Water Quality in the Coos Estuary and Lower Coos Watershed: Physical Factors

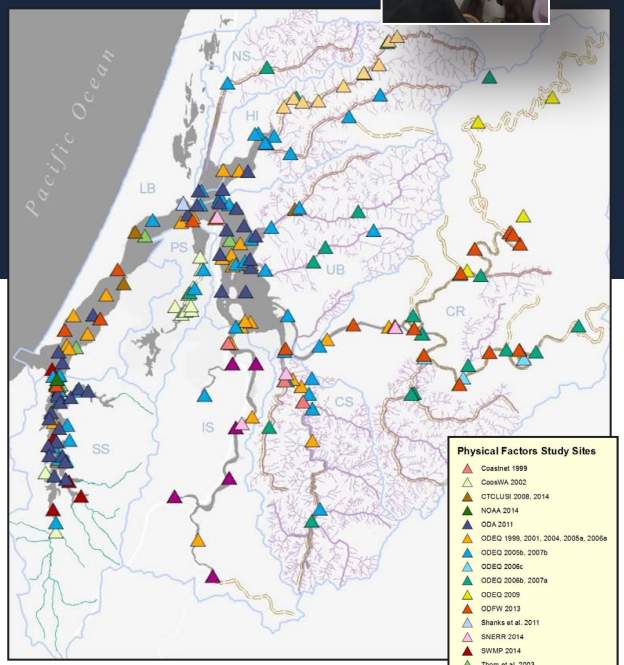
CLW DATA SOURCE

Summary:

- *<u>Dissolved Oxygen</u>: Dry season dissolved oxygen levels often drop into unhealthy levels in upper regions of the estuary.*
- *<u>Temperature</u>: Summertime water temperatures frequently exceed state criteria for healthy waters in most sectors of the project area.*
- *<u>pH</u>: In general, the waters of the Coos estuary and contributing tributaries have healthy pH levels.*
- *<u>Turbidity</u>: Compared to other Oregon estuaries, turbidity levels in the Coos estuary are high. Turbidity levels often peak above healthy levels after heavy wintertime precipitation events.*

Evaluation

Dissolved oxygen, and temperature levels are in need of significant action and should be closely monitored.



Subsystems: SS = South Slough; LB = Lower Bay; PS = Pony Slough; NS = North Slough; HI = Haynes Inlet; UB = Upper Bay; IS = Isthmus Slough; CS = Catching Slough; CR = Coos River

What's happening?

Physical water properties such as dissolved oxygen (DO), temperature, salinity, pH and turbidity affect the chemistry, solubility, and availability of nutrients and contaminants in water. These parameters change in relation to each other and in response to environmental variables (e.g., precipitation or tidal cycle).

The following summary describes the results of multiple monitoring and research efforts focused on Coos estuary habitats. We first describe conditions in the Coos estuary in general, then focus on specific subsystems organized into three groups: 1) South Slough/ Lower Bay; 2) Upper Bay/Pony Slough/North Slough/Haynes Inlet; and 3) Isthmus Slough/ Catching Slough/Coos River.

Sites listed as impaired under the Clean Water Act are discussed along with Oregon Department of Environmental Quality's (ODEQ's) criteria for maintaining water quality conditions suitable for aquatic life (Table 1).

Estuary Wide

Coos estuary water quality data have been collected by various researchers in the following studies. Additional studies will be referenced in subsequent sections.

CEMAP: Water quality in the Coos estuary was assessed by the U.S. Environmental Protection Agency's (USEPA) Coastal Environmental Monitoring and Assessment Program (CEMAP), initiated in 1999 and continued until 2007 by ODEQ (Hayslip et al. 2006; Sigmon et al. 2006). This study provided raw "grab sample" data for DO, temperature, pH, and salinity collected over several days during July, August, or September each year (ODEQ 1999, 2001, 2004, 2005a, 2006a). The averages of multiple samples at each station are used in this report.

SWMP: South Slough National Estuarine Research Reserve (SSNERR) has a network of System-Wide Monitoring Program (SWMP) long-term water quality monitoring stations located in South Slough. In 2013, SSNERR add-

Form	What is it?	Water Quality Standards	Water Quality Standard Source
Dissolved Oxygen (DO)	Amount of oxygen dissolved in water	For estuarine* water: > 6.5 mg/L ; For active spawning areas: > 11.0 mg/L; For cold-water aquatic life (e.g., salmon): > 8.0 mg/L; For cool-water aquatic life (e.g., sturgeon, lamprey): > 6.5 mg/L	OAR 340-041-0016
pH	The amount of free hydrogen in the water. A value of 7 is neutral with more hydrogen (or values < 7) being acidic and less hydrogen (or values > 7) being basic.	Estuarine and Fresh water: 6.5-8.5	OAR 340-041-0021
Water Temperature	How hot or cold the water is	For spawning use: < 13.0 oC (7d moving avg); For salmon rearing/migration: < 18 oC (7d moving avg)	OAR 340-041-0028
Turbidity	The amount of particulate matter (e.g., clay or microscopic organisms) suspended in water	< 50 NTU	OWEB 1999
Salinity	Measure of salt dissolved in the water, mainly sodium and chloride (NaCl2) - ocean water has a salinity of 35	NA	

* Estuarine waters defined as those with conductivity >200 µS/cm

Table 1. Physical water quality parameters commonly measured and the standards set for each to indicate unhealthy waters.

ed four new long-term water quality monitoring stations to the four already in place; these new stations are located in the Upper Bay, Isthmus Slough, Catching Slough, and Coos River (Figure 1). All stations collect continuous data (every 15 minutes) describing DO, water temperature, salinity, pH, turbidity, and depth (SSNERR 2014). Daily averages of these data are used in this report and combined with similar long term water quality data collected at three sites operated by the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI)(Figure 1).

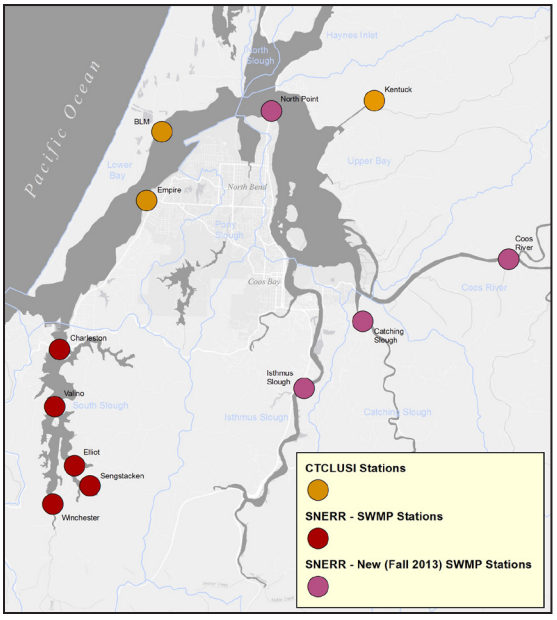


Figure 1. Location of continuous water quality monitoring stations run by CTCLUSI and SSNERR. Project area subsystems are delineated and labeled in blue. Labeled symbols refer to site names within this report.

<u>ODEQ TMDL</u>: Researchers monitored water temperature at 30 minute intervals at 26 sites during two monitoring efforts in 2006 and 2007 to assess total maximum daily loads (TMDL) for impaired waters (Figure 2)(ODEQ 2006b, 2007a). Monthly averages of the data are used in this report.

<u>ODA Fecal Coliform</u>: Oregon Department of Agriculture (ODA) monthly salinity and temperature data (1999-2011) from its 33 fecal coliform sampling stations are included in this report (Figures 2 and 7)(ODA 2011).

<u>Brown and Folger (2009)</u>: Researchers compared the Coos estuary to six other Oregon estuaries based on seven Coos estuary stations where DO, salinity, and total suspended solids (TSS) were measured at 15 minute intervals, June-August 2005 (Figure 2).

<u>Thom et al. (2003)</u>: Researchers in this eelgrass study collected water temperature data every hour from summer 1998 to fall 2001 at

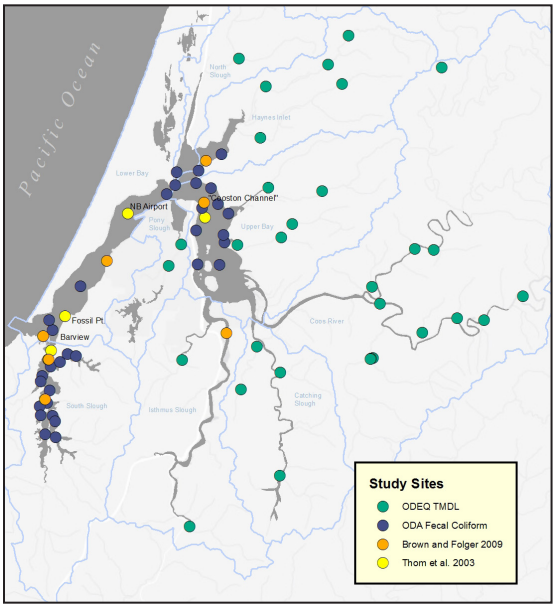


Figure 2. Location of ODEQ, ODA, Brown and Folger and Thom et al. study/monitoring sites. Project subsystems are delineated and labeled in blue. Labeled symbols refer to site names used in this document. Note that Cooston Channel is in quotes because it's a mis-located site name used by Thom et al. (2003). The actual Cooston channel is located at the mouth of the Coos River.

two sites in the Lower Bay and one site each in the Upper Bay and South Slough (Figure 2).

Further, temperature data were sporadically collected during Oregon Department of Fish and Wildlife's (ODFW) long-term seining program (ODFW 2013). Not all sites were sampled on every trip or in every year, thus only a single sample was taken at many sites. Averages of summer (May-October) data were used at sites with more than single samples taken.

Finally, some turbidity data were gleaned from ODEQ's storm-related bacteria monitoring efforts (ODEQ 2005b, 2007b).

Results

Dissolved Oxygen

Water samples taken for ODEQ's CEMAP project met the state DO standard for aquatic life (≥6.5 mg/L) at stations in the lower Coos estuary (e.g., South Slough, Lower Bay, Haynes Inlet subsystems) but frequently were below that standard further up the estuary (Figure 4A). The lowest DO levels were sampled at a site midway along Isthmus Slough, with an average of 3.9 mg/L in August 2001. The highest average DO levels were found at three stations near the mouth of the Coos estuary and one in the Upper Bay subsystem (>8.0 mg/L).

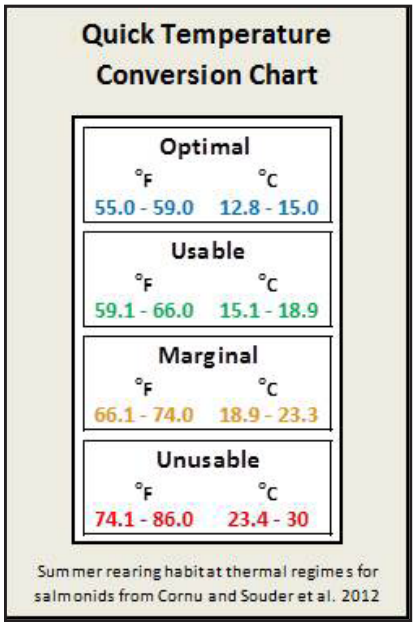
Preliminary DO data from the new SSNERR North Point station in the Upper Bay (blue line in Figure 5A) indicate generally healthy levels. However, this dataset spans less than a full year, and lacks late summer data, when DO is generally lowest. Isthmus Slough, Catching Slough and Coos River stations show healthy DO levels for the first winter of monitoring but dipped below the 6.5 mg/L standard in mid-June (Coos River) or mid-July (Catching Slough and Coos River) and remained low.

In the Brown and Folger study (2009)(Figure 2), no dissolved oxygen measurements were below 5 mg/L at any of the seven stations sampled.

Water Temperature

The majority of ODEQ CEMAP stations exceeded the state temperature standard of ≤18° C (64.4° F), especially those sites furthest upstream (Figures 3, 4B). Samples at six sites showed average temperatures over 20° C (68° F). The highest average temperature (21.1° C [70° F] in September 2005) was found at the uppermost CEMAP site on Isthmus Slough.

Figure 3. Juvenile salmonid stream temperature requirements



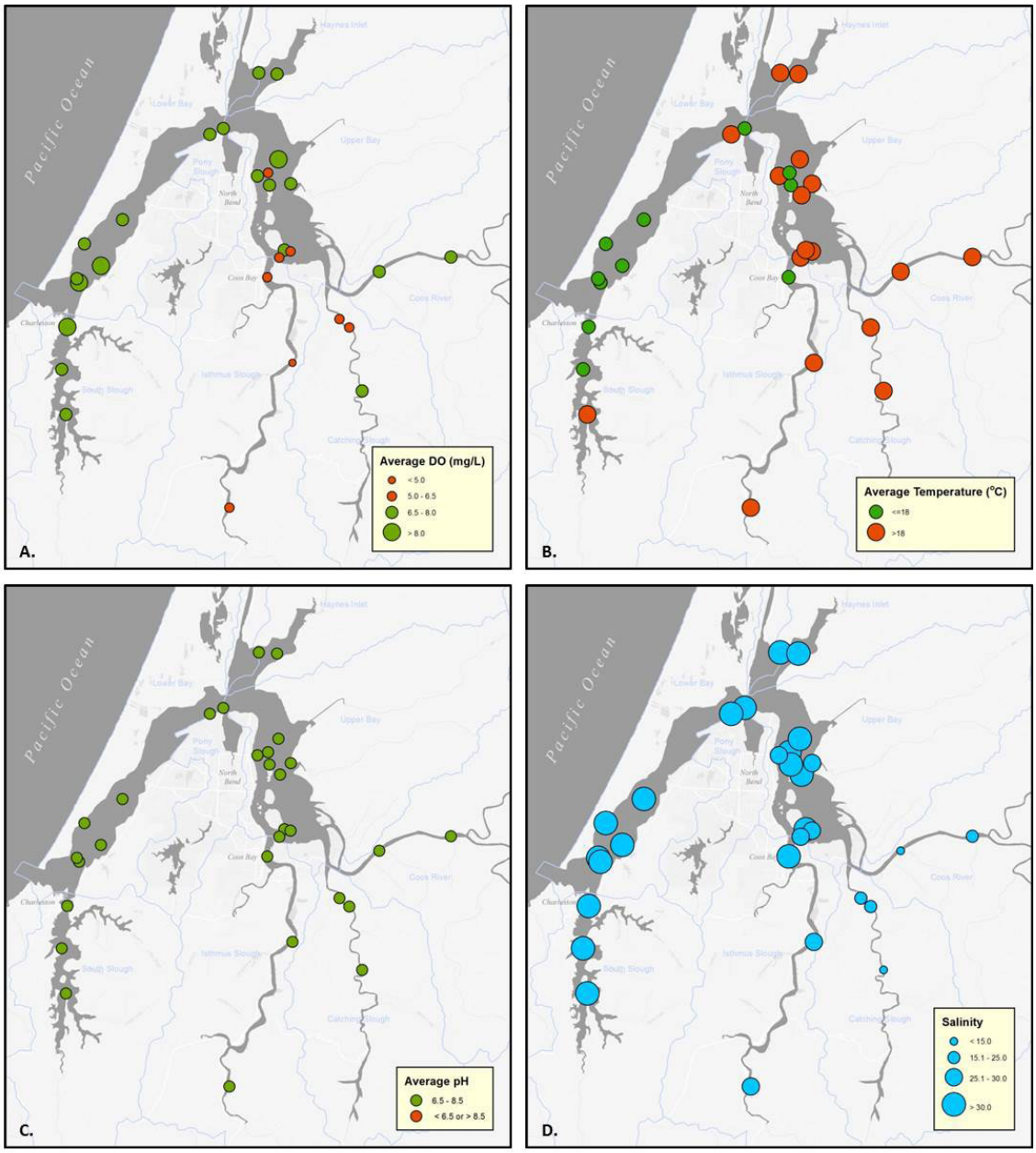


Figure 4. Coos estuary CEMAP data: A. Dissolved oxygen, B. Temperature, C. pH, and D. Salinity. Green symbols meet water quality standards; red exceed standards, blue have no standards. Data: ODEQ 1999, 2001, 2004, 2005a, 2006a.

