for elevated levels of both fecal coliform and nitrogen.

In monitored creeks, levels of Phosphorous as Phosphate and total Phosphorous were consistent from 2019 – 2021, with Bell Creek, Golden Sands Slough, and Sequim Bay State Park Creek having the highest mean values (Figs. 10 and 11). As marine water typically has a much higher concentration of phosphate-P than unpolluted freshwater, and Golden Sands Slough has input of marine water as evidenced by relatively high salinity, it is likely that the high level of phosphate-P at Golden Sands is partially due to input of marine water.

Physical and Chemical Water Quality Parameters

Figures 12 and 13 highlight water temperature and salinity for all CWD creeks. As in 2019, Golden Sands Slough, Cooper Creek, and Meadowbrook Creek had the highest measured water temperatures in 2020 and 2021, likely due to lack of riparian vegetation providing shade, and slow-moving water.

Cooper Creek, Golden Sands Slough, Meadowbrook Creek, and Meadowbrook Slough salinity data are indicative of periodic marine water influence at these sites. Golden Sands Slough, with mean salinity over 20 ppm in 2020 and 2021, is most influenced by influx of marine water. Due to the potential for tidal influence, secondary sample sites were added at Sequim Bay State Park Creek (0.1) and Cassalery Creek (0.6) to avoid complications with low flow events and tides that occasionally confound data collection. The highest salinity measurements at Sequim Bay State Park Creek and Cassalery Creek come from the lower, primary sample sites when the secondary site was not used.

Conclusion

Long-Term PIC Baseline Trends Monitoring continues to help project partners adaptively manage the PIC Program and select focus areas where limited resources will lead to the greatest improvements in water quality.

Many needed corrections identified during the course of PIC project monitoring from 2015-2018 have taken place. Many of these corrections were related to repairs and installations of onsite septic systems. Some of these septic system installations happened thanks to low-interest loans (such as Clean Water Loans offered by Craft3) and/or cost-share funding accessed by Clallam Conservation District. To continue gains, Clallam County Environmental Health will have to keep track of recalcitrant wastewater disposal problems and use all available tools to compel use of conforming wastewater treatment only.

Parcel surveys and source investigations along Matriotti and Lotzgesell Creeks noted many potential critical areas problems, including removed vegetated buffers. Cleared stream corrider appears prevalent across properties of varying uses from commercial to residential to agricultural. Clallam County's Clean Water Strategy for Addressing Bacteria Pollution in Dungeness Bay and Watershed (Streeter and Hempleman 2004) notes: "Although not considered a pollution source, the lack of vegetation along ditches and stream banks limits the landscape's ability to filter contaminated run-off." However, the U.S. EPA considers infrared heat a pollutant (hence, Ecology can develop TMDLs based on temperature), and maintaining and/or restoring riparian buffers are effective best management practices to reduce temperature and increase infiltration. It is possible Matriotti and Lotzgesell Creek water quality will not improve appreciably—especially in terms of pathogens and water temperature—unless a concerted effort is made to protect the remaining vegetated corridor bording the streams and to restore vegetated buffers previously removed contrary to criticial areas codes.

In addition to ongoing PIC work, Environmenal Health and Environmental Protection Agency Region 10/Manchester Laboratory are exploring a possible Microbial Source Tracking (MST) study to complement pathogen reduction efforts in the Dungeness Watershed. Sites on Matriotti Creek and Meadowbrook slough are proposed for bacteria source tracking. This may help identify the range of pollution sources present in the watershed, while addressing bacteria "hotspots" that persist in spite of pollution corrections such as repair of failing septic systems and exclusion of domesticated animals from streams. The additional line of evidence may help overcome the threshold required to tackle needed changes such as restoring vegetated buffers that help keep contaminated run-off out of streams.

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Appendix A: Map of Clean Water District

Appendix B: Data from January 2020 – December 2021

This table presents data for fecal coliform (FC), nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), ammonia-nitrogen (NH_3-N), phosphate-phosphorus (PO_4-P), silicate-silicon (SiO_4-Si), total nitrogen (TN), total phosphorus (TP), water temperature, turbidity, and dissolved oxygen.

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Agnew Creek/Ditch 0.3	1/22/2020	114								4.2		12.4
Agnew Creek/Ditch 0.3	4/20/2020	33								11.2	2.0	12.2
Agnew Creek/Ditch 0.3	8/18/2020	264								16.0	4.0	9.0
Agnew Creek/Ditch 0.3	11/17/2020	176								7.1	13.0	10.9
Agnew Creek/Ditch 0.3	4/20/2021	10								13.7	6.0	12.2
Agnew Creek/Ditch 0.3	8/10/2021	37								16.9	2.0	10.4
Agnew Creek/Ditch 0.3	11/16/2021	179								7.3	13.0	11.9
Bagley 0.7a	1/22/2020	16								3.4	82.0	13.4
Bagley 0.7a	4/20/2020	4								9.3	1.0	11.4
Bagley 0.7a	8/18/2020	42								13.9	3.0	9.9
Bagley 0.7a	11/17/2020	92								7.2	28.0	11.5
Bagley 0.7a	4/20/2021	10								9.8	1.0	11.3
Bagley 0.7a	8/10/2021	48								13.4	2.0	9.9
Bagley 0.7a	11/16/2021	80								6.7	34.0	12.3
Bell 0.2	1/21/2020	226	1749	7	19	87	8732	2609	132	5.6	8.0	11.9
Bell 0.2	2/11/2020	96								5.7	9.0	12.2
Bell 0.2	3/10/2020	66	2760	5	18	85	7963	3424	102	5.2	2.0	12.5
Bell 0.2	4/12/2020	73								9.8	1.9	11.6
Bell 0.2	5/12/2020	119								12.0	7.0	10.4
Bell 0.2	6/15/2020	212	2543	6	13	226	8227	3198	287	11.7	6.0	10.2
Bell 0.2	7/14/2020	271	3060	6	19	225	8191	3657	264	12.2	4.2	10.1
Bell 0.2	8/12/2020	163								12.5	3.0	10.0
Bell 0.2	9/28/2020	77								11.1	3.3	11.0
Bell 0.2	10/12/2020	73	2991	4	10	43	8800			10.7	2.0	10.5

