WINTER STORM TURBIDITY AND BIOLOGICAL INTEGRITY OF OREGON COAST STREAMS 1997

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ABSTRACT
In March of 1997 winter storm turbidity was measured at 27 first through third order streams in the coast ecoregion of Oregon and compared to the biological integrity scores for the same streams. Three storm events were monitored using continuous turbidity monitoring equipment and discrete grab samples. Biological integrity was evaluated using the macroinvertebrate assemblages of pool and riffle habitat and vertebrate surveys conducted during July, August, and September of 1994-1995. Results indicate that the integrity of all three portions of the stream biota correlate with winter storm turbidity. Streams with higher winter storm turbidity tended to have lower biological integrity scores. The results also indicate the value of monitoring fewer sites more frequently rather than sampling more sites fewer times when conducting storm chasing studies.

INTRODUCTION

The study described in this report looks at the winter time storm turbidity of 27 coast ecoregion streams measured during March 1997, and how turbidity during high stream flows relate to the stream biological integrity. The streams monitored had a range of biological conditions. The streams were part of approximately 60 randomly selected first through third order streams surveyed in the Regional Environmental Monitoring and Assessment Program (REMAP). REMAP is an EPA sponsored study that describes the chemical, habitat and biological integrity of streams on a regional basis by using a random sampling approach. The Department of Environmental Quality (DEQ) conducted a REMAP study in Oregon Coast ecoregion streams in July, August, and September of 1994, 95, and 96. The stream conditions ranged from relatively pristine sites to highly disturbed sites with a range of biological integrity.

Turbidity and sedimentation are known to impair stream organisms in many ways (Waters, 1995). High turbidities are ephemeral and often associated with high stream flows. Impairment causing turbidity may not be present at summer time base stream flows when biological surveys are conducted. Sites for turbidity monitoring were selected to represent a range of biological conditions to see if summer time biological condition was correlated to wintertime storm turbidity.

OVERVIEW

Turbidity is a measure of the opacity of water and is a natural element of all flowing waters. Turbidity results from material dissolved or suspended in the water. The dissolved and suspended material in streams has many forms and sources. The ecological integrity of our streams and rivers can be impaired by excessive turbidity from fine particulate materials that result from human activity.

Excessive fine particulate material in streams can have a number of undesirable effects on the stream biota. It can decrease primary productivity by smothering, abrading or shading photosynthesizing organisms. The macroinvertebrate assemblage can be effected by excessive fine particulate material by smothering, filling in habitat space by fine sediment deposition, decreased food availability for grazers, and decreased feeding efficiency for visual predators. Excessive fine particulate material harms fish and amphibian communities by smothering respiratory surfaces, smothering eggs laid in spawning gravel, trapping emerging newly hatched fry in spawning gravel, decreasing food availability and visual feeding efficiency, and by filling in pools and interstitial habitat spaces (Waters 1995). Excessive fine particulate material and sedimentation are identified as “Factors for Decline” in the Oregon Plan for Salmon and Watersheds.

Using the biota as an indicator of ecological integrity of a stream has advantages over traditional grab sampling for water chemistry for evaluating the effects of ephemeral pollutants such as turbidity (Plafkin et al. 1989). Excessive turbidity and sedimentation may occur in streams only briefly due to some human activity or increased stream flow due to heavy rainstorms, but the detrimental effects are often reflected in the stream biota long afterwards.

METHODS

Sites Selection and Description

Approximately 60 randomly selected sites were surveyed in the REMAP study of 1994 and 1995, from which 27 sites were selected for this turbidity study. The 27 sites were selected to include a range of biological conditions. Table 1 is a site list and Figures 1 and 2 are site location maps. The sites were divided into a north coast and mid coast group. An additional south coast group was planned but was not surveyed due to a lack of storms.

North Coast Sites:

Sites in the northern half of the study area were monitored for eight days that included two storms; one that occurred on March 1 and one on March 6, 1997. We installed Data Sonde continuous monitoring equipment in four streams. Grab samples for turbidity were collected one to three times at an additional eleven sites.

