Macroinvertebrate Report: Oregon Coast Coho Evolutionarily Significant Unit (2006-2007)

Final Report for Oregon Watershed Enhancement Board Grant R037-06

Laboratory and Environmental Assessment Division
3150 NW 229th Avenue, Suite 150
Hillsboro, Oregon, 97124
(503) 693-5700

State of Oregon
Department of Environmental Quality

Prepared by:

Shannon Hubler

August 2008

Table of Contents

List of Tables

List of Figures

Executive Summary

Macroinvertebrate samples were collected in the Coastal Coho ESU during the summer months of 2006 and 2007. They were assessed for biological condition and signs of both temperature and fine sediment stress. Results from these surveys indicate that biological condition is better overall in the Mid Coast and North Coast monitoring areas than in the Mid South Coast and Umpqua monitoring areas. These conditions appear to be related to higher levels of temperature stress and fine sediment stress exhibited by the macroinvertebrate assemblages in the Mid South Coast and especially the Umpqua monitoring area.

Overview

In 1997, the Oregon Department of Environmental Quality (ODEQ) began monitoring water quality and beneficial use impairments along the Oregon coast for the Oregon Plan for Salmon and Watersheds program. Specific water quality and watershed health indicators known to be "factors for decline" for Oregon coastal coho salmon were identified in "The Oregon Plan: Oregon Coastal Salmon Restoration Initiative" document (State of Oregon, 1997). These factors included: general water quality, water temperature, dissolved oxygen, pH, stream fertility (nutrients), sediment and biological conditions (macroinvertebrate communities). Toxic chemicals were also listed as potential factors for decline, but were not assessed due to the high cost of analysis. In addition, the episodic use and presence of toxic chemicals makes it difficult to time sampling with pesticide application processes. Surrogates such as indices of biological integrity, may provide a more general indication of exposure to toxic chemicals.

In 2005, these data collected by ODEQ and other state agencies were synthesized in a final report (State of Oregon 2005). This report assessed the information collected on the "factors for the decline" and evaluated their relative importance to the continued viability of Oregon's coastal coho runs into the future. The information was assessed for the Oregon Coastal Coho Evolutionary Significant Unit (ESU) and for four monitoring area nested within the ESU. The information was used by the National Oceanic and Atmospheric Administration Fisheries (NOAAF) division in its final decision to re-list coastal coho as "threatened" on the Oregon coast.

In 2007, the Oregon Department of Fish and Wildlife (ODFW) released the final draft of the Oregon Coast Coho Conservation Plan (State of Oregon 2007). The plan outlines the Oregon's strategy to ensure the continued viability of threatened coastal coho salmon runs. Part of the plan identifies the need for higher resolution monitoring of water quality and macroinvertebrates in each of twenty-one independent coho population units in Oregon.

This report summarizes macroinvertebrate data collected in cooperation with the ODFW in the twenty-one independent coho populations units from 2006-2007. These data were collected by ODFW crews and analyzed by ODEQ staff. Biological integrity, temperature stress and fine sediment stress were evaluated for each of the twenty-one population units.

Methods

Study Area and Site Selection

The Coastal Coho ESU contains over 9,000 miles of rivers and streams. Most of these stream miles (over 80%) are on small wadeable streams (1st through 3rd order). A practical and effective approach for evaluating such a large resource is to use a probabilistic or random sampling survey design. A probabilistic survey of streams operates in the same manner as public opinion polls used to describe the public's opinion on social issues or winners and losers of political races. A subsample of stream sites is selected at random to represent the population of streams in a region, just as the subsample of individuals in a public opinion poll is selected to represent the voting population as a whole. Random stream sites for this study were selected from a US Geologic Survey 1:100,000 digital stream map as a spatially balanced, probability sample by the US Environmental Protection Agency (USEPA), Corvallis Oregon.

While the sites were selected via a random survey design, site weights were not available for this report.

Reference Site Selection

Most reference sites used in this analysis are hand picked using a combination of Geographic Information System (GIS) tools and a Human Disturbance Index (HDI) (Drake, 2004). Prior to visiting potential reference locations, a target region is analyzed using human disturbance indicators such as road density, cattle grazing or timber harvest information. Watersheds were delineated and ranked according to percentage of human disturbance surrogates contained within their boundaries.

Field crews evaluated five different human disturbance categories at each potential reference location: urbanization/agriculture, logging activity, rangelands, roads, and miscellaneous. The miscellaneous category includes natural disturbance regimes such as fires and floods and human related pressures such as exotic plant species and recreational use. The presence of natural disturbance did not necessarily disqualify a candidate reference site. Within each of the five categories are a number of specific uses that field crews place into one of four proximity categories. Activities which are closer and more prevalent in the stream reach receive a higher score than activities which are less extensive and further away. The highest use value from each of the five categories is summed for the final HDI score. Low HDI scores indicate low human activity and high scores indicate high human impacts. The field crews are also asked to provide a qualitative A-F grade for each site. In areas with low human disturbance, only sites which receive an "A" or "B" grade are qualified for final consideration as reference sites. In regions with ubiquitous human impacts lower grades may be considered out of necessity. In addition to hand picked reference sites, some reference sites are derived from the random site population. The selection criterion for the random sites is the same as for handpicked sites except that the GIS analysis is performed after the site has been surveyed.

Bug sampling methods

Macroinvertebrate samples were collected from fastest available habitat in the study streams. Typically this resulted in samples collected from riffle habitat, but on low-gradient streams samples were collected from either run/glide habitat (second choice) or pool habitat (third choice). Samples were collected using a D-frame kicknet with 500 μm mesh. Samples consisted of eight 1-ft^2 kicks from separate riffles (where available) composited into a single sample. Following field collection, samples were preserved with 95% denatured ethanol. In the laboratory, samples were randomly sub-sampled and sorted at 10x magnification until a target of 500 individuals was reached. These sub-samples were then identified to standard taxonomic levels, typically genus/species. For complete details of macroinvertebrate sampling and processing, see ODEQ (2004).

Bioassessment indices

Three indices were used to evaluate overall biological condition and diagnose potential causes of stress, or degradation, to macroinvertebrate assemblages.

PREDictive Assessment Tool for ORegon (PREDATOR)

The PREDATOR tool is a multivariate predictive model used to assess the integrity of an aquatic insect assemblage. Predictive modeling estimates the expected occurrence of macroinvertebrates at a sample location. This is done by developing a list of insect species that commonly occur at least disturbed, or reference, locations that have similar natural characteristic to the sample locations. The list of species generated from the reference locations is known as the "Expected" taxa list or "E". This list is compared to the captured aquatic insects or, "Observed" taxa ("O"), at an assessment site. The predictive model output is the observed to expected (O/E) taxa ratio. Scores less than 1.0 have fewer taxa at a site than were predicted by the model. Scores greater than 1.0 are either equivalent to the reference location or may have an enhanced insect community as a result of some type of enrichment.

Assessing biological condition

Samples were assessed using one of two PREDATOR models. For sites in the Coast Range and Willamette Valley ecoregions, they were assessed using the Marine Western Coastal Forest model. Sites in the Cascades and Klamath Mountains ecoregions were assessed using the Western Cordillera and Columbia Plateau model. Based on differing precision and accuracy between the models, different benchmarks were used to classify the samples into one of three biological condition classes: least disturbed (similar to reference condition), moderately disturbed, and most disturbed (different from reference).

For a detailed description of DEQ's PREDATOR models, see Hubler (2008).

Stressor Identification (Stressor ID)

Unlike the PREDATOR models, the Stressor ID models were not created with reference sites. Any site with paired macroinvertebrate assemblage data and/or temperature and fine sediment data were used to construct the models. Macroinvertebrate taxa present in a sample were used to infer an overall macroinvertebrate assemblage preference for

temperature (TS) and fine sediments (FSS). The indices use weighted-averaging statistical methods to calculate scores. A total of 320 sites were used for substrate model calibration and 269 sites used for temperature model calibration.

The relationship between individual macroinvertebrate taxa abundance and environmental variables were used to model the optimum temperature and fine sediment values for each taxa. For TS, individual taxa abundances were compared to the average daily maximum temperatures for the warmest seven-day period of the season (7-DSMT) based on data from continuous data loggers. For FSS, taxa abundances were compared to fine sediment values, based on 105 systematically random pebble counts throughout the reach.

Optima were then used to infer the temperature (^{o}C) and fine sediment (%) of any site using a macroinvertebrate sample alone. Inferred values were calculated by weighing the optimum of each modeled taxon collected in a sample by its relative abundance within the sample. These weighted optima were then summed across all taxa in the sample for a weighted-average temperature and fine sediment score.

For a detailed description of DEQ's Stressor ID models, see Huff et. al (2006). The relationship between paired 7-day seasonal maximum temperatures collected from data loggers (placed by ODFW crews in 2006 and 2007) and macroinvertebrate samples used to infer TS is shown in Appendix 2.

Assessing temperature and fine sediment stress

TS values were placed into one of four categories for each stressor (Table 1). These categories were chosen because they align with DEQ's temperature standards for supporting core cold-water , salmon and trout rearing and migration and salmon and steelhead migration . These 2 ^{o}C increments also correspond to the error associated with the TS model (RMSE = 1.8-2.5 ^{o}C; Hubler 2008).

Table 1. Categories used for assessing temperature stress on the macroinvertebrate assemblage.

DEQ temperature standards	Core cold water habitat <16 ^{o}C	Salmon and trout rearing and migration < 18 ^{o}C	Salmon and steelhead migration < 20 ^{o}C	Not supporting
Temperature Stressor (TS) categories	<16 ^{o}C	16–17.9 ^{o}C	18–19.9 ^{o}C	≥20 ^{o}C

FSS values were also placed into one of four categories (Table 2). These categories correspond to the error associated with the FSS model (RMSE = 2-14 % fines). They also correspond with the benchmarks used in the assessment of macroinvertebrates for the Coastal Coho ESU (ODEQ March, 2005)

Table 2. Categories used for assessing fine sediment stress on the macroinvertebrate assemblage.

	Percent Fines (%)			
Fine Sediment Stressor categories (FSS)	0-10	11-20	21-30	>30

Summarizing the results

Descriptive statistics of the biological indices were used to summarize Oregon Coastal Coho monitoring areas and populations. Results were summarized for four monitoring areas and for populations with at least 10 samples. Biological indices were averaged for sites with multiple samples.

Macroinvertebrate samples with < 200 individuals are considered outliers, because fewer individuals can greatly affect the final results. Results from these samples are outside of the model specifications until it is verified that sampling methods were adequately followed. However, for this report, all macroinvertebrate samples were scored using PREDATOR and the Stressor ID models, regardless of total count of individuals. Sites considered to be potential outliers due to low counts are noted in Appendix 1. Low count samples were included in this report because the results may indicate high levels of disturbance and low habitat diversity (e.g., a system comprised mostly of bedrock slides) which can result in reduced total macroinvertebrate numbers. ODFW staff familiar with sample collection and stream conditions at these sites should validate the adequacy of these samples for future analyses. If it is determined that the low count samples represents natural conditions (i.e., the sampling methods were well executed but low total counts were observed), then they should be included in future assessments.

Results

Sample sizes

From 2006 to 2007, ODFW crews collected 353 macroinvertebrate samples in the Coastal Coho ESU (Appendix 1). Thirty-nine samples were flagged as outliers due to low total abundance (< 200 macroinvertebrates). For statistical summaries, data from repeated site visits were averaged. Two hundred and eighty-three sites total were characterized for biological integrity. A total of 75 sites were sampled in the North Coast (NC), 86 sites in the Mid Coast (MC), and 61 sites in each of the Mid-South Coast (MSC) and Umpqua (UMP) monitoring areas Eleven independent coho populations had a sufficient sample size (> 10 samples) for statistical summaries (Table 3).

Statistical summaries

Relationships among biological indices

Both temperature stress (TS) and fine sediment stress (FSS) models showed an inverse relationship to overall macroinvertebrate assemblage condition. As both TS and FSS increased, O/E decreased. However, FSS was more highly correlated with O/E (r^2 = 0.59) than TS.