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Bell 0.2	11/16/2020	495	2617	6	32	79	8758			7.3	4.0	11.1
Bell 0.2	12/7/2020	3								7.9	3.0	11.4
Bell 0.2	1/11/2021	70								6.8	5.0	11.6
Bell 0.2	2/9/2021	58								5.1	4.0	12.5
Bell 0.2	3/8/2021	99	2719	6	22	62	6644	3814	91	5.9	3.0	12.6
Bell 0.2	4/19/2021	741								10.3	2.0	11.5
Bell 0.2	5/10/2021	375	2542	4	13	50	6036	2923	86	10.4	3.0	11.2
Bell 0.2	6/14/2021	173								12.3	6.5	9.9
Bell 0.2	7/12/2021	258	2633	9	19	239	7620	3181	327	13.3	5.0	9.7
Bell 0.2	8/9/2021	424								13.7	5.0	9.8
Bell 0.2	9/13/2021	999	2684	19	50	160	7721	3556	260	12.5	5.0	9.7
Bell 0.2	10/11/2021	52								8.7	2.0	11.3
Bell 0.2	11/8/2021	12	2821	6	24	52	7954	3429	82	7.0	3.0	11.4
Bell 0.2	12/13/2021	352								4.9	9.0	11.9
Cassalery 0.0	2/11/2020	28								7.0	3.0	10.6
Cassalery 0.0	3/10/2020	36	1188	5	22	16	6743	1855	40	6.0	6.0	11.9
Cassalery 0.0	4/12/2020	64								11.1	4.3	11.0
Cassalery 0.0	5/12/2020	216								13.0	11.0	9.5
Cassalery 0.0	6/15/2020	210	1206	4	15	12	6454	1586	36	12.5	3.0	10.1
Cassalery 0.0	7/14/2020	98	1205	4	11	12	6388	1256	31	13.3	2.2	9.8
Cassalery 0.0	8/12/2020	256								13.4	3.0	9.7
Cassalery 0.0	9/28/2020	38								12.2	3.0	10.0
Cassalery 0.0	4/19/2021	2								12.2	6.0	10.9
Cassalery 0.0	5/10/2021	38	940	4	13	11	5157	1116	31	12.5	5.0	10.6
Cassalery 0.0	6/14/2021	50									5.0	9.9
Cassalery 0.0	7/12/2021	108	795	4	26	16	5070	960	38		6.0	9.3
Cassalery 0.0	8/9/2021	86								15.6	3.0	8.9
Cassalery 0.6	1/21/2020	14	967	10	19	16	7295	1326	37	7.4	2.0	9.9
Cassalery 0.6	2/11/2020											
Cassalery 0.6	3/10/2020											
Cassalery 0.6	4/12/2020	12								10.6	2.8	10.3
Cassalery 0.6	6/15/2020											

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Cassalery 0.6	9/28/2020											
Cassalery 0.6	10/12/2020	286								11.0	0.0	9.0
Cassalery 0.6	11/16/2020	12	823	12	43	19	6076			5.0	3.0	9.3
Cassalery 0.6	12/7/2020	22								7.7	12.0	10.4
Cassalery 0.6	1/11/2021	40								7.9	10.0	10.3
Cassalery 0.6	2/9/2021	24								6.3	6.0	11.3
Cassalery 0.6	3/8/2021	15	1107	3	15	7	5487	1533	30	6.7	9.0	11.6
Cassalery 0.6	4/19/2021											
Cassalery 0.6	5/10/2021											
Cassalery 0.6	6/14/2021											
Cassalery 0.6	7/12/2021											
Cassalery 0.6	8/9/2021											
Cassalery 0.6	9/13/2021	90	779	4	18	7	5377	970	29	12.7	2.0	9.4
Cassalery 0.6	10/11/2021	30								8.8	4.0	10.4
Cassalery 0.6	11/8/2021	4	723	9	24	8	5505	1032	26	7.3	3.0	10.0
Cassalery 0.6	12/13/2021	20								6.2	5.0	10.5
Chicken Coop 0.24	1/22/2020	5								4.9	49.0	12.8
Chicken Coop 0.24	4/20/2020	2								7.7	1.0	12.0
Chicken Coop 0.24	8/18/2020	60								14.0	0.0	9.6
Chicken Coop 0.24	11/17/2020	20								7.6	3.0	11.3
Chicken Coop 0.24	4/20/2021	446								7.9	1.0	11.9
Chicken Coop 0.24	8/10/2021	80								13.4	1.0	52.5
Chicken Coop 0.24	11/16/2021	28								7.0	29.0	12.2
Cooper 0.1	1/21/2020	16	502	15	170	25	8371	1181	43	6.6	2.0	9.6
Cooper 0.1	2/11/2020	18								6.8	3.0	8.4
Cooper 0.1	3/10/2020	4	253	2	40	23	7874	518	46	5.8	3.0	9.2
Cooper 0.1	4/12/2020	8								12.3	4.5	7.0
Cooper 0.1	5/12/2020	56								15.1	46.0	4.8
Cooper 0.1	6/15/2020	34	54	3	41	27	7880	356	52	14.1	3.0	7.5
Cooper 0.1	7/14/2020	32	49	3	39	23	8245	277	53	16.4	23.0	7.3
Cooper 0.1	8/12/2020	40								16.3	4.0	7.4
Cooper 0.1	9/28/2020	124								12.5	14.0	4.7

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Cooper 0.1	10/12/2020	346	92	4	263	95	6969			11.5	29.0	3.0
Cooper 0.1	11/16/2020	16	351	6	152	66	1579			7.5	29.0	8.6
Cooper 0.1	12/7/2020	6								7.5	25.0	6.5
Cooper 0.1	1/11/2021	2								7.8	8.0	9.6
Cooper 0.1	2/9/2021	8								6.7	6.0	9.8
Cooper 0.1	3/8/2021	12	183	2	27	16	6197	519	34	6.8	1.0	9.4
Cooper 0.1	4/19/2021	34								14.9	3.0	8.0
Cooper 0.1	5/10/2021	52	27	2	34	16	5621	308	43	15.8	3.0	8.5
Cooper 0.1	6/14/2021	32								14.7	4.0	31.8
Cooper 0.1	7/12/2021	39	24	3	59	28	6737	299	59	18.7	3.0	6.3
Cooper 0.1	8/9/2021	40									3.0	5.9
Cooper 0.1	9/13/2021	382	70	6	60	23	6457	433	58	12.9	4.0	4.7
Cooper 0.1	10/11/2021	60								9.0	13.0	4.5
Cooper 0.1	11/8/2021	8	243	2	63	19	5464	561	43	6.1	3.0	8.4
Cooper 0.1	12/13/2021	30								6.5	12.0	9.4
Dean 0.17	1/22/2020	12								4.3	38.0	13.1
Dean 0.17	8/10/2021	140								15.0	1.0	7.3
Dean 0.17	11/16/2021	60								6.7	35.0	12.4
Dungeness 0.7	1/21/2020	16	126	0	3	5	4229	261	24	4.5	12.0	12.8
Dungeness 0.7	2/11/2020	4								5.3	7.0	12.7
Dungeness 0.7	3/10/2020	4	101	0	5	4	3964	188	10	4.3	1.0	13.3
Dungeness 0.7	4/12/2020	18								8.2	1.3	12.2
Dungeness 0.7	5/12/2020	42								8.6	29.0	11.5
Dungeness 0.7	6/15/2020	16	22	0	2	3	3163	99	15	9.5	4.0	11.4
Dungeness 0.7	7/14/2020	14	30	0	3	3	3023	139	11	12.4	1.0	10.9
Dungeness 0.7	8/12/2020	36								13.6	0.0	10.6
Dungeness 0.7	9/28/2020	12								11.8	2.0	10.8
Dungeness 0.7	10/12/2020	68	34	1	4	3	2691			10.2	48.0	11.2
Dungeness 0.7	11/16/2020	8	55	0	5	5	3075			5.7	1.0	12.2
Dungeness 0.7	12/7/2020	2								5.8	1.0	12.4
Dungeness 0.7	1/11/2021	18								5.7	4.0	12.3
Dungeness 0.7	2/9/2021	4								3.8	2.0	13.1

