Technical Report

Rogue River Algae Reconnaissance

A response to the algae concerns related to the Medford WWTP

September 2014

State of Oregon
Department of Environmental Quality

Laboratory and Environmental Program

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Executive Summary

This report comes as a response to a complaint filed by the Rogue Fly Fishers & Federation of Fly Fishers, and a subsequent report (Hafele 2013) documenting nuisance algal growth below the Medford Wastewater Treatment Plant (WWTP). Hafele (2013) documented significant changes in the algal and macroinvertebrate assemblages below the Medford WWTP, compared to upstream conditions. The report also documented potential nuisance algal growth below the WWTP, as well as surface scums outside of the mixing zone.

DEQ sent a crew to perform a qualitative study of algal, macroinvertebrate, and water quality field parameters along 31 miles of the Rogue River. The study reach spanned from one mile below Lost Creek Reservoir, downstream to the former Gold Ray Dam location.

Results from our survey directly above and below the Medford WWTP showed quite similar conditions to those reported by Hafele (2013). Above the WWTP, algal abundance was low and macroinvertebrate density and diversity was high. At the site 0.3 miles below the WWTP, algal abundace was high and macroinvertebrate diversity was low. The macroinvertebrate assemblage below the WWTP was dominated by tolerant organisms in both studies. One mile below the WWTP, conditions were in-between those observed both upstream and downstream of the WWTP. We observed a noticeable plume for at least ¼ mile downstream of the WWTP discharge. We also observed much higher densities of macrophytes in the main channel, downstream of the WWTP, than we observed anywhere else in the study area.

The observations in this study and Hafele (2013) showed detrimental changes in the resident biological communities for up to one mile below the Medford WWTP. The responses of the algal and macroinvertebrate assemblages were consistent with responses typically associated with nutrient enrichment.

Other reports of nuisance algae were noted in the Rogue River, in the section downstream of Lost Creek Reservoir and upstream of Dodge Bridge. Our surveys showed potential nuisance algae growth downstream of the Cole M. Rivers fish hatchery. Evidence from another resource management agency showed nuisance algal growth in the stretch immediately downstream of the reservoir and the fish hatchery. Moreover, 72 hour continuous monitoring of water quality field parameters showed daily exceedances of the pH standard at Dodge Bridge (approximately 20 miles downstream of Lost Creek Reservoir). Additionally, there are regular Harmful Algal Blooms (HABs) in Lost Creek Reservoir. All of this information suggests nuisance algal growth and nutrients concerns are not just confined to below the Medford WWTP, they are a broader issue in the Rogue River from below the Lost Creek Reservoir downstream to the former Gold Ray dam.

Acknowledgements

I am thankful to Kurt Carpenter and Chauncey Anderson of the USGS Oregon Water Science Center. Both Kurt and Chauncey provided excellent insight into potential nutrient sources, critical feedback on our study design, and thoughtful reviews of this report. Kurt, additionally, provided taxonomic identifications of algal samples collected in the field. I'd also like to thank Marc Stewart, of the USGS Central Point Field Office. Marc provided field support during the surveys and continuous monitoring. Marc's knowledge of the river was extremely useful during the surveys. Bill Meyers and Steve Schnurbush of DEQ provided additional support in reviewing this report.

Background

During the last week of September 2013, DEQ sent a field crew to float the Rogue River to scout for potential nuisance algae issues in the Rogue River. The survey was in response to a complaint filed by the Rogue Fly Fishers and the Federation of Fly Fishers, based on the findings in a report prepared by Rick Hafele (Hafele 2013). In this complaint and report, the Medford Waste Water Treatment Plant (WWTP) was identified as the likely cause of nuisance algae and significant changes in the macroinvertebrate assemblage below the WWTP.

DEQ managers and staff decided to investigate the Rogue River upstream of the Medford WWTP to see if similar conditions were present throughout the Rogue River. In addition, we investigated whether other discharges into the Rogue River near the Medford WWTP could be related to the nuisance algae. The survey was conducted in a similar time of year as in the 2012 Hafele study. A separate mixing zone study of the Medford WWTP, funded by the City of Medford, occurred in October 2013.

This qualitative investigation was not a mixing zone study. The intent of the survey was observational, with the goal of gaining a better general understanding of the magnitude of nuisance algae conditions in the Rogue River across a broader spatial scale than studied by Hafele (2013).

The primary objectives of this survey were:

1) To examine the algal and macroinvertebrate conditions directly above and below the Medford WWTP, as described by the Hafele study.
2) To scout the mainstem Rogue River and mouths of major tributaries upstream of the WWTP to identify the prevalence of similar conditions to those observed downstream from the Medford WWTP.
3) To look for other potential nutrient inputs in the vicinity of the Medford WWTP.

Methods

As an informal, qualitative assessment of general algal, macroinvertebrate, and water chemistry conditions throughout a broad reach of the Rogue River, we did not create an official Sampling Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP). The following study design was implemented:

1) We sampled on September 25, 2013 at a similar date as in the Hafele study (October 10, 2012).

2) We sampled the same locations as in the Hafele study.

3) We extended the survey as far up river as possible. We started below Lost Creek Reservoir and surveyed as far below Medford WWTP as possible. The major limitation being that sampling was constrained to a single day.

4) We sampled or made visual observations at all known flowing outfalls in the study area to see if similar conditions existed at other outfalls.

5) We stopped for visual observations and/or samples at five locations in the Upper Reach identified by local fishing groups as having potential nuisance algae problems (Figure 1).

6) From riffle habitat, we collected qualitative algae samplesfor taxonomic identification by scraping rocks and collecting filamentous algae grabs. Aeral algal coverage was estimated. Qualitative laboratory identifications and estimates of algal abundances were performed by Kurt Carpenter with the United States Geological Survey (USGS).

7) We collected qualitative macroinvertebrate samples from riffle habitat, with visual estimates of density and diversity. Dominant taxa and assemblage characteristics to order/family were recorded.

8) Water quality field parameters (temperature, pH, dissolved oxygen (DO), DO saturation, and specific conductance) were measured by data sondes.

9) At major tributaries, we collected water quality information and recorded visual observations of algal coverage. No observations were taken at minor tributaries.

10) Local USGS staff placed one data sonde for continuous measurements for ~48 hrs at the Dodge Bridge site.

11) We visually scouted the river for undocumented locations of heavy (nuisance) algal and/or macrophyte growth.

Sampling Locations

The study area spanned approximately 31 miles of the Rogue River. We split into two separate crews to be able to sample as much as possible in the one day allotted for this survey.

Upper Reach

The crew leader was Shannon Hubler (DEQ Lab). He was joined by Cassie Schwanger (DEQ Lab) and Marc Stewart (USGS , Central Point). The Upper Reach consisted of floating approximately 18 miles, from the boat ramp at the Cole M. Rivers fish hatchery (~ 1 mile downstream of Lost Creek Reservoir) downstream to Dodge Bridge (Figure 1). Eight sites were sampled in this reach. Five sites were on the Rogue River and three sites were tributaries.

Lower Reach

The crew leader was Bill Meyers (DEQ Medford). He was joined by Nick Haxton (DEQ Lab) and Eli Murphy (DEQ Lab). The Lower River reach consisted of floating approximately 13 miles, from Dodge Bridge down to the former Gold Ray dam (Figure 2). The three pre-determined sampling locations in this reach were the same sampling points in the Hafele study, associated with upstream of the WWTP (Lower 2), the closest riffle below the WWTP (Lower 3), and downstream of the Medford WWTP about one mile (Lower 4). Four mainstem Rogue River sites and four tributaries were sampled.