Monitoring areas

PREDATOR Observed/Expected

Summary statistics of the three biological indices for the monitoring areas are shown in Figure 1. A map of survey locations and PREDATOR scores is shown in Figure 2. . The Mid Coast had the highest biological condition scores, with a median of 1.02. Over seventy-five percent of the samples assessed in the Mid Coast were classified as either "least disturbed" (0.92 – 1.24) or "moderately disturbed" (0.86 – 0.91). The North Coast had over fifty percent of the samples in least disturbed condition (median = 0.94), but over twenty-five percent of the samples were in "most disturbed" condition (< 0.86). Eight samples were identified as outliers, with PREDATOR scores outside 1.5*IQR (interquartile range). Biological condition was lower in the Mid-South Coast and substantially lower in the Umpqua. Over half of the sites in the Mid-South Coast had either moderately or most disturbed PREDATOR scores(median = 0.86). For the Umpqua monitoring area (median = 0.72), greater than fifty percent of the samples were in most disturbed condition and fewer than twenty-five percent of samples were in least disturbed condition. (Tables of summary statistics for the biological indices are shown in Appendix 3.)

Mean PREDATOR scores for the North Coast was 0.92 for samples with more than two hundred total macroinvertebrates, but only 0.57 for samples with less than two hundred bugs. The same trend was observed in the Mid South Coast and the Umpqua (MSC mean O/E > 200 bugs = 0.90, < 200 = 0.45; UMP mean O/E >200 = 0.75, <200 = 0.58). No samples from the Mid Coast had total counts of less than two hundred.

Table 3. The number of samples assessed within each Coastal Coho ESU monitoring area and population.

Monitoring Area	Type	Population	Count
North Coast	Dependent	Ecola Creek	1
North Coast	Dependent	Sand Creek	1
North Coast	Independent	Necanicum River	8
North Coast	Independent	**Nehalem River**	**32**
North Coast	Independent	**Nestucca River**	**12**
North Coast	Independent	**Tillamook Bay**	**21**
			75
Mid-Coast	Dependent	Big Creek (Siuslaw)	1
Mid-Coast	Dependent	Cape Creek	1
Mid-Coast	Dependent	Cummins Creek	2
Mid-Coast	Dependent	Devils Lake	1
Mid-Coast	Dependent	Spencer Creek	1
Mid-Coast	Dependent	Tenmile Creek	3
Mid-Coast	Dependent	Yachats River	3
Mid-Coast	Independent	**Alsea River**	**15**
Mid-Coast	Independent	Beaver Creek	3
Mid-Coast	Independent	Salmon River	4
Mid-Coast	Independent	**Siletz River**	**12**
Mid-Coast	Independent	**Siuslaw River**	**34**
Mid-Coast	Independent	Yaquina River	6
			86
Mid-South Coast	Independent	**Coos Bay**	**18**
Mid-South Coast	Independent	**Coquille River**	**24**
Mid-South Coast	Independent	Floras Creek	4
Mid-South Coast	Independent	Siltcoos River (Lake)	1
Mid-South Coast	Independent	Sixes River	6
Mid-South Coast	Independent	Tahkenitch Lake	3
Mid-South Coast	Independent	Tenmile Lake	5
			61
Umpqua	Independent	**Lower Umpqua River**	**20**
Umpqua	Independent	**Middle Umpqua**	**16**
Umpqua	Independent	North Umpqua	5
Umpqua	Independent	**South Umpqua**	**20**
			61

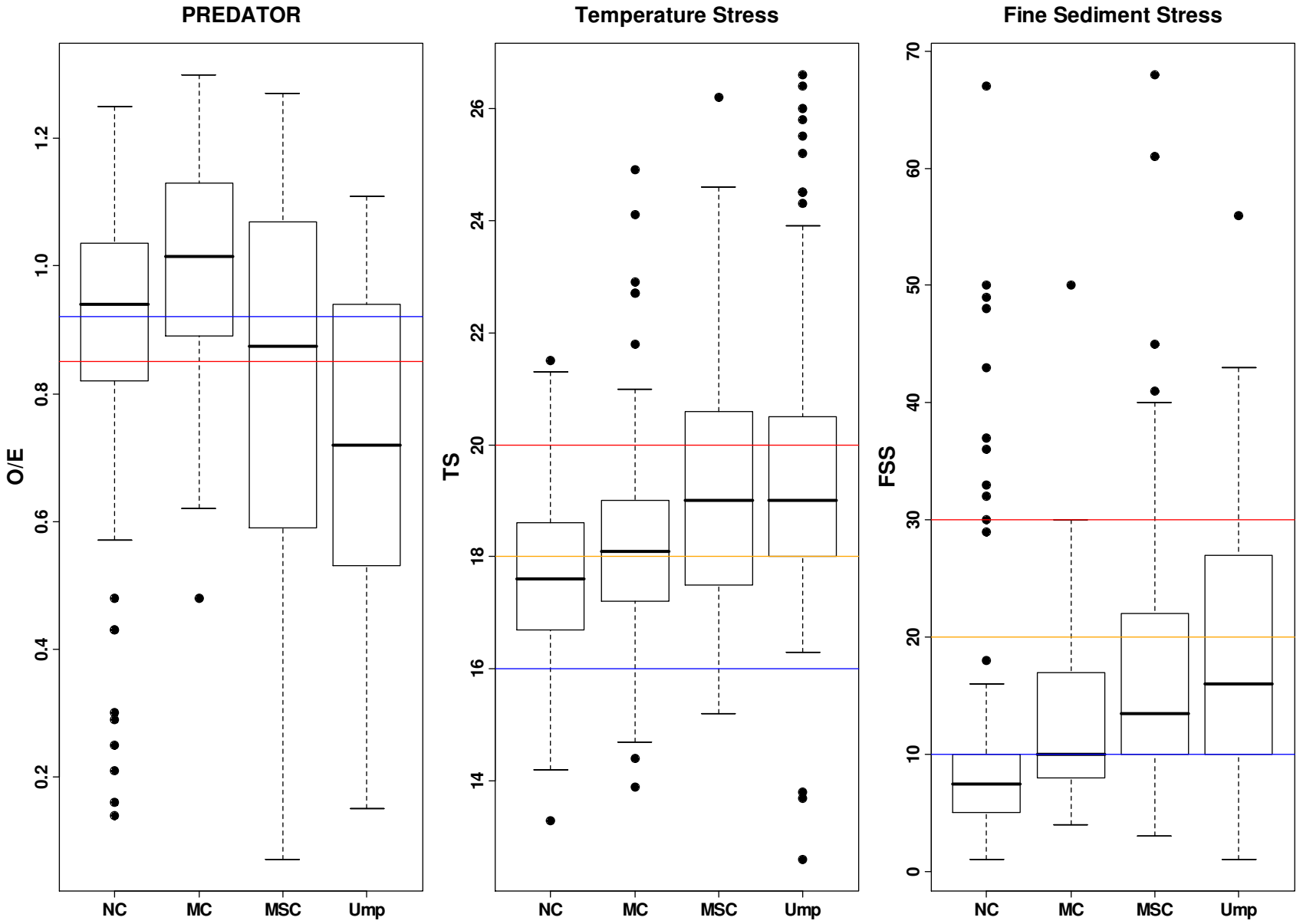

Figure 1. Summary results of biological indices for each of the four monitoring areas in the Coastal Coho ESU. Boxplots show the median (horizontal band), interquartile range (boxes), non-outlier range (dashed lines and hashes), and outliers (black circles). "NC" = North Coast, "MC" = Mid Coast, "MSC" = Mid-South Coast, and "Ump" = Umpqua. "O/E" is the ratio of observed reference taxa to expected reference taxa. "TS" and "FSS" are the inferred temperature and fine sediment (respectively) preferences of the macroinvertebrate assemblages. Colored horizontal lines show the benchmarks used to categorize sites for each biological index.

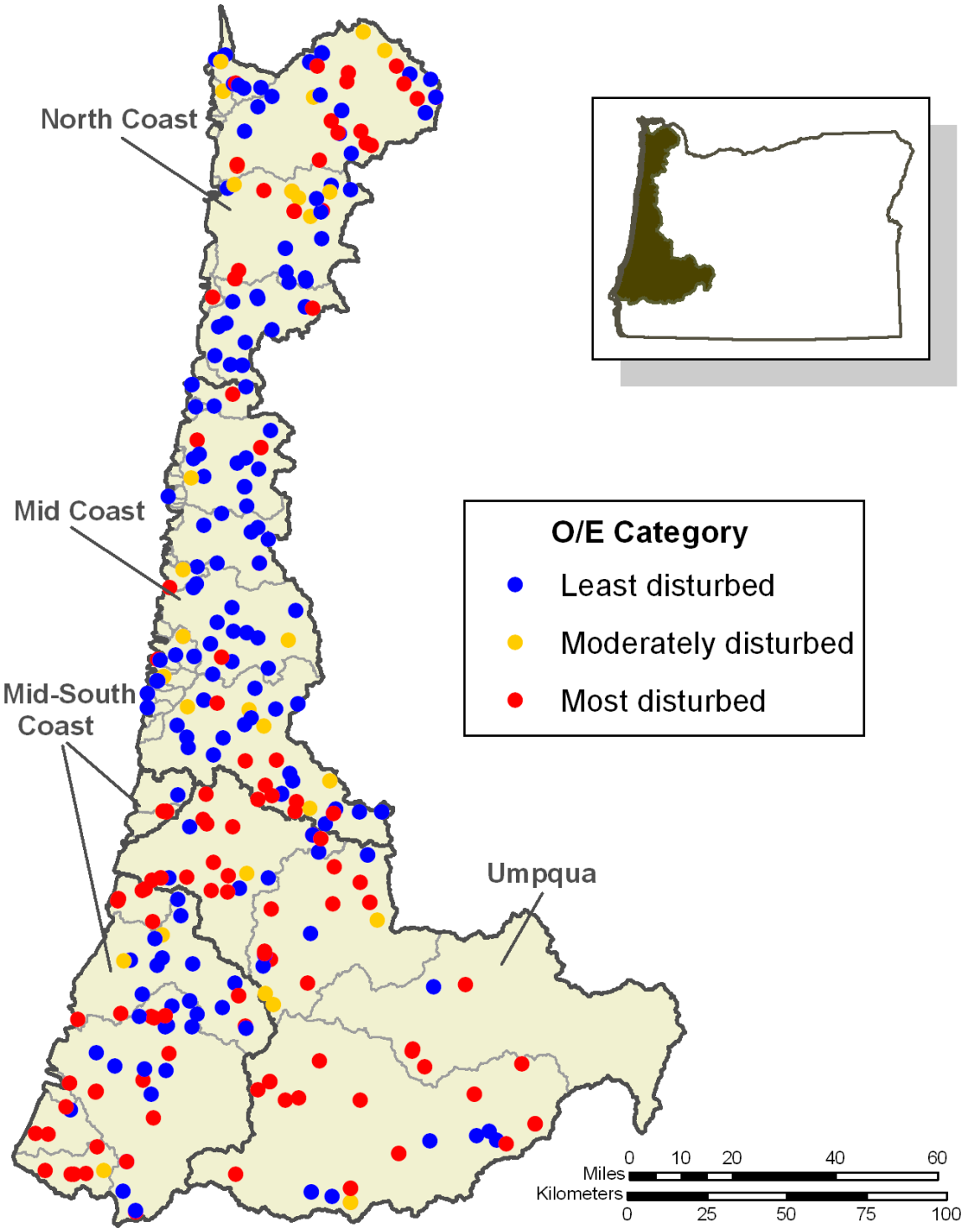

Figure 2. A map of the Coastal Coho ESU displaying PREDATOR O/E (Observed/Expected) scores at survey sites. For sites with multiple samples, O/E scores were averaged. Monitoring areas are outlined in black, and populations are outlined in grey.

Stressor Indices—Temperature and Fines

Summary statistics of temperature scores (TS) and fine sediment scores (FSS) for the monitoring areas are shown in Figure 2. Maps of each site surveyed in the Coastal Coho ESU are shown in Figures 3 and 4. These scores represent preferred macroinvertebrate temperature and fine sediment conditions No monitoring areas had more than twenty-five percent of the samples below the 16 ^{o}C benchmark established to protect core cold water habitat. Only the North Coast had more than half of samples attaining the 18 ^{o}C salmon and trout rearing and migration benchmark (median TS = 17.6). The Mid Coast was close with a median value one tenth over the benchmark (median TS = 18.1 ^{o}C). Both the North Coast and Mid Coast had median FSS values at or below the lowest fine sediment benchmark. The North Coast had a substantial number of FSS outliers within the monitoring area. The Mid South Coast and Umpqua had median FSS values within the second lowest benchmark range (11-20%). The Umpqua had nearly a quarter of samples above the highest benchmark range (FSS > 30%).