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4.Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Dungeness 0.7	3/8/2021	2	62	0	3	3	3229	216	11	5.7	1.0	12.7
Dungeness 0.7	4/19/2021	16								9.3	8.0	11.8
Dungeness 0.7	5/10/2021	6	31	0	3	2	2598	114	7	9.6	2.0	11.7
Dungeness 0.7	6/14/2021	42								8.5	26.0	11.6
Dungeness 0.7	7/12/2021	36	23	0	0	2	2355	73	11	13.8	3.0	10.6
Dungeness 0.7	8/9/2021	14								14.7	1.0	10.6
Dungeness 0.7	9/13/2021	64	122	2	38	7	3088	297	21	13.1	1.0	10.0
Dungeness 0.7	10/11/2021	14								8.6	1.0	11.3
Dungeness 0.7	11/8/2021	2	47	0	0	5	2475	173	21	5.1	5.0	12.6
Dungeness 0.7	12/13/2021	8								4.0	7.0	12.7
Dungeness 0.8	1/21/2020											
Dungeness 0.8	2/11/2020											
Dungeness 0.8	8/9/2021											
Gierin 1.8	1/22/2020	10								4.7	7.0	12.0
Gierin 1.8	4/20/2020	38								9.1	7.0	11.2
Gierin 1.8	4/20/2021	118								8.8	9.0	11.3
Gierin 1.8	8/10/2021	208								14.5	9.0	9.8
Gierin 1.8	11/16/2021	182								7.1	5.0	10.4
Golden Sands Slough 0.0	1/21/2020	12	343	3	25	62	1298	467	82	7.8	8.0	9.4
Golden Sands Slough 0.0	2/11/2020	8								8.4	4.0	6.9
Golden Sands Slough 0.0	3/10/2020	2	105	2	56	42	1820	477	79	8.6	2.0	10.3
Golden Sands Slough 0.0	4/12/2020	78								14.4	2.6	10.5
Golden Sands Slough 0.0	5/12/2020	66								18.4	27.0	0.8
Golden Sands Slough 0.0	6/15/2020	32	3	0	72	178	7054	965	289	17.8	4.0	11.6
Golden Sands Slough 0.0	7/14/2020	72	1	2	72	56	4432	465	103	21.6	5.0	11.3
Golden Sands Slough 0.0	8/12/2020	26								20.6	2.0	12.3
Golden Sands Slough 0.0	9/28/2020	131								14.1	668.0	0.1
Golden Sands Slough 0.0	10/12/2020	999	1	3	1815	623	9557			12.6	44.0	0.5
Golden Sands Slough 0.0	11/16/2020	18	186	10	487	230	4938			7.5	26.0	0.9
Golden Sands Slough 0.0	12/7/2020	14								7.8	62.0	3.9
Golden Sands Slough 0.0	1/11/2021	36								7.8	21.0	9.3
Golden Sands Slough 0.0	2/9/2021	2								7.4	2.0	9.4

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Golden Sands Slough 0.0	3/8/2021	8	460	5	191	100	1789	1036	122	10.0	2.0	8.7
Golden Sands Slough 0.0	4/19/2021	72								16.9	2.0	9.5
Golden Sands Slough 0.0	5/10/2021	8	2	1	108	36	1352	605	87	19.9	4.0	8.6
Golden Sands Slough 0.0	6/14/2021	168								16.0	4.0	5.5
Golden Sands Slough 0.0	7/12/2021	29	2	2	60	33	737	427	76	19.7	2.0	9.2
Golden Sands Slough 0.0	8/9/2021	4								20.1	1.0	10.9
Golden Sands Slough 0.0	9/13/2021	74	13	2	56	85	984	322	121	12.5	3.0	6.3
Golden Sands Slough 0.0	10/11/2021	404								8.6	84.0	0.4
Golden Sands Slough 0.0	11/8/2021	195	22	4	768	101	6284	1930	350	6.4	11.0	0.6
Golden Sands Slough 0.0	12/13/2021	8								3.9	5.0	6.0
Hurd 0.2	1/22/2020	10								8.4	1.0	9.4
Hurd 0.2	4/20/2020	12								9.6	1.0	10.1
Hurd 0.2	8/18/2020	34								11.1	0.0	9.4
Hurd 0.2	11/17/2020	4								9.4	3.0	8.7
Hurd 0.2	4/20/2021	16								9.7	1.0	10.7
Hurd 0.2	8/10/2021	38								11.3	0.0	9.5
Hurd 0.2	11/16/2021	2								9.1	12.0	10.0
Jimmycomelately 0.15	1/21/2020	16	593	2	22	15	8419	1271	97	4.2	80.0	12.9
Jimmycomelately 0.15	2/11/2020	8								4.4	10.0	12.9
Jimmycomelately 0.15	3/10/2020	6	234	1	3	14	9044	439	27	2.9	2.0	13.2
Jimmycomelately 0.15	4/12/2020	2								7.6	0.8	11.5
Jimmycomelately 0.15	5/12/2020	2								10.8	3.0	10.4
Jimmycomelately 0.15	6/15/2020	32	235	2	2	11	9045	552	47	9.5	13.0	11.2
Jimmycomelately 0.15	7/14/2020	10	107	0	3	18	9579	302	34	11.0	0.0	10.5
Jimmycomelately 0.15	8/12/2020	24								12.7	0.0	9.7
Jimmycomelately 0.15	9/28/2020	172								11.0	1.0	9.7
Jimmycomelately 0.15	10/12/2020	90	85	6	26	29	8858			10.4	1.0	9.6
Jimmycomelately 0.15	11/16/2020	18	474	1	10	23	8544			5.0	1.0	12.1
Jimmycomelately 0.15	12/7/2020	4								4.6	1.0	12.4
Jimmycomelately 0.15	1/11/2021	4								6.1	7.0	12.2
Jimmycomelately 0.15	2/9/2021	2								2.8	3.0	13.2
Jimmycomelately 0.15	3/8/2021	4	295	1	11	13	6245	568	26	3.3	2.0	13.3