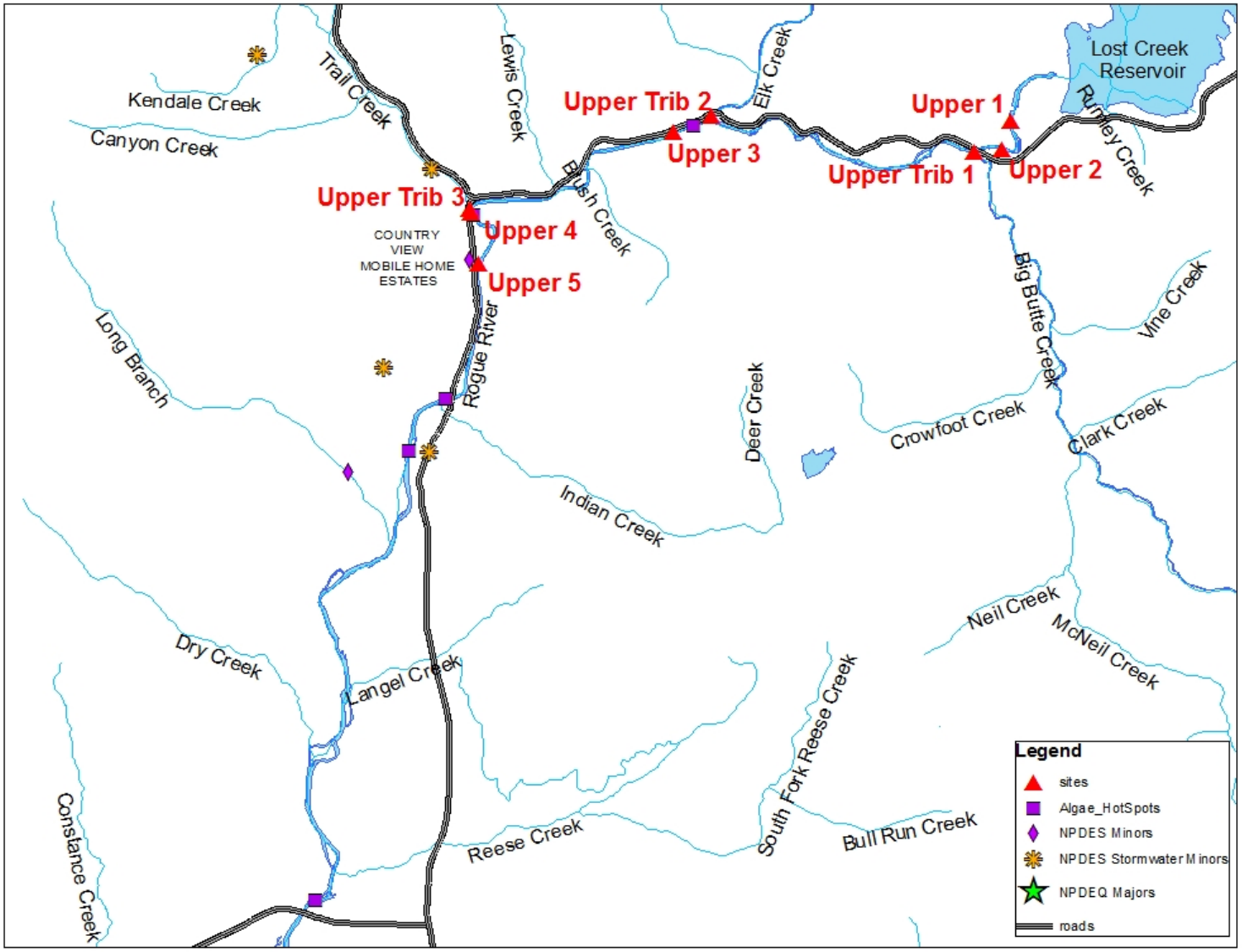

Figure 1. The Upper Reach of the Rogue River algal reconnaissance study was approximately 18 miles long. Five mainstem Rogue River sites were surveyed for macroinvertebrates, algae, and field water chemistry. At the three tributary sites, only field water chemistry parameters and visual observations of algal coverage were taken.

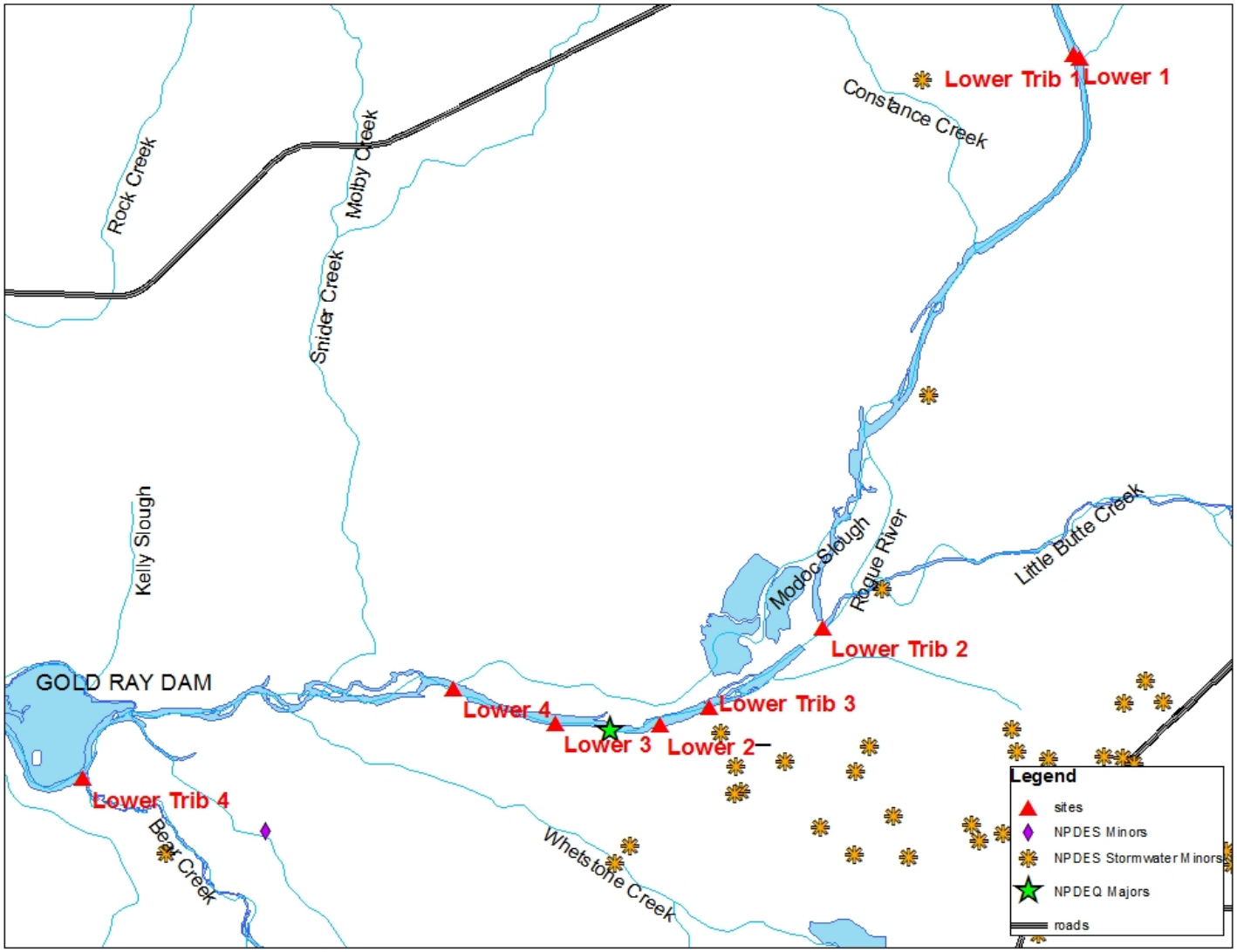

Figure 2. The Lower Reach of the Rogue River algal reconnaissance study was approximately 13 miles long. Four mainstem Rogue River sites were surveyed for macroinvertebrates, algae, and field water chemistry. At the four tributary sites, only field water chemistry parameters and visual observations of algal coverage were taken.