Populations

Biological indices were summarized for twelve independent populations in the Coastal Coho ESU. Only populations with ten or more samples were summarized.

PREDATOR Observed/Expected

The populations with the best overall biological condition were the Nestucca, Siletz, and Alsea, each with more than three quarters of samples in least disturbed condition (O/E > 0.91) (Figure 5). The Necanicum was similar, with slightly less than three quarters of samples in least disturbed condition. In the Mid South Coast, the Coos population also had a high median value (median O/E = 1.05), but showed a greater range of scores in the moderate to most disturbed conditions (~25% of samples). More than half of samples in each of the Umpqua populations were in most disturbed conditions (median O/E = 0.68 – 0.79). The South Umpqua population had the highest percentage of samples in most disturbed condition (> 75% of samples).

Three populations had multiple samples identified as outliers (Nehalem = 4, Tillamook = 3, and Coquille = 4).

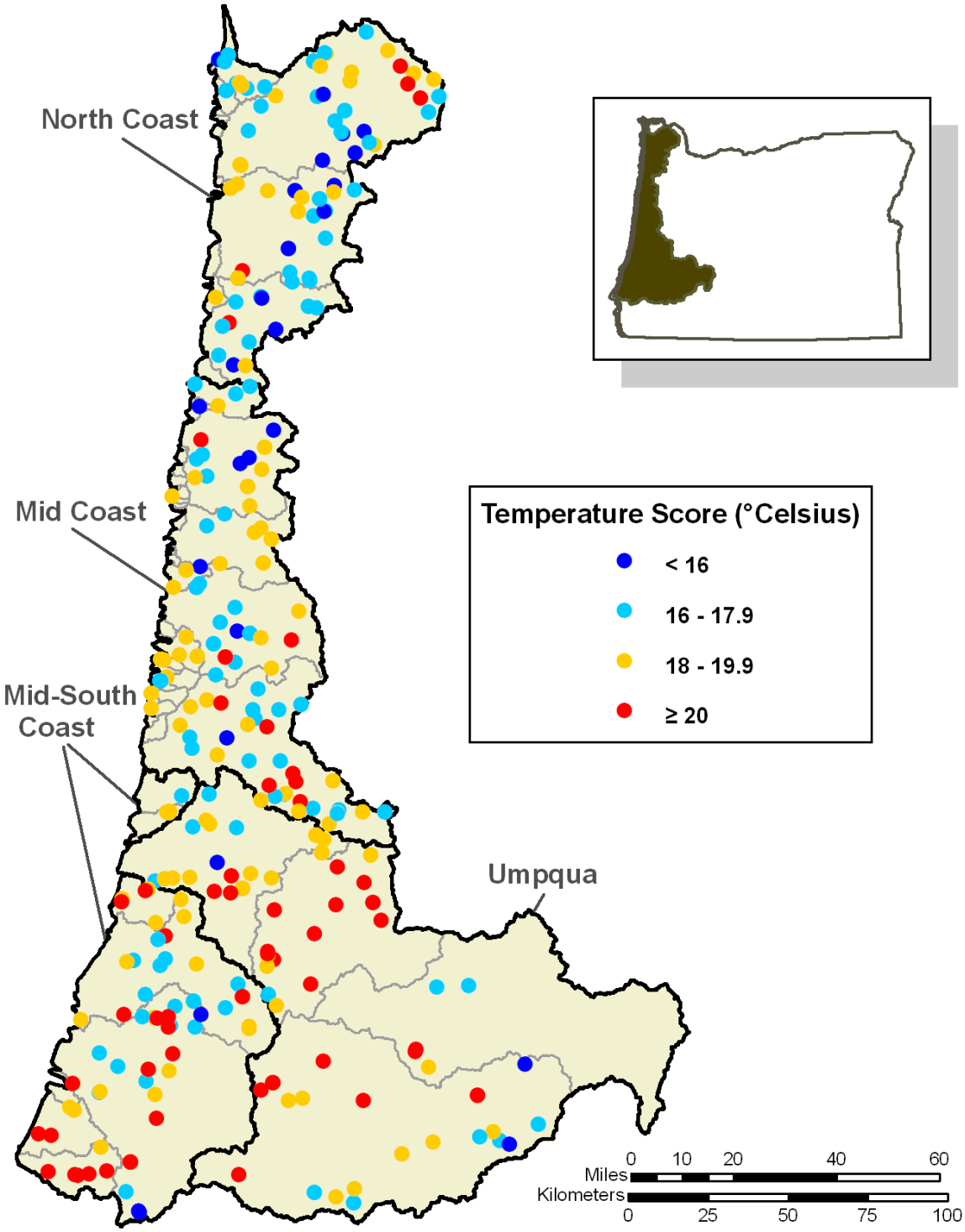

Figure 3. A map of the Coastal Coho ESU displaying macroinvertebrate assemblage preferences for temperature (Temperature Score) at survey sites. For sites with multiple samples, TS were averaged. Monitoring areas are outlined in black, and populations are outlined in grey.

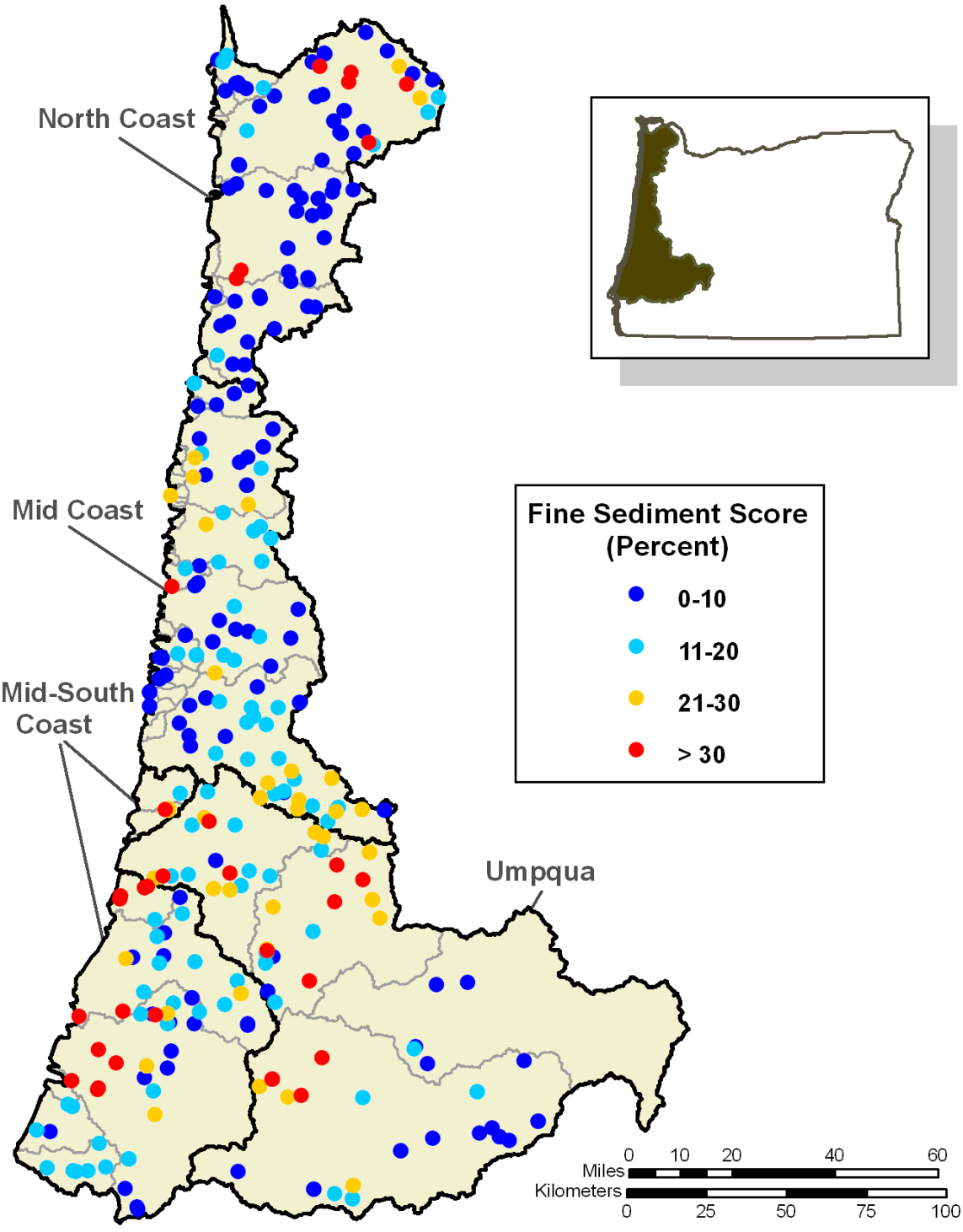

Figure 4. A map of the Coastal Coho ESU displaying macroinvertebrate assemblage preferences for fine sediments (Fine Sediment Score) at survey sites. For sites with multiple samples, FSS were averaged. Monitoring areas are outlined in black, and populations are outlined in grey.

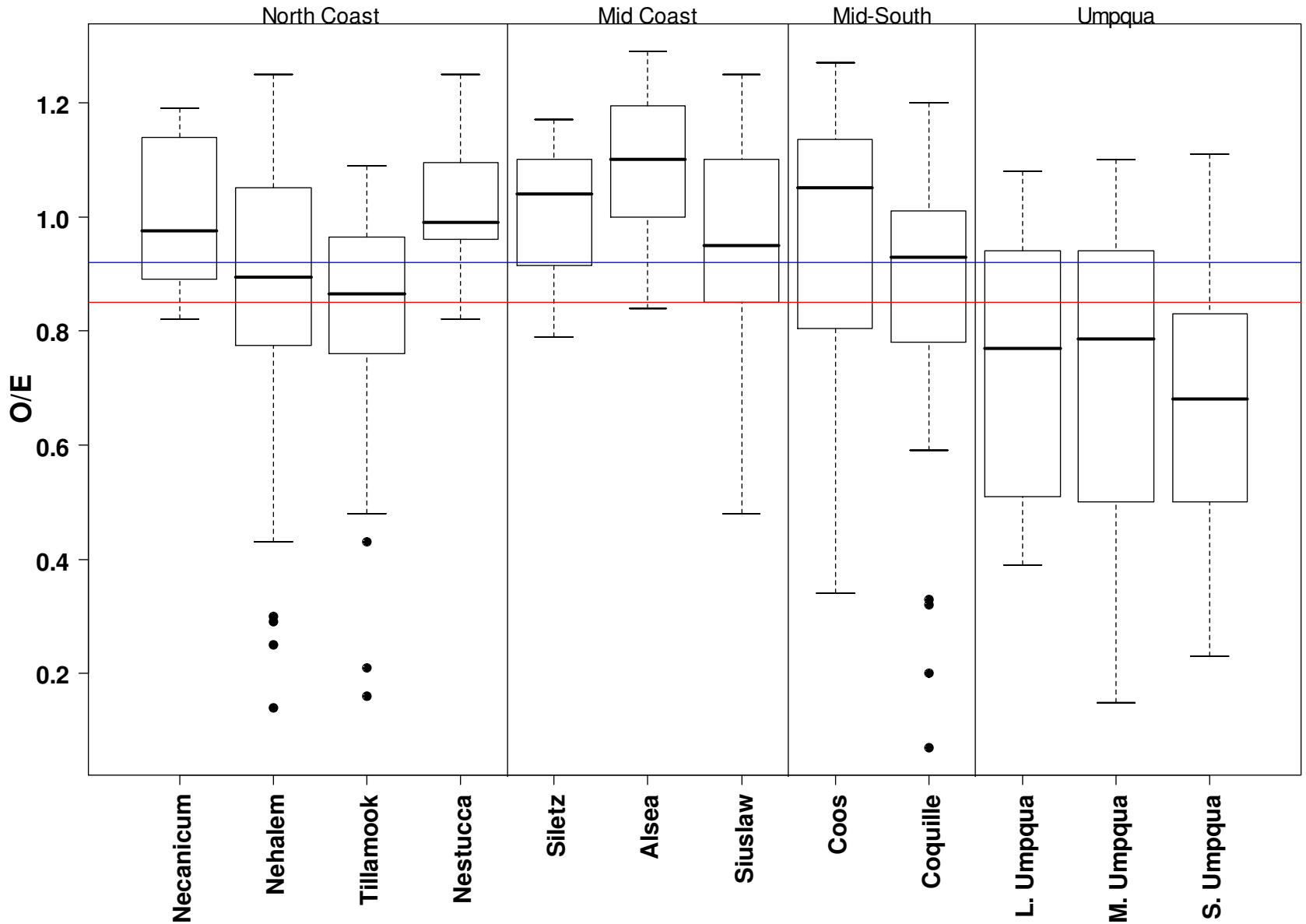

Figure 5. Summary results of O/E for independent populations in the Coastal Coho ESU with at least ten samples. Boxplots show the median (horizontal band), interquartile range (boxes), non-outlier range (dashed lines and hashes), and outliers (black circles). "O/E" is the ratio of observed reference taxa to expected reference taxa from the PREDATOR model.