The four north coast streams with Data Sondes were:

- Joes Creek, a small, steep, forested, headwater stream in the Nestucca basin. It had the highest riffle macroinvertebrate score of the streams in this survey indicating a relatively non-impaired biological condition. We moved the Data Sonde continuous turbidity monitor from Joes Creek to Bewley Creek when it appeared that snow and bad road conditions might prevent us from reaching this higher elevation site.
- Kilchis River, a large stream with boulder-cobble substrate in a forested watershed. This stream is in the Tillamook State Forest. Our site appeared to be upstream of most human activity. The Kilchis River had an intermediate riffle macroinvertebrate score indicating a moderately impaired biological condition.

Table 1: Coastal Turbidity and Biological Integrity Study Site List

Site Number	Site Name	Monitoring Activity	Riffle Bug Bio Score	Pool Bug Bio Score	Vertebrate IBI	Stream Order	County	USGS HUC	River Mile	Elevation (feet)
North Coast: February 28 to March 7, 1997										
OR822S	Agency Cr.	Grab Samples Only	60	46	17	3	POLK	17090008	0.20	10.0
OR798S	Bewley Cr.	Continuous and Grab Samples	45	69	28	2	TILLAMOOK	17100203	0.30	1320.0
OR818S	Big Cr.	Grab Samples Only	82	89	*	3	TILLAMOOK	17080006	2.90	140.0
OR007S	Cedar Cr.	Grab Samples Only	59	69	28	2	YAMHILL	17090008	0.60	20.0
OR796S	Dart Cr.	Grab Samples Only	64	74	27	1	COLUMBIA	17090012	3.70	340.0
OR831S	Fall Cr.	Grab Samples Only	85	51	49	2	TILLAMOOK	17100203	0.70	100.0
OR826S	Fishhawk Cr.	Grab Samples Only	48	37	33	3	COLUMBIA	17100202	1.70	470.0
OR019S	Joes Cr.	Continuous and Grab Samples	88	63	41	1	TILLAMOOK	17100203	0.50	360.0
OR829S	Kilchis R.	Continuous and Grab Samples	70	68	*	3	TILLAMOOK	17100203	8.50	400.0
OR832S	Mill Cr.	Continuous and Grab Samples	48	55	23	2	TILLAMOOK	17100203	1.00	505.0
OR013S	N.F. Nehalem R.	Grab Samples Only	82	60	41	3	CLATSOP	17100202	13.10	310.0
OR011S	Nehalem R. Tributary	Grab Samples Only	*	33	23	1	COLUMBIA	17100202	0.30	350.0
OR823S	Rock Cr.	Grab Samples Only	80	73	28	3	POLK	17090008	1.40	250.0
OR001S	S.F.Goble Cr.	Grab Samples Only	56	43	45	2	COLUMBIA	17080003	0.90	530.0
OR009S	Williams Canyon Cr.	Grab Samples Only	24	48	50	1	YAMHILL	17090010	1.80	270.0

* No sample collected

Mid Coast: March 15 to 18, 1997

Site Number	Site Name	Monitoring Activity	Riffle Bug Bio Score	Pool Bug Bio Score	Vertebrate IBI	Stream Order	County	USGS HUC	River Mile	Elevation (feet)
OR043S	Cabin Cr.	Grab Samples Only	37	43	27	2	DOUGLAS	17100303	5.60	570.0
OR850S	Cox Cr.	Grab Samples Only	*	58	36	1	DOUGLAS	17100303	0.30	850.0
OR027S	Drift Cr.	Grab Samples Only	73	108	16	3	LINCOLN	17100205	7.30	20.0
OR851S	Elk Cr.	Grab Samples Only	*	88	11	3	DOUGLAS	17100303	34.20	380.0
OR790S	Fox Hollow Cr.	Grab Samples Only	47	49	13	2	LANE	17090003	1.30	540.0
OR839S	Honey grove Cr.	Grab Samples Only	68	102	37	2	BENTON	17100205	1.20	500.0
OR003S	Long Tom R.	Continuous and Grab Samples	64	77	18	3	LANE	17090003	48.50	510.0
OR841S	S.F. Siuslaw R.	Grab Samples Only	37	60	22	3	LANE	17100206	2.30	680.0
OR846S	Smith R.	Grab Samples Only	34	69	24	3	DOUGLAS	17100303	81.30	760.0
OR029S	Tenmile Cr.	Continuous and Grab Samples	98	117	42	3	LANE	17100205	6.30	310.0
OR835S	Yaquinna R at Eddyville	Continuous and Grab Samples	30	59	20	3	LINCOLN	17100204	36.30	60.0
OR836S	Yaquinna R upstream of Eddyville	Grab Samples Only	6	62	17	3	LINCOLN	17100204	38.90	90.0