Results

Upper Reach

Biological conditions in the Upper Reach

Field observations showed high algae and macrophyte densities in riffle habitat at one sampling location in the Upper River—site Upper 1, below the Cole M. Rivers fish hatchery (Figure 1, Table 1). Areal algal coverage of rocks in the first riffle below the hatchery was estimated at 90%. We also observed high abundance of filamentous green algae here, with filaments reaching their longest length observed in the Upper Reach. Macroinvertebrates appeared to be dominated by chironomids (midges) and mites. Dominance appeared higher at this site than any other in the Upper Reach. There were also relatively few sensitive EPT taxa (EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)). This was also the only site in the Upper Reach with low EPT abundances and without caddisflies collected. Overall, the extent of observed potential nuisance algae at the site below the hatchery (Upper 1) was higher than at any other site in the Upper Reach.

Algal hot-spots

Of the five sites identified by local fishermen as having algae problems, we observed what could possibly be considered nuisance algal growth in the Rogue River upstream of Elk Creek (Upper Trib2) and at the Rogue River below Trail Creek (Upper 4) (Figure 1, Table 1). At both of these sites, algal coverage was heavy only in slow water habitats, reaching ~75% coverage. However, in higher velocity habitats, coverage by algae was low to moderate. Heavy algal coverage was also observed in Trail Creek as it entered the Rogue.

Permitted discharges

There were three NPDES discharges in the mainstem Rogue River within the Upper Reach: Cole M. Rivers Fish Hatchery, Country View Mobile Home Estates, and Shady Cove Sewage Treatment Plant. We did not observe potential nuisance algae conditions directly below either the Country View or Shady Cove outfalls, nor at the cloasest downstream riffles from either outfall. We did, however, observe potential nuisance algae conditions in the area downstream of the fish hatchery (site Upper 1; see Table 1).

Water quality field parameters in the Upper Reach

DO saturation, as would be expected, increased steadily throughout the day. Saturation at the hatchery was 96% at 10:39 am. In the afternoon, the lowest two sites in this reach had DO saturations ~110%. In the mainstem sites, pH ranged from 7.34 – 8.48. The highest pH values were observed in the afternoon, approaching the Oregon water quality standard upper limit (8.5) at the Rogue River downstream of Trail Creek (Upper 4; Table 1). Conductivity in the Upper Reach was consistent in the mainstem, ranging from 62-68 uS/cm (Table 1). Big Butte and Elk creeks had higher conductivities (117 and 153 uS/cm, respectively), but Trail Creek was similar to the Rogue mainstem, at 67 uS/cm.

Rogue River Algae Reconnaissance

Table 1. Results of water, algal, and macroinvertebrate field observations in the 'Upper Reach' of the Rogue River. The reach spanned from the Cole M. Rivers boat launch, downstream to Dodge Bridge. "chiros" = Chironomidae (midges), "EPT" = Ephemeroptera, Plecoptera, Trichoptera (mayflies, stoneflies, and caddisflies); "baetids" = Baetidae (a mayfly family).

Site ID	Upper 1	Upper 2	Upper Trib 1	Upper Trib 2	Upper 3	Upper Trib 3	Upper 4	Upper 5
Site Location	**Rogue R. at Hatchery**	**Rogue R. downstream of spillway**	**Big Butte Creek at mouth**	**Elk Creek at mouth**	**Rogue R. downstream of Elk Island**	**Trail Creek at mouth**	**Rogue R. downstream of Trail Creek**	**Rogue R. at Countryview Mobile Home Estate outfall**
Lat/Long	42.66352 -122.68713	42.56865 -122.688.73	42.658 -122.695	42.663 -122.755	42.66007 -122.76331	42.646 -122.809	42.64533 -122.8088	42.63671 -122.80679
Time	10:39	11:08	-	-	13:05	-	14:15	14:45
Field Parameters								
Temperature (°C)	9.13	9.44	11.04	12.4	10.4	10.3	11.07	11.3
Baro. Pressure (mmHg)	720.4	720.4	719	722	722	722.5	724	722.9
Diss. Oxygen (mg/L)	11.1	11.0	10.9	10.9	11.7	11.5	12.3	11.8
DO Saturation (%)	96	96	99	102	100	101	111	108
pH	7.3	7.4	7.7	7.8	8.1	7.9	8.5	8.4
Conductivity (µS/cm)	62	62	117	153	62	67	68	68
Algae Observations								
Aerial Coverage Visual Estimate (%)	90	35	-	-	n/a	-	75	10-15
Categorical Estimate	moderate	light	-	-	light/moderate	-	moderate	light
Filament Length and Color	-	Brown- short: <1 inch	-	-	green to brown, more abundant in shallows	-	brown <1 inch	brown and green, most > 0.5 inches
Macroinvertebrate Observations								
Density	moderate	high	-	-	moderate	-	moderate	moderate
Diversity	moderate	high	-	-	moderate	-	moderate	moderate
Dominant Taxa	chiros & mites; EPT present	chiros and limpet snails; EPT present	-	-	worms then stoneflies; other EPT	-	midges and baetids; other EPT present	baetids and midges

Lower Reach

Daily maximum flow during our survey was 1360 cfs (USGS Gauge at Dodge Bridge). For comparisons, during Hafele's survey, daily maximum flow was similar at 1380 cfs.

Algae, macroinvertebrates, water chemistry samples, and general observations were collected at four mainstem sites in the lower reach (Figure 2; Table 2). Water chemistry and algal coverage observations were recorded at two tributaries and one stormwater outfall above the Medford WWTP. One additional tributary was sampled below the WWTP. The first algae and macroinvertebrate site on the Rogue River was above Hog Creek (site Lower 1), while the last three mainstem sites were the same sites as sampled by Hafele (2013; sites Lower 2 – 4), which include one site upstream and two sites downstream from the WWTP.

Biological conditions in the lower reach

Algal, macroinvertebrate, and macrophyte conditions that would potentially indicate poor conditions were only observed at the two sites below the Medford WWTP (Lower 3 and 4) (Figure 2; Table 2). The Rogue River site above Hog Creek (Lower 1) had low algal coverage (5%; see Table 2). The riffle upstream of the WWTP (Lower 2) had estimated algal coverage of 20%. Macroinvertebrates in Lower 1 and Lower 2 (both above the Medford WWTP) were dominated by EPT taxa, which are generally considered a sensitive group of macroinvertebrates and indicators of good water quality and habitat. Compared to the two upstream sites in the Lower Reach (Lower 1 and 2), the site 0.3 miles below the WWTP (Lower 3) showed an increase in algal coverage (90%). At Lower 3, macroinvertebrate diversity was low, with dominance by taxa generally considered tolerant of organic pollution (flatworms) (Table 2). In addition, macrophyte density in the sampled riffle and the main channel below the WWTP was higher than observed anywhere else in either the Upper Reach or Lower Reach (see photos in Appendix 1).

Further downstream, the site 1.0 miles below the WWTP (Lower 4) showed conditions in between those observed at the two sites above the WWTP (Lower 1 and 2) and the site below the WWTP outfall (Lower 3). Algal coverage one mile below the WWTP was 40-50% (Table 2). Macroinvertebrate diversity increased and dominant taxa shifted back to include EPT taxa.