The lowest temperatures were sampled near the mouth of the Coos estuary, at different stations and various years, with 10.6° C (51.1° F) in 1999 being the lowest temperature recorded.

Although the available data from the SSNERR North Point station indicate healthy temperatures, they do not yet include the late summer months, when temperatures are generally warmest (Figure 5B). Temperatures at Isthmus Slough, Catching Slough and Coos

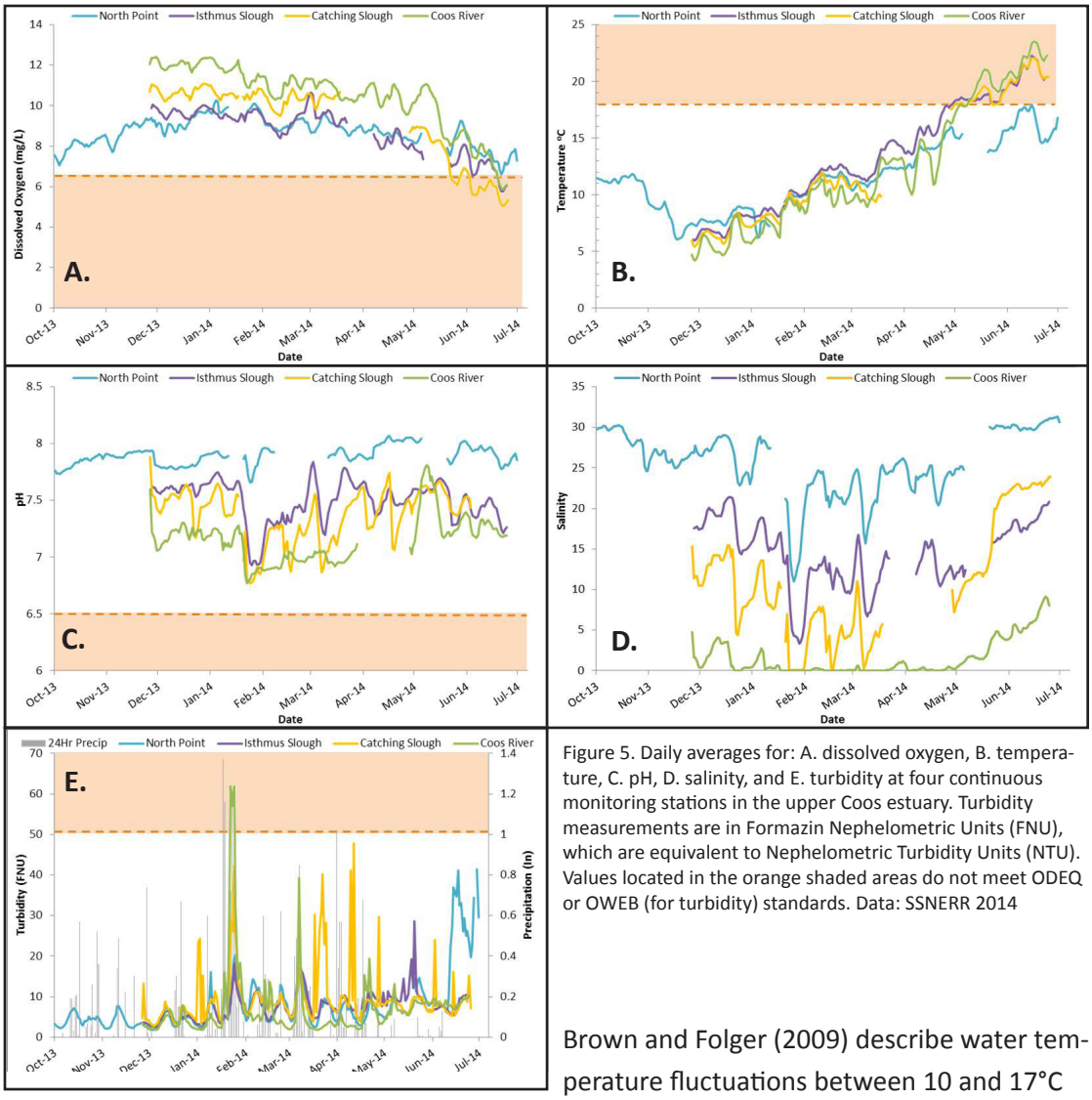


Figure 5. Daily averages for: A. dissolved oxygen, B. temperature, C. pH, D. salinity, and E. turbidity at four continuous monitoring stations in the upper Coos estuary. Turbidity measurements are in Formazin Nephelometric Units (FNU), which are equivalent to Nephelometric Turbidity Units (NTU). Values located in the orange shaded areas do not meet ODEQ or OWEB (for turbidity) standards. Data: SSNERR 2014

River stations all exceed state criteria beginning mid-May. The highest daily average thus far is 23.6° C (74.5° F)(July 8, 2014) at the Coos River Station, which tends to have both the highest and lowest seasonal temperatures. In contrast, the North Point station is the least variable with warm winter and cool summer temperatures.

Brown and Folger (2009) describe water temperature fluctuations between 10 and 17°C (50-63° F) being common until mid-July, after which temperatures remained between 8 and 10° C (46-50° F).

Figure 6 shows the ODEQ Coos basin temperature monitoring results. In general, temperatures are higher in floodplain waters near the estuary and lower further upstream. The highest maximum monthly average was in July 2006 at Ross Slough (22.2° C [72° F]), a tributary to Catching Slough, followed by two tributaries of Isthmus Slough, Coalbank Creek

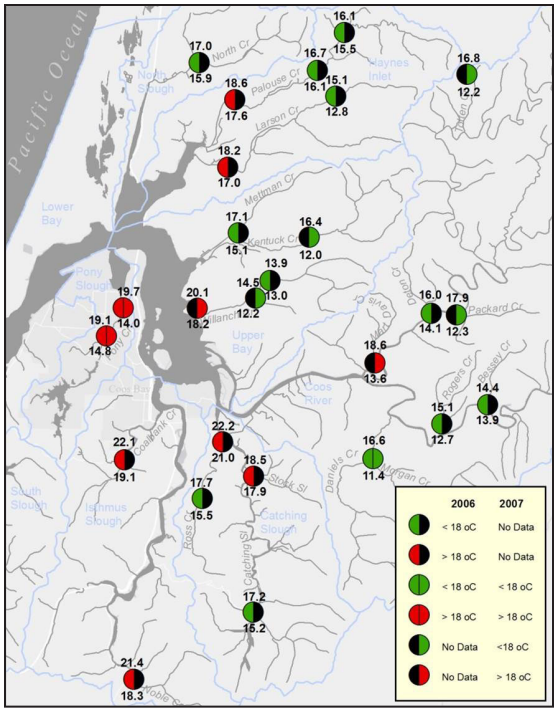


Figure 6. Location and average temperatures at continuous water temperature monitoring sites in summer 2006 (sampled in 30 minute intervals June-September) and summer/early fall 2007 (June-October). The red color indicates at least one monthly average during sampling period exceeding the state standard of 18˚ C. Numbers above symbols are maximum monthly average temperatures at that location; numbers below signify minimum monthly averages. All temperatures are in ˚C. Bodies of water with sampling sites are labeled. Data: ODEQ 2006b, 2007a

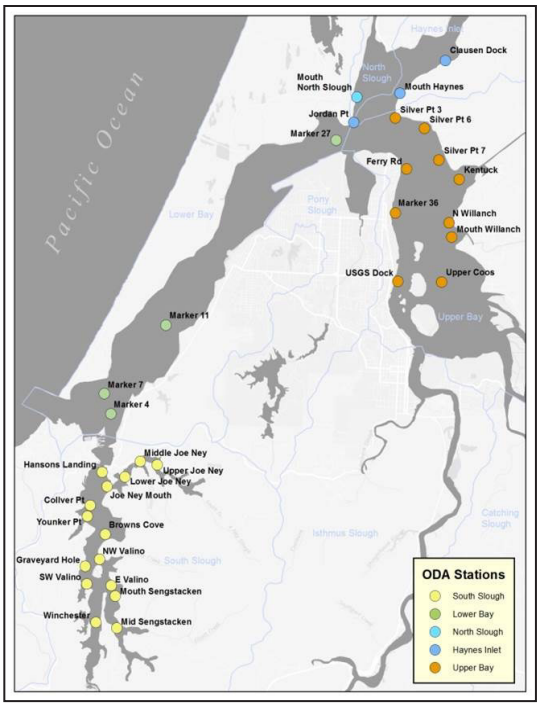


Figure 7. Sampling stations for the ODA shellfish growing areas sampling stations in the Coos estuary. Project area subsystems are delineated and labeled in blue. Labeled symbols refer to site names within this report. Data: ODA 2011

(22.1° C [71.8° F]) and Noble Creek (21.4° C [70.5° F]) also in July 2006. Highest minimum monthly averages were again at Ross Slough (21.0° C [69.8° F]), Coalbank Creek (19.1° C [66.4° F]) and Noble Creek (18.3° C [64.9° F]) all in September of 2006. Sampling at these sites, along with the mouth of Willanch Creek, demonstrated consistently the high temperatures that characterize summertime conditions at those sites, with averages never below the state 18° C (64° F) standard. Two upper Willanch Creek sample sites and the Bessey Creek site had the lowest maximum monthly temperatures at 13.9° C (57° F) in July 2006, 14.5° C (58.1° F) in July 2007, and 14.4° C (57.9° F) in July 2006 respectively. The lowest minimum monthly average was 11.4° C (52.5° F) in October 2007 at the confluence of Daniels and Morgan Creeks.

For year-round, median water temperatures, all ODA stations met ODEQ criteria for healthy waters (Figures 7 and 8). The highest median temperatures were at the Willanch Mouth and Clausen Dock stations, both at 17.1° C (62.8° F), closely followed by the Silver Point 6 and Kentuck sites (16.9° C [62.4° F] and 16.85° C [62.3° F], respectively).

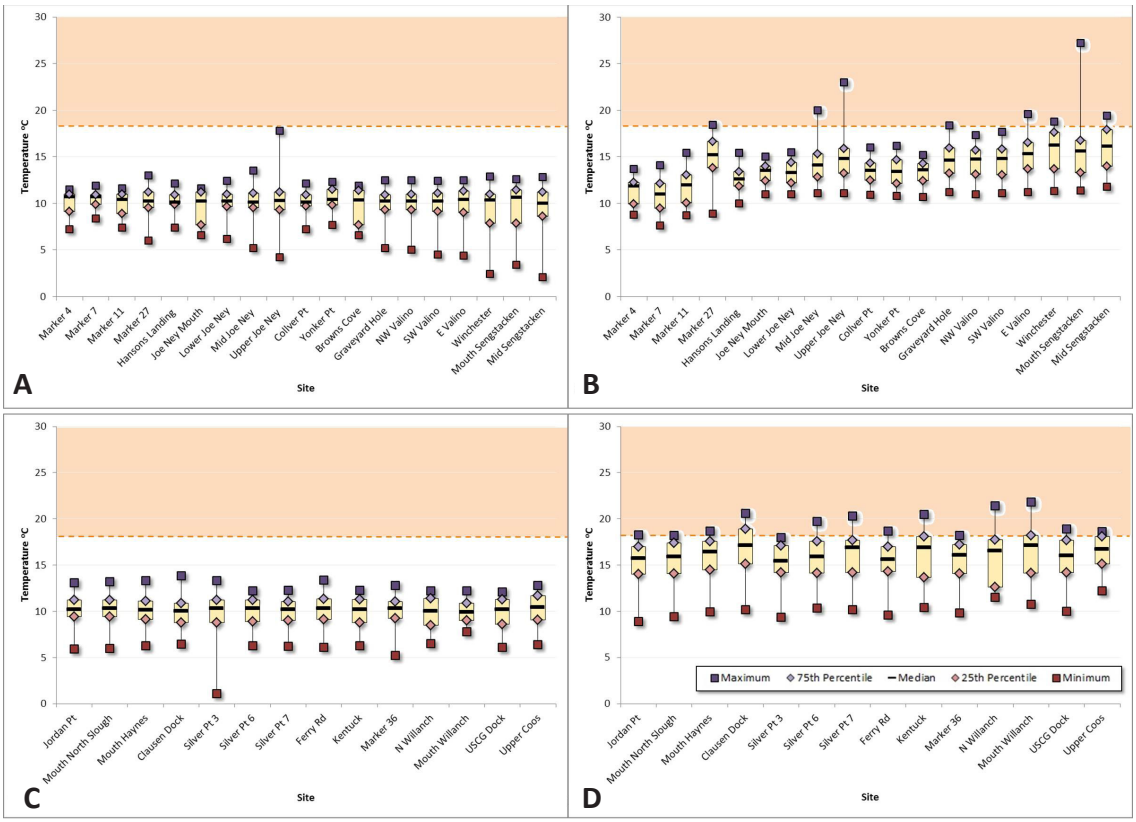


Figure 8. Temperature box plots summarizing minimum, maximum, median and central 50% of data (yellow boxes) at: A. lower bay and South Slough stations in wet season (November-April), B. Lower Bay and South Slough stations in dry season (November-April), C. North Slough, Haynes Inlet and upper bay stations: in wet season (November-April), D. North Slough, Haynes Inlet and Upper Bay stations: in dry season (May-October) from 1999-2011 (dates vary by station). Shaded orange area is above ODEQ standards and considered unhealthy. Data: ODA 2011

Maximum dry season temperatures exceeded the state standard at 21 of 33 sites. The Sengstacken mouth station had the highest max temperature (27.2° C [81° F] in June 2003)(Figure 8B). Dry season temperatures are slightly more variable than wet season temperatures. Continuous water temperatures taken by Thom et al. (2003) show seasonal fluctuations with Barview and Fossil Pt. having the lowest seasonal range in temperature (9-15° C [48-59° F]) while two sites further up the estuary (North Bend Airport and the misnamed "Cooston Channel"-see Figure 2) had much higher annual fluctuations (5-18° C [41-64° F])(Figure 2). Also, Barview and Fossil Pt. had smaller variability and lower summertime temperatures (10.0-16.7° C [50-62.1° F] and 13.1-16.7° C [55.6-62.1° F] respectively) than the North Bend Airport and the misnamed "Cooston Channel" stations (15.4-18.6° C [59.7-65.5° F] and 17.0-20.1° C [62.6-68.2° F] respectively).