* No sample collected

Macroinvertebrate Score Categories:
>72 No Impairment
72-44 Moderate Impairment
<44 Severe Impairment

Vertebrate Score Categories:
Maximum Score=50
>34 No Impairment
34-24 Moderate Impairment
<24 Severe Impairment

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Figure 1 North Coast Turbidity Study

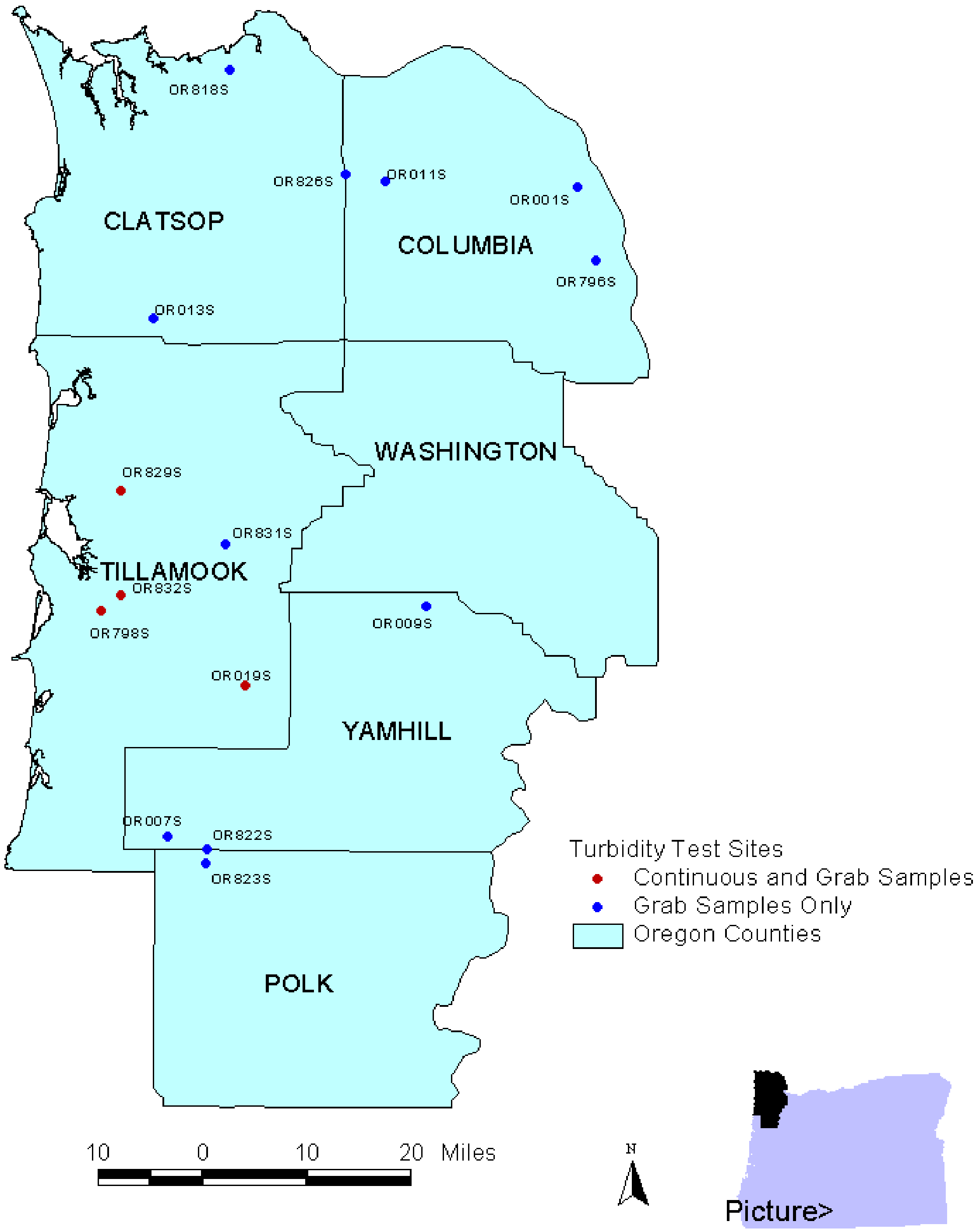
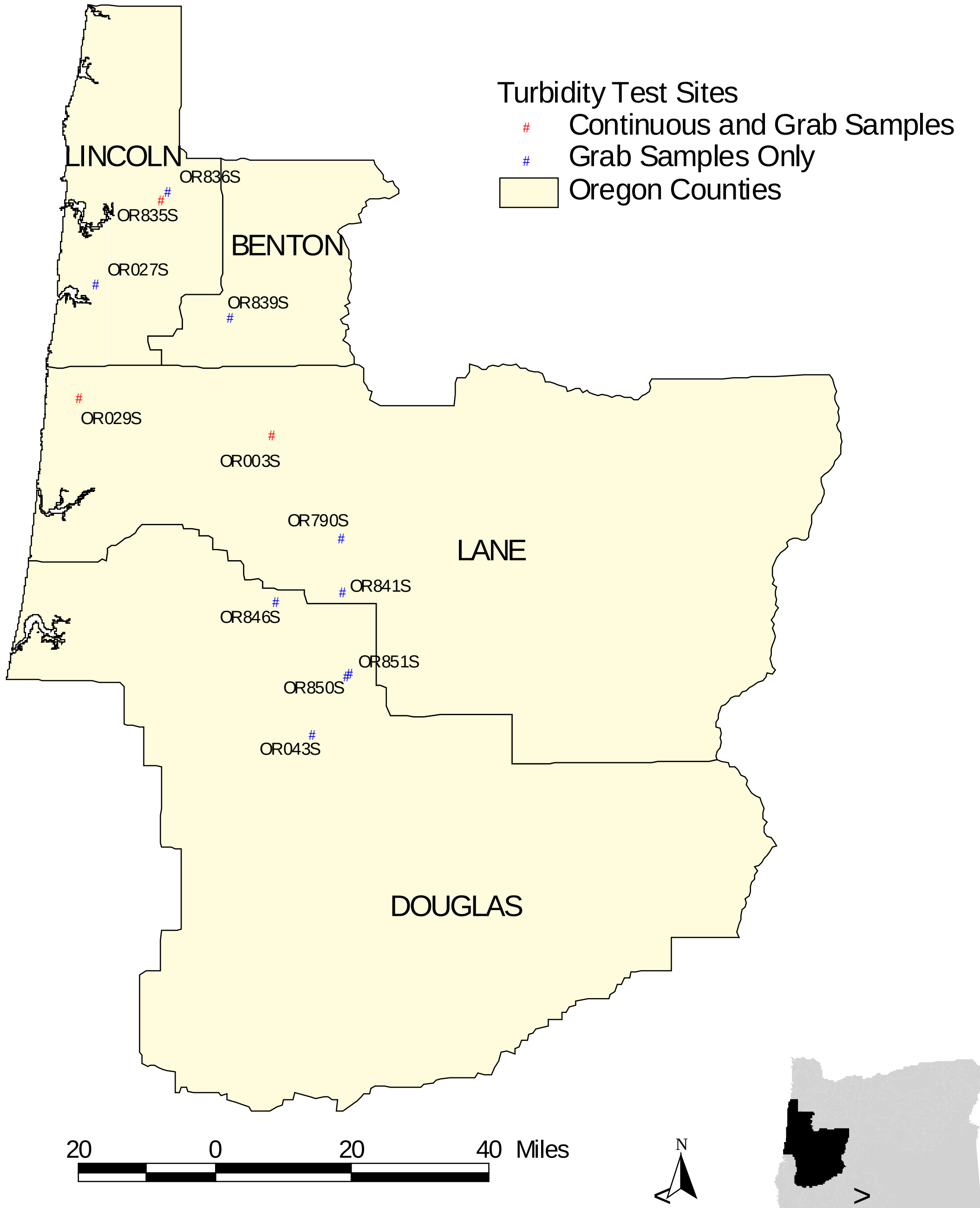