Water quality field parameters in the lower reach

Increased temperature, higher conductivity, and higher DO concentration and saturation were observed at the site 0.3 miles downstream of the WWTP outfall (Lower 3), compared to the sites directly upstream and downstream. Over a span of ~ 70 minutes, water temperature increased from 10.9 ºC at the upstream site (Lower 2) to 12.5 ºC below the WWTP (Lower 3), then dropping back to 11.7 ºC at 1.0 mile below the WWTP (Lower 4) (Table 2). Conductivity increased from 93 uS/cm upstream of the WWTP outfall (Lower 2) to 144 uS/cm 0.3 miles downstream (Lower 3), falling to 121 uS/cm at 1.0 miles downstream of the outfall (Lower 4). This represents a 55% increase in conductivity below the outfall, while one mile downstream conductivity dropped to a 30% increase over background conditions observed upstream of the WWTP (Lower 2). DO saturation also showed an increase below the WWTP outfall. Upstream (Lower 2) the DO saturation was 113%, below the outfall (Lower 3) it increased to 144%, then decreased back to background conditions one mile below (Lower 4) with 112% saturation. Finally, pH was higher below the outfall (8.5) than the sites immediately above (8.4) and below (8.3). In the Upper Reach, pHs of ~8.4 were observed at several sites in the afternoon. The water quality standard upper limit for pH in the Rogue basin is 8.5 (OAR 340-041-0275).

Table 2. Results of water, algal, and macroinvertebrate observations in the 'Lower Reach' of the Rogue River. The reach spanned from Dodge Bridge downstream to the former Gold Ray dam location. "EPT" = Ephemeroptera, Plecoptera, Trichoptera (mayflies, stoneflies and caddisflies).

Site ID	Lower 1	Lower Trib 1	Lower Trib 2	Lower Trib 3	Lower 2	Lower 3	Lower 4	Lower Trib 4
Site Location	Rogue R. upstream of Hog Creek	Hog Creek at mouth	Little Butte Creek at mouth	storm discharge upstream of WWTP intake	Rogue R. upstream of WWTP	Rogue R. 0.3 miles downstream of WWTP	Rogue R. 1.0 miles downstream of WWTP	Bear Creek at mouth
Lat/Long	42.50134 -122.85011	42.501036 -122.849460	42.447885 -122.878920	42.440173 -122.892480	42.438458 -122.898508	42.438342 -122.911366	42.441260 -122.923988	42.431953 -122.969011
Time	10:01	10:25	11:54	12:33	approx. 13:00	13:30	14:10	15:02
Field Parameters								
Temperature (°C)	9.48	12.63	14.12	14.41	10.64	12.53	11.71	15.44
Baro. Pressure (mmHg)	726.8		730.6	725.5	726.7	725.8	729.3	730.2
Diss. Oxygen (mg/L)	11.3	9.7	10.5	9.7	11.9	13.7	11.6	10.2
DO Saturation (%)	103	95	107	99	113	135	112	106
pH	7.7	7.6	8.1	7.9	8.4	8.5	8.3	8.2
Conductivity (µS/cm)	91	146	136	296	93	144	121	230
Algae Observations								
Aerial Coverage Visual Estimate (%)	5	-	-	-	20	90	40- 50	-
Categorical Estimate	light	-	-	-	moderate	heavy	moderate	-
Filament Length and Color	1.5 inches/dark green or light brown	-	-	-	2 inches; light brown and dark green	1-3 inches; light brown	1 inch; dark green	-
Macroinvertebrate Observations								
Density	high	-	-	-	high	high	high	-
Diversity	moderate	-	-	-	high	low	high	-
Dominant taxa	EPTdominant	-	-	-	Dominant EPT, more worms	Flatworms dominant; one EPT taxa	Caddisflies dominant; worms prevalent	-

It appeared that there was insufficient effluent mixing downstream of the WWTP's discharge into the river. The majority of the effluent seemed to be coming out of the first port in the diffuser. The port five feet from the left (south) bank was bubbling and no indication of discharge could be seen from other ports further across the river. There was a slight foam line visible from the first port which hugged the south bank for 100 yards where it then slowly moved across to the North bank. The foam line was visible for ¼ mile. This lack of proper mixing was also documented by Hafele (2013).

Water quality observations from the Lower Reach tributaries upstream of the Medford WWTP (Lower Trib 1 – Lower Trib 3) did not indicate nuisance algal growth (Table 2). Specific conductances were slightly elevated at Hog Creek (Lower Trib 1) and Little Butte Creek (Lower Trib 2), compared to mainstem background (Lower 1). In the stormwater discharge (Lower Trib 3), specific conductance was approximately three times higher (296 uS/cm) than mainstem conductivities. The discharge from the drain was clear and there were no signs of excessive algal or macrophyte growth below this stormwater outfall. Dissolved oxygen and pH at all three of the upstream tributaries in the Lower Reach were similar to mainstem conditions. Little Butte Creek did show signs of fine sedimentation deposition, with a somewhat heavy covering of silt on the substrate.

Continuous Chemistry

A data sonde was placed at Dodge Bridge (rivermile 138.4; Figure 1) from 17:00 on Tuesday, September 24th through 12:30 on Friday, September 27th. Conductivity, temperature, DO, and pH of the Rogue River were collected every 15 minutes, for a total of 68.5 hours. The range of values observed in the Rogue River at Dodge Bridge are shown in Table 3.

Diel fluctuations in temperature, DO, and pH were observed each day (Table 3; Figure 3). The peaks for temperature and pH were synchronous, while they occurred several hours earlier for DO. The weather was mostly cloudy on the day prior to (24th) and of the survey (25th). Cloud cover dissipated in the evening of the 25th and skies were clear for the 26th and the 27th. The lack of cloud cover was associated with a peak temperature increase of almost half a degree (C) on the 26th. The sunnier days of the 26th and 27th also saw a rise in peak DO and pH values. While we were unable to capture peak conditions on the 27th, DO at 12:30 was at the maximum value observed in our study period. This maximum DO was recorded 75 minutes earlier than the time of peak DO on the previous two days.

Table 3. Ranges and timing of peak values for continuous monitoring of field chemistry for the Rogue River at Dodge Bridge.

Parameter	Minimum	Maximum	Range	Peak Time on the 25th	Peak Time on the 26th
Temperature (^{o}C)	8.12	11.55	3.43	1815	1730
pH	7.54	8.68	1.14	1645	1745
D.O (mg/L)	10.28	11.99	1.71	1345	1345
Conductivity (uS/cm)	67	71	4	--	--

Periphyton Observations

Algal assemblages were collected from nine sites in the study area, with a total of 16 samples collected (nine rock scrapes and seven filamentous grabs). Samples were analyzed by Kurt Carpenter (USGS) using light microscopy to identify algal taxa presences and dominant taxa in each sample.

Upper Reach

Among the diatoms, *Melosira*, *Cymbella*, and *Epithemia* were the dominant taxa at all sites in the Upper Reach (Table 4). The main differences observed among sites in the Upper Reach were primarily in the presence of filamentous green algae, macrophytes (aquatic plants), and bryophytes (mosses) at two sites. Filamentous green algae (*Cladophora* and *Mougeotia*) were among the dominant taxa below the hatchery (Upper 1) and below Elk Creek (Upper 3). These taxa were sub-dominant or absent at all other sites in the Upper Reach. The site below the hatchery showed dominance by mosses and the introduced macrophyte Parrotfeather in the filamentous grab samples. Blue-Green algae (B-G) were encountered twice in the upper Reach, in the rock scrapes at the site below the spillway return (Upper 2) and in the filamentous grabs of the Rogue River downstream of Trail Creek (Upper 4).