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Jimmycomelately 0.15	4/19/2021	2								8.5	1.0	11.8
Jimmycomelately 0.15	5/10/2021	168	108	1	3	17	7920	261	26	8.2	1.0	11.5
Jimmycomelately 0.15	6/14/2021	60								11.3	1.0	10.4
Jimmycomelately 0.15	7/12/2021	75	170	1	5	23	8652	283	43	13.2	1.0	9.6
Jimmycomelately 0.15	8/9/2021	20								13.6	1.0	9.5
Jimmycomelately 0.15	9/13/2021	56	150	1	14	32	7859	292	55	12.3	1.0	9.7
Jimmycomelately 0.15	10/11/2021	74								7.8	1.0	10.7
Jimmycomelately 0.15	11/8/2021	16	378	1	4	17	7482	703	32	5.3	2.0	54.1
Jimmycomelately 0.15	12/13/2021	10								4.5	9.0	12.5
Johnson 0.0	1/21/2020	6	441	4	17	39	9162	1126	89	4.3		12.9
Johnson 0.0	2/11/2020	6								4.8	19.0	13.0
Johnson 0.0	3/10/2020	4	236	1	3	39	9243	709	60	3.3	5.0	13.4
Johnson 0.0	4/12/2020	6								8.6	1.1	11.9
Johnson 0.0	5/12/2020	8								11.2	4.0	10.7
Johnson 0.0	6/15/2020	112	227	3	5	35	8906	657	85	10.0	20.0	11.1
Johnson 0.0	7/14/2020	88	199	1	5	41	7637	389	54	11.7	0.0	10.7
Johnson 0.0	8/12/2020	80								12.4	0.0	10.5
Johnson 0.0	9/28/2020	58								11.0	1.0	10.8
Johnson 0.0	10/12/2020	368	101	1	8	65	10242			10.3	1.0	10.7
Johnson 0.0	11/16/2020	2	246	1	5	67	9653			5.5	1.0	11.9
Johnson 0.0	12/7/2020	4								5.5	1.0	12.3
Johnson 0.0	1/11/2021	56								6.0	35.0	12.4
Johnson 0.0	2/9/2021	10								3.0	7.0	13.4
Johnson 0.0	3/8/2021	4	215	1	13	41	7951	639	57	3.8	4.0	13.4
Johnson 0.0	4/19/2021	18								9.7	1.0	12.6
Johnson 0.0	5/10/2021	20	71	1	8	26	4563	258	35	8.8	2.0	11.8
Johnson 0.0	6/14/2021	142								11.5	10.0	10.7
Johnson 0.0	7/12/2021	71	92	1	2	28	4149	182	40	13.2	2.0	10.4
Johnson 0.0	8/9/2021	158									2.0	54.6
Johnson 0.0	9/13/2021	620	201	1	4	39	7133	303	70	12.5	1.0	10.5
Johnson 0.0	10/11/2021	8								7.8	3.0	11.7
Johnson 0.0	11/8/2021	26	45	1	1	46	9178	301	65	5.7	1.0	12.1

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Johnson 0.0	12/13/2021	80								4.2	20.0	12.8
Lotzgesell 0.1	1/21/2020	4	1286	5	14	11	8238	1826	33	7.7	3.0	9.6
Lotzgesell 0.1	2/11/2020	4								8.8	5.0	10.2
Lotzgesell 0.1	3/10/2020	16	1911	3	10	10	8272	2484	26	7.8	2.0	11.0
Lotzgesell 0.1	4/12/2020	32								11.1	3.8	10.7
Lotzgesell 0.1	5/12/2020	58									9.5	9.4
Lotzgesell 0.1	6/15/2020	108	1954	4	11	11	8369	2286	36	11.7	11.0	9.4
Lotzgesell 0.1	7/14/2020	104	1981	5	13	11	8480	2342	35	13.2	7.3	9.3
Lotzgesell 0.1	8/12/2020	204								12.7	4.0	9.3
Lotzgesell 0.1	9/28/2020	336								12.1	6.0	9.2
Lotzgesell 0.1	10/12/2020	348	1728	4	6	9	8677			11.5	4.0	9.1
Lotzgesell 0.1	11/16/2020	999	1483	8	248	39	7673			7.9	35.0	9.0
Lotzgesell 0.1	12/7/2020	30								8.6	8.0	9.9
Lotzgesell 0.1	1/11/2021	52								7.0	10.0	10.6
Lotzgesell 0.1	2/9/2021	34								7.5	6.0	10.7
Lotzgesell 0.1	3/8/2021	4	1649	3	12	10	6457	2102	31	9.0	5.0	10.8
Lotzgesell 0.1	4/19/2021	56								13.0	8.0	10.5
Lotzgesell 0.1	5/10/2021	94	1829	3	8	6	6515	2006	24	12.9	7.0	10.4
Lotzgesell 0.1	6/14/2021	104								12.0	7.0	9.7
Lotzgesell 0.1	7/12/2021	156	1883	5	9	9	7404	1977	30	13.2	6.0	9.5
Lotzgesell 0.1	8/9/2021	430								13.6	5.0	9.3
Lotzgesell 0.1	9/13/2021	126	1777	4	10	10	7098	2040	44	12.1	5.0	9.5
Lotzgesell 0.1	10/11/2021	280								9.8	5.0	10.0
Lotzgesell 0.1	11/8/2021	16	1511	3	7	12	7530	1745	32	8.3	4.0	9.9
Lotzgesell 0.1	12/13/2021	14								6.9	5.0	9.6
Matriotti 0.3a	1/21/2020	100	929	4	22	30	8070	1905	81	5.3	14.0	10.9
Matriotti 0.3a	2/11/2020	52								5.8	14.0	11.1
Matriotti 0.3a	3/10/2020	48	1276	3	17	22	8342	5953	130	5.3	9.0	11.4
Matriotti 0.3a	4/12/2020	226								10.0	4.9	9.8
Matriotti 0.3a	5/12/2020	190								12.2	9.0	9.3
Matriotti 0.3a	6/15/2020	678	1335	4	41	29	7866	1867	80	11.8	17.0	9.6
Matriotti 0.3a	7/14/2020	652	1856	6	124	22	8541	2391	48	13.2	6.0	9.3