Stressor Indices—Temperature and Fines

The Necanicum and Nestucca macroinvertebrate assemblages had the lowest overall temperature preferences with more than seventy-five percent of samples below the 18 ^{o}C benchmark (Figure 6). All populations in the North Coast had median TS less than 18 ^{o}C. Outside of the North Coast, only the Alsea had median TS (17.9 ^{o}C) below this benchmark. In addition, the variability in temperature stress also showed an increasing trend from north to south (except for the Lower Umpqua, which was one of the populations with the least variability). The Middle Umpqua showed the highest temperature stress of any population in the Coho ESU, with greater than half of samples showing macroinvertebrate assemblage preferences above the 20 ^{o}C benchmark.

Similar trends were observed in the fine sediment stressor scores among each of the assessed populations (Figure 7). In general, median stressor values for sediment showed an increasing trend from northern populations to southern populations. Also, variability (IQR) tended to increase from north to south. The Nehalem and Tillamook populations had several outlier samples. All of the North Coast populations and the Siletz and Alsea populations in the Mid-Coast had more than half of samples with fine sediment stressor scores below the lowest benchmark (0-10%). The Middle Umpqua population had macroinvertebrate assemblages with the highest fine sediment preferences (median FSS = 23).

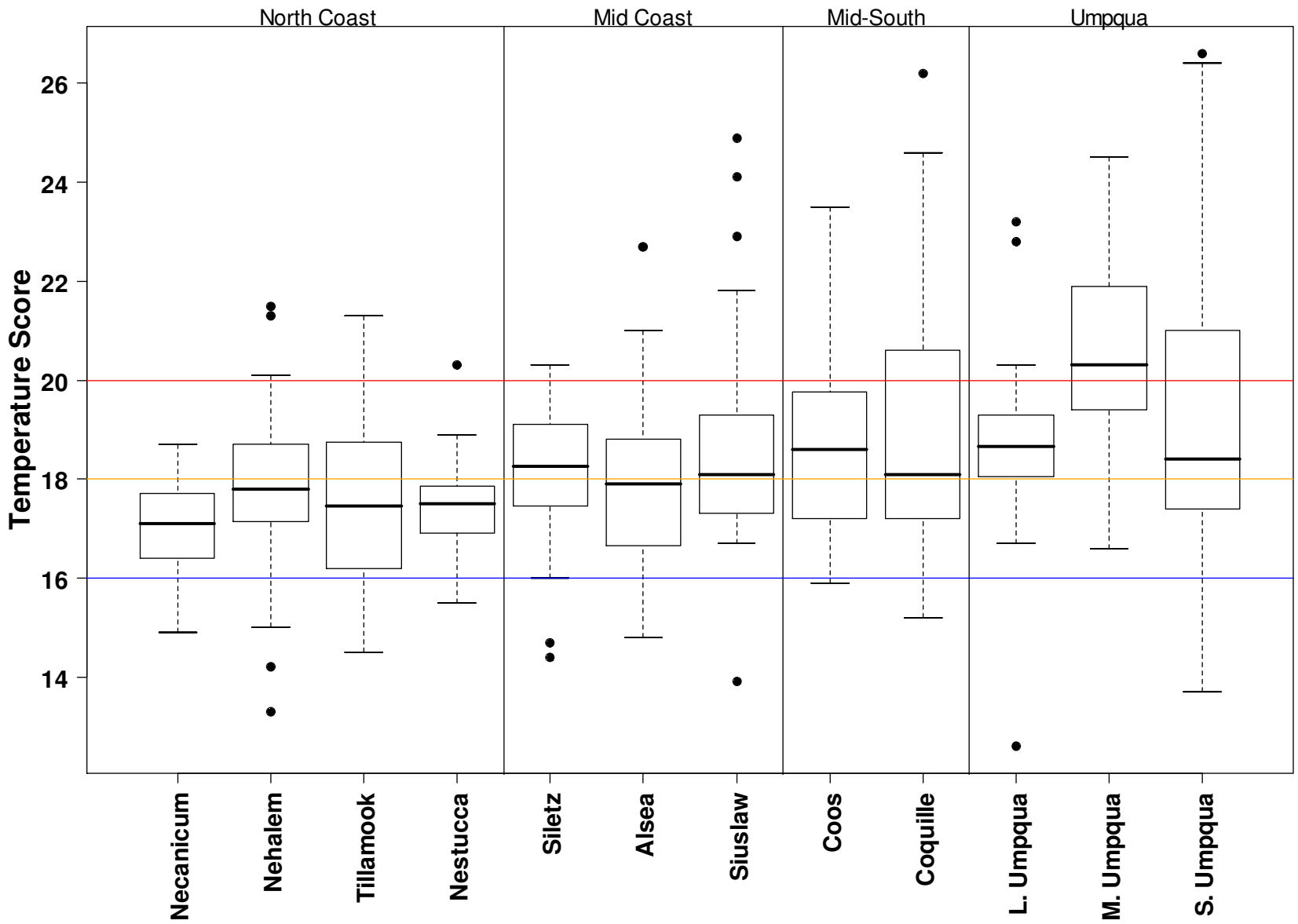

Figure 6. Summary results of temperature Stressor ID for independent populations in the Coastal Coho ESU with at least ten samples. Boxplots show the median (horizontal band), interquartile range (boxes), non-outlier range (dashed lines and hashes), and outliers (black circles). "Temperature Score" is the inferred temperature preference of macroinvertebrate assemblages based on weighted averaging of taxa abundances and temperature optima.

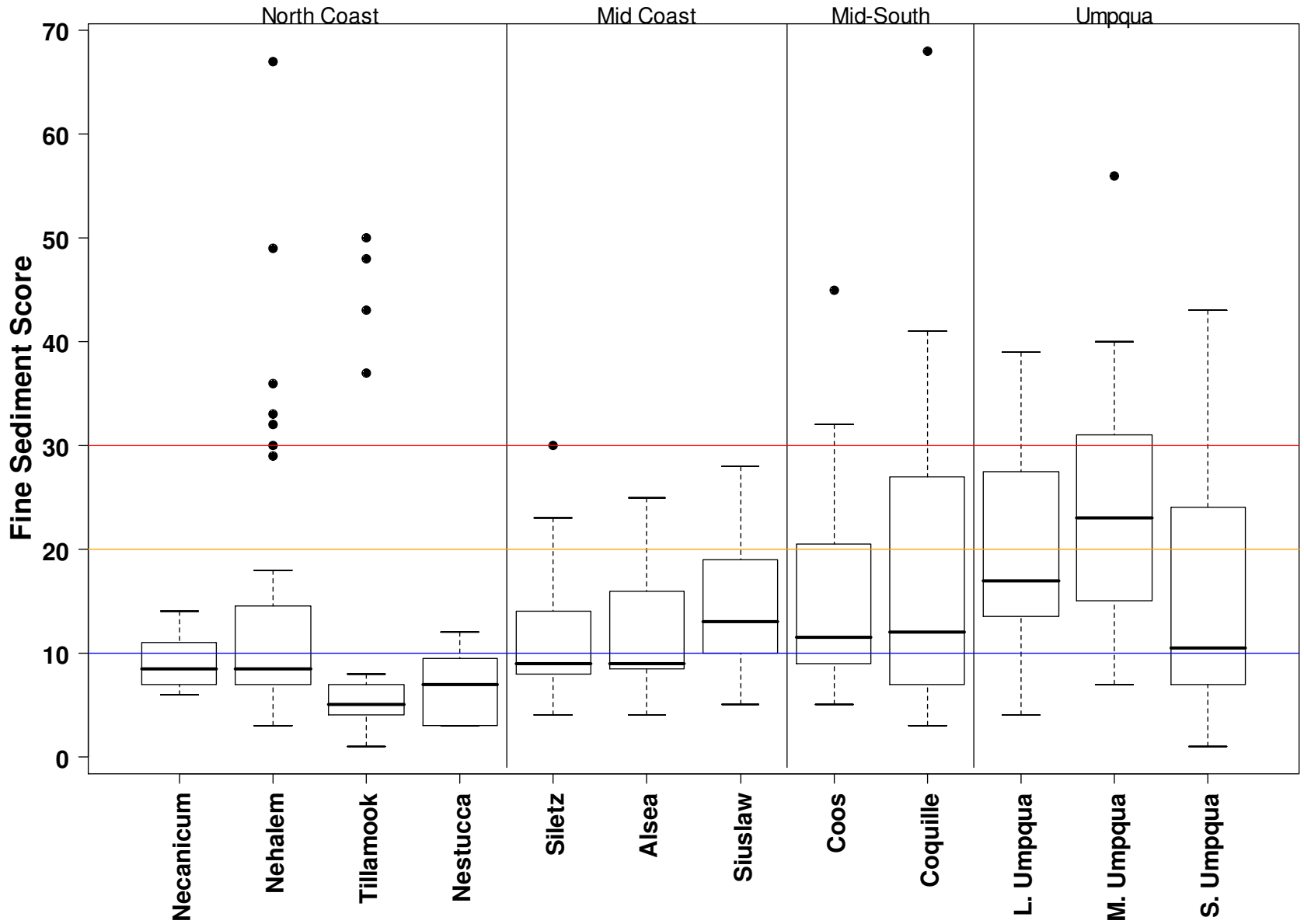

Figure 7. Summary results of the fine sediment Stressor ID index for independent populations in the Coastal Coho ESU with at least ten samples. Boxplots show the median (horizontal band), interquartile range (boxes), non-outlier range (dashed lines and hashes), and outliers (black circles). "Fine Sediment Score" is the inferred fine sediment preference of macroinvertebrate assemblages based on weighted averaging of taxa abundances and temperature optima.

Discussion

Outliers

Future assessments of these data should involve a careful examination of individual samples flagged as potential outliers due to low overall macroinvertebrate abundances (< 200 individuals). Low total abundances can greatly affect the biological indices, especially O/E which can be considered a measure of taxonomic completeness. Sample abundances are highly correlated with taxonomic richness, thus a sample with low abundances is likely to have low richness and result in low score.

Samples identified as a potential outliers due to low abundances need to be verified by project managers or field staff as to whether the protocols were followed closely, whether the sample was anomalous in any way (low total sample area due to a lack of habitat, unfavorable habitat features such as bedrock, and overall level of human disturbances in the watershed). The main reason to exclude a sample from analyses would be due to deviations from the sampling protocol.

Biological condition and stress

A stronger correlation between biological condition (O/E) and fine sediment stress (FSS) is consistent with previous analyses performed in the Coastal Coho ESU as part of the Oregon Plan (ODEQ 2005). We also observed similar results in analyses of macroinvertebrate data collected as part of the Malheur Basin TMDL (unpublished). At least biologically, there seems to be a more significant effect on biological condition due to increased sedimentation than high temperatures. However, a greater emphasis is placed on temperature for monitoring and resource management plans. Currently, fine sediment has a loosely defined narrative water quality criteria, while temperature has a highly specified and more easily applied water quality criteria.

Several general trends were observed in the assessment of the macroinvertebrate data collected by ODFW crews during 2006 and 2007 in the Coastal Coho ESU. Biological condition (O/E) was highest in the Mid Coast and lowest in the Umpqua. The only populations in the North Coast, Mid Coast, and Mid South Coast that didn't have a majority of samples in least disturbed condition were the Nehalem and Tillamook Bay populations. Based on the stressor scores it appears that this may be more related to issues with sedimentation than with temperature. These two populations also had several samples identified as potential outliers for O/E and FSS, and the possible reasons why these sites are flagged should be explored. In the Umpqua, the majority of samples in each population were in most disturbed condition.