Based on the limited data gathered by ODFW, the highest average summertime temperature was about 14° C (about 57° F), and none of the stations averaged higher than the ≤18° C (64° F) ODEQ aquatic life standard. However, these values should be considered with

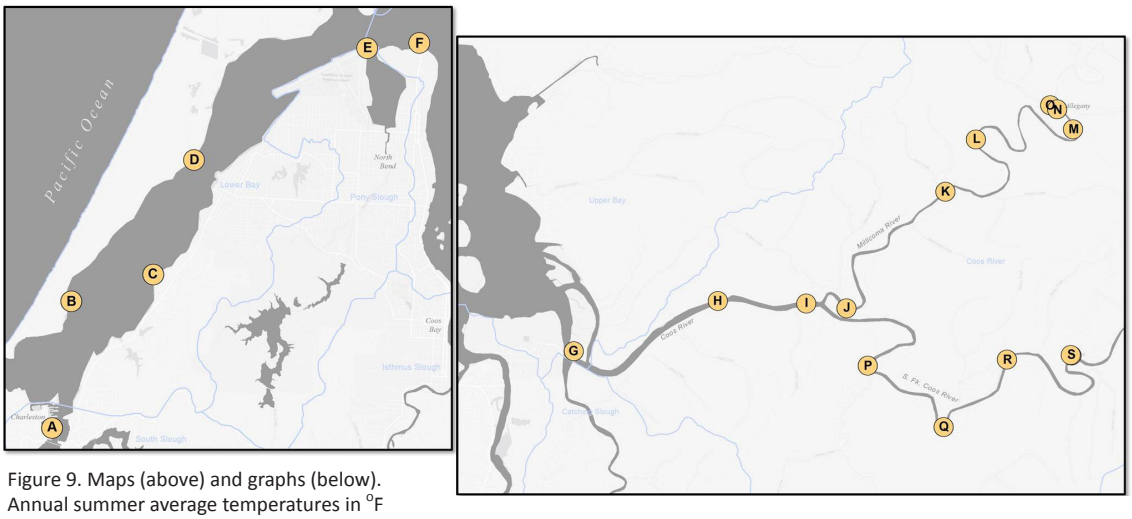
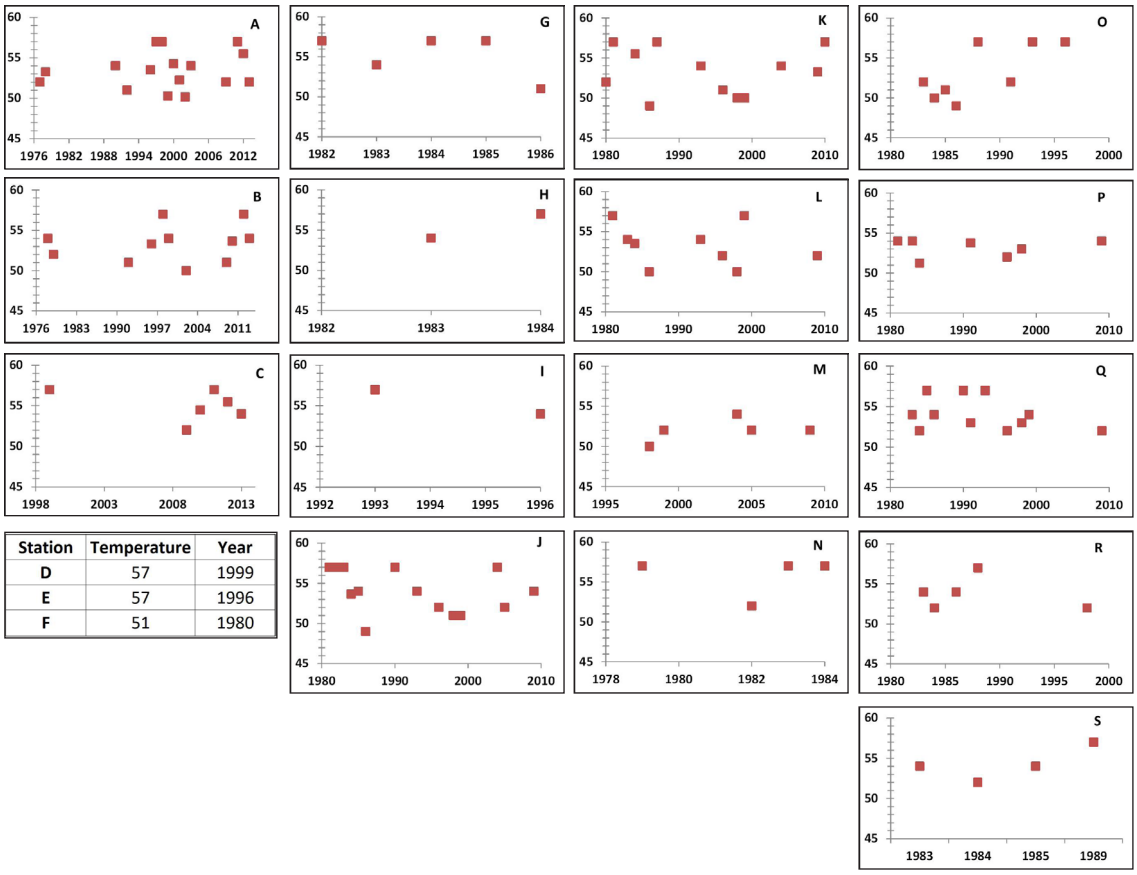


Figure 9. Maps (above) and graphs (below). Annual summer average temperatures in ^{o}F (y-axis in scatterplot graphs below). Scatterplots shown for stations where multiple years of data exist; sites with only one year are shown in chart format (i.e., sites D, E, F). Not all sites were measured each year (i.e., x-axis varies by site). For display purposes, stations that were close in proximity and not influenced by a separate body of water (e.g., a tributary) were averaged together and the most central station displayed on the map. Data: ODFW 2013.



Station	Temperature	Year
D	57	1999
E	57	1996
F	51	1980

caution because many stations were sampled only once and lack corroborating measurements (Figure 9).

pH

All ODEQ CEMAP stations met state standards for healthy pH levels (>6.5 and <8.5), with a combined, multi-year average of 7.6 (Figure 4C). Water with pH levels below 6.5 are strongly acidic, and with levels above 8.5 are strongly alkaline.

In addition, pH values fell within state standards at all the new Coos estuary SWMP stations, and on all sampling dates (Figure 5C). North Point had the highest overall average pH (7.9), followed by Isthmus Slough (7.5 average), Catching Slough (7.4 average) and Coos River (7.1 average).

Salinity

The Coos estuary is shallow, with an average depth of 2m below Mean Lower Low Water (MLLW), which allows for a thorough mixing of fresh and saltwater most of the year. However, stratification can occur, particularly in deeper portions of the estuary (e.g., the dredged shipping channel) with seasonally high contributions of fresh water (Rumrill 2006). The Coos is a drowned river mouth estuary dominated by river discharges in the wet season (i.e., influx of fresh water) and dominated by ocean water in the dry season (i.e., influx of salt water). Brown and Folger (2009) classified the Coos estuary as the most marine-dominated of the seven Oregon estuaries they investigated (Alsea, Nestucca, Yaquina, Salmon River, Coos, Umpqua River and Tillamook), based on salinities and normalized freshwater inflows.

Summertime data from the ODEQ CEMAP study indicate the highest salinities are near the mouth, and decrease upstream to the lowest salinity (13.3) on the Coos River (Figure 4D)(Note that salinity values are now expressed with no units.). Ocean-derived salinities (roughly 35) were found as far up the estuary as Haynes Inlet.

Year round, salinity values were highest at the new SSNERR North Point station (fluctuating between 30's and low teens), followed by Isthmus Slough, Catching Slough, and the Coos River (Figure 5D). As expected, salinity is lowest in winter months, when precipitation is heaviest, and gradually increases into summer months.

Salinity data from the 33 ODA stations were also consistently higher in the dry season than the wet season (Figures 7 and 10). Dry season salinities were less variable and markedly skewed towards higher values than in the winter months. As expected, stations further from the mouth of the Coos estuary (e.g., "Marker 27") have lower median salinities and are more variable than sites closer to the ocean (e.g., "Marker 4").

Turbidity

At all SSNERR stations, turbidity remains low most of the time, but peaks after precipitation events (Figure 5E). The highest turbidity levels occurred at the Coos River station

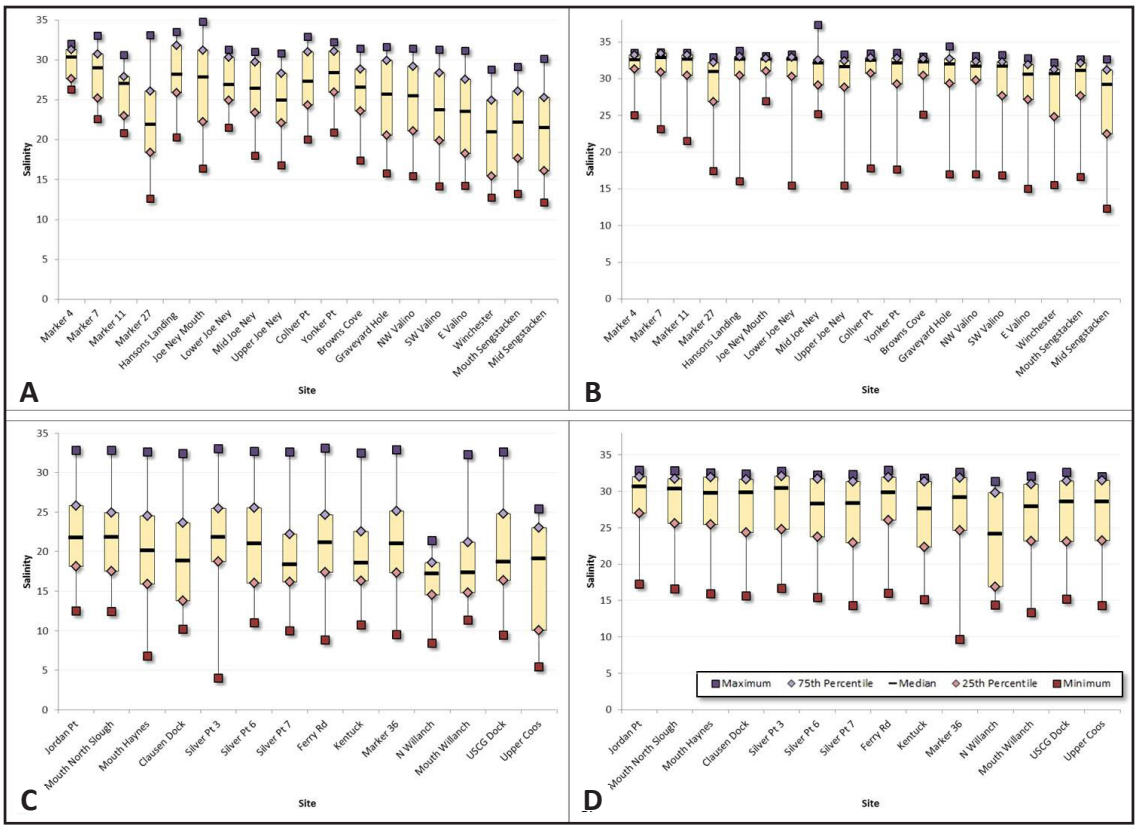


Figure 10. Salinity box plots summarizing minimum, maximum, median and central 50% of data (yellow boxes) at A: Lower Bay and South Slough stations in wet season (November-April); B: Lower Bay and South Slough stations in dry season (November-April); C: North Slough, Haynes Inlet and Upper Bay stations in wet season (November-April); and D: North Slough, Haynes Inlet and Upper Bay stations in dry season (May-October) all from 1999-2011 (dates vary by station). Ocean salinity is ~35. Data: ODA 2011.

following a two-day rain event (62.0 FNU). Turbidity is measured in Formazin Nephelometric Units (FNU), which are equivalent to Nephelometric Turbidity Units (NTU).

Some turbidity peaks are not associated with rain events, but are caused by biofouling (plant and animal growth) on the surface of the sensors, usually during summer months. Biofouling is often difficult to identify in the data, but for this report, single occurrences of anomalously high values and values above 50 FNU in the dry season were assumed to be caused by biofouling (or by a creature crawling across the optical turbidity sensor) and were removed from our analyses. Despite this adjustment, high turbidity levels in the dry season, especially at the most heavily fouled station (North Point) are understood to be overestimates of actual conditions. Compared with six other Oregon estuaries sampled by Brown and Folger (2009), the Coos had the highest median Total Suspended Solids, another measure of turbidity (13.8 mg/L).

Secchi depth measurements of turbidity by Thom et al. (2003) indicated the "Cooston Channel" site had the most turbid conditions while the Fossil Pt. site had the least.