Lower Reach

The algal assemblages in the Lower Reach appeared to be somewhat different from those in the Upper Reach. The Lower Reach sites above the WWTP (Lower 1 and 2) also appeared different from the sites below the WWTP (Lower 3 and 4). Lower Reach sites differed from Upper Reach sites primarily by a reduction in dominance by diatoms (*Cymbella*, *Epithemia*, and *Gomphoneis*), as well as an increased prevalence of Blue-Green algae (Table 4).

The sites above the WWTP (Lower 1 and 2) showed Blue-Green algae to be a dominant taxa group (primarily *Oscillatoria*) in both the rock scrapes and filamentous grabs. The site 0.3 miles below the WWTP (Lower 3) showed low dominance by Blue-Greens, with only *Phormidium* observed—this taxa was not observed at any other site in the entire study area (Table 4). Blue-Greens were absent from the rock scrapes at the site 1.0 miles below the WWTP (Lower 4), but *Oscillatoria* was a dominant taxa in the filamentous grabs at this site.

Several diatoms (*Cymbella*, *Epithemia*, *Synedra*) observed in the rock scrapes at the two upstream sites (Lower 1 and 2) were absent below the WWTP (Lower 3 and 4). In the filamentous grabs upstream of the WWTP (Lower 1 and 2), diatoms showed lower dominance than the two sites below the WWTP; while below the WWTP diatom dominance shifted from *Melosira* at Lower 3 to *Cymbella* and *Gomphoneis* at Lower 4.

Filamentous green algae were absent from both the rock scrapes and filamentous grabs at the two upstream sites in the Lower Reach, but they were dominant at sites below the WWTP (Table 4). Below the WWTP, dominant filamentous algae taxa in the rock scrapes shifted from *Cladophora* and *Mougeotia* (sub-dominant) just below the WWTP (Lower 3) to *Oedogonium* and *Cladophora* (sub-dominant) one mile below the WWTP (Lower 4).

Rogue River Algae Reconnaissance

Table 4. Results of algal identifications for the Upper Reach and Lower Reach of the Rogue River, between the Cole M. Rivers boat ramp and the former Gold Ray dam site.

		Rock Scrapes																			Filamentous Grabs														
		General			Filamentous Green Algae (FGA)						Diatoms					Bluegreens (B-G)				Inverts	General		Macrophyte	Bryophyte	FGA		Diatoms						B-G	Inverts		
Site ID	Site name	Lots of detritus/organic particles	Not a lot of Diatoms	Stalked diatoms	Cladophora	Mougeotia	Oedogonium	Spirogyra	Zygnema	FGA epiphytes	Melosira	Cymbella	Epithemia	Gomphoneis	Synedra	Oscillatoria	Phormidium	Nostoc-like	Nostoc	midge	Lots of Diatoms	mucilage clumps/stalks	Parrotfeather	Moss	Cladophora	Mougeotia	Epithemia	Melosira	Fragilaria intermedia	Cymbella	Gomphoneis	Tabellaria	Oscillatoria	Flatworms	Snails	Nematodes
Upper 1	Rogue R. at Hatchery			X	X	x					X	X											X	X			x	X		x	x					
Upper 2	Rogue R. downstream of spillway			X							X	x	x	x				x[1]		X		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Upper 3	Rouge R. downstream of Elk Island			X	X	X					x	x	X												X	X	X	x								
Upper 4	Rogue R. downstream of Trail Creek			X		x				x	X	x	x	x							X				X	x	x	x		x			x			
Upper 5	Rogue R. at Countryview Mobile Home Estate outfall			X		x		x	x		X		x									--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lower 1	Rogue R. upstream of Hog Creek										x				x	X			x								x	x		x			X			
Lower 2	Rogue R. upstream of WWTP			X							X	x	x			X						X											X			
Lower 3	Rogue R. 0.3 miles downstream of WWTP		X		X	x					X						x								X	x	x	X	X	x	x					
Lower 4	Rogue R. 1.0 miles downstream of WWTP	X			x		X				X														X			x		X	X	x	X	X	X	X

Most abundant (overall)

X = Dominant taxa

x = Sub-dominant taxa

[1] Nostoc like - heterocystous BGA, short filament

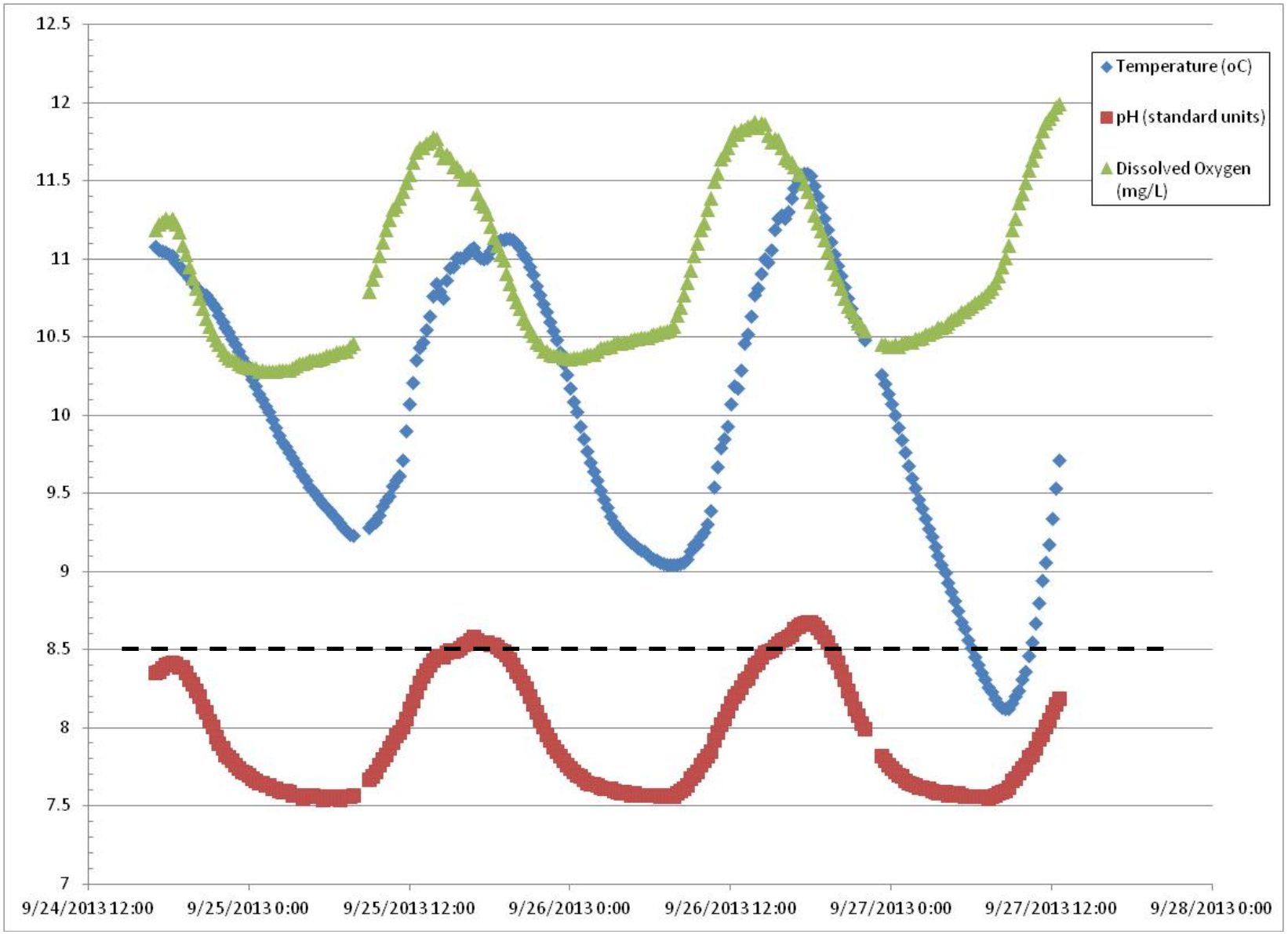

Figure 3. Results of continuous monitoring for temperature (Temp), pH, and dissolved oxygen (D.O.) in the Rogue River at Dodge Bridge (rivermile 138.4). The black dashed line represents the upper pH criteria (8.5).