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Matriotti 0.3a	8/12/2020	716								13.0	3.0	9.3
Matriotti 0.3a	9/28/2020	776								11.9	4.0	9.1
Matriotti 0.3a	10/12/2020	280	1658	5	123	20	8576			11.3	9.0	9.7
Matriotti 0.3a	11/16/2020	930	1489	4	29	23	7698			8.2	19.0	9.2
Matriotti 0.3a	12/7/2020	100								8.2	3.0	9.8
Matriotti 0.3a	1/11/2021	36								8.2	5.0	9.6
Matriotti 0.3a	2/9/2021	36								6.3	7.0	11.4
Matriotti 0.3a	3/8/2021	192	1212	4	48	21	7069	1965	50	7.9	7.0	11.3
Matriotti 0.3a	4/19/2021	999								12.5	6.0	10.4
Matriotti 0.3a	5/10/2021	848	1514	4	17	23	6387	1699	27	10.0	9.0	10.1
Matriotti 0.3a	6/14/2021	608								10.8	14.0	9.9
Matriotti 0.3a	7/12/2021	540	995	3	22	18	5130	1189	51	12.7	9.0	9.4
Matriotti 0.3a	8/9/2021	372								12.9	4.0	9.0
Matriotti 0.3a	9/13/2021	262	1569	4	17	16	6835	1977	56	11.2	3.0	9.2
Matriotti 0.3a	10/11/2021	200								8.9	5.0	10.2
Matriotti 0.3a	11/8/2021	48	1357	3	33	16	6575	1666	49	7.4	10.0	9.9
Matriotti 0.3a	12/13/2021	150								5.1	16.0	10.8
McDonald 01.6	1/22/2020	26								3.6	42.0	13.3
McDonald 01.6	4/20/2020	10								8.4	1.0	12.3
McDonald 01.6	8/18/2020	114								15.3	0.0	10.0
McDonald 01.6	11/17/2020	34								6.1	9.0	11.8
McDonald 01.6	4/20/2021	48								9.3	1.0	12.7
McDonald 01.6	8/10/2021	680								14.4	1.0	10.2
McDonald 01.6	11/16/2021	58								6.1	42.0	12.5
McDonald 03.1	1/22/2020											
Meadowbrook 0.2	1/21/2020	18	274	3	36	48	2253	420	62	7.6	3.0	9.1
Meadowbrook 0.2	2/11/2020	12								7.7	4.0	8.1
Meadowbrook 0.2	3/10/2020	140	153	1	16	13	7215	284	29	6.3	2.0	10.1
Meadowbrook 0.2	4/12/2020	33								12.0	3.1	8.8
Meadowbrook 0.2	5/12/2020	215								14.5	6.0	7.4
Meadowbrook 0.2	6/15/2020	50	43	1	16	16	6435	257	35	13.4	2.0	8.0
Meadowbrook 0.2	7/14/2020	24	40	1	18	19	6788	231	46	16.8	1.3	9.9

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4.Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Meadowbrook 0.2	8/12/2020	332								16.2	14.0	8.3
Meadowbrook 0.2	9/28/2020	134								13.9	7.0	8.3
Meadowbrook 0.2	10/12/2020	116	217	13	396	140	2015			12.3	24.0	5.1
Meadowbrook 0.2	11/16/2020	114	183	2	22	36	750			8.2	9.0	8.3
Meadowbrook 0.2	12/7/2020	72								7.3	5.0	7.3
Meadowbrook 0.2	1/11/2021	13								8.1	24.0	8.9
Meadowbrook 0.2	2/9/2021	21								6.3	2.0	9.6
Meadowbrook 0.2	3/8/2021	43	129	2	32	9	4659			8.4	3.0	10.5
Meadowbrook 0.2	4/19/2021	73								14.5	5.0	9.1
Meadowbrook 0.2	5/10/2021	61	45	1	19	15	5498	232	32	15.0	3.0	9.4
Meadowbrook 0.2	6/14/2021	102								14.2	4.0	7.9
Meadowbrook 0.2	7/12/2021	89	26	1	14	20	5681	210	44	17.7	3.0	10.2
Meadowbrook 0.2	8/9/2021	336								18.1	13.0	7.8
Meadowbrook 0.2	9/13/2021	121	30	1	25	19	5396	273	46	14.8	2.0	7.7
Meadowbrook 0.2	10/11/2021	72								9.7	5.0	7.9
Meadowbrook 0.2	11/8/2021	226	127	5	126	53	4495	596	106	6.9	7.0	6.7
Meadowbrook 0.2	12/13/2021	116								7.6	11.0	8.2
Meadowbrook Slough 0.23	1/21/2020	30	265	3	63	36	2666	416	47	6.8	3.0	8.1
Meadowbrook Slough 0.23	2/11/2020	23								6.9	2.0	9.0
Meadowbrook Slough 0.23	3/10/2020	137	204	1	25	16	4473	357	21	6.3	0.0	9.9
Meadowbrook Slough 0.23	4/12/2020	434								7.8	2.6	9.2
Meadowbrook Slough 0.23	5/12/2020	278								9.8	5.0	8.6
Meadowbrook Slough 0.23	6/15/2020	371	50	1	25	24	4408	153	43	9.8	1.0	8.3
Meadowbrook Slough 0.23	7/14/2020	645	57	1	23	21	4342	189	36	11.7	2.0	7.7
No Name 0.03	1/22/2020	138								5.5	31.0	12.6
No Name 0.03	4/20/2020	2								9.2	3.0	11.3
No Name 0.03	8/18/2020	22								16.5	6.0	8.9
No Name 0.03	11/17/2020	66								8.7	200.0	11.2
No Name 0.03	4/20/2021	25								9.6	2.0	11.0
No Name 0.03	11/16/2021	26								7.3	20.0	12.0
Sequim Bay State Park Creek 0.0	2/11/2020	4								5.0	25.0	12.9
Sequim Bay State Park Creek 0.0	4/12/2020	6								8.3	0.8	11.3