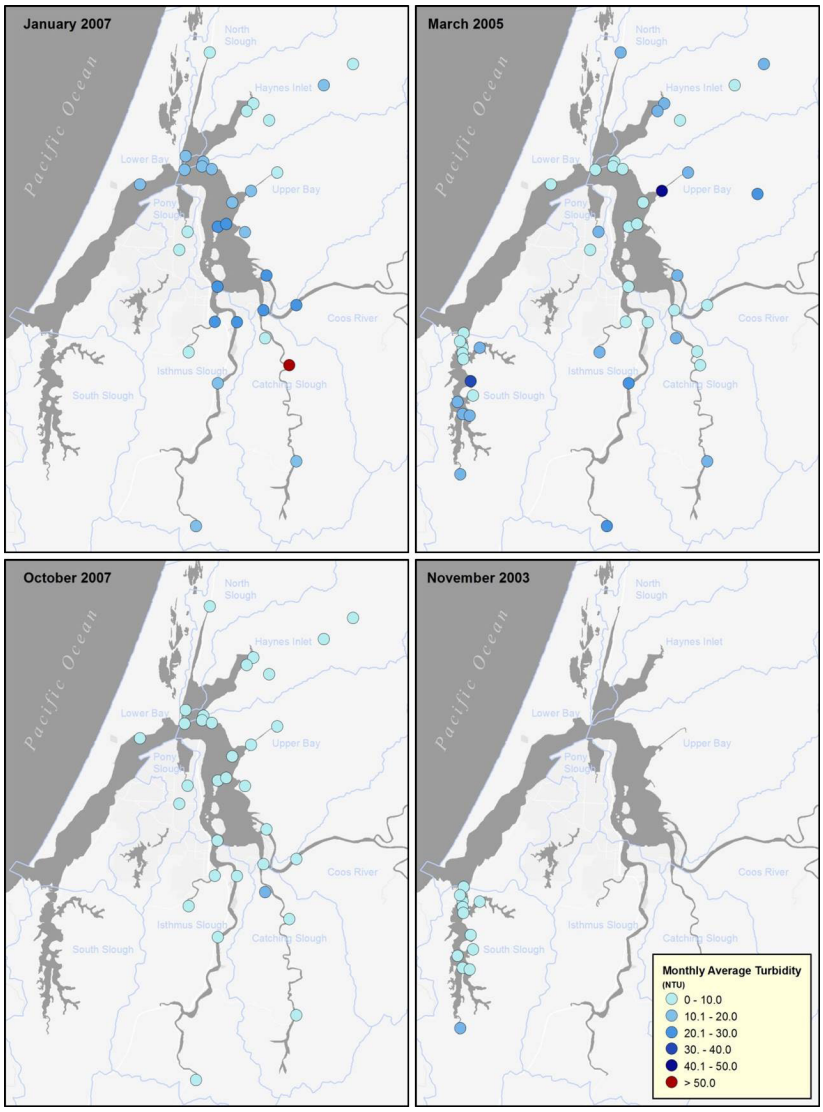


Figure 11. Monthly average turbidity data sampled in four different months and three different years as part of ODEQ's storm-related bacteria monitoring. Monthly averages at each site are shown. Not all sites were measured each time period and some sites were more intensely monitored within a single month than others (the number of sites and samples sizes varied between sites ; between 1 and 5 samples were collected at each site per month).
Data: ODEQ 2005b, 2007b

Some turbidity data were retrieved from ODEQ's storm-related bacteria monitoring (ODEQ 2005b, 2007b) but the collection locations and dates were irregular (Figure 11). Sampling events are triggered by predicted or actual precipitation levels (1.5 inches in 24 hours or 2.5 inches in 3 days) sufficient to close shellfish growing areas to harvesting activities (per ODA regulations) during storm runoff conditions when watershed soils are saturated. ODEQ's data indicated that turbidity values were highest in January, which was the only month turbidity values exceeded ODEQ's turbidity standard (<50 NTU) at a single site in the Catching Slough subsystem (Figure 11). High turbidity values were also found during ODEQ's March sampling, especially along the extremities of the estuary. In January the highest turbidity values were

found in the main part of the estuary. A possible explanation for this contrast is differing tidal levels (i.e., ocean influence) at the time of each sampling event but more data would be needed to confirm that interpretation. Turbidity was uniformly low throughout the estuary in October and in November at some sites in South Slough.

South Slough and Lower Bay

Dissolved Oxygen

Although regression analyses suggest a very slight decline, DO concentrations appear to have remained relatively consistent between 1995-2014 at four of five South Slough long term water quality monitoring stations (SWMP 2014)(Figure 12A). DO levels generally drop below ODEQ's aquatic life standard (6.5 mg/L) during the dry summer months (Figure 12B).

A similar, but more variable pattern, occurred at a fifth site, the Sengstacken station– displayed separately for ease of reading (Figure 13)(the Sengstacken station was moved to a different location in 2012 because the original site drained completely during extreme low tides, leaving data collector's sensors high and dry, unable to record water quality conditions during those tides).

For all five South Slough stations, the combined 2009-2014 data revealed that median DO concentrations met or exceeded ODEQ's standards (Figure 14). Winchester and Sengstacken stations have the most variability, while the Charleston station is the least

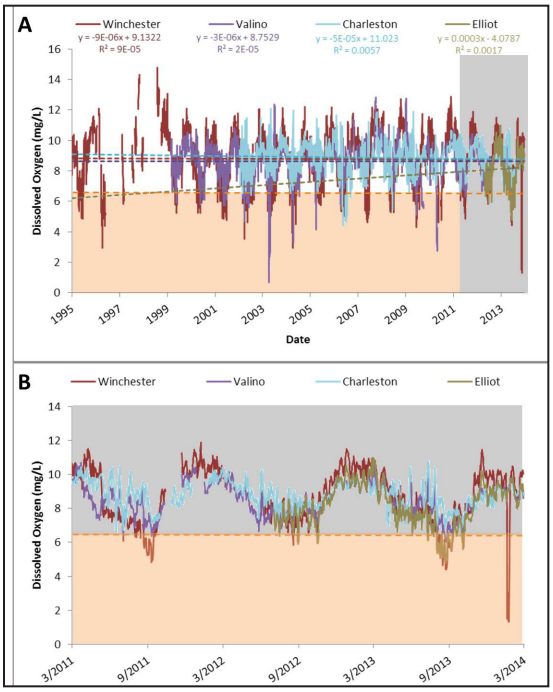


Figure 12. A: Daily dissolved oxygen levels at four sites in South Slough. The orange area defines DO concentrations below ODEQ's DO standard (6.5 mg/L). The four stations have up to 19 years of data and the color-coded dashed lines represent regression trend lines for each station. The Elliot station dataset spanned too few years to generate a trend line. The gray area delineates the timeframe expanded for a more detailed display in graph B (below). B: Comparison of seasonal DO variation in recent years at the four sites. Data: SWMP 2014.

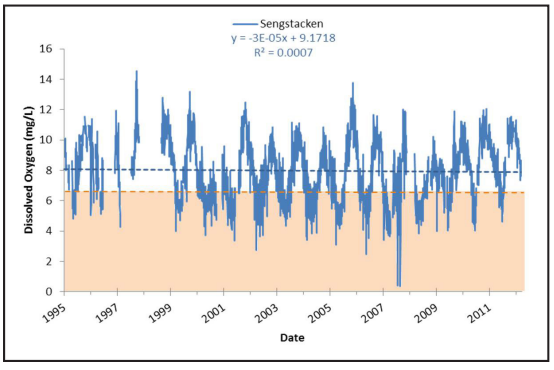


Figure 13. Daily dissolved oxygen at Sengstacken Station in the South Slough from 1995-2012. Orange area defines DO concentrations below ODEQ's DO standard (6.5 mg/L). Blue dashed line is the regression trend line for the Sengstacken station Data: SWMP 2014.

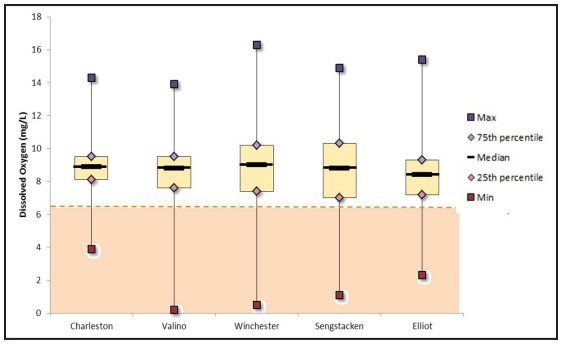


Figure 14. Box plot of dissolved oxygen concentrations at the five SWMP stations in South Slough between 2009-2014. Orange area defines DO concentrations below ODEQ's DO standard (6.5 mg/L). Data: SWMP 2014.

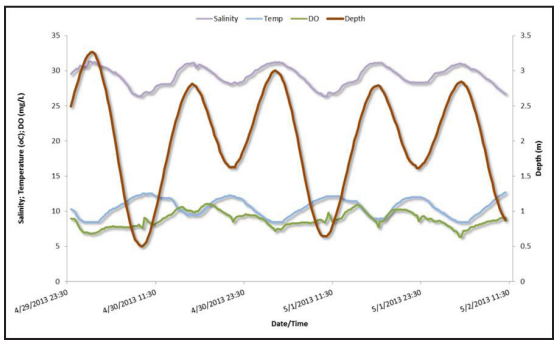


Figure 15. Relationships between water depths (tide levels) and salinity, temperature, and dissolved oxygen at the Charleston SWMP station over the course of 2 consecutive spring days in 2013. Data: SWMP 2014.

variable (Figure 14). Measurements at the Charleston station also suggest DO is weakly correlated with tide level (DO arguably decreases with lower water depths)(Figure 15). Dissolved oxygen is also negatively related to water temperature, because cold water holds more dissolved oxygen than warm water (Figure 15).

CTCLUSI reported the average, minimum, and maximum DO values at their two lower bay stations (BLM and Empire). Average values at both stations are well above ODEQ's DO standard during both winter and summer seasons, although generally higher in the winter (Figure 16A). DO concentrations at both stations sometimes drop below the ODEQ standard, but CTCLUSI reports that these values are not encountered consistently and are likely anomalies attributed to seasonal variability or localized site conditions.

Water Temperature

Water temperatures are more variable at the upper estuary SWMP stations (i.e., Sengstacken, Winchester, Elliot) than those at the two lower estuary stations closer to the ocean (i.e., Valino and Charleston)(Figure 17). Also, not surprisingly, water temperatures are higher during summer months (dry season) at all sites (Figure 17). Temperature values are typically below ODEQ's standard for salmon rearing and migration (≤18° C [64° F]) during the wet season, but more frequently reach or exceed this standard during the dry season at the three most upstream stations (Sengstacken, Winchester, and Elliot). At all stations, the highest 25% temperatures are above 20° C (68° F)(temperatures above 23° C [73° F] inhibit salmon rearing).

At the South Slough SWMP stations, average water temperatures appear to be trending downward over time, but the statistical correlation is weak (e.g., Valino station linear regression: $y = -0.0003x + 21.833$, $R^2 = 0.0297$).

As expected, water depth and water temperature follow opposite sinusoidal ("S" wave) patterns, reinforcing the notion that temperature has an inverse relationship with tide levels (Figure 15).

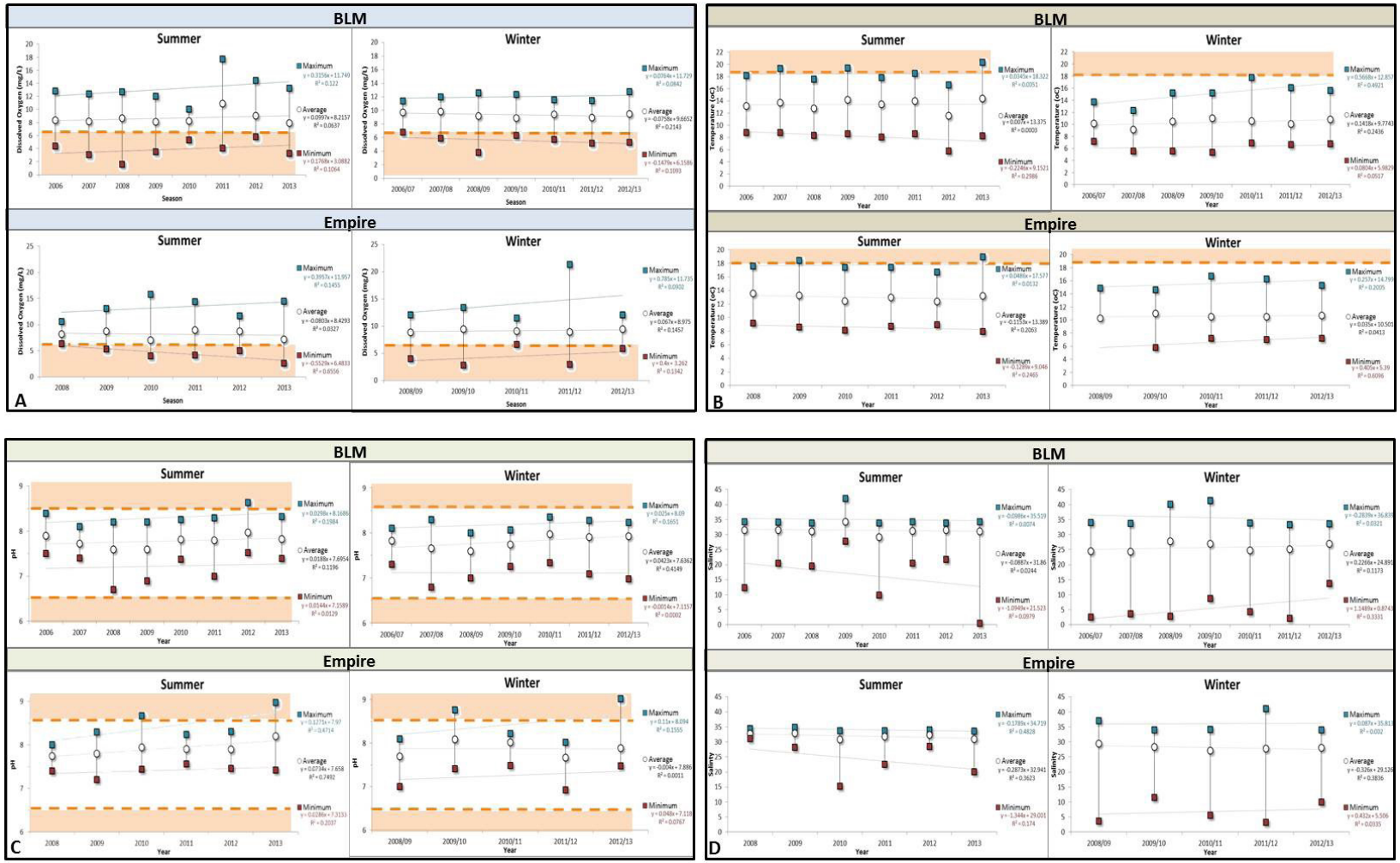


Figure 16. Seasonal averages, minimum and maximum values along with corresponding regression trendlines at two stations in the Lower Bay (2008-2013) for DO (A); temperature (B); pH (C); and salinity (D). Summer months are May-October; winter months are November-April. Values in orange shading do not meet ODEQ standards. Data: CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014.

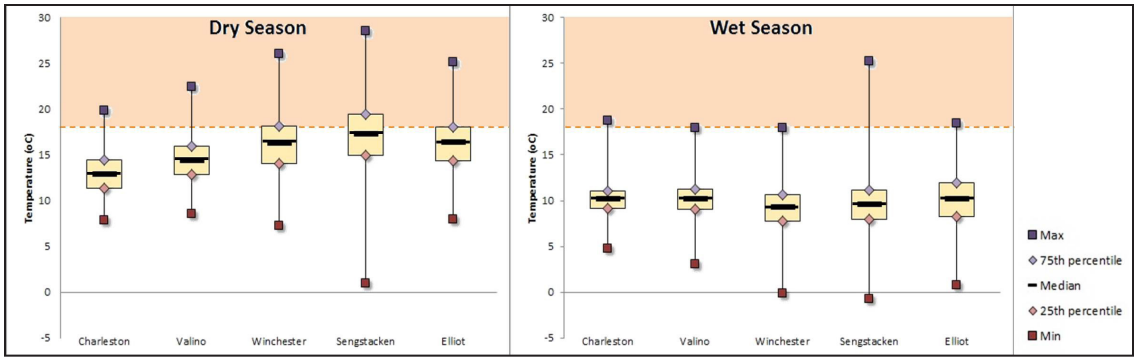


Figure 17. Box plot of dry season and wet season temperatures taken at the five SWMP stations in South Slough from 2009-2014. Values 18°C and higher (in orange shading above dashed line) are considered unhealthy for salmon rearing and migration by ODEQ. Data: SWMP 2014.