Figure 2 Mid Coast Turbidity Study



- Bewley Creek, a low elevation, low gradient stream with fine sediment substrate. Bewley Creek drains a basin of a mixed forestry and agricultural land uses. The site is located behind a logging equipment yard. It had a low riffle macroinvertebrate score indicating a severely impaired biological condition.
- Mill Creek, a low elevation, low gradient, fine sediment stream in a predominantly agricultural watershed. The sample site is a little north of the blimp hanger. It had the lowest riffle macroinvertebrate score of the sites in this survey indicating a severely impaired biological condition.

Mid Coast Sites:

A total of twelve mid coast sites were monitored for four days that included a storm on March 16, 1997. Three sites were monitored with Data Sondes and nine with grab samples.

The three mid coast sites with Data Sondes were:
- Tenmile Creek, a large stream with boulder-cobble substrate in a forested watershed. It is in the Siuslaw National Forest. Human activity in the watershed includes logging, roads and recreation. The site is at a Forest Service campground. It had the highest riffle macroinvertebrate score of the mid coast sites in this survey indicating a relatively non-impaired biological condition.
- Long Tom River, a large, low gradient river with bedrock and fine sediment substrate. Basin land use include agriculture, forestry, and rural residential. Our site is at a church camp and the riparian area there is relatively natural. Its riffle macroinvertebrate score indicates a moderately impaired condition.
- The Yaquina River at Eddyville, a large, low gradient river with fine sediment substrate. Forestry is the predominant land use with some rural residential and small farms. Yaquina River had the lowest riffle macroinvertebrate score indicating a severely impaired biological condition.

Macroinvertebrate Biological Survey Methods
Biological assessment sites were selected by EPA using a computer program to randomly select points on a first, second and third order streams. A survey reach 40 times the wet stream width was centered on the randomly selected points. The survey reach length varied with the stream size. Typically reach lengths were 300 to 600 meters with a minimum length of 150 meters. The reach was divided into eleven evenly spaced transects.

At predetermined locations along each transect a 1 foot by 2 foot benthic kick sample was collected using a ‘D’ frame kick net. The benthic material was composited into pool and riffle habitat types, preserved in ethanol, and transported back to the lab for processing. At the lab, the composites were quantitatively sub-sampled and sorted to obtain a sample containing at least 300 macroinvertebrates. The macroinvertebrates were identified to the lowest taxonomic level practicable (usually genus).

Vertebrate Biological Survey Methods

The vertebrate survey was conducted over the entire reach using a single pass with a Model 12 Smith-Root backpack electro-fisher (Smith-Root Inc., Vancouver, WA). One crewmember operated the electro-fisher while two crewmembers netted stunned fish and amphibians. Individuals were identified to the lowest practicable level (usually species) length measured, examined for parasites and abnormalities, and released. A few individuals were sometimes kept to verify field identifications.

The macroinvertebrate sampling and vertebrate survey occurred during the summer of 1994 and 1995. The site biological condition scores for the riffle macroinvertebrate, pool macroinvertebrate, and vertebrate assemblages are presented in Table 1. The average score is given for the few sites that were surveyed more than once. For more information the on REMAP monitoring methods see Hayslip et al. 1994.

Biological Integrity Analysis

The biological integrity of the riffle and pool macroinvertebrate samples were evaluated relative to macroinvertebrate assemblages of minimally impaired reference sites using multivariate analysis (George Canale, DEQ unpublished). The macroinvertebrate analysis assigns a score to the site ranging from 0 to over 100 with scores of 100 (or higher) indicating assemblages the same as reference conditions.

The biological integrity of the vertebrate assemblage was evaluated relative to selected minimally impaired sites using a prototype index of biotic integrity (IBI) (Mike Mulvey, DEQ unpublished). Vertebrate scores ranged from 5 to 50 with higher scores being more similar to minimally impaired reference conditions. This prototype IBI is only a preliminary exploration of the analytical tool and is not intended to be the final vertebrate assessment for these streams.