Discussion

In the Upper Reach, we observed the highest algae and macrophyte abundance at the site below the fish hatchery (Upper 1, see Figure 1). Algae and macrophyte coverage at this site, especially in the fast-flowing riffle habitat, was high compared to other locations throughout the Upper Reach. However, evidence of nuisance aglal growths upstream of the fish hatchery suggest more of an influence from Lost Creek Reservoir than the hatchery itself (see below). Two other sites in the Upper Reach (Upper Trib 2 and Upper 4) showed relatively high algal coverage only in the slow water habitats. Relatively dense algal coverage was also associated with the mouth of Trail Creek (Upper Trib 3).

In the Lower Reach, high levels of algal and macrophyte growth were only observed below the Medford WWTP. There was 90% aerial algal coverage directly below the WWTP (Lower 3) and 40-50% coverage 1.0 mile below the WWTP (Table 2). In addition, macrophyte density in the main channel below the WWTP was higher than observed anywhere else in either the Upper Reach or Lower Reach (see photos in Appendix 1). Nowhere else in the entire 31 miles of the survey did we observe dense macrophytes in the mid-channel of the Rogue River. Large patches of macrophytes throught the rest of the river were only observed in slow moving habitats or the margins of the river. The macroinvertebrate assemblage at the site below the WWTP (Lower 3) was unlike the assemblages observed at any other site in either the Upper or Lower Reaches. No other site was dominated by flatworms (Turbellaria; tolerant of organic pollution) and no other site was visually estimated to have “low” diversity (Tables 1 and 2).

Assessing the concerns of “algal hot-spots” identified by local fishing groups

Prior to our survey, local fishing groups identified five locations in the Upper Reach with high algal or macrophyte densities—at least at one time, if not currently (Figure 1). In the Lower Reach, only the site 0.3 miles below the WWTP (Lower 3, Figure 2) was identified prior to our survey as having algal and/or macrophyte nuisance-growth issues.

In the upper Reach we observed possible nuisance algae and/or macrophyte conditions at three sites. The first site, below the fish hatchery (Upper 1), was not identified as an “algal hot-spot” prior to our surveys. Here we observed higher algal coverage (90%) and possibly lower macroinvertebrate assemblage condition (moderate density and diversity, combined with low diversity and abundances of EPT taxa), compared to other Upper Reach sites (Table 2). The other two sites in the Upper Reach that we identified as potentially experiencing high algal/macrophytes densities were the Rogue River above Elk Creek (Upper Trib 2) and the Rogue River below Trail Creek (Upper 4). At these two sites, we only observed high algal coverage in slow-moving habitats.

Assessing the potential for study area nutrient issues leading to excessive algal growth

There is evidence of high nutrient conditions and nuisance algal growth at several points in both the Upper and Lower Reaches. This evidence comes from direct observations made in this study, observations from local fishing groups, historical observations, and data from other agencies and researchers.

The high abundance of *Melosira*, combined with the presence of filamentous green algae (*Cladophora* and *Mougeotia*) (see Table 4) may indicate that nutrient enrichment is an issue throughout the study area, not just below the Medford WWTP (Kurt Carpenter, USGS, pers. comm.). *Melosira* is a eutrophic indicator taxa (Porter et al. 2008). However, *Melosira varians* (the taxa found in this study) may not be a consistent indicator of eutrophic conditions, with this taxa frequently occurring in cold, nutrient poor waters (Yangdong Pan, Portland State University, pers. comm.). Stalked diatoms (*Cymbella* and *Gomphoneis*) may in many instances be associated with good water quality, but under certain conditions they can form nuisance "blooms".

Direct observations by field crews during this study showed the potential for nuisance algae conditions at four locations (below the hatchery, Upper 1; above Elk Creek, Upper Trib 2; below Trail Creek, Upper 4; and below the Medford WWTP, Lower 3). The presence of several algae with the ability to reach high biomass were observed (*Cladophora*, *Oedogonium*, *Spirogyra*, *Zygnema*, *Cymbella mexicana v.janischii*, and *Gomphoneis herculeana*). Effects of these blooms range from large swings in pH and dissolved oxygen to the smothering of substrates. In turn, these effects can make local habitats unfavorable for macroinvertebrates and fish spawning.

Unfortunately, we did not have time to sample within the Holy Waters stretch of the Rogue River (the stretch of the Rogue River just below the Lost Creek Reservoir and upstream of the fish hatchery). It would have been beneficial to see if conditions observed downstream of the fish hatchery were also observed in the upstream (Holy Water) stretch of river. However, there is evidence that releases from the Lost Creek Reservoir are a source of nutrient rich water, feeding the nuisance algae observations reported by anglers in this area. Early summer harmful algal blooms (HABS) in Lost Creek Reservoir were observed every year from 2009 – 2013 and fall-winter HABS were observed every year from 2008 – 2013 (OHA 2014). In August of 2007, ODFW District Biologist Dan VanDyke documented the presence of dense algal mats in the "Holy Water" section of the Rogue River (Figure 4). In 2009, samples taken from this reach were positively identified by researchers at Portland State University as the mat-forming algae *Cymbella mexicana v.janischii*. There is some evidence that this species prefers low temperature rivers with low dissolved solids concentrations and low N:P ratios (Y. Pan, pers. comm.). According to the Brown and Caldwell (2014) study, the N:P ratios are on the low end, suggesting nitrogen limitation.

Similar patterns of high periphyton biomass downstream of hydroelectric reservoirs in the Cascades have been documented (Carpenter, 2004; Anderson and Carpenter, 1998; Carpenter and others, 2014). In addition, there are recent concerns of potential nuisance algal growth in the Deschutes River, several years following construction of a variable withdrawal structure on Round Butte Dam (Lake Billy Chinook).

The invasive macrophyte parrotfeather, *Myriophyllum aquaticum*, was collected at a single site—Upper 1, downstream of the fish hatchery. It can exert negative ecological effects by forming dense mats that shade out native algal assemblages and result in diel swings in pH and D.O. It appears to be adapted to high nutrient conditions, which is another indicator of eutrophication in the Rogue River directly below Lost Creek Reservoir.

Assessing biological and water quality conditions at NPDES outfalls throughout the study area

We surveyed or made visual observations below several NPDES discharges in the Upper and Lower Reaches. The objective with this aspect of the survey was to see if we observed conditions at other outfalls similar to those below the Medford WWTP. Only two sites showed signs of nuisance algal growth and reduced macroinvertebrate conditions. The site below the Cole M. Rivers fish hatchery (Upper 1) and the site 0.3 miles below the Medford WWTP (Lower 3) both showed high algal growth and signs of reduced macroinvertebrate assemblage quality. Given the confirmation of nuisance algae blooms in both Lost Creek Reservoir and the Holy Water stretch of the Rogue River above the hatchery, it is likely that upstream nutrient conditions are having a greater potential impact on conditions observed below the hatchery (Upper 1) than the actual effluent from the hatchery itself. Future studies assessing nutrient conditions in the Rogue River should investigate all known permitted sources, but evidence suggests that conditions and contributions from Lost Creek Reservoir are of major concern.