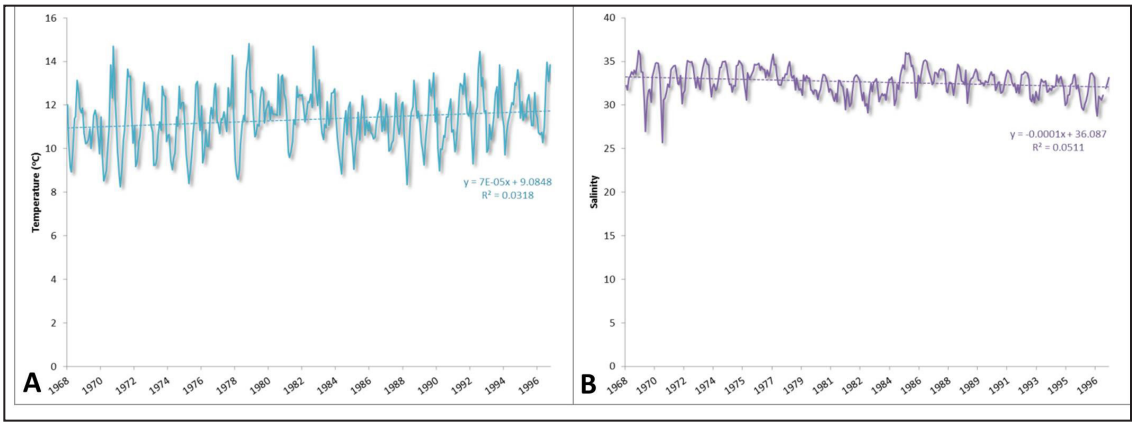


Figure 18. Monthly averages for A: temperature, and B: salinity near the mouth of the Coos estuary (1966-1997). Regression lines (dashed) and equations shown. Data: Shore Stations Program 1997.

Seasonal averages at the two lower bay CTCLUSI stations are healthy (≤18° C [64° F]), though summer maximums occasionally rise above that threshold (Figure 16B). For the 2009 water year, CTCLUSI reported the maximum temperature measured at Empire was 18.4° C (65.1° F), but this site only exceeded 7 day maximum daily averages once. The BLM station maximum temperature was 19.4° C (66.9° F) and exceeded 7 day averages only twice.

Five year water temperature trends (2008-13) for the Empire station have trended downward slightly during summer months, while winter averages show a slightly increasing trend (Figure 17). Across the channel at the BLM station, summer water temperature averages are trending slightly upwards along with similar upward water temperature trends during winter months.

Likewise, long-term temperature data at the Shore Stations (1997) site near the mouth of the Coos estuary show a weak increasing trend (Figure 18A). The Shore Stations program, a collaboration between the Oregon Institute of Marine Biology (OIMB) and the

University of San Diego included the daily collection of water temperature and salinity data near the mouth of the Coos estuary for 31 years (1966-1997)(quality checks were limited to key-entry stroke errors only; monthly averages were calculated and displayed for this data summary).

The highest temperatures at this site only exceeded 18° C (64° F) on a handful of occasions (not unexpected given its proximity to the ocean) while monthly averages were consistently well below this standard.

Summer stream temperature monitoring in the Sough Slough, recorded as part of the State of the Watersheds effort (Cornu et al. 2012), indicate healthy temperatures at the majority of South Slough stream sites sampled in 2011 for the project (Figures 19 and 20). The three highest 7-day average maximums associated with this effort were

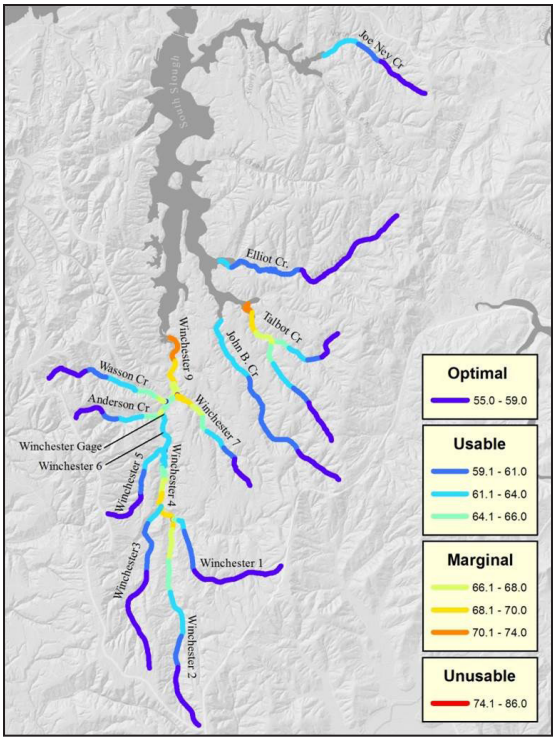


Figure 19. 7-day average maximum and minimum temperatures (°F) at stream monitoring stations in the South Slough watershed during summer 2011. Legend indicates salmonid summer rearing habitat thermal regimes. Amended from: Cornu et al. 2012

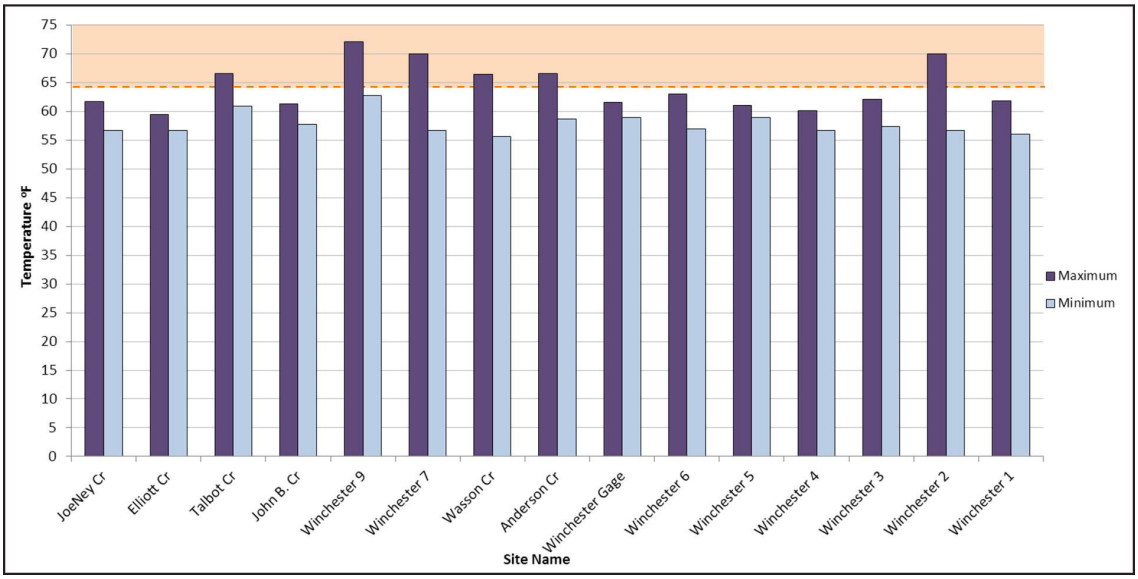


Figure 20. Comparison of 7-day average maximum and minimum temperatures at stream monitoring stations (ordered north to south) in the South Slough watershed during summer 2011. Shaded orange area indicates temperatures exceeding ODEQ standards. Amended from: Cornu et al. 2012.

on tributaries of Winchester Creek, with the most downstream segment (Winchester 9) having the highest 7-day maximum (23.6° C [74.4° F]). Additionally, this reach had the highest number of summer days exceeding 18° C (64° F). Anderson, Talbot and Wasson Creeks also had 7-day averages that exceeded the state standard.

Raw data (1993-2014) from NOAA's National Water Level Observation Network Station (Charleston, at the mouth of South Slough) are displayed using boxplots to minimize the effects of outliers with unknown causes (Figure 21). The results, again not surprisingly, show lower water temperatures in the estuary during the wet season than the dry season. Average monthly temperatures never exceeded the 18° C (64° F) standard, indicating healthy year-round temperatures at that location.

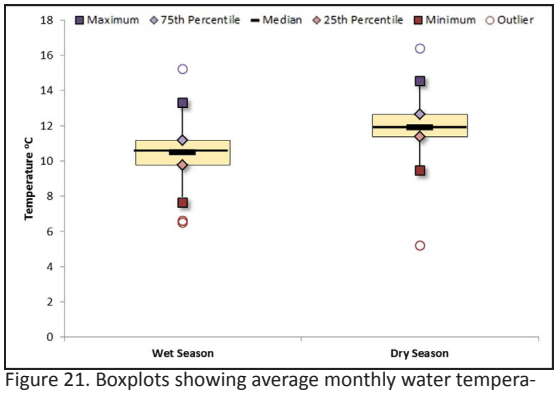


Figure 21. Boxplots showing average monthly water temperature at NOAA's National Water Level Observation Network Station in Charleston, OR from 1993-2014. Wet season (November-April) and Dry Season (May-October) values are displayed separately. Yellow boxes represent middle 50% of the data. Maximum and minimum shown in this figure include 99.3% of normal distribution data. Outliers outside this coverage are shown. National Ocean Service data used for this report were raw (i.e., no quality assurance checks) and were released as preliminary data only. Processing for this figure included removing values <5 oC and greater than 25 oC before analysis. Data: NOAA 2014.

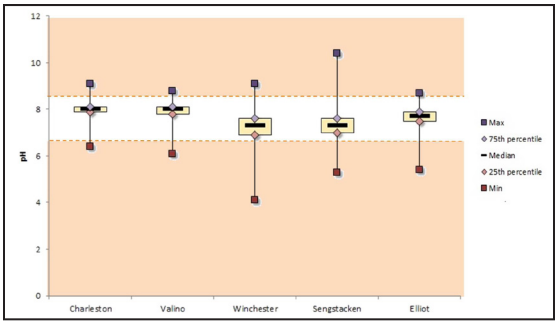


Figure 22. Box plot of pH at the five SWMP stations in South Slough (2009-2014). Values between 6.5 and 8.5 are considered healthy levels by ODEQ. Data: SWMP 2014.

pH

pH at South Slough SWMP stations over the past five years is generally well within ODEQ's standard for healthy estuarine waters with occasional episodic dips outside this range (Figure 22). In the past, it has been reported that long-term water quality data for South Slough pH has been increasing (getting less acidic), although the trendlines were near 0 and a weak positive relationship was indicated (opposite the decreasing trend in ocean pH – i.e., ocean acidification). Although an overall weak positive trend still exists, further analyses now indicate that the rise in pH shifted to a decline in pH sometime around 2010 (Figure 23).

Average pH at the two CTCLUSI lower bay stations range between 7.6 and 8.1 with no difference between winter and summer levels (Figure 16C). Maximum pH at these sites has occasionally exceeded ODEQ's criteria for healthy estuary waters.

Salinity

At SWMP stations lower in the slough (Valino and Charleston) salinities are higher and have

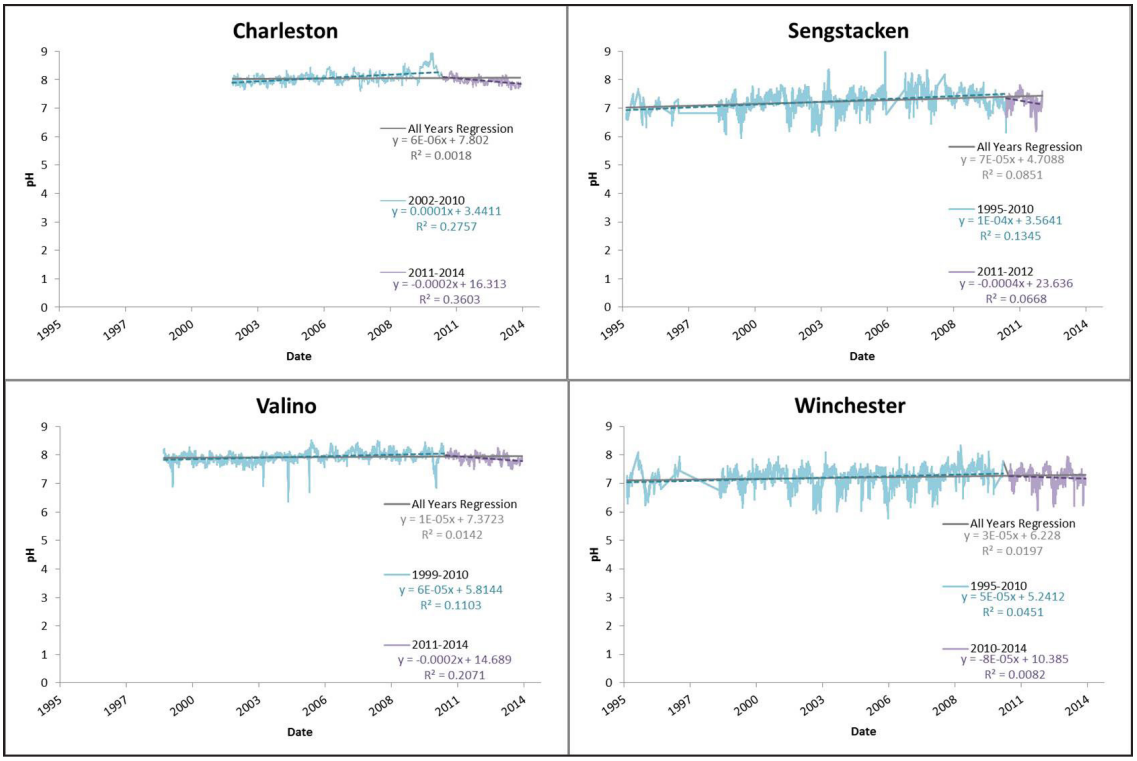


Figure 23. Average daily pH levels at four stations in the South Slough estuary. At each station, values in blue indicate those values taken before 2010 and describe an increasing trend in pH. Values in purple indicate pH taken after 2010 and show a decrease in pH. Elliot station was excluded due to its relatively short-term dataset. Data: SWMP 2014.

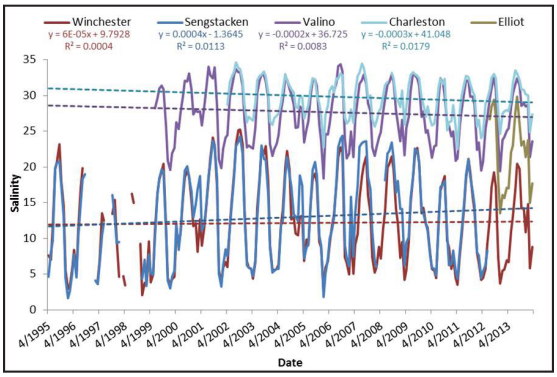


Figure 24. Average monthly salinity at five stations in the South Slough estuary. Dashed lines represent linear regression trendlines. Elliot station trends are excluded due to the relatively short time span of data collection. Data: SWMP 2014.

shown a weak trend towards decreasing salinity over time (Figure 24). As expected, the stations higher up the slough (Sengstacken and Winchester) have lower salinities due to proximity to freshwater inputs. These upper stations indicate an increasing trend over time. When overlaid with depth (an indicator of tidal stage), salinity follows a similar sinusoidal signal (Figure 15).