Turbidity

Continuous turbidity data were collected in 15-minute intervals using three Data Sonde 3 Hydrolabs (Hydrolab Corporation, Austin, TX). Field measurement of instantaneous turbidity was measured using 2100P Turbidimeters (Hach Company, Loveland, CO). Water samples were also collected and taken to the DEQ Laboratory for turbidity, total solids, and suspended solids analysis. Turbidity was measured in the laboratory with a 2100 AN Turbidimeter (Hach Company, Loveland, CO).

Storm Event Stream Flow

The US Geological Survey operates stream flow gages in several streams in the area where we were monitoring. The flow records from these gages were used to indicate storm event high flows. North coast flow measurements from the Nehalem, Siletz, Trask and Wilson Rivers were averaged. The Alsea River gage station flow records were used for the mid coast survey.

Quality Assurance

Data Sonde accuracy was checked in the lab before and after the field survey with standard turbidity samples. Data Sondes were also audited several times during field deployment and the meters were cleaned with de-ionized water. Audits measurements were taken with field turbidimeters as well as by collecting samples for laboratory analysis.

The calibration of field turbidimeters was checked with standard samples at the beginning and end of each field day. All sample collection, handling, and analysis was performed according to the DEQ laboratory Field Sampling Reference Guide (Revision 4.0, 1995).

RESULTS

Continuous turbidity and stream flow data from the north coast sites are graphed in Figure 3. Mid coast continuous turbidity and stream flow data are graphed in Figure 4. Grab turbidity sample data are in Appendix A.