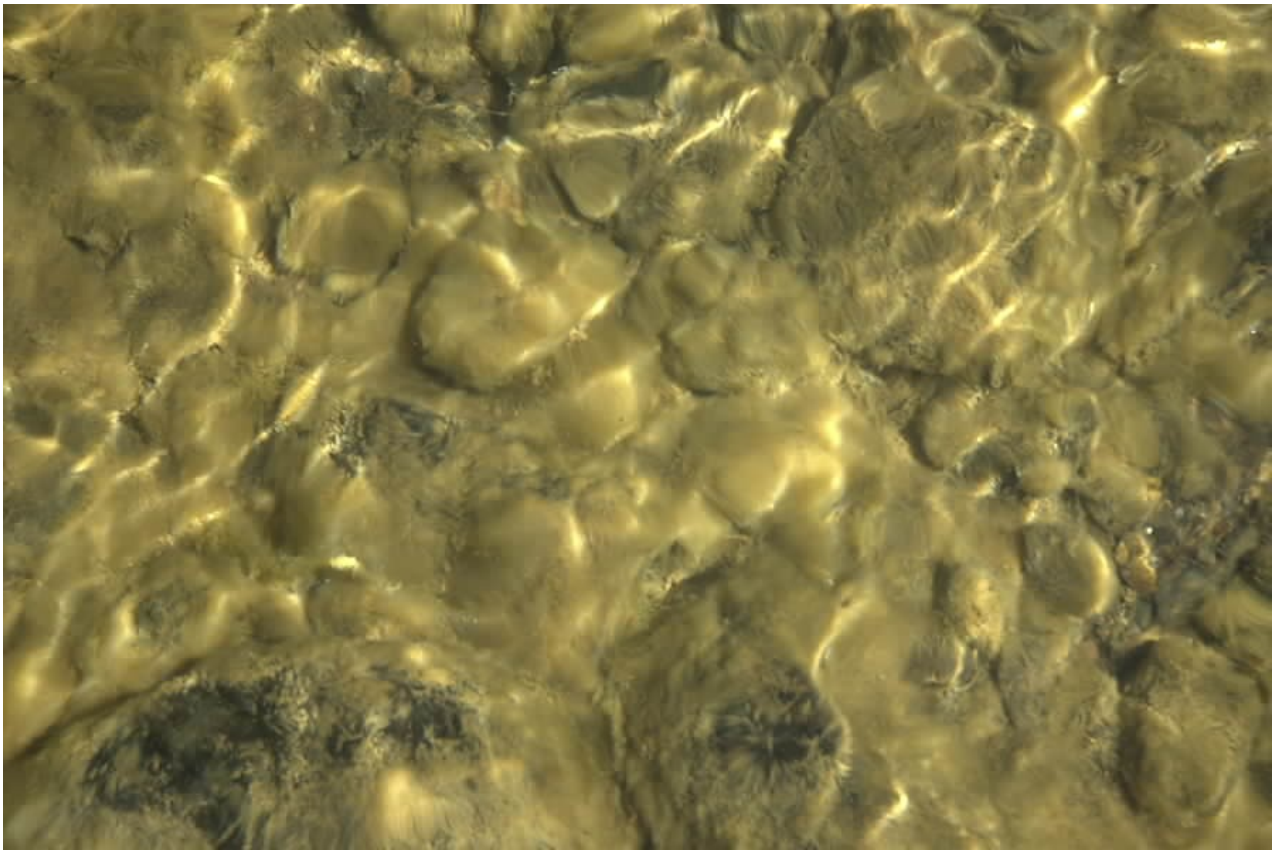

Figure 4. *Cymbella mexicana v.janischii* was observed covering large sections of the substrate in the "Holy Water" section of the Rogue River in 2007. (Photo provided by Dan VanDyke, ODFW.)

Assessing the biological conditions of the Rogue River below the Medford WWTP

Our qualitative methods were not intended to identify a biocriteria exceedance at the site 0.3 miles below the WWTP (Lower 3). However, we observed obvious changes in macroinvertebrate and algal assemblages at the nearest site downstream from the WWTP, compared to not only the nearest upstream and next downstream sites, but also to any other site in the Upper or Lower Reaches observed during this study.

Hafele (2013) used standard DEQ study design and field methods, which we would use in our own mixing zone studies. The results from the Hafele study demonstrated statistically different shifts in the macroinvertebrate and algal assemblages. The changes observed in the biological community were consistent typical responses to nutrient enrichment.

Given the similarities between the two studies and the quantitative nature of the results presented by Hafele, there is clear evidence of detrimental changes in the resident biological communities 0.3 miles below the WWTP (Lower 3). These changes were represented by significant reductions in density, diversity, and sensitive macroinvertebrates. The signal of these changes appear to persist downstream to at least 1.0 miles below the WWTP outfall (Lower 4), where the algal and macroinvertebrate assemblages in both this study and the Hafele study showed conditions in-between those observed at the sites upstream of the WWTP outfall (Lower 1 and 2) and the site 0.3 miles below the WWTP outfall (Lower 3) (Table 2).

While detrimental changes in resident biological communities have been demonstrated below the WWTP, the underlying cause(s) and source(s) have not been clearly identified. There is evidence suggesting that nutrient issues may be contributing to excessive algal growth throughout the 31-mile study area, starting with conditions in Lost Creek Reservoir. There is also strong evidence that the Medford WWTP is having an impact locally, as shown by the shifts in algal and macroinvertebrate assemblages and uncommonly high macrophyte density in the mid-channel.

Moving Forward

The results of this qualitative study agree with the biological conditions upstream and downstream of the Medford WWTP as reported by Hafele (2013). We observed detrimental changes in the resident macroinvertebrate assemblage 0.3 miles below the WWTP, and degraded conditions continued for atleast 1.0 mile below the WWTP . The findings of the commissioned study showed higher than background levels of nutrients, primarily nitrogen, below the WWTP (Brown and Caldwell 2014). While not as dramatic as the observation made by Hafele, or even the qualitative observations we observed, Brown and Caldwell also showed evidence of nutrient enrichment adversely impacting the periphyton and macroinvertebrate assemblages downstream of the Medford WWTP.

Our study also showed a high probability of nutrient issues throughout the 31-mile study area. A more detailed study of nutrient conditions would be useful to determine potential ecological impacts on the entire Rogue River system. At a minimum, continuous monitoring of pH and D.O. at multiple sites throughout the Rogue River should be considered, even beyond our study area (both upstream and downstream). This would provide a background set of information to examine the potential scale of nutrient impacts through excessive algal growth, and subsequently harmful swings in pH and D.O.caused by excessive algal photosynthesis, that may impact aquatic life. Given the observations of instantaneous pH between 8.4 – 8.5 at multiple sites, plus continuous pH measurements above the water quality standard at Dodge Bridge, broader pH issues appear to be a concern in the Rogue River.

Future work should include quantitative algal samples and identifications. Follow up work should include detailed literature review of potential indicator taxa. Additionally, understanding nutrient dynamics in the Rogue River may provide insight into where and why certain algal species may be reaching nuisance levels (e.g., shifts in N:P ratios below reservoirs or discharges).

One discussion with a local fishing guide on the day of our survey made it seem that algal conditions change routinely throughout the summer and fall months, with the locations of algal “hot-spots” changing from week to week. It would be useful to get a group of dedicated citizens to do similar observations to those undertaken in this survey for at least one summer through the autumn growing season. Qualitative observations with algae and macroinvertebrate assemblages can be accomplished fairly easily, requiring minimal training.