At the two CTCLUSI lower bay sites (BLM and Empire), average salinity tends to be higher in the summer (~31) and lower in the winter (~25)(Figure 16D). Maximum salinities reach ocean salinity (> 35) even in the winter but this area of the Coos estuary can also experience very fresh water; salinities recorded as

low as 2.2 at the BLM station in the winter of 2011/12.

Salinity data from the Shore Stations site near the mouth of the bay show a weak decreasing trend over 31 years (Figure 18B), like the decreasing trend described by the 18 year SWMP data. Salinity values sampled at this site tend to be near full ocean salinity, but some monthly averages were as low as 25.

Turbidity

Long-term trends in South Slough SWMP station turbidity show a slight increase at four stations, while the Winchester shows a slight decrease (Figure 25). High turbidity levels are more common in the winter (rainy) months, yet overall levels were generally below Oregon Watershed Enhancement Board's (OWEB) criteria of less than 50 NTU for healthy estuarine and fresh waters. Summer peaks are likely associated with increases in biofouling (i.e., attachment of organisms blocking the sensors), although no formal analysis to separate out fouling from natural turbidity has been made.

Turbidity in the lower bay generally averages low, even in the winter, at both CTCLUSI stations (Table 2). High summer maximums are again likely due to biofouling.

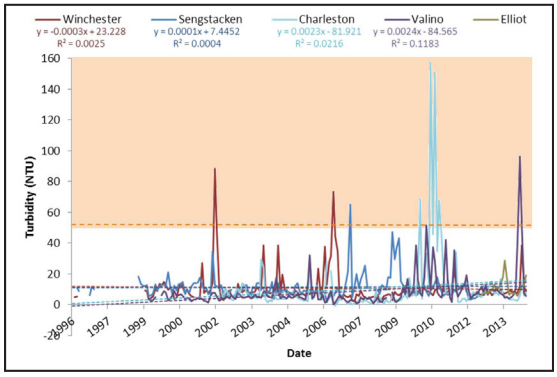


Figure 25. Average monthly turbidity levels at five sites in the South Slough estuary. Dashed color-matched lines represent linear regression trendlines at each station. Elliot trendlines are not included due to the relatively short period of data collection at that site. Values above 50 NTU (shaded region) are considered unhealthy levels in estuarine and fresh waters by OWEB. Data: SWMP 2014.

<u>Upper Bay/Pony Slough/North Slough/Haynes Inlet</u>

Dissolved Oxygen

Kentuck Slough is a water body in the upper Coos estuary which is listed as DO-limited under the Clean Water Act (section 303(d)) (ODEQ 2014)(Figure 26).

Season	Year	Min	Average	Max
BLM				
Summer	2006	-1	37.52	1000
Summer	2007	-1	3.768333333	1063
Summer	2008	-1	3.292	1055
Summer	2009	0	4	907
Summer	2010	-1	101	999
Summer	2011	-1	4	260
Summer	2012	-0.5	8	945
Summer	2013	-1	8	933
Winter	2006/07	0	3.465	510
Winter	2007/08	0	3.51	286
Winter	2008/09	0	3	994
Winter	2009/10	0.1	6	956
Winter	2010/11	-1	9	988
Winter	2011/12	-0.7	5	906
Winter	2012/13	-1	4	781
Empire				
Summer	2008	-1	2.55	109
Summer	2009	0	5	741
Summer	2010	-0.6	7	925
Summer	2011	-1	3	921
Summer	2012	-0.5	3	295
Summer	2013	0	32	999
Winter	2008/09	0	4	545
Winter	2009/10	0	4	958
Winter	2010/11	7	8	
Winter	2011/12	-0.3	4	372
Winter	2012/13	-1	4	529

Table 2. Minimum, average and maximum turbidity summary during summer and winter at two lower bay stations. Orange bars indicate relative averages across dates. Data: CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014.

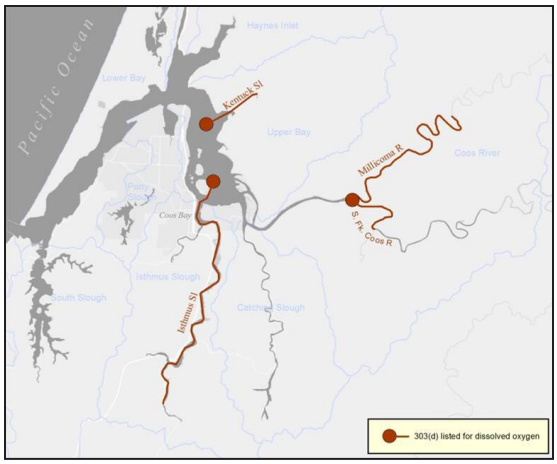


Figure 26. Streams listed as impaired for dissolved oxygen (303 (d) listed) under USEPA's Clean Water Act. Red dot signifies the start of the stream segment that is listed. Report subsystems delineated and labeled in blue. Data: ODEQ 2014

Kentuck station, monitored semi-monthly in 2007 by CTCLUSI had minimal differences between high and low tide sampling (Figure 27). At no time during sampling did values drop below ODEQ's criteria of 6.5 mg/L.

Water Temperature

There are seven water bodies in this part of the project area that are currently 303(d) listed for year-round high temperatures in salmon rearing habitat (Figure 28). Kentuck station, monitored by CTCLUSI

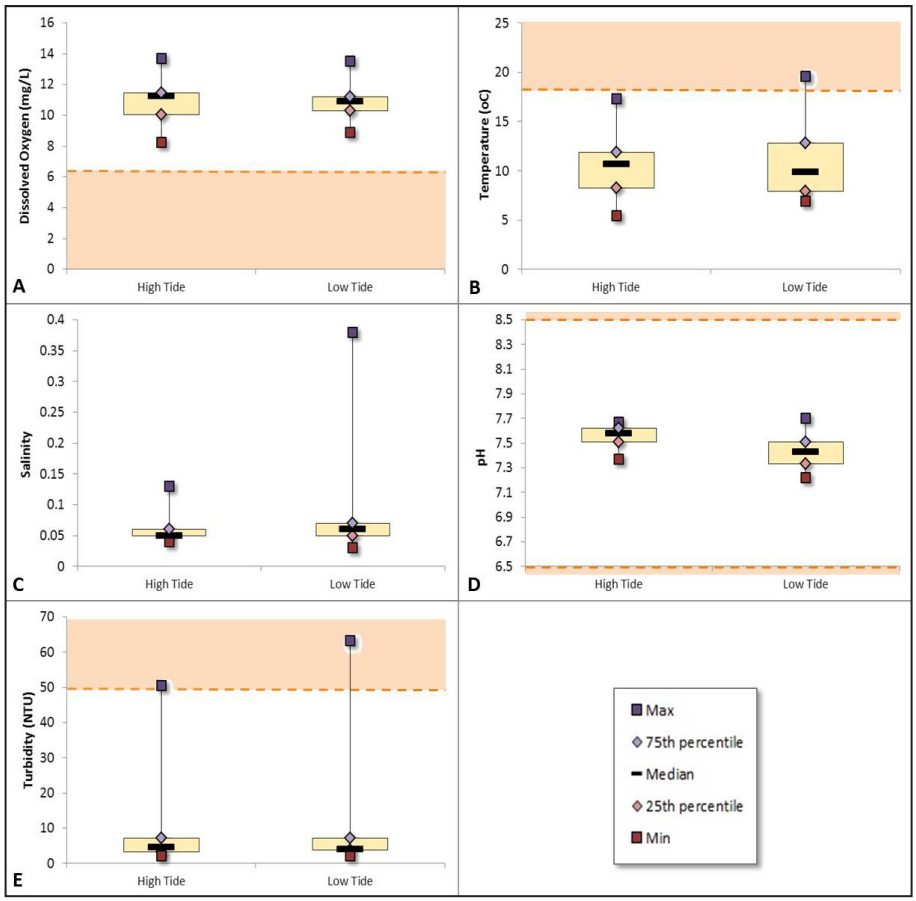


Figure 27. Box plots summarizing low and high tide minimum, maximum, median and central 50% of data fall (yellow boxes) during 2007 water year at Kentuck station for: A. dissolved oxygen, B. temperature, C. salinity, D. pH, and E. turbidity.Values in orange shaded areas and bounded by orange dashed line are considered unhealthy by ODEQ or OWEB standards. Data: CTCLUSI 2008.

(2008), averaged healthy temperatures during water year 2007. Low tide maximums exceeded ODEQ's criteria for healthy waters (Figure 27B).

Summertime temperature monitoring in Pony Creek by the Coos Watershed Association (CoosWA) shows maximum temperatures below ODEQ's standard (18° C [64° F]) and daily temperature fluctuations of 2-3° F (4-5° C) in four of five upstream stations (those closest to the reservoir dam)(Figure 29)(CoosWA 2002). CoosWA measured water temperature every 30 minutes from June to September in 2001 as part of their Pony Watershed Assessment (CoosWA 2002)(The CoosWA later completed assessments in North Slough, Haynes Inlet, and parts of the Upper bay (CoosWA 2006). The later assessments lack specific location information to protect private landowner interests, but general conclusions about water quality conditions are included later in this data summary).

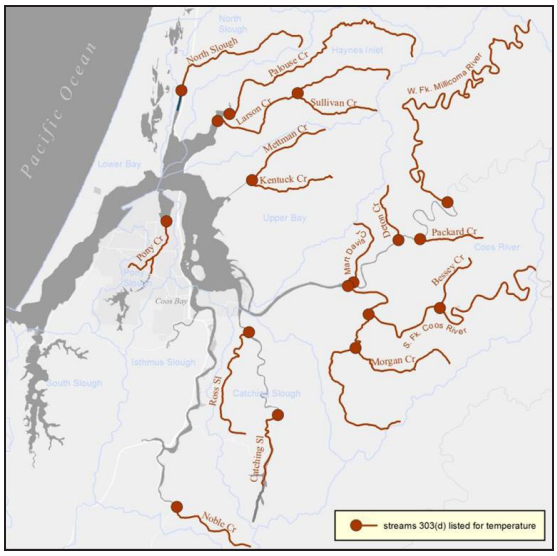


Figure 28. Streams listed as impaired for water temperature (303(d) listed) under USEPA's Clean Water Act. Red dot signifies the start of the stream segment that is listed. Report subsystems delineated and labeled in blue. Data: ODEQ 2014

Maximum temperatures and daily temperature fluctuations were quite a bit higher at downstream stations. Of all the sites, the North Bend High School had the highest maxi-

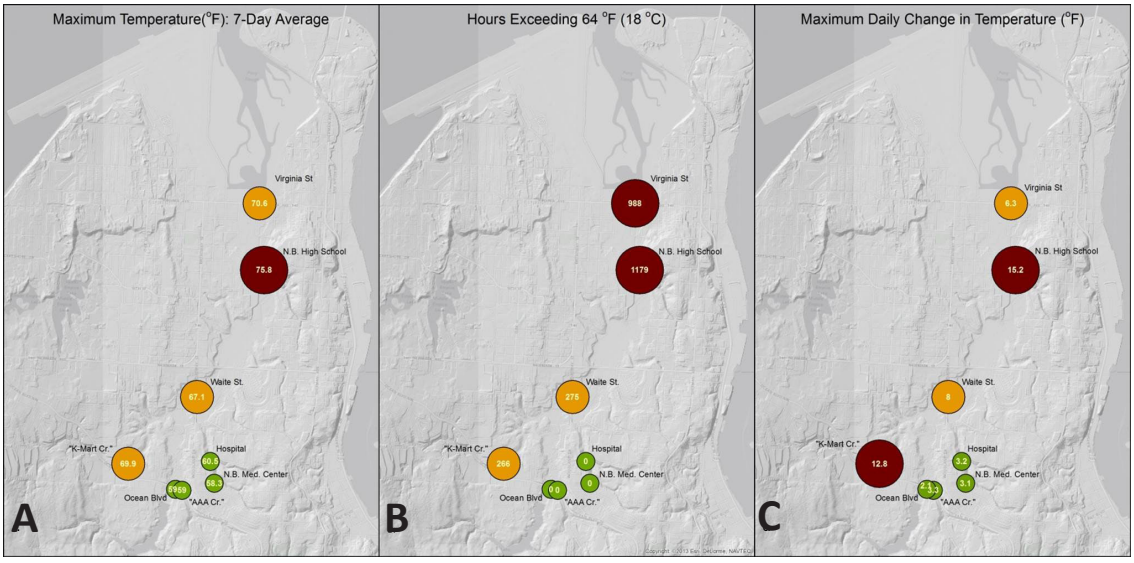


Figure 29. Water temperature results from 2001 sampling at 8 sites on Pony Creek. A: Maximum temperatures over a 7-day moving average; B: number of hours that exceeded 64°F (18°C) over the three and a half month sampling period; C: maximum daily temperature fluctuations over a 7-day moving average. Symbol size/color is relative to the value within (e.g., large red dots have the highest values, small green dots the lowest): Data: CoosWA 2002

Subsystem	Waterbody	# sites Max Temp > 64 °F *	Max Days > 64 °F	Max Days > 70 °F	Max Daily Δ Temp	Source	Sample Year(s)
North Slough	North Slough Cr	10 of 10	102	65	12.4	CoosWA 2006	2003/2004
Haynes Inlet	Palouse Cr	6 of 7	110	89	15.5	CoosWA 2006	2003/2004
Haynes Inlet	Larson Cr	5 of 5	98	38	14.7	CoosWA 2006	2003/2004
Upper Bay	Kentuck Cr/Mettman Cr	5 of 6	110	72	9.9	CoosWA 2006	2003/2004
Upper Bay	Willanch Cr	4 of 10	58	14	16.2	CoosWA 2006	2003/2004
Upper Bay	Echo Cr	1 of 2	33	1	4.5	CoosWA 2006	2003/2004
Catching Slough	Catching Sl/Ross Sl/Stock Sl/Matson Cr/Wilson Cr/Seelander Cr/Boone Cr	17 of 20	96	55	18.3	CoosWA 2008	2006
Coos River	Daniels Cr/Morgan Cr/Wren Smith Cr	4 of 8	101	66	13.1	CoosWA 2008	2006
Coos River	Packard Cr/Rogers Cr	9 of 11	94	68	20.5	CoosWA 2008	2002/2003/2004/2005

Table 3. Water temperature results from water bodies sampled continuously over the dry season (May-Sept), including sites where maximum temperatures exceeded 64° F (18° C)(*over a 7-day moving average) and maximum daily temperature fluctuations. See Figure 30 map for creek locations. Data: CoosWA 2006, 2008

mum temperatures (peaking at 75.8° F [24.3° C], nearly 12° F [6.3° C] higher than ODEQ's standard), the most hours exceeding the 64° F (18° C) standard (1,179 hours/over 49 days), and the highest maximum daily temperature changes (15.2° F [8.5° C]). Further downstream, the Virginia St. station had lower maximum temperatures and less daily fluctuation, most likely due to tidal input from Pony Slough.