Site	Date	FC (CFU/100ml)	NO_3-N (µg/L)	NO_2-N (µg/L)	NH_3-N (µg/L)	PO_4-P (µg/L)	SiO_4-Si (µg/L)	TN (µg/L)	TP (µg/L)	Temp H_2O °C	Turbidity (FNU)	Dissolved Oxygen (mg/L)
Sequim Bay State Park Creek 0.0	5/12/2020	6								11.0	4.0	10.5
Sequim Bay State Park Creek 0.0	6/15/2020	156	27	5	2	71	9234	802	156	11.8	18.0	10.5
Sequim Bay State Park Creek 0.0	7/14/2020	44	203	1	4	70	9539	588	85	12.0	0.0	9.4
Sequim Bay State Park Creek 0.0	8/12/2020	16								13.2	1.0	8.4
Sequim Bay State Park Creek 0.0	9/28/2020	16								11.5	1.0	9.4
Sequim Bay State Park Creek 0.0	10/12/2020	4	57	1	5	59	6494			10.6	1.0	10.0
Sequim Bay State Park Creek 0.0	11/16/2020	2	13	1	4	82	8727				1.0	11.8
Sequim Bay State Park Creek 0.0	12/7/2020	2								5.9	1.0	12.1
Sequim Bay State Park Creek 0.0	2/9/2021	2								3.7	6.0	13.0
Sequim Bay State Park Creek 0.0	3/8/2021	2	126	1	23	45	6914	679	66	4.3	4.0	12.9
Sequim Bay State Park Creek 0.0	4/19/2021	2								8.7	1.0	11.1
Sequim Bay State Park Creek 0.0	5/10/2021	2	107	1	8	52	7078	500	62	9.0	2.0	11.1
Sequim Bay State Park Creek 0.0	6/14/2021	26								11.8	2.0	10.3
Sequim Bay State Park Creek 0.0	7/12/2021	49	117	1	9	52	8293	472	84	13.6	0.0	5.4
Sequim Bay State Park Creek 0.0	8/9/2021	18								14.1	0.0	7.9
Sequim Bay State Park Creek 0.0	11/8/2021	2	8	1	3	62	7188	511	80	6.6	1.0	11.6
Sequim Bay State Park Creek 0.1	1/21/2020	24	244	6	9	76	8850	1215	134	5.0	45.0	12.7
Sequim Bay State Park Creek 0.1	3/10/2020	2	81	2	20	48	8674	698	71	4.1	6.0	13.1
Sequim Bay State Park Creek 0.1	1/11/2021	42								6.1	30.0	12.5
Sequim Bay State Park Creek 0.1	10/11/2021	4								8.0	2.0	10.6
Sequim Bay State Park Creek 0.1	12/13/2021	12								4.6	10.0	12.7
Siebert 1.0	1/22/2020	6								4.0	40.0	13.2
Siebert 1.0	4/20/2020	8								9.3	1.0	11.8
Siebert 1.0	8/18/2020	18								14.9	0.0	10.1
Siebert 1.0	11/17/2020	26								6.6	120.0	11.9
Siebert 1.0	4/20/2021	4								9.8	1.0	12.2
Siebert 1.0	8/10/2021	100								14.8	1.0	10.2
Siebert 1.0	11/16/2021	14								6.5	74.0	12.4

Appendix C: Charts of Additional Physical and Chemical Parameters

Summaries of data collected per Streamkeepers QAPP (in addition to data collected per the PIC QAPP) are presented in the charts below.