USGS staff indicated a willingness to partner with DEQ and the community to complete a larger-scale synoptic survey of nutrient and biological conditions throughout the Rogue River. This would be an excellent opportunity for DEQ to collaborate with expert peers and determine the scale and magnitude of any potential nutrient problems and their ecological impacts. Understanding the conditions in the Rogue River may lead us to a better understanding of similar conditions reported from the North Umpqua, North Santiam, Clackamas, and Deschutes Rivers.

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Appendix 1. Site Photos.

Upper Reach

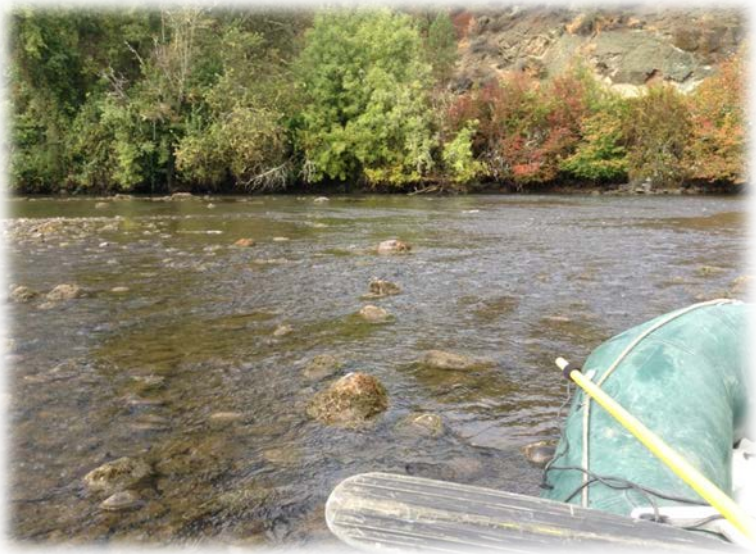
Upper 1. Rogue River at hatchery.

Looking upstream towards Cole M. Rivers fish hatchery.

Looking downstream.

Left bank.

Right bank.



Rogue River Algae Reconnaissance

Three different views of the substrate in the first riffle below the hatchery.

Heavy macrophyte growth was observed in the backwater pool below the boat ramp (right bank).

A view of the macroinveretebrate kick sample collected below the hatchery. The amount of plant material in the sample was heavy.

Upper 2. Rogue River downstream of spillway.

Looking upstream (left), downstream (right), and at the right bank (bottom).

A rock sampled for algae (left) and the macroinvertebrate sample in the sorting tray (right).

Upper Trib 1. Big Butte Creek at mouth.

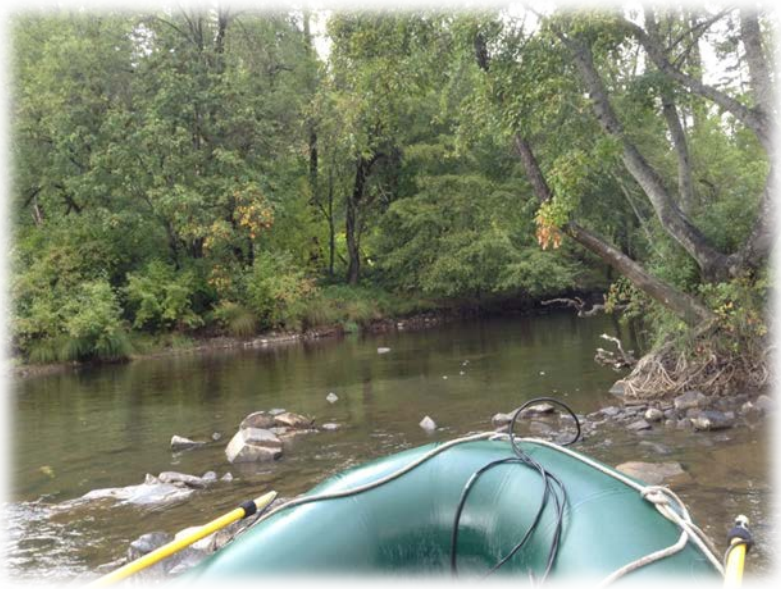
Big Butte Creek looking upstream.

Substrate in Big Butte Creek at the mouth.

Rogue River Algae Reconnaissance

Upper Trib 2. Elk Creek at mouth.

Looking upstream, from the confluence with the Rogue River (left). The substrate in the Rogue River just upstream of the confluence with Elk Creek showed moderate algal coverage in fast moving habitat (right).



Heavy algal growth was observed in the slow moving habitat of the Rogue River, just upstream from Elk Creek confluence.

Upper 3. Rogue River downstream of Elk Creek island.

The Rogue River, at the downstream end of the island below Elk Creek. Upstream (top left), downstream (top right), left bank (bottom left), and right bank (bottom right).

Upper 3. Rogue River downstream of Elk Creek island. (cont.)

Substrate in the slow moving habitat of the Rogue River at the downstream end of the island below Elk Creek showed moderate to heavy algal growth.

Substrate in the fast moving habitat of the Rogue River at the downstream end of the island below Elk Creek showed light to moderate algal growth.

Upper 4. Rogue River downstream of Trail Creek.

Looking upstream (left) and downstream (right), and at the left bank (bottom).

The substrate in the Rogue River below Trail Creek showed heavy algal growth in slow water habitat.

Upper 5. Rogue River at Country View Mobile Home Estates outfall.

Looking upstream (top left), downstream (top right), at the left bank (lower left), and right bank (lower right).

Upper 5. Rogue River at Country View Mobile Home Estates outfall. (cont.)

Substrates sampled at Upper 5 showed low algal coverage.

The macroinvertebrate sample from Upper 5 in the sorting tray.

Lower Reach

Lower 1. Rogue R. upstream of Hog Creek.

(Clockwise, from top left) Upstream, downstream, right bank, left bank.

Upstream

Downstream

Left bank.

Right bank.

Rogue River Algae Reconnaissance

Lower 1. Rogue R. upstream of Hog Creek.

Substrate in the algae and macroinvertebrate sampling areas.

Filamentous algae grab (left), algae rock scrape (right), macroinvertebrate sample (bottom).

Rogue River Algae Reconnaissance

Lower Trib 1. Hog Creek at Mouth.

Confluence of Hog Creek and the Rogue River.

The Rogue River downstream of Hog Creek.

Hog Creek at mouth, looking upstream (left).

Substrate at the mouth of Hog Creek.

Lower Trib 2. Little Butte Creek at mouth.

Looking upstream (top) and downstream (bottom) in the Rogue River, at the mouth of Little Butte Creek.

Rogue River Algae Reconnaissance

Lower Trib 3. Storm discharge, upstream pf WWTP intake.

Photos for this site were lost.

Lower 2. Rogue River upstream of WWTP.

Photos for this site were lost.

Lower 3. Rogue River 0.3 miles downstream of WWTP.

Most photos for this site were lost.

Macrophyte growth was particularly dense in the pool below the Medford WWTP. These photos were taken looking upstream from approximately 0.25 miles below the WWTP outfall, just above the Lower 3 site.

Lower 4. Rogue River 1.0 miles downstream of WWTP.

Substrate at Lower 4.

Close-up view of substrate at Lower 4.

A view of the river bed (left) shows macrophytes and algae (green patches). A look at the macrophytes observed at Lower 4 (right).

Lower Trib 4. Bear Creek at mouth.

Rogue River at Bear Creek, looking upstream (left), downstream (right), and at the right bank (bottom).

Bear Creek at the mouth, looking upstream.