A similar trend was observed when assessing the indices of temperature (TS) and fine sediment stress (FSS). Macroinvertebrate assemblages in the Umpqua monitoring area consistently showed higher preferences for temperature and fine sediment. The Mid-South Coast showed slightly higher TS and FSS scores than the North Coast and Mid Coast monitoring areas. Perhaps the best method to determine if these macroinvertebrate assemblage preferences represent a shift away from natural conditions, and are

representative of stress induced by human activities, is to compare these results to the preferences of assemblages at reference sites (see below).

Assessment benchmarks

The choice of assessment benchmarks varied from the PREDATOR to Stressor ID indices. PREDATOR benchmarks were established from the O/E scores at reference sites used to build the models. Sites in the Coast Range and Willamette Valley were assessed only by reference O/E scores in these ecoregions. Sites in the Klamath Mountains and Cascades were assessed only by reference O/E scores in these ecoregions. On the other hand, the Stressor ID models used benchmarks established for other purposes (TS = DEQ water quality standards, FSS = benchmarks used in previous Coastal Coho ESU assessments). These stock benchmarks may not adequately reflect the natural conditions within the Coastal Coho ESU.

Ultimately, I feel the best approach would be to establish ecoregion benchmarks for each of the Stressor ID models. The benchmarks would be based on the distribution of TS and FSS values for reference sites within each ecoregion. The Stressor ID models were constructed with a dataset covering the entire state of Oregon. We routinely observe different temperature and sediment regimes among ecoregions, yet it would be inappropriate to break out reference sites by ecoregion from the statewide model. Instead, independent ecoregion models would be required to establish these more appropriate benchmarks. Exploratory analyses show that models for the Coast Range and Cascades ecoregions would improve model performance (reduced RMSE). I recommend that future work should include creation of Stressor ID model for all four Level III Ecoregions in the Coastal Coho ESU (Coast Range, Willamette Valley, Cascades, and Klamath Mountains). The limiting factor may be the existence of sufficient sample sizes of paired macroinvertebrate and temperature/fine sediment data.

Future assessments

The sites sampled in this study were selected via a probabilistic (random) sampling design. The greatest strengths of a random design are the reduction in bias in the sample population and the ability to report the extent of the target population in each condition class with known statistical confidence. Unfortunately, the random site weights which allow for the calculation of extent and confidence estimates were not available for this report. Inclusion of site weights in these analyses would allow for improved confidence in the results.

In addition to incorporating the random site weights, it would be useful to explore the relationships among the macroinvertebrate biological indices and habitat and fish data collected by ODFW crews. If significant relationships are observed between the macroinvertebrate assemblages and metrics representing salmonid condition, we could strengthen future assessments in the Coastal Coho ESU. To this end, I recommend that ODFW and ODEQ monitoring staff work together on the next round of assessments.

Literature Cited

Cleveland, W. S. (1981) LOWESS: A program for smoothing scatterplots by robust locally weighted regression. *The American Statistician*, **35**, 54.

ODEQ. 2004. Mode of Operations Manual. Oregon Department of Environmental Quality. http://www.deq.state.or.us/lab/qa/DEQ03-LAB-0036-SOP.pdf

ODEQ. 2005. *Oregon Plan for Salmon and Watersheds Oregon Coastal Coho Assessment Water Quality Report.* Prepared by Department of Environmental Quality. March 6, 2005. http://nrimp.dfw.state.or.us/OregonPlan/default.aspx?p=152&path=ftp/reports/Final%20Reports/Agency%20Reports/ODEQ&title=&link=#

Drake, Doug. 2004. Selecting Reference Condition Sites – An Approach for Biological Criteria and Watershed Assessment. DEQ Technical Report WASO4-002. Portland, OR

Hubler, S. 2008. PREDATOR: Development and use of RIVPACS-type macroinvertebrate models to assess the biotic condition of wadeable Oregon streams. DEQ08-LAB-0048-TR.

Huff D.D., S. Hubler, Y. Pan, and D. Drake. 2006. Detecting Shifts in Macroinvertebrate Community Requirements: Implicating Causes of Impairment in Streams. Oregon Department of Environmental Quality. DEQ06-LAB-0068-TR.

State of Oregon. Primary author. Jay Nicholas. *The Oregon plan : Oregon Coastal Salmon Restoration Initiative.* March 1997. http://ir.library.oregonstate.edu/dspace/handle/1957/4983

State of Oregon. Oregon Department of Fish and Wildlife. *Oregon Coastal Coho Assessment.* Primary authors: Jay Nicholas, Bruce McIntosh and Ed Bowles. May 6, 2005. http://nrimp.dfw.state.or.us/OregonPlan/

State of Oregon. Oregon Department of Fish and Wildlife. *Oregon Coast Coho Conservation Plan For the State of Oregon*. Prepared by the Oregon Department of Fish and Wildlife. February 26, 2007. http://www.wrd.state.or.us/OPSW/cohoproject/coho_proj.shtml

Appendix 1. Biological indices results by sampling location.

Table 4. Biological indices results for individual samples within the Coastal Coaho ESU. "Area" refers to ODFW monitoring units. "Populations" refer to unique independent and dependent river/stream basins that support coho populations. "SVN" refers to DEQ's tracking number for a given sample. "Count" is the total number of macroinvertebrates from the laboratory sub-sample. "O/E" is the observed to expected ratio derived from the PREDATOR model. "TS" and "FSS"are the temperature score and fine sediment score (respectively) derived from the Stressor ID model.

Area	Population	Site name	SVN	Count	O/E	TS	FSS
NC	Ecola	Ecola Cr, N Fk	06098DFWa	401	0.91	17.5	6
NC	Ecola	Ecola Cr, N Fk	06098DFW	556	0.91	16.7	5
NC	Necanicum	Bergsvik Cr at RM 0.50 US of Joe Cr	07038DFW	556	0.96	17.7	11
NC	Necanicum	Little Muddy Cr	07022DFW	**140**	0.89	16.1	6
NC	Necanicum	Little Muddy Cr	06099DFW	534	1.14	14.9	7
NC	Necanicum	Mail Cr at Mouth	07054DFW	322	0.99	16.7	6
NC	Necanicum	Neawanna Cr	06103DFW	525	1.15	16.4	11
NC	Necanicum	Necanicum R	06100DFW	563	0.82	18.7	8
NC	Necanicum	Necanicum R SF (RM 1.71) Trib at Mouth	07037DFW	523	1.19	16.9	7
NC	Necanicum	SF Necanicum River	06097DFW	549	1.03	18.5	9
NC	Necanicum	Williamson Cr at RM 0.13	07051DFWd	540	0.92	17.3	13
NC	Necanicum	Williamson Cr at RM 0.13	07051DFW	560	0.86	17.4	14
NC	Nehalem	Belding Cr	06096DFW	547	0.75	13.3	3
NC	Nehalem	Beneke Cr	06106DFW	601	1.08	18.2	6
NC	Nehalem	Bull Heifer Cr at Mouth	07043DFW	581	0.99	17.5	6
NC	Nehalem	Buster Cr	06110DFW	202	0.64	18.3	32
NC	Nehalem	Cow Cr at RM 1.51	07034DFW	551	0.89	17.6	5
NC	Nehalem	Crooked Cr at RM 1.40	07045DFW	**119**	0.29	21.3	49
NC	Nehalem	Deer Cr at RM 0.34	07044DFW	237	0.43	20.1	29
NC	Nehalem	Derby Cr at RM 0.16	07035DFW	554	0.95	14.2	3
NC	Nehalem	Fishhawk Cr	06108DFW	454	0.90	17.9	8
NC	Nehalem	Foley Cr	06102DFW	594	0.77	18.9	5
NC	Nehalem	Foley Cr at RM 1.86	07042DFWa	483	0.84	19.4	10
NC	Nehalem	Foley Cr at RM 1.86	07042DFWa/d	566	0.84	18.8	8
NC	Nehalem	Foley Cr at RM 1.86	07042DFW	606	0.89	19.2	9
NC	Nehalem	Ford Cr	06111DFW	576	0.86	18.8	9
NC	Nehalem	Hamilton Cr	06107DFW	567	1.25	17.3	7
NC	Nehalem	Hamilton Creek at River Mile 1.7	07001DFW	546	1.19	17.3	8
NC	Nehalem	Kenusky Cr	06113DFW	565	0.78	17.0	16
NC	Nehalem	Kenusky Cr	06113DFWa	578	0.97	17.5	18
NC	Nehalem	Lousignont Cr at RM 1.06 US of NF Lousignont Cr	07046DFW	**115**	0.81	18.6	16
NC	Nehalem	Lousignont Cr, N Fk	06123DFW	**195**	0.76	17.8	33
NC	Nehalem	Moores Cr	06104DFW	264	1.03	15.2	7
NC	Nehalem	Nehalem R E Fk Trib (S bank at RM 7.1) at Mouth	07139DFWa	545	1.02	17.5	11
NC	Nehalem	Nehalem R E Fk Trib (S bank at RM 7.1) at Mouth	07139DFW	586	1.07	17.4	10
NC	Nehalem	Nehalem R Little NF at RM 2.23	07039DFW	563	0.96	18.5	8
NC	Nehalem	Nehalem R, E Fk	06115DFW	**8**	0.14	21.5	30
NC	Nehalem	Oak Ranch Cr	06114DFW	558	1.09	18.3	9

NC	Nehalem	Oak Ranch Cr	06112DFWd	559	1.00	18.8	9
NC	Nehalem	Oak Ranch Cr	06112DFW	628	0.95	18.4	8
NC	Nehalem	Rack Heap Cr at RM 1.25	07040DFW	**197**	0.94	17.0	13
NC	Nehalem	Rock Cr, S Fk	06095DFW	545	1.11	15.0	7
NC	Nehalem	Rock Cr, S Fk	06093DFW	561	0.83	17.7	6
NC	Nehalem	Rock Cr, S Fk	06093DFWa	600	0.88	17.7	5
NC	Nehalem	Sager Cr	06109DFW	303	0.30	18.6	36
NC	Nehalem	Soapstone Cr	06101DFW	563	1.17	17.9	6
NC	Nehalem	South Fork Rock Creek at headwaters (Nehalem)	07013DFW	525	0.81	17.8	7
NC	Nehalem	Trib to Gilmore Cr (Nehalem)	06105DFW	**125**	0.25	19.0	67
NC	Nehalem	Weed Cr	06094DFW	486	1.20	16.4	8
NC	Nehalem	Weed Cr	06094DFWd	504	1.15	16.6	9
NC	Nehalem	Weed Cr	06094DFWa	602	1.15	16.5	8
NC	Nehalem	Wolf Cr at RM 3.26 US of NF Wolf Cr	07036DFW	569	0.57	15.4	10
NC	Nestucca	Bays Cr	07017DFW	553	1.06	16.9	3
NC	Nestucca	Bays Cr	07017DFWd	587	1.13	16.9	3
NC	Nestucca	Bays Cr (RM 0.98) Trib at Mouth	07050DFW	575	1.25	15.6	7
NC	Nestucca	Buelah Cr (RM 1.90) Trib at Mouth	07052DFW	246	0.99	15.6	5
NC	Nestucca	Crazy Cr at RM 0.07	07033DFW	560	0.93	17.6	3
NC	Nestucca	Elk Creek at mouth (Nestucca)	07011DFW	546	0.94	17.5	3
NC	Nestucca	Elk Creek at mouth (Nestucca)	07011DFWd	575	0.99	17.2	3
NC	Nestucca	Judson Cr (Little Nestucca R)	07047DFW	352	1.12	15.5	10
NC	Nestucca	Kellow Cr	06087DFW	570	0.96	17.2	12
NC	Nestucca	Louie Cr	06086DFWa	442	0.98	18.9	10
NC	Nestucca	Louie Cr	06086DFW	519	1.13	18.9	9
NC	Nestucca	Nestucca R at RM 40.05	07057DFW	554	0.82	17.8	4
NC	Nestucca	Sanders Cr (Smith Cr)	06084DFW	533	1.07	17.8	9
NC	Nestucca	Three Rivers	06085DFW	683	0.96	20.3	9
NC	Nestucca	West Cr	06092DFW	692	1.01	17.9	10
NC	Sand	Jewel Cr at RM 0.99	07032DFW	569	0.83	18.7	10
NC	Tillamook	Ben Smith Cr (Wilson)	07009DFW	**151**	0.85	17.7	5
NC	Tillamook	Ben Smith Cr (Wilson)	06117DFW	573	0.94	16.6	8
NC	Tillamook	Bill Cr at RM 0.59	07048DFW	529	0.94	17.2	6
NC	Tillamook	Boundary Cr	06083DFW	563	0.94	16.3	4
NC	Tillamook	Boundary Cr at Mouth	07031DFW	557	1.05	17.1	6
NC	Tillamook	Cedar Cr	06118DFW	589	0.85	18.1	4
NC	Tillamook	Cedar Cr (RM 2.88) Trib at RM 0.92	07049DFW	544	0.85	15.7	3
NC	Tillamook	Cedar Cr (RM 2.88) Trib at RM 0.92	07049DFWa	653	0.80	14.5	1
NC	Tillamook	Clear Cr tributary	06121DFW	576	1.05	16.9	4
NC	Tillamook	Devils Lake Fork Wilson River at mouth	07006DFW	324	0.86	19.6	4
NC	Tillamook	Elk Cr	06120DFW	621	1.09	15.8	3
NC	Tillamook	Joe Cr	06091DFW	316	0.16	21.3	43
NC	Tillamook	Jordan Cr	06122DFW	512	1.04	15.4	4
NC	Tillamook	Jordan Cr	06116DFWa	575	0.71	18.5	8
NC	Tillamook	Jordan Cr	06116DFW	607	0.76	18.4	6
NC	Tillamook	Jordan Cr	06116DFWad	648	0.57	18.2	8
NC	Tillamook	Jordan Cr at RM 3.69	07056DFW	397	0.91	17.7	4
NC	Tillamook	JORDAN CREEK AT RM 7.52	07010DFW	287	0.76	17.0	4
NC	Tillamook	Kilchis R SF at RM 1.55	07055DFW	549	0.81	19.5	5
NC	Tillamook	Miami R at RM 6.07 US of Peterson Cr	07053DFW	558	0.93	19.2	5
NC	Tillamook	Miami R at RM 7.90	07041DFW	561	0.87	18.7	5
NC	Tillamook	Rawe Cr	06088DFW	545	0.94	14.6	2