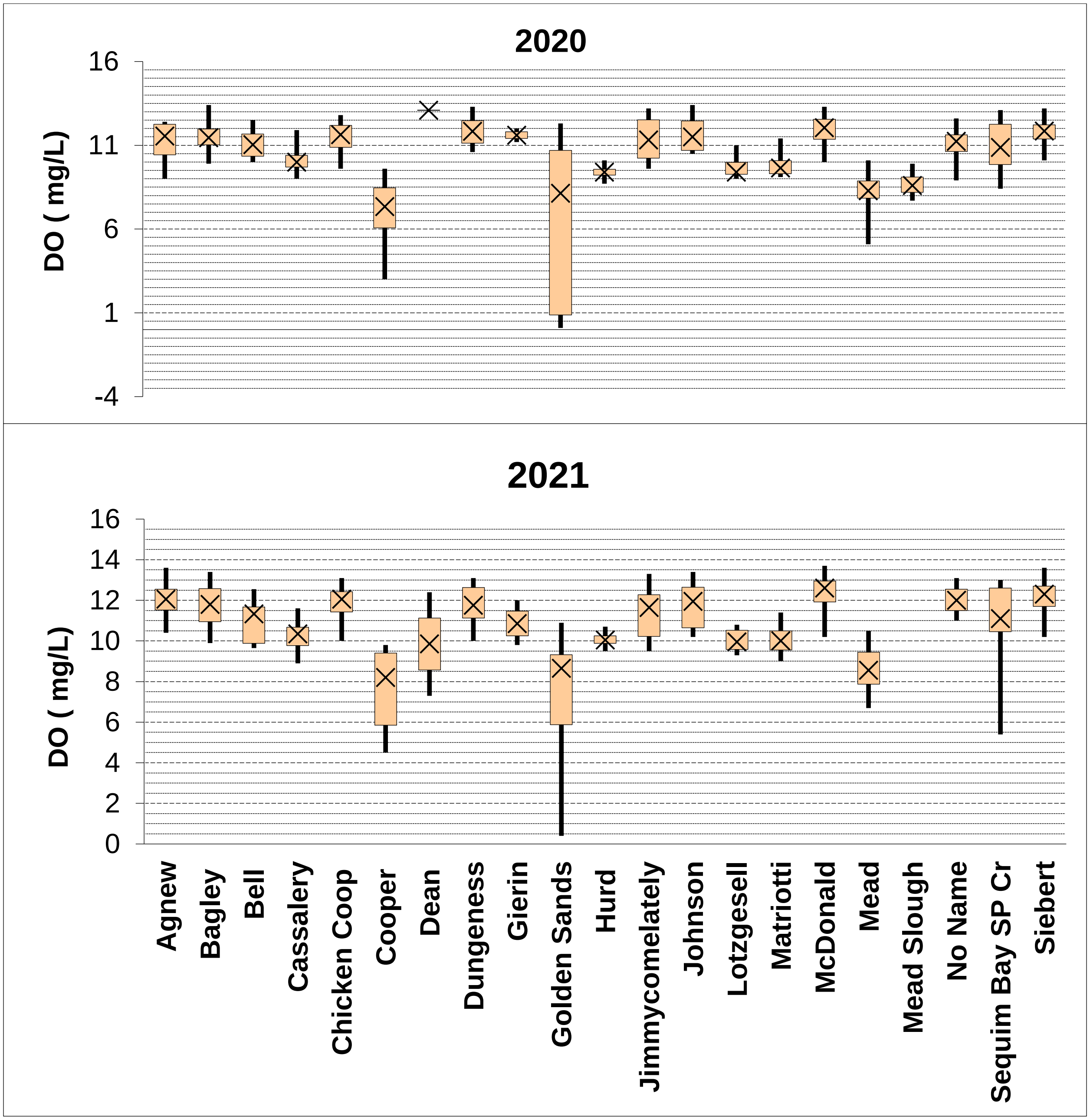

Figure 13. Dissolved Oxygen, all CWD streams. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values. According to Washington State Freshwater Aquatic Life Criteria for salmonid spawning and rearing, the 1-day minimum D.O. for Core Summer Salmonid Habitat is 9.5 mg/L (WAC 173-201A-200, 2019). According to Washington State Marine Aquatic Life Criteria for fish and shellfish spawning and rearing (extraordinary quality category), the 1-day minimum D.O. is 7.0 mg/L (WAC 173-201A-210, 2019).

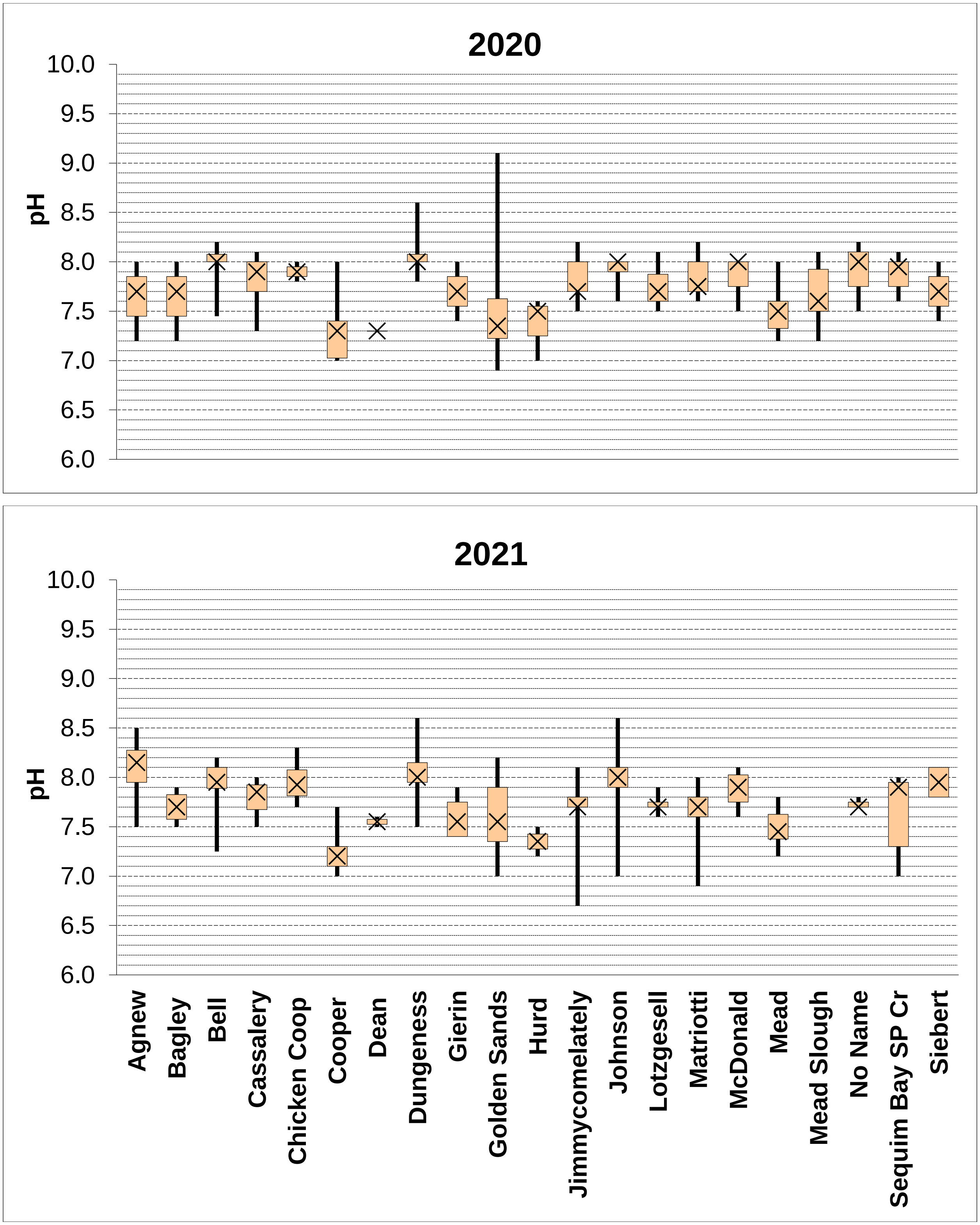

Figure 14. pH, all CWD streams. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values. Due to malfunctioning of the pH probe in June, July, and August 2020, data for those months was excluded. According to Washington State Freshwater Aquatic Life Criteria for Core Summer Salmonid Habitat, pH should be in the range 6.5-8.5 (WAC 173-201A-200, 2019).