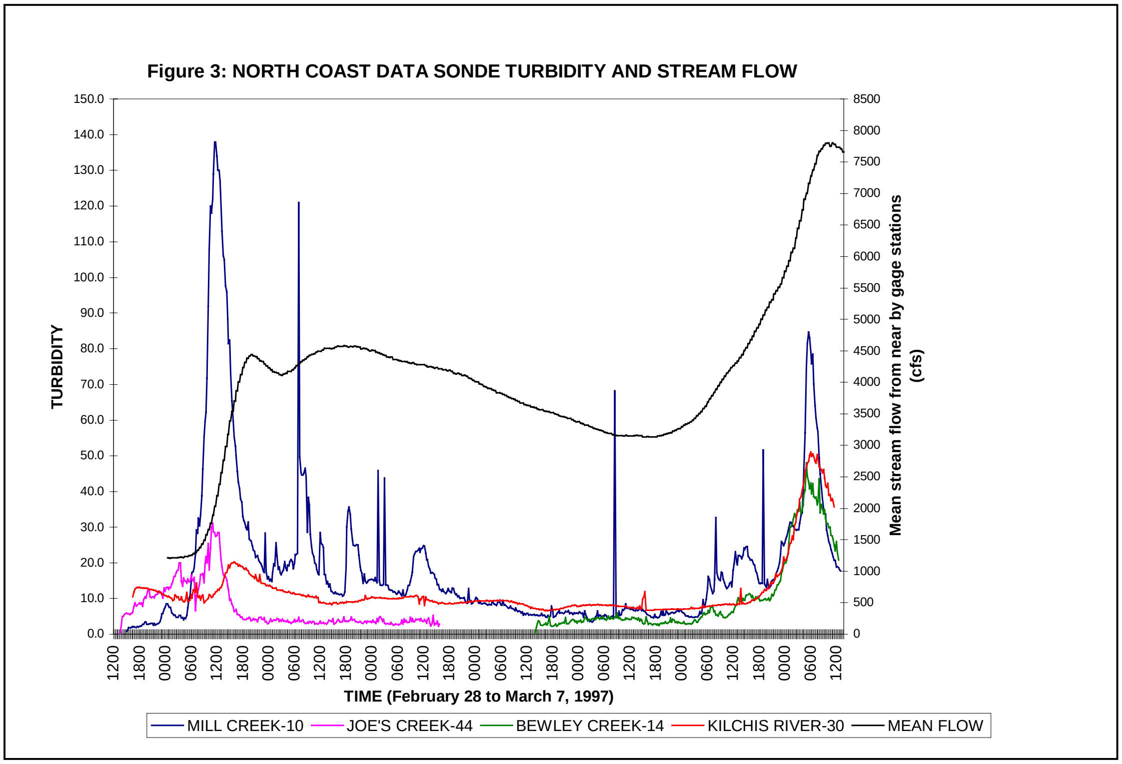


Figure 3 has turbidity data from two streams (Mill Creek and Kilchis River) for both the March 1 and March 7 storms. The graph shows that a stream may not necessarily have higher peak turbidity with higher relative stream flow. For example, Mill Creek turbidity was much higher during the March 1 storm compared to March 7 storm even though the flow the stream flow was almost twice as high during the later storm. In contrast, Kilchis River storm turbidity peak does increase with higher storm event stream flow. This indicates that there are probably a number of factors contributing to turbidity increases during a given storm event, and that caution should be used in evaluating storm turbidity-biological relationships across different storm events.

Figures 5, 6, and 7 are the maximum Data Sonde measured storm turbidities with the scores for riffle macroinvertebrate, pool macroinvertebrate and vertebrate indicators of stream biotic condition, respectively. All three indicators of biotic condition decrease with increasing storm event turbidity.