NC	Tillamook	Rawe Cr	06088DFWa	548	1.09	14.6	2
NC	Tillamook	Summit Cr, S Fk	06090DFW	573	0.99	16.1	5
NC	Tillamook	Tillamook River	07008DFW	**30**	0.21	20.3	37
NC	Tillamook	Tillamook River	06089DFWa	494	0.43	18.8	50
NC	Tillamook	Tillamook River	06089DFW	511	0.48	19.4	48
NC	Tillamook	Wilson R, Devil'S Lake Fk	06119DFW	576	0.99	17.0	3
MC	Alsea	Alsea R, S Fk	06036DFW	531	0.89	21.0	10
MC	Alsea	Bear Cr	06045DFW	549	1.20	14.8	8
MC	Alsea	Benner Cr at Mouth (Alsea R)	07060DFW	530	1.29	16.7	9
MC	Alsea	Benner Cr at Mouth (Alsea R)	07060DFWa	534	1.24	15.6	8
MC	Alsea	Brush Cr at RM 0.60	07080DFW	530	1.24	16.7	9
MC	Alsea	Cascade Cr NF at Mouth	07059DFW	530	1.04	17.9	10
MC	Alsea	Cascade Cr NF at Mouth	07059DFWa	577	1.10	17.6	9
MC	Alsea	Cedar Cr at Mouth (Five Rivers)	07058DFW	523	0.94	17.9	17
MC	Alsea	Crooked Cr at RM 1.18 (NF Alsea R)	07063DFW	568	1.04	18.7	4
MC	Alsea	Five R (Lobster Cr)	06035DFW	521	0.89	22.7	15
MC	Alsea	Five R (Lobster Cr)	06035DFWa	867	0.84	22.7	20
MC	Alsea	Flynn Cr	06034DFW	509	1.04	18.9	20
MC	Alsea	Lobster Cr	06004DFW	471	1.15	19.4	9
MC	Alsea	NF Salmonberry Creek at RM 0.80 (Alsea)	07004DFW	568	1.10	18.4	14
MC	Alsea	North Fork Green River	07018DFW	543	1.00	16.6	25
MC	Alsea	Scott Cr EF at RM 3.07	07081DFW	525	1.00	18.1	18
MC	Alsea	Trout Cr at RM 3.12	07085DFW	356	1.11	18.0	6
MC	Alsea	Trout Cr, E Fk	06043DFW	501	1.19	15.9	7
MC	Alsea	Trout Cr, E Fk	06043DFWa	520	1.29	16.6	9
MC	Beaver	Beaver Cr NF (RM 6.42) Trib at RM 0.67	07082DFW	563	1.21	16.0	9
MC	Beaver	Beaver Cr NF at RM 3.06	07078DFW	558	0.85	19.0	15
MC	Beaver	Oliver Cr at RM 0.63	07079DFW	524	0.80	18.8	50
MC	Big	Big Cr (Rock Cr Wilderness)	06038DFWa	562	0.90	17.9	7
MC	Big	Big Cr (Rock Cr Wilderness)	07007DFW	568	0.95	18.7	8
MC	Big	Big Cr (Rock Cr Wilderness)	07007DFWd	582	0.89	18.5	7
MC	Big	Big Cr (Rock Cr Wilderness)	06038DFW	600	1.00	18.6	9
MC	Cape	Cape Cr	06015DFW	572	0.95	18.1	10
MC	Cape	Cape Cr	06015DFWa	857	0.95	17.8	8
MC	Cummins	Cummins Cr	06033DFW	524	1.06	19.4	7
MC	Cummins	Cummins Cr at RM 1.94	07077DFWa	559	0.77	18.4	5
MC	Cummins	Cummins Cr at RM 1.94	07077DFW	578	0.77	18.1	5
MC	Devils Lake	Rock Cr Trib (RM 3.84) near mouth	07076DFW	553	1.15	15.6	9
MC	Salmon	Bear Cr	06032DFW	583	1.02	18.1	7
MC	Salmon	Crowley Cr	06066DFW	605	1.19	16.6	12
MC	Salmon	Crowley Cr	06066DFWa	619	1.13	16.5	10
MC	Salmon	Deer Cr at Mouth	07091DFW	566	0.84	16.4	4
MC	Salmon	Salmon R (RM 15.90) Trib at Mouth	07092DFW	544	1.05	17.2	5
MC	Siletz	Buck Cr, E Fk	06026DFW	511	1.07	16.0	7
MC	Siletz	Drift Cr	06041DFW	804	0.82	20.3	9
MC	Siletz	Fourth Of July Cr	06027DFW	485	1.08	19.5	17
MC	Siletz	Little Boulder Cr	06025DFW	558	1.09	14.7	4
MC	Siletz	Mill Cr, N Fk	06028DFWd	491	1.11	17.9	9
MC	Siletz	Mill Cr, N Fk	06028DFW	508	1.04	18.6	9
MC	Siletz	Mill Cr, N Fk	07024DFWd	524	1.04	18.4	8
MC	Siletz	Mill Cr, N Fk	07024DFW	538	1.04	18.7	9
MC	Siletz	Reed Cr at RM 1.1	07075DFW	523	1.01	17.1	11

MC	Siletz	S Roy Cr	06040DFW	719	0.91	18.3	30
MC	Siletz	Sam Cr at RM 6.53	07073DFW	516	1.13	18.2	21
MC	Siletz	Siletz R	06039DFW	482	1.15	14.4	7
MC	Siletz	Siletz R Trib at RM 1.5	07087DFW	507	1.17	17.8	8
MC	Siletz	Siletz R, S Fk	06024DFWa	608	0.79	19.6	8
MC	Siletz	Siletz R, S Fk	06024DFW	621	0.84	19.6	9
MC	Siletz	Stemple Cr	06029DFW	506	0.92	18.1	23
MC	Siuslaw	Bear Cr	06012DFW	666	0.83	18.5	23
MC	Siuslaw	Buck Cr, Trib B	06009DFW	543	0.95	18.6	19
MC	Siuslaw	Buck Creek (Deadwood)	06005DFW	464	1.25	18.0	8
MC	Siuslaw	Chappell Cr	06019DFW	590	1.25	17.6	12
MC	Siuslaw	Clay Cr	06013DFW	502	1.15	18.5	16
MC	Siuslaw	Clay Cr at RM 0.16 (Siuslaw R)	07065DFW	292	1.10	16.9	10
MC	Siuslaw	Collins Cr at RM 0.49 (Siuslaw R)	07066DFW	520	0.48	16.8	17
MC	Siuslaw	Condon Cr	06016DFW	682	0.98	18.3	10
MC	Siuslaw	Divide Cr	06020DFW	413	1.14	16.8	9
MC	Siuslaw	Divide Cr	06021DFW	571	1.13	17.3	10
MC	Siuslaw	Esmond Cr, Trib A	06014DFW	632	0.65	18.1	22
MC	Siuslaw	Farman Cr at RM 2.15	07088DFW	507	0.95	18.6	25
MC	Siuslaw	Fish Cr at RM 4.07	07061DFWa	500	1.19	16.9	9
MC	Siuslaw	Fish Cr at RM 4.07	07061DFW	535	1.14	16.8	9
MC	Siuslaw	Hadsall Cr	06018DFW	541	1.10	19.7	14
MC	Siuslaw	Hawley Cr at RM 3.46	07067DFW	483	0.96	18.0	10
MC	Siuslaw	Hula Cr at Mouth	07070DFW	377	1.05	18.9	13
MC	Siuslaw	Indian Cr	06003DFW	1067	0.79	21.8	20
MC	Siuslaw	Jeans Cr	06010DFW	590	0.85	17.3	19
MC	Siuslaw	Lamb Cr	06006DFW	536	1.14	17.4	11
MC	Siuslaw	Nelson Cr at RM 1.95	07090DFW	550	0.86	20.2	14
MC	Siuslaw	Old Man Cr at Mouth	07069DFW	300	0.93	13.9	10
MC	Siuslaw	Panther Cr	06008DFW	566	0.88	19.7	26
MC	Siuslaw	Porter Cr at RM 3.15	07068DFW	560	0.91	18.5	10
MC	Siuslaw	Potato Patch Cr at RM 0.97	07089DFW	546	0.81	16.7	13
MC	Siuslaw	Raleigh Cr at RM 0.14 (Deadwood Cr)	07062DFW	377	0.91	17.7	11
MC	Siuslaw	Rogers Cr	06002DFW	478	1.00	19.3	7
MC	Siuslaw	Rogers Cr	07023DFWa	535	0.87	18.0	5
MC	Siuslaw	Rogers Cr	07023DFW	546	0.98	18.6	5
MC	Siuslaw	Russell Cr at RM 0.20	07064DFW	313	1.05	19.3	19
MC	Siuslaw	Russell Cr at RM 1.07	07083DFW	554	1.14	17.2	11
MC	Siuslaw	Simpson Cr	06011DFW	502	0.76	17.1	23
MC	Siuslaw	Siuslaw R at RM 57.02	07084DFW	556	0.62	24.1	28
MC	Siuslaw	Siuslaw River at RM 76.2	07014DFW	573	0.79	24.9	23
MC	Siuslaw	Waite Cr (RM 0.93) Trib at RM 0.18	07086DFW	504	0.64	17.6	15
MC	Siuslaw	Wolf Cr	06072DFW	568	0.94	22.9	22
MC	Siuslaw	Wolf Cr	06037DFW	613	0.94	20.4	18
MC	Spencer	Spencer Cr at RM 0.06	07074DFW	513	1.16	19.3	27
MC	Tenmile	Mill Cr	06017DFW	526	1.21	17.0	9
MC	Tenmile	Mill Cr at RM 2.51	07140DFW	569	1.10	16.8	4
MC	Tenmile	Mill Cr at RM 2.51	07140DFWd	579	1.30	16.7	4
MC	Tenmile	Tenmile Creek at River Mile 4.82	07021DFWd	532	0.88	19.8	4
MC	Tenmile	Tenmile Creek at River Mile 4.82	07021DFW	554	0.88	19.1	4
MC	Yachats	Grass Cr	06047DFW	546	1.08	18.7	10
MC	Yachats	Grass Cr	06047DFWa	623	1.13	18.3	11