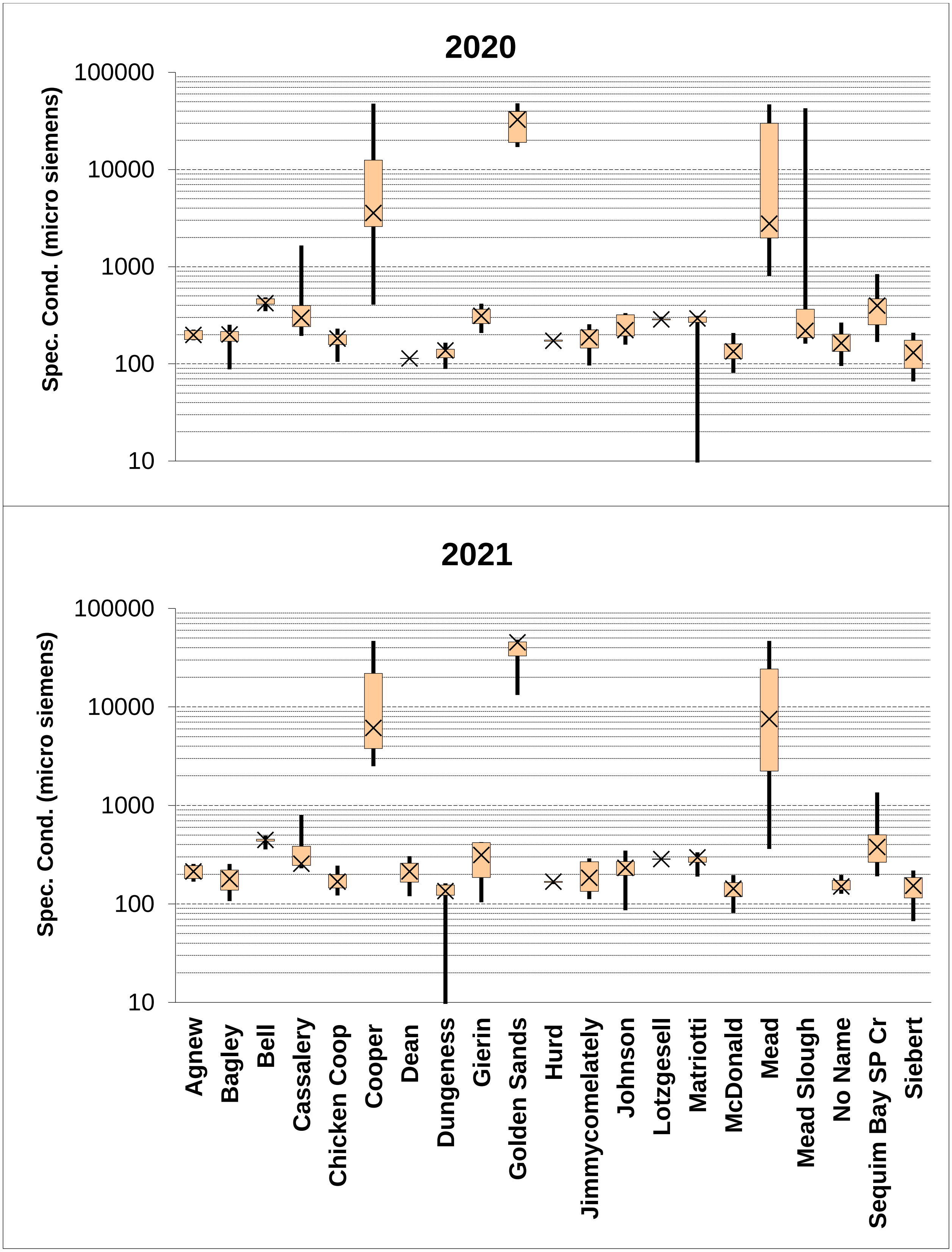

Figure 15. Specific conductivity, all CWD streams. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.

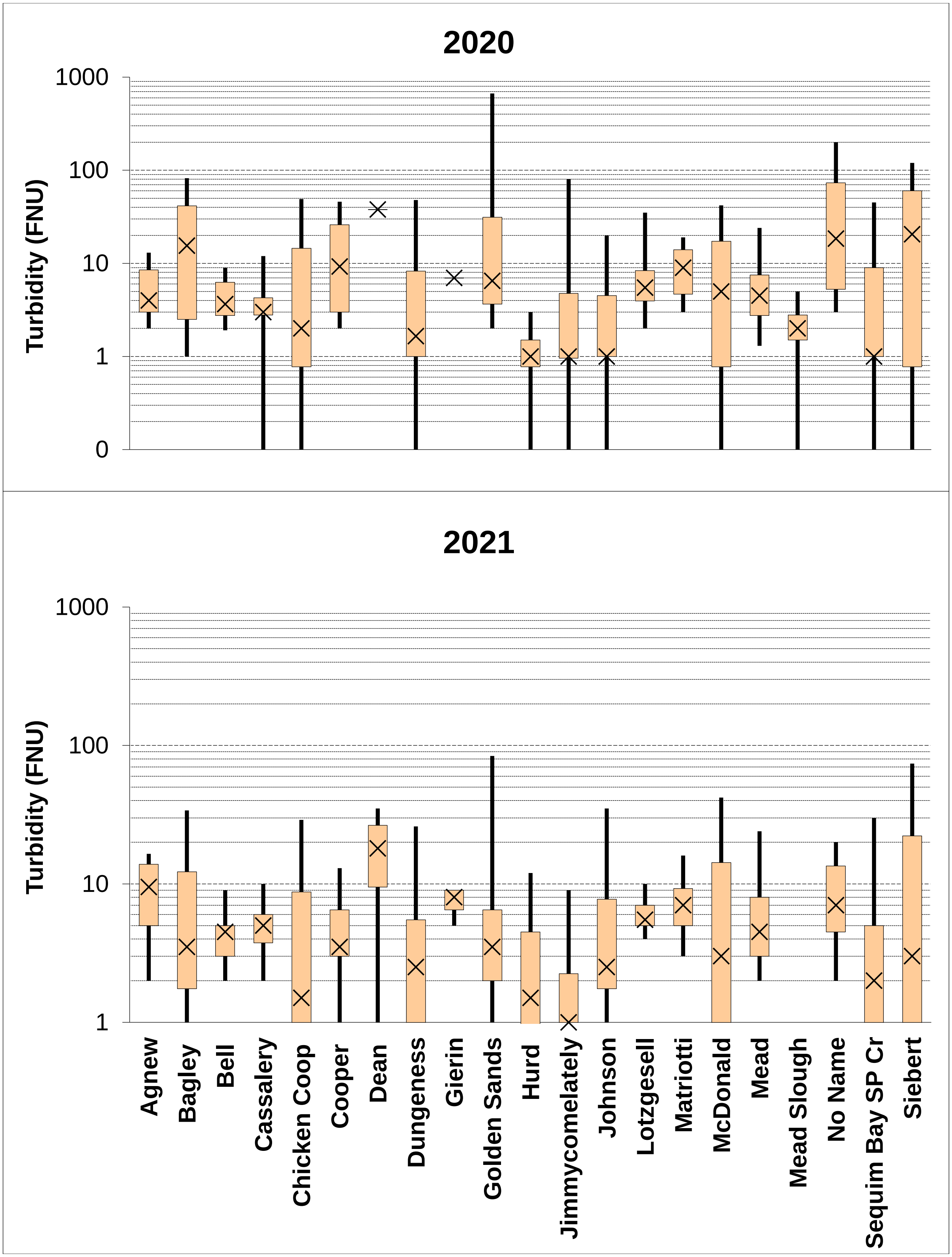

Figure 16. Turbidity, all CWD streams. Note log scale. X marks median; bottom and top of box represent 1st and 3rd quartiles; ends of whiskers represent min. and max. values.