Figure 4: MIDCOAST DATA SONDE TURBIDITIES AND STREAM FLOW

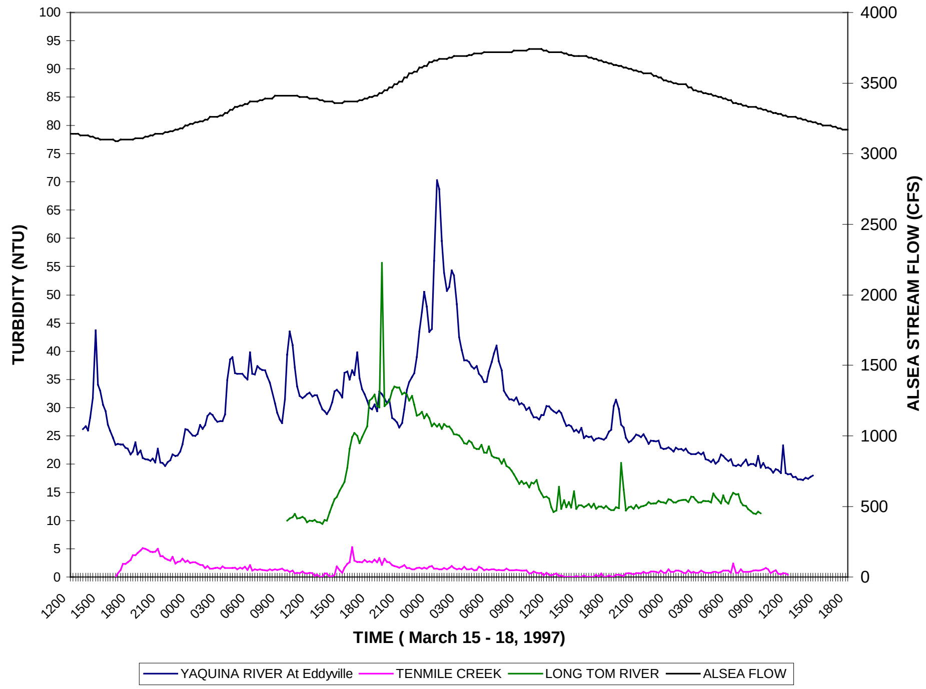
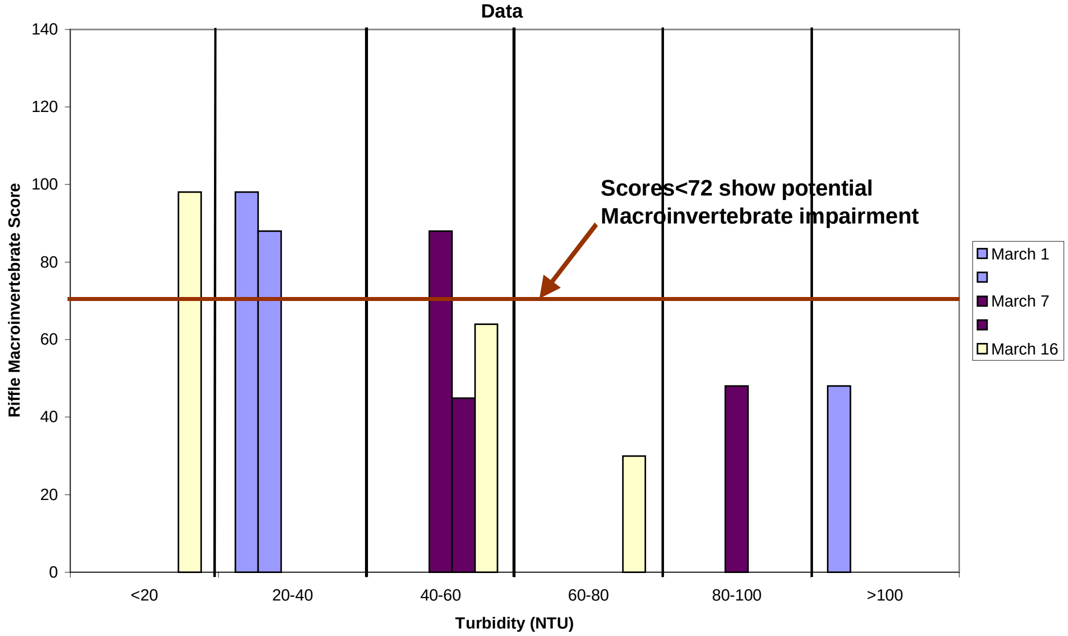
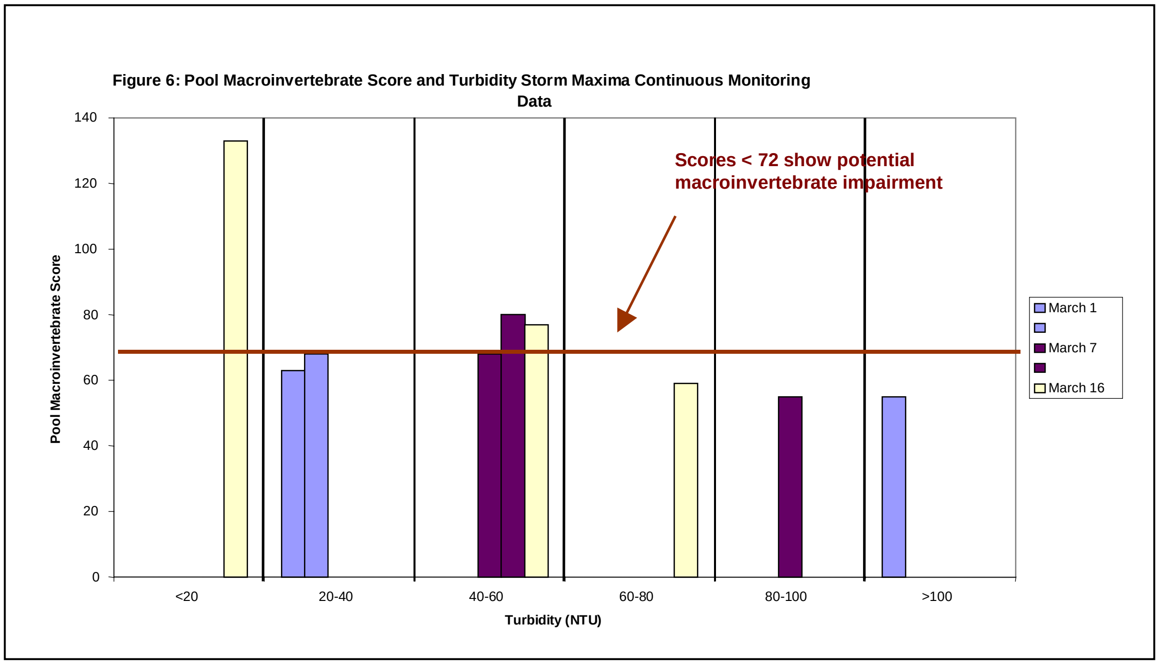


Figure 5: Riffle Macroinvertebrate Score and