MC	Yachats	Grass Cr	06047DFWd	642	0.97	19.0	11
MC	Yachats	Winters Cr	06001DFW	564	1.09	18.1	20
MC	Yachats	Yachats R, N Fk	06042DFW	550	0.96	17.5	7
MC	Yachats	Yachats R, N Fk	06042DFWa	602	0.85	18.1	7
MC	Yaquina	Buttermilk Cr at RM 1.40	07072DFW	579	1.19	18.6	13
MC	Yaquina	Klamath Cr	06030DFW	602	1.15	17.8	20
MC	Yaquina	Little Elk Cr at RM 8.18	07071DFWd	569	1.05	19.1	18
MC	Yaquina	Little Elk Cr at RM 8.18	07071DFW	572	0.91	19.2	16
MC	Yaquina	Oglesby Cr	06023DFW	534	1.01	18.6	15
MC	Yaquina	Olalla Cr, Trib A	06031DFW	558	1.08	17.6	24
MC	Yaquina	Spout Creek	07005DFW	558	1.03	19.6	14
MC	Yaquina	Spout Creek	06022DFW	1073	0.79	19.2	14
MSC	Coos Bay	Bottom Cr	06044DFW	451	1.27	17.8	13
MSC	Coos Bay	Catching Cr at RM 3.73	07113DFW	**126**	0.34	20.6	45
MSC	Coos Bay	Cedar Cr at RM 2.58 (Williams R)	07093DFW	**108**	0.57	22.2	22
MSC	Coos Bay	Cedar Cr at RM 2.58 (Williams R)	07093DFWa	**132**	0.73	21.3	21
MSC	Coos Bay	Deer Cr at RM 0.96	07116DFW	567	1.08	18.8	8
MSC	Coos Bay	Eight R Cr	06051DFW	564	1.01	15.9	20
MSC	Coos Bay	Elk Cr	06170DFW	220	1.08	19.6	11
MSC	Coos Bay	Millicoma R EF at RM 15.37	07110DFW	302	1.03	19.8	13
MSC	Coos Bay	Packard Cr	06082DFW	531	1.13	16.6	11
MSC	Coos Bay	Schumacher Cr at Mouth US of WF Millicoma Rd	07111DFW	243	1.07	16.1	16
MSC	Coos Bay	Shotgun Cr	06046DFW	517	1.19	16.8	11
MSC	Coos Bay	WF Millicoma River 0.25 MI U/S of hatchery	07003DFW	494	0.88	23.5	9
MSC	Coos Bay	Willanch Cr	06059DFW	656	0.90	18.4	22
MSC	Coos Bay	Willanch Cr, Trib A	06060DFWa	496	0.89	17.3	8
MSC	Coos Bay	Willanch Cr, Trib A	06060DFW	501	1.16	17.1	8
MSC	Coos Bay	Williams R	06074DFW	511	1.10	19.7	9
MSC	Coos Bay	Williams River at River Mile 15 near Mile Post 37	07020DFW	**105**	0.69	19.5	5
MSC	Coos Bay	Winchester Cr, Trib D	06169DFW	538	0.56	19.4	32
MSC	Coos Bay	Woodruff Cr at RM 1.12	07112DFW	548	1.14	17.7	9
MSC	Coos Bay	Wren Smith Cr	06064DFW	574	1.14	17.5	12
MSC	Coquille	Bill Cr	06069DFW	464	0.67	20.3	34
MSC	Coquille	Coquille R NF at RM 30.15	07108DFW	**10**	0.20	19.6	4
MSC	Coquille	Coquille R NF at RM 31	07100DFW	**14**	0.07	26.2	68
MSC	Coquille	Coquille R, N Fk	06062DFW	524	1.13	17.4	6
MSC	Coquille	Coquille R, N Fk	06062DFWa	574	1.18	17.8	7
MSC	Coquille	Crater Cr	06076DFW	589	0.98	16.0	7
MSC	Coquille	Fat Elk Cr	06067DFW	555	0.94	17.8	41
MSC	Coquille	Hudson Cr at RM 3.61	07098DFW	**14**	0.33	21.3	22
MSC	Coquille	Johns Cr	06055DFW	**157**	0.74	18.0	10
MSC	Coquille	Johnson Cr at RM 3.43 US of Poverty Gulch	07119DFW	427	1.01	16.4	3
MSC	Coquille	Kausen Cr	06081DFW	536	0.98	17.2	33
MSC	Coquille	King Cr	06054DFW	344	1.17	18.9	11
MSC	Coquille	Lake Cr at RM 0.16	07117DFW	**35**	0.32	15.2	5
MSC	Coquille	Lost Cr at RM 0.05 (Middle Cr)	07099DFW	230	1.13	17.7	7
MSC	Coquille	Middle Cr	06052DFW	385	0.98	20.6	11
MSC	Coquille	Middle Cr at RM 21.72	07097DFW	385	1.20	17.1	6
MSC	Coquille	Moon Cr	06061DFW	397	1.14	16.7	15
MSC	Coquille	Myrtle Cr	06048DFW	554	0.81	24.6	27
MSC	Coquille	S. Fk. Elk Cr	06053DFW	551	0.94	19.5	10
MSC	Coquille	Salmon Cr	06056DFWd	505	0.91	20.8	12

MSC	Coquille	Salmon Cr	06056DFWa	507	0.80	21.0	14
MSC	Coquille	Salmon Cr	06056DFW	541	0.96	20.2	12
MSC	Coquille	Steel Cr at Mouth (EF Coquille R)	07101DFW	534	0.78	20.6	10
MSC	Coquille	Ward Cr	06049DFW	541	0.59	18.1	34
MSC	Coquille	Ward Cr at RM 2.55	07094DFWa	402	0.82	16.2	29
MSC	Coquille	Ward Cr at RM 2.55	07094DFW	536	0.82	16.5	32
MSC	Coquille	Weekly Cr at RM 0.11 (EF Coquille R)	07096DFW	541	0.93	19.8	20
MSC	Coquille	Weekly Cr at RM 0.11 (EF Coquille R)	07096DFWd	557	0.93	20.6	22
MSC	Coquille	Woodward Cr (RM 3.90) Trib at RM 0.60	07109DFW	305	1.09	17.4	13
MSC	Floras	Floras Cr at RM 2.69	07104DFW	**67**	0.58	21.8	19
MSC	Floras	Floras Creek at Mormon Camp	07012DFW	**67**	0.49	21.5	7
MSC	Floras	Fourmile Cr	06050DFW	555	0.94	18.9	12
MSC	Floras	Fourmile Cr	06050DFWa	571	0.94	19.0	9
MSC	Floras	Fourmile Cr at RM 7.78	07095DFW	**51**	0.59	19.0	19
MSC	Siltcoos	Billy Moore Cr	06073DFW	587	1.17	16.9	14
MSC	Sixes	Sixes Cr	06057DFW	509	0.60	21.4	12
MSC	Sixes	Sixes R	06077DFW	575	0.80	20.5	13
MSC	Sixes	Sixes R at RM 17.0 US of Elephant Rock Cr	07103DFW	569	0.81	21.9	19
MSC	Sixes	Sixes R at RM 20.28 DS of Big Cr	07118DFW	276	0.71	22.2	14
MSC	Sixes	Sixes R at RM 25.29	07102DFW	450	0.85	22.5	11
MSC	Sixes	Sixes R, N Fk	06075DFW	494	0.37	18.4	16
MSC	Tahkenitch	Bell Cr	06071DFW	556	0.56	19.2	30
MSC	Tahkenitch	Fivemile Cr	06070DFW	551	0.87	18.1	25
MSC	Tahkenitch	Fivemile Cr	07025DFW	561	0.41	19.9	32
MSC	Tahkenitch	Fivemile Cr at Mouth	07114DFW	421	0.81	18.4	21
MSC	Tenmile	Eel Cr	06080DFW	522	0.54	18.9	39
MSC	Tenmile	Eel Cr at RM 0.60	07115DFW	218	0.32	20.4	61
MSC	Tenmile	Johnson Cr at RM 6.0	07107DFW	533	0.51	18.9	19
MSC	Tenmile	Murphy Cr at RM 1.20	07105DFW	**36**	0.23	22.8	40
MSC	Tenmile	Murphy Cr at RM 1.86	07106DFW	297	0.78	19.3	32
UMP	L. Umpqua	Blackwell Cr at Mouth	07127DFW	**74**	0.84	17.5	15
UMP	L. Umpqua	Camp Cr	06141DFW	238	0.63	22.8	29
UMP	L. Umpqua	Camp Cr at RM 2.12	07125DFW	442	0.48	23.2	26
UMP	L. Umpqua	Charlotte Cr	06132DFW	**109**	0.74	19.3	11
UMP	L. Umpqua	Dean Cr	06133DFW	529	0.94	18.4	15
UMP	L. Umpqua	Dry Cr	06135DFW	575	0.61	17.6	27
UMP	L. Umpqua	Elk Cr	06143DFW	255	0.80	18.5	19
UMP	L. Umpqua	Elk Cr	06143DFWa	426	0.94	18.1	21
UMP	L. Umpqua	Little Mill Cr at RM 3.65	07134DFW	**66**	0.43	12.6	4
UMP	L. Umpqua	Little Paradise Cr at RM 1.30	07135DFW	259	1.00	18.8	13
UMP	L. Umpqua	Lutsinger Cr	06140DFW	549	0.94	20.3	11
UMP	L. Umpqua	Lutsinger Cr	07026DFW	582	0.99	19.9	15
UMP	L. Umpqua	Miller Cr	06134DFWa	629	0.40	18.8	32
UMP	L. Umpqua	Miller Cr	06134DFW	634	0.47	18.0	28
UMP	L. Umpqua	Peach Cr at RM 1.30 (W Branch NF Smith R)	07129DFW	**94**	0.54	16.7	12
UMP	L. Umpqua	Purdy Cr	06139DFW	**68**	0.61	20.2	39
UMP	L. Umpqua	Railroad Cr	06142DFW	519	1.08	18.0	13
UMP	L. Umpqua	Scott Cr at RM 0.18	07136DFW	**169**	0.86	18.2	14
UMP	L. Umpqua	Smith R	06145DFW	469	0.64	18.8	30
UMP	L. Umpqua	Smith R, S Fk	06144DFW	543	0.94	19.3	20
UMP	L. Umpqua	Spencer Cr (RM 2.41) Trib at RM 0.23	07131DFW	326	0.39	18.9	32
UMP	L. Umpqua	Spencer Cr NF Trib at Mouth	07126DFW	564	0.46	18.2	26