In their lowlands assessment report, CoosWA summarized several summers of water temperature data at seven different creeks from the North Slough, Haynes Inlet, and Upper Bay subsystems (CoosWA 2006). Of the 40 sites sampled, maximum temperatures over a 7-day moving average exceeded the 64° F (18° C) standard at all but nine sites (Table 3, Figure 30). The highest daily temperature fluctuation was 16.2° F (9.0° C) on Willanch Creek. Days with stream temperatures exceeding the standard varied by site. A North Slough creek site exceeded the standard the most frequently (102 days). Many sites exceeded 70° F (21.1° C) on multiple days.

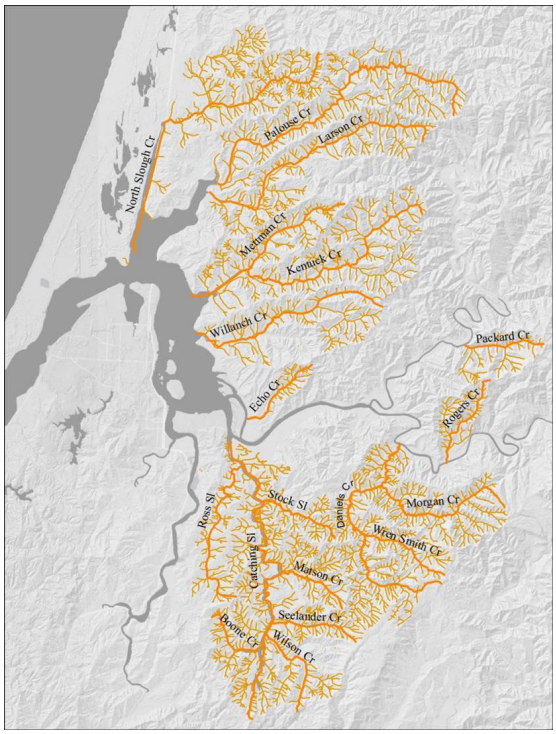


Figure 30. Streams referenced in Coos Watersheds assessment reports. Exact site locations for water temperature measurements were not included in the reports, to protect landowner privacy.

Weybright (2011) collected summer stream temperature data at sites along Palouse Creek in 2009 and 2010 (Figure 31). Nearly every site in both years exceeded the state standard. The highest maximum weekly temperatures were found at the site closest to the mouth (25.5° C [77.9° F] in 2009 and 23.5° C [74.3° F] in 2010). The site on Bear Cr. (a tributary to Palouse) had the lowest maxi-

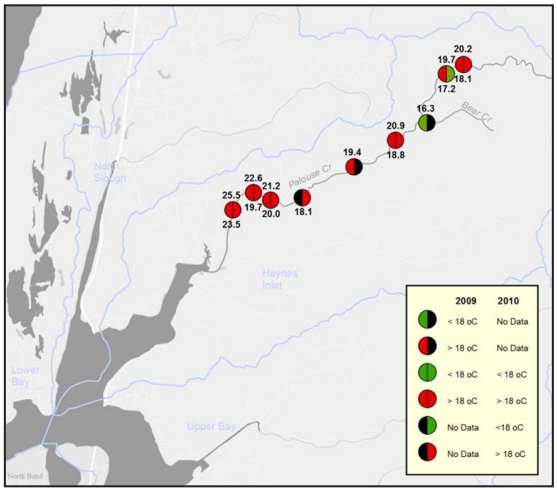


Figure 31. Location and condition of nine sites on Palouse Cr. in 2009 and 2010. Condition based on monthly water temperature average. Numbers above and below symbols denote maximum 7-day moving average values from 2009 and 2010 respectively. All temperatures are in °C. Data: Weybright 2011.

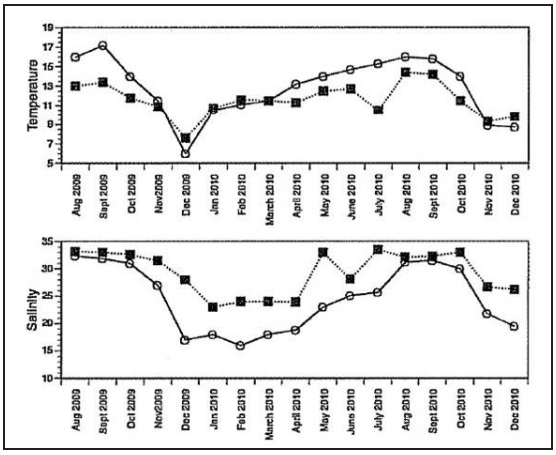


Figure 32. Monthly low tide (open circles) and high tide (black squares) surface temperature and salinity at Jordan Cove. From Shanks et al. 2011.

mum weekly temperature (16.3° C [61.3° F] in 2009).

In the Jordan Cove area, Shanks et al. (2011) found higher temperatures in the dry season than wet season at both low and high tides over one and a half years of sampling (Figure 32). The lowest temperatures measured (<7° C [45° F]) were in December 2009 when cold air temperatures rapidly cooled the estuary. Maximum temperature observed (~17° C [63° F]) occurred at low tide in September of that same year.

pH

Grabs taken by CTCLUSI in 2007 at their Kentuck station indicated healthy pH levels (Figure 27D).

Salinity

The Kentuck site monitored in 2007 by CTCLUSI indicated a freshwater location, with an average salinity near 0 (Figure 27C).

At the Jordan Cove study site, Shanks et al. (2011) reported a dramatic drop in salinity during the rainy season at both low and high tides, but especially during falling tides (Figure 32). Salinities during this period averaged ~25 at high tide and <20 at low tide.

Turbidity

At CTCLUSI's Kentuck station, levels were generally low, although peaks above OWEB's criteria for healthy turbidity levels have occurred (Figure 27E).

Isthmus Slough/Catching Slough/Coos River

Dissolved Oxygen

Isthmus Slough is 303(d) listed, considered an impaired waterway for low DO levels under the Clean Water Act (ODEQ 2014)(Figure 26). Low DO levels affect resident fish, juvenile

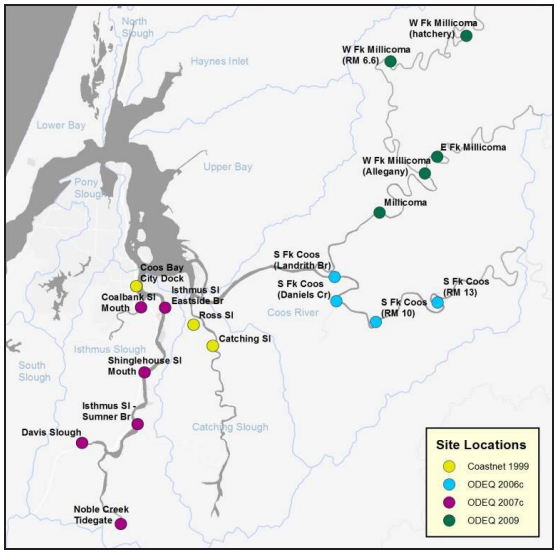


Figure 33. Site map for several studies or monitoring sites in the Isthmus Slough, Catching Slough and Coos River subsystems. Labeled symbols are site names referred to in this data summary.

salmon rearing, and aquatic life in general. Catching Creek has been 303(d) listed as DO limited for salmon rearing; the Millicoma River from miles 0 to 8.9 and the South Fork Coos River from miles 0 to 2.6 are also 303(d) listed for low DO levels.

Water quality samples were also collected as part of Marshfield High School's Coastnet program in 1998-99 at three sites (Figure 33), closely supervised by MHS biology teacher, George Tinker. Although generally above 6.5 mg/L, DO dipped into unhealthy levels at all three Coastnet sites – Coos Bay City dock (July, September 1998), Catching Slough (July 1998) and Ross Slough (Jul-November 1998)

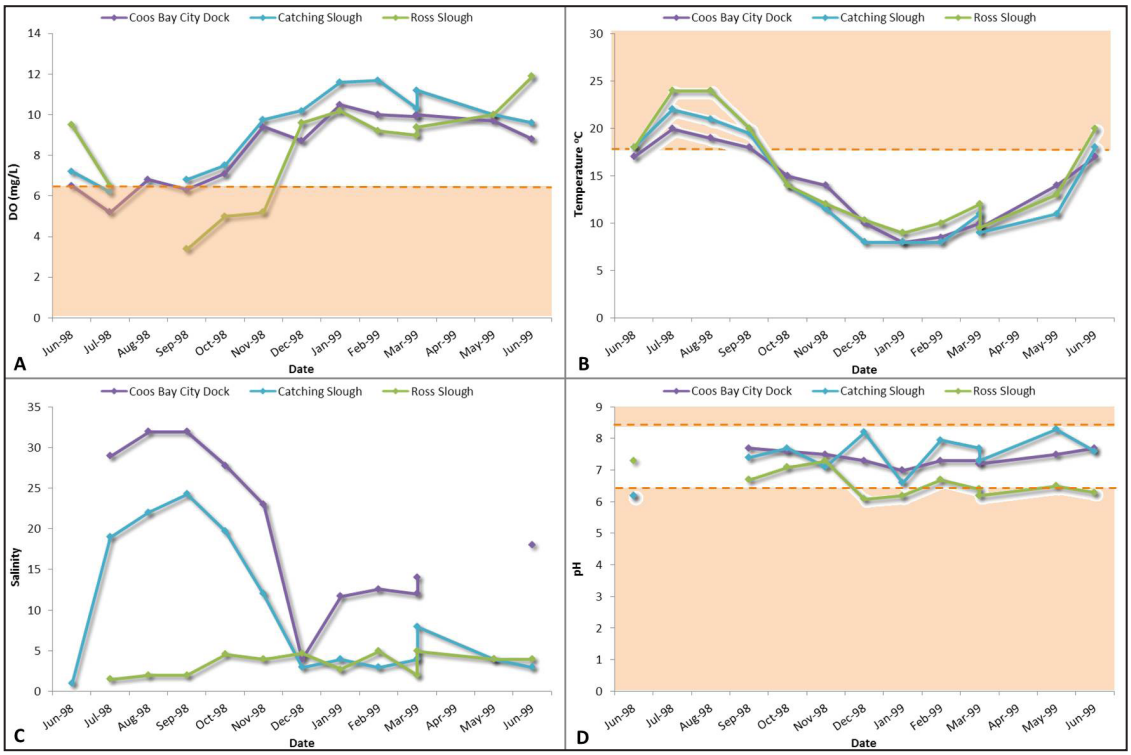


Figure 34. Average monthly samples (triplicate sampling 1x/month) at three sites in the Coos estuary: A: DO (mg/L); B: Temperature (°C); C: Salinity; D: pH. Data that appear in shaded orange areas do not meet ODEQ standards. Data: Coastnet 1999.

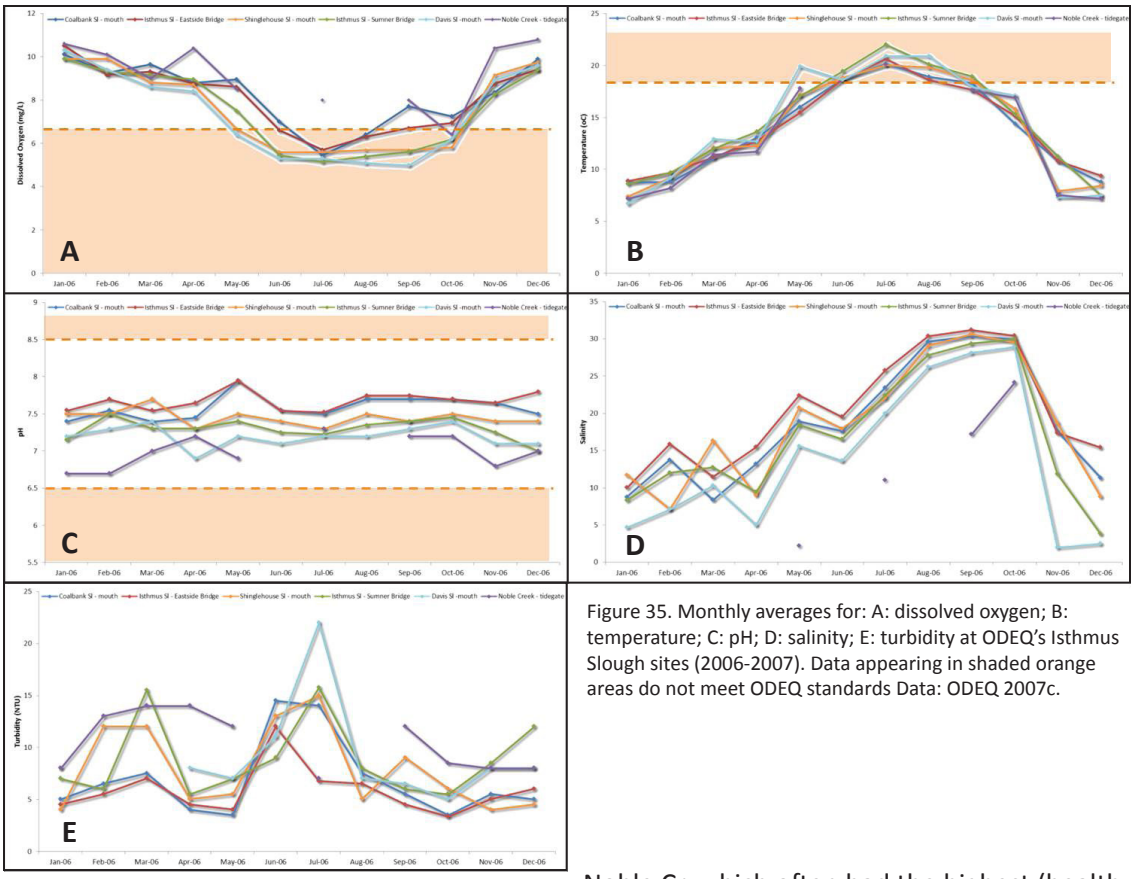


Figure 35. Monthly averages for: A: dissolved oxygen; B: temperature; C: pH; D: salinity; E: turbidity at ODEQ's Isthmus Slough sites (2006-2007). Data appearing in shaded orange areas do not meet ODEQ standards Data: ODEQ 2007c.

(Figure 34A). Lowest levels (3.4 mg/L) occurred at Ross Slough in September 1998.

Short duration continuous monitoring data have been collected during various projects by ODEQ including a year-long Isthmus Slough study (ODEQ 2007c), three days at four sites on the South Fork Coos River (ODEQ 2006c), and four days of data collection (15 min intervals) on the Millicoma River (ODEQ 2009) (Figure 33).

At ODEQ's Isthmus Slough study sites, DO levels fell below the ODEQ standard at all stations during part or all of the dry season (May-Oct)(Figure 35A). With the exception of Noble Cr, which often had the highest (healthiest) DO, sites closer to the mouth of Isthmus had higher DO levels than sites further up the slough.

Two ODEQ sites on the South Fork Coos River were monitored continuously over three days for DO; they had nearly identical DO levels (Figures 33 and 36A)(ODEQ 2006c). Both sites were just above the ODEQ standard for healthy DO levels in estuarine waters. The upper site (S Fk Coos [RM 10]) had slightly higher (healthier) DO levels, averaging 6.76 mg/L over the entire period, compared with 6.64 mg/L at S Fk Coos (Daniels Cr).