UMP	L. Umpqua	Upper South Fork Smith River	07016DFWa	552	1.00	19.3	15
UMP	L. Umpqua	Upper South Fork Smith River	07016DFW	562	0.90	18.5	14
UMP	M. Umpqua	Bear Cr	06125DFW	514	0.91	16.6	7
UMP	M. Umpqua	Billy Cr SF at Mouth	07128DFW	435	0.50	21.9	40
UMP	M. Umpqua	Burke Cr	06149DFW	**53**	0.15	23.3	56
UMP	M. Umpqua	Camp Cr	06124DFW	209	0.91	18.1	11
UMP	M. Umpqua	Elk Cr at RM 41.20	07120DFW	558	0.91	21.0	24
UMP	M. Umpqua	Elk Creek at RM 34.97	07121DFWa	**136**	0.38	24.5	26
UMP	M. Umpqua	Elk Creek at RM 34.97	07121DFW	201	0.43	24.5	21
UMP	M. Umpqua	Hardscrabble Cr	06147DFW	576	0.49	20.2	36
UMP	M. Umpqua	Little Wolf Cr	06136DFW	563	1.05	19.3	17
UMP	M. Umpqua	Little Wolf Creek	07015DFW	231	0.81	20.5	8
UMP	M. Umpqua	Mehl Creek at River Mile 0.6 (UMP)	07019DFW	**107**	0.59	21.5	24
UMP	M. Umpqua	Miner Cr	06137DFW	530	1.10	19.0	15
UMP	M. Umpqua	Pheasant Cr	06148DFWa	553	1.00	19.4	22
UMP	M. Umpqua	Pheasant Cr	06148DFW	560	0.95	19.5	27
UMP	M. Umpqua	Wehmeyer Cr	06146DFW	529	0.57	20.2	31
UMP	M. Umpqua	Wolf Cr	06138DFW	593	0.76	20.4	22
UMP	M. Umpqua	Wolf Cr at RM 3.12 (UMP)	07124DFW	**157**	0.60	22.6	34
UMP	M. Umpqua	Yellow Cr	06126DFW	551	0.94	20.1	12
UMP	N. Umpqua	Cavitt Cr	06167DFW	564	0.72	23.9	18
UMP	N. Umpqua	Cavitt Cr	06168DFW	742	0.53	19.7	8
UMP	N. Umpqua	Cavitt Cr at RM 3.72	07133DFW	215	0.62	24.3	8
UMP	N. Umpqua	Rock Cr (RM 4.70) Trib at RM 0.31	07138DFW	259	1.06	16.3	8
UMP	N. Umpqua	Rock Cr, E Fk	06166DFW	207	0.54	18.0	8
UMP	S. Umpqua	Black Canyon Cr	07028DFW	554	1.02	17.3	5
UMP	S. Umpqua	Black Canyon Cr	06165DFW	751	0.83	18.4	4
UMP	S. Umpqua	Boulder Cr	07030DFW	301	0.68	25.8	15
UMP	S. Umpqua	Boulder Cr	06162DFW	583	0.54	25.5	19
UMP	S. Umpqua	Bull Run Cr	06131DFWa	517	0.73	17.3	11
UMP	S. Umpqua	Bull Run Cr	06131DFW	799	0.82	17.4	16
UMP	S. Umpqua	Byron Cr, N Fk	06127DFW	576	0.54	19.9	28
UMP	S. Umpqua	Clear Cr	07027DFW	**188**	0.64	19.6	24
UMP	S. Umpqua	Clear Cr	06130DFW	630	0.78	18.0	22
UMP	S. Umpqua	Coffin Cr	06161DFW	**174**	0.98	17.3	10
UMP	S. Umpqua	Cow Cr WF at RM 6.53	07123DFW	**151**	0.74	21.0	8
UMP	S. Umpqua	Cow Cr, Fortune Br	06129DFW	506	1.01	18.4	17
UMP	S. Umpqua	Deep Cut Cr	06163DFW	382	1.03	18.9	7
UMP	S. Umpqua	Donegan Cr	06164DFW	607	0.73	13.8	6
UMP	S. Umpqua	Falcon Cr	07029DFWd	553	0.68	18.1	3
UMP	S. Umpqua	Falcon Cr	07029DFW	575	0.73	17.4	4
UMP	S. Umpqua	Falcon Cr	06079DFW	709	0.68	17.6	1
UMP	S. Umpqua	Myrtle Cr N at RM 4.88	07130DFW	625	0.50	25.2	19
UMP	S. Umpqua	Porter Cr	06078DFW	331	0.34	19.7	32
UMP	S. Umpqua	Prong Cr at RM 2.98	07132DFW	**130**	0.53	13.7	3
UMP	S. Umpqua	Roberts Cr at RM 1.12 (South UMP R)	07122DFW	**13**	0.23	22.2	43
UMP	S. Umpqua	SALT Creek at RM 0.64	07002DFW	555	0.93	18.3	10
UMP	S. Umpqua	Sheilds Cr	06160DFW	523	0.50	20.4	29
UMP	S. Umpqua	Stouts Cr WF at RM 2.72	07137DFW	**84**	0.38	18.5	10
UMP	S. Umpqua	Stouts Cr WF at RM 2.72	07137DFWa	**108**	0.57	18.0	8
UMP	S. Umpqua	Tenmile Cr	06150DFWa	541	0.49	26.4	38
UMP	S. Umpqua	Tenmile Cr	06150DFW	552	0.35	26.0	36

UMP	S. Umpqua	Tenmile Cr	06150DFWad	596	0.44	26.6	37
UMP	S. Umpqua	Wood Cr	06128DFW	513	1.11	17.3	7
UMP	S. Umpqua	Wood Cr	06128DFWa	734	1.01	17.0	7

Appendix 2. Relationship between measured and inferred temperature.

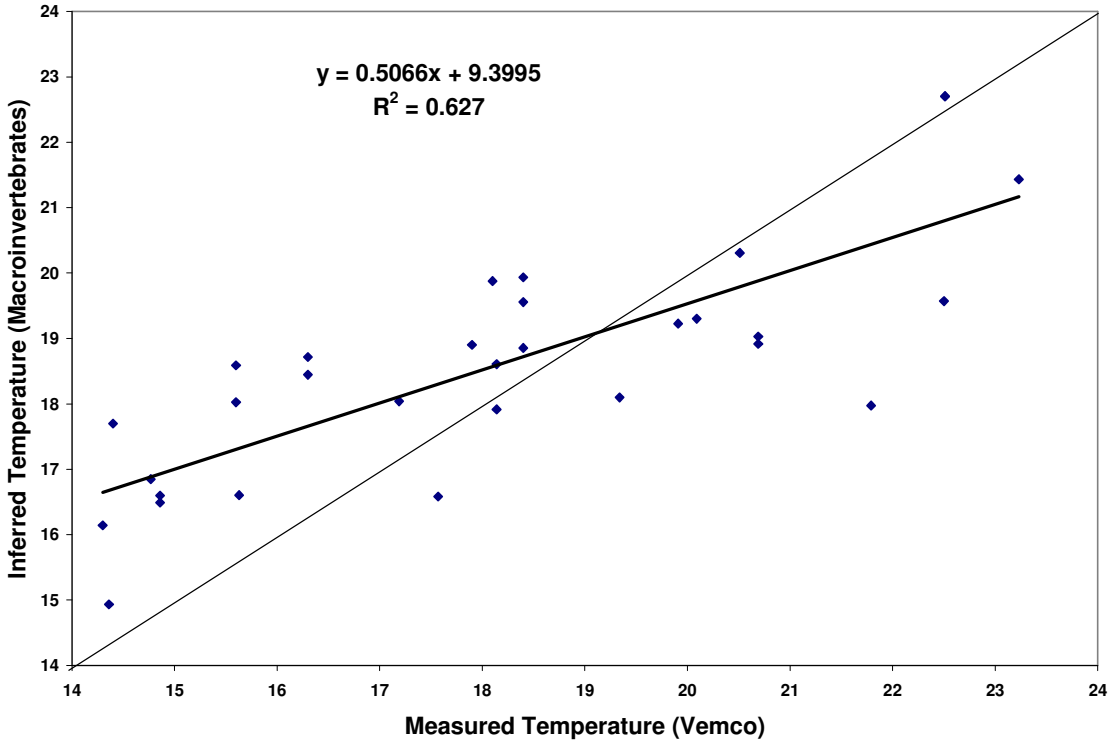

Figure 8. Relationship among inferred temperature values from macroinvertebrate samples and vemcos placed at the same sites by ODFW crews.

Appendix 3. Summary statistics of the biological indices by monitoring area and populations.

Monitoring Areas

Table 5. Summary statistics of PREDATOR O/E scores for each of the four monitoring areas in the Coastal Coho ESU. Scores are color coded to match PREDATOR benchmarks for biological condition (red: ≤ 0.86, orange: 0.86 – 0.91, blue: 0.92 – 1.24, black ≥ 1.25).

	Minimum	1st Quarter	Median	Mean	3rd Quarter	Maximum
North Coast	0.14	0.82	0.94	0.89	1.03	1.25
Mid Coast	0.48	0.89	1.02	1.00	1.13	1.3
Mid-South Coast	0.07	0.59	0.86	0.82	1.06	1.27
Umpqua	0.15	0.53	0.72	0.71	0.94	1.11

Table 6. Summary statistics of temperature scores (TS) for each of the four monitoring areas in the Coastal Coho ESU. Scores are color coded to match DEQ's temperature standard benchmarks (blue: <16 °C, light blue: 16–17.9 °C, orange: 18–19.9 °C, red: ≥20 °C).

	Minimum	1st Quarter	Median	Mean	3rd Quarter	Maximum
North Coast	13.3	16.7	17.6	17.6	18.6	21.5
Mid Coast	13.9	17.2	18.1	18.2	19.0	24.9
Mid-South Coast	15.2	17.6	19.0	19.2	20.6	26.2
Umpqua	12.6	18.0	19.0	19.7	20.5	26.6

Table 7. Summary statistics of fine sediment scores (FSS) for each of the four monitoring areas in the Coastal Coho ESU. Scores are color coded to match benchmarks used for previous assessments of fine sediment condition in the Coastal Coho ESU (blue: 0–10% fines, light blue: 11–20% fines, orange: 21–30% fines, red: > 30% fines).

	Minimum	1st Quarter	Median	Mean	3rd Quarter	Maximum
North Coast	1	5	8	11	10	67
Mid Coast	4	8	10	13	17	50
Mid-South Coast	3	10	14	18	22	68
Umpqua	1	10	16	19	27	56

Populations

Table 8. Summary statistics of PREDATOR O/E scores for each of the four monitoring areas in the Coastal Coho ESU. Scores are color coded to match PREDATOR benchmarks for biological condition (red: ≤ 0.86, orange: 0.86 – 0.91, blue: 0.92 – 1.24, black ≥ 1.25).

Coho Population	Minimum	1st Quarter	Median	Mean	3rd Quarter	Maximum
Necanicum River	0.82	0.90	0.98	1.0	1.11	1.19
Nehalem River	0.14	0.78	0.90	0.86	1.04	1.25
Tillamook Bay	0.16	0.76	0.87	0.82	0.95	1.09
Nestucca River	0.82	0.96	0.99	1.02	1.10	1.25
Siletz River	0.79	0.92	1.04	1.01	1.10	1.17
Alsea River	0.84	1.00	1.10	1.08	1.20	1.29
Siuslaw River	0.48	0.85	0.95	0.95	1.10	1.25
Coos Bay	0.34	0.84	1.05	0.95	1.13	1.27
Coquille River	0.07	0.78	0.93	0.85	1.01	1.20
Lower Umpqua River	0.39	0.53	0.77	0.73	0.94	1.08
Middle Umpqua	0.15	0.52	0.79	0.73	0.93	1.10
South Umpqua	0.23	0.51	0.68	0.68	0.83	1.11

Table 9. Summary statistics of temperature scores (TS) for each of the four monitoring areas in the Coastal Coho ESU. Scores are color coded to match DEQ's temperature standard benchmarks (blue: <16 °C, light blue: 16–17.9 °C, orange: 18–19.9 °C, red: ≥20 °C).

Coho Population	Minimum	1st Quarter	Median	Mean	3rd Quarter	Maximum
Necanicum River	14.9	16.5	17.1	17.1	17.6	18.7
Nehalem River	13.3	17.2	17.8	17.8	18.7	21.5
Tillamook Bay	14.5	16.3	17.5	17.5	18.7	21.3
Nestucca River	15.5	16.9	17.5	17.4	17.9	20.3
Siletz River	14.4	17.6	18.3	18.0	18.9	20.3
Alsea River	14.8	16.7	17.9	18.1	18.8	22.7
Siuslaw River	13.9	17.3	18.1	18.6	19.3	24.9
Coos Bay	15.9	17.3	18.6	18.8	19.7	23.5
Coquille River	15.2	17.2	18.1	19.0	20.6	26.2
Lower Umpqua River	12.6	18.1	18.7	18.8	19.3	23.2
Middle Umpqua	16.6	19.4	20.3	20.7	21.8	24.5
South Umpqua	13.7	17.4	18.4	19.7	20.9	26.6

Table 10. Summary statistics of fine sediment scores (FSS) for each of the four monitoring areas in the Coastal Coho ESU. Scores are color coded to match benchmarks used for previous assessments of fine sediment condition in the Coastal Coho ESU (blue: 0–10% fines, light blue: 11–20% fines, orange: 21–30% fines, red: > 30% fines).

Coho Population	Minimum	1st Quarter	Median	Mean	3rd Quarter	Maximum
Necanicum River	6	7	8	9	11	14
Nehalem River	3	7	9	14	14	67
Tillamook Bay	1	4	5	10	7	50
Nestucca River	3	3	7	7	10	12
Siletz River	4	8	9	12	13	30
Alsea River	4	9	9	12	16	25
Siuslaw River	5	10	13	15	19	28
Coos Bay	5	9	12	15	20	45
Coquille River	3	7	12	18	27	68
Lower Umpqua River	4	14	17	20	27	39
Middle Umpqua	7	16	23	24	30	56
South Umpqua	1	7	11	16	24	43