Mid-October monitoring by ODEQ in 2009 demonstrated unhealthy DO levels (based on

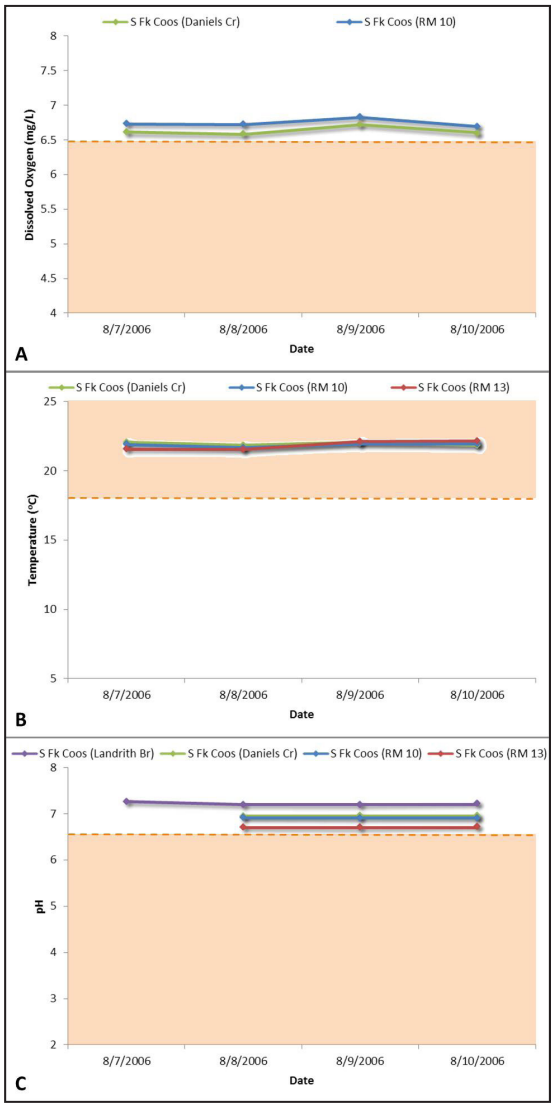


Figure 36. Daily averages of A: DO; B: temperature; C: pH from three days of continuous monitoring at four sites in 2006. Data in shaded orange area do not meet ODEQ standards. Data: ODEQ 2006c.

ODEQ's more stringent standard of 11 mg/L for cold-water aquatic life bearing waters during spawning season) at all fives sites on the Millicoma River (Figures 33 and 37A) (ODEQ 2009). Sites further downstream had lower levels of DO, beginning at the Millicoma River site (7.9 mg/L).

Water Temperature

Noble Creek, a tributary to Isthmus Slough, and multiple tributaries to the Coos River, including large sections of the South Fork Coos River (miles 0-31.1) and the West Fork Millicoma River (miles 0-34.8) have been 303(d) listed under the Clean Water Act as limited for salmon rearing due to high water temperatures (ODEQ 2014)(Figure 28).

In their assessment report, CoosWA summarized water temperature data at multiple creeks in Catching Slough and Coos River (CoosWA 2008). Of the 39 sites sampled, maximum temperatures over a 7-day moving average exceeded the 64° F (18° C) standard at all but nine sites (Figure 30 and Table 3). The highest daily temperature fluctuation was 20.5° F (11.4° C)(in 2005 at Roger's Cr). Total days with temperatures over the standard varied by site. The site with the most days, Daniel's Creek, exceeded the standard on 102 days; other sites' stream temperatures were over 70° F (21° C) on multiple occasions.

Dry season (May- October) temperatures at all three Coastnet stations were higher than in the wet season, and often rose into unhealthy levels (i.e., >18° C [64° F])(Figures 33 and 34B). Highest temperatures were found

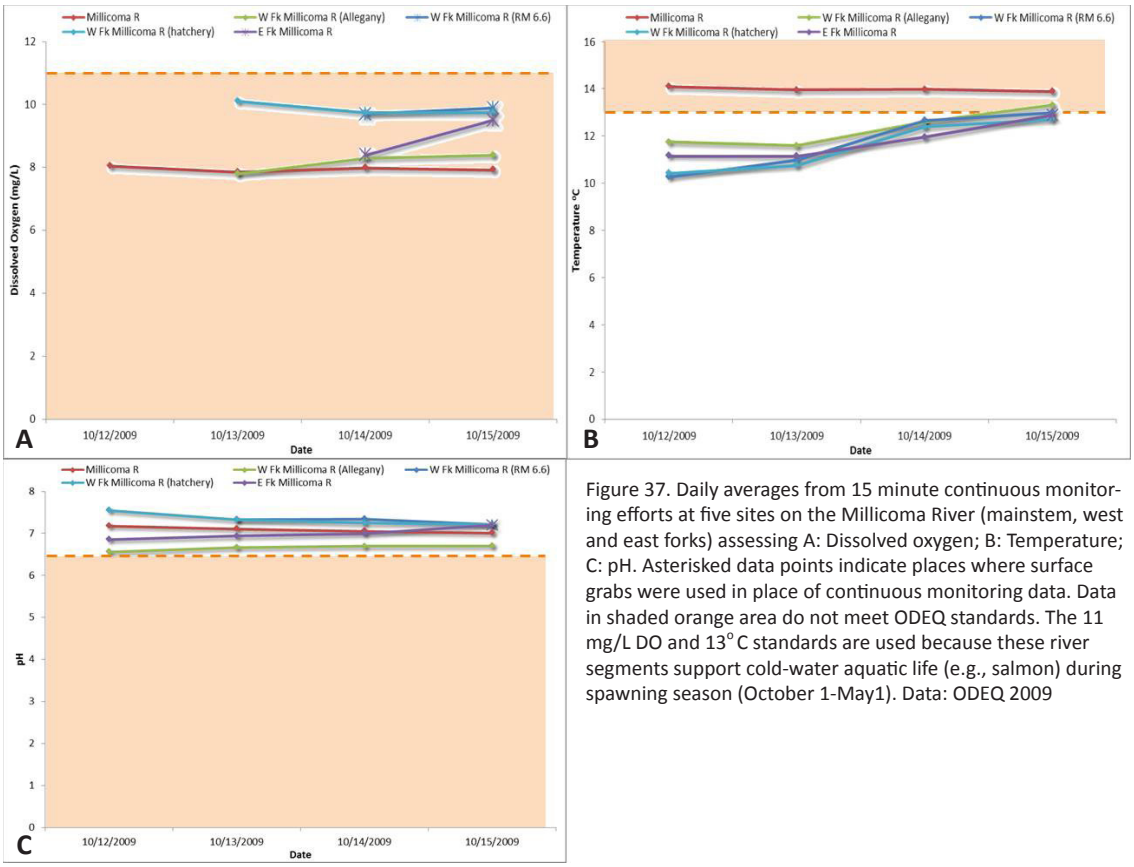


Figure 37. Daily averages from 15 minute continuous monitoring efforts at five sites on the Millicoma River (mainstem, west and east forks) assessing A: Dissolved oxygen; B: Temperature; C: pH. Asterisked data points indicate places where surface grabs were used in place of continuous monitoring data. Data in shaded orange area do not meet ODEQ standards. The 11 mg/L DO and 13°C standards are used because these river segments support cold-water aquatic life (e.g., salmon) during spawning season (October 1-May1). Data: ODEQ 2009

at Ross Slough in the dry season, peaking at 24° C (75° F) in both July and August 1998.

The one-year study by ODEQ on Isthmus Slough indicated healthy water temperatures during the wet season, but heightened levels during the dry season (May-Oct)(Figures 33 and 35B). Monthly averages frequently exceeded the ODEQ's <18° C (64° F) standard during the dry season.

High water temperatures exceeded ODEQ's <18° C (64° F) standard at three sites monitored continuously over three days on the South Fork Coos River (Figures 33 and 36B). All three sites averaged nearly 22° C (72° F) over the entire sample period.

Temperature data collected by ODEQ on the Millicoma River exceeded their <13° C (55° F) standard (established in salmonid spawning reaches) at three of five stations (Figures 33 and 37B)(ODEQ 2009). The station closest to the estuary (Millicoma River) exceeded the standard on all four days of monitoring, averaging 13.9° C (57° F) over the entire sampling period. Slightly lower temperatures were found at upstream sampling stations.

pH

All six stations monitored for one year on Isthmus Slough by ODEQ met their pH standard in all months sampled (Figures 33 and 35C). In general, sites closer to the mouth had higher (more alkaline/less acidic) pH than sites

further upstream. The four ODEQ South Fork Coos River stations monitored in August 2006 were all within healthy levels (Figures 33, 36C). Three of the four stations were slightly more acidic than pure water (which has a pH of 7) with South Fork Coos River (mile 13) having the lowest overall average pH (6.7 mg/L).

Likewise, all five stations ODEQ monitored on the Millicoma River for four days in October 2009 were within healthy levels (Figures 33 and 37C). The West Fork Millicoma River (Allegany) site had the lowest pH, averaging 6.7 over the entire sampling period.

At Catching Slough and Coos Bay City Dock Coastnet sampling sites, pH levels remained within ODEQ criteria for healthy waters (Figures 33 and 34D). Ross Slough station frequently dropped below 6.5 mg/L into unhealthy (acidic) pH levels.

Salinity

Not surprisingly, the Isthmus Slough sites monitored by ODEQ for a year all had lower salinity during the wet season than the dry (May-Oct) when salinities neared 30 at the mouth (Figures 33 and 35D). As expected, sites closer to the mouth of Isthmus Slough had consistently higher salinities than those further upstream.

Of the three Coastnet stations, Ross Slough station had lowest salinities (<5) year-round (Figures 33 and 34C). Catching Slough and Coos Bay City Dock stations varied with the season, with much higher salinities July-November (10-25 at Catching and 25-30 at Coos Bay City Dock) than the rest of the year (~5 at Catching, ~10 at Coos Bay City Dock).

Turbidity

All six Isthmus Slough stations monitored by ODEQ over the course of a year demonstrated healthy turbidity levels (Figures 33 and 35E).

Background

Dissolved Oxygen

Dissolved oxygen (DO) is the amount of unbound oxygen dissolved in water. This is the oxygen available for aquatic fauna (e.g. fish and clams) to breathe. Hypoxia, low DO levels, is lethal at different concentrations depending on species. A study by Vaquer-Sunyer and Duarte (2008) found median lethal DO levels was ~0.75 mg/L for gastropods, ~1.75 mg/L for fish and bivalves and ~2.0 mg/L for crustaceans. Median lethal oxygen concentrations were as high as 8.6 mg/L in one larval crab species and ~5.0 for one bivalve species. Ghost and mud shrimp are two species in our estuary that are particularly sensitive to low DO (Lee II and Brown 2009).

Slow moving, higher temperature water tends to contain less dissolved oxygen than cool, fast flowing waters. This can be seen in Figure 5A and 5B where DO in the faster flowing Coos River is high during the cooler parts of the year and lower during the warmer times of the year compared with the North Point SWMP station data. Slow flowing, higher water temperature conditions combined with

accumulations of organic material (sometimes caused by an overabundance of nutrients in the water column- see Water Quality in the Coos Estuary: Nutrients) can cause blooms of oxygen-metabolizing decomposers in waterways.Large scale decomposition activity in water reduces the availability of dissolved oxygen which, in turn, can affect a variety of aquatic animals (mentioned previously) while also decreasing the water clarity needed for submerged aquatic vegetation to grow.

There have been occurrences of severe hypoxia along the inner continental shelf off central Oregon during the past decade, allowing for these low oxygen waters to be advected into adjacent estuaries (Grantham et al. 2004 and Chan et al. 2008 as cited in Brown and Power 2011). Data collected near the mouth of Coos estuary show low DO at cooler water temperatures, implying that low DO in the estuary is related to ocean conditions (Brown and Power 2011). Flood tide DO higher than ebb tide DO would further demonstrate the influence of ocean upwelling on estuarine DO.

Water Temperature

Different aquatic organisms have different preferred temperature ranges, some more sensitive than others. For example, water temperature is a significant component of salmon distribution, health, and survival (USEPA 2003). Cooling water temperatures in fall months serve as a cue for upstream migration and spawning. Juvenile Coho salmon growth can cease in water temperatures above 20° C (68° F) and water temperatures of 25° C (77° F) can be lethal to fishes (Reiser and Bjornn 1971 as cited in Weybright 2011; ODEQ 2000 as cited in CoosWA 2008).
Daily and seasonal water temperature fluctuations determine which organisms will inhabit particular aquatic habitats in particular locations. In waters where temperature regimes have shifted, the composition of associated biological communities has also shifted (Booth et al. 2011).

Other key water temperature-related points (USEPA 2003):

- Temperature is closely linked to water chemistry, with warmer waters dissolving more minerals and allowing less oxygen saturation (see DO section).
- Runoff from the impervious surfaces associated with human development that direct enters streams, rivers and estuaries can contribute to “thermal loading” (raise water temperatures).
- Along streams, loss of riparian vegetation significantly affects stream temperatures.
- Bank erosion and resultant sedimentation in adjacent water bodies leads to increased temperatures (wider/shallower streams).

pH

pH is a measure of hydrogen ions in the water; it determines the level of water acidity or alkalinity. Pure water has a pH of 7 at 25° C (77° F). Solutions less than 7 are considered acidic (e.g. acid rain = ~4) and those greater than 7 are considered basic or alkaline (e.g., baking soda = 9). Most marine organisms

function in a narrow pH range of 6.5 to 8.0. At low pH (<6.5), egg hatch and juvenile growth in some fish species can be significantly reduced (Menendez 1976).

pH affects many chemical and biological processes including the solubility and biological availability of dissolved nutrients and heavy metals. For example, metals tend to be more soluble at lower pH and are therefore more toxic to organisms. The form of nutrients in the water can be helpful or toxic to organisms, partly determined by pH. For example, ammonia (NH_3) is toxic to fish in very small amounts but at low pH converts readily to the non-toxic form, ammonium (NH_{4+}). Solubility of calcium carbonate, important for shell-forming organisms such as clams and corals, is affected by pH – waters that are too acidic inhibit shell growth. In the face of declining ocean pH, it is critical to establish baseline pH records in the Coos estuary (Randall and Tsui 2002).

Salinity

Like temperature, salinity affects community composition with some organisms able to tolerate freshwater only, some able to tolerate salt water only and some a mixture. Several species, such as salmon, can physiologically change their needs and survive in fresh water and salt water at different life stages.

Turbidity

High turbidity levels are often associated with heavy rain events, when sediment runoff and more turbulent waters stir up sediment and contaminants from river and stream beds, estuary channels, and mudflats. As such, turbidity is often an indicator of potential pollution in a water body. High turbidity also makes the water opaque which can negatively affect recreational use (Osmond et al. 1995).

In particular, high turbidity levels can significantly affect aquatic species and the habitat in which they live. For example, chronic turbidity impairs growth of juvenile salmon compared to those reared in clear waters (Sigler et al. 1984). Additionally, decreased light availability in chronically turbid water bodies has detrimental impacts to aquatic vegetation such as eelgrass (Moore et al. 1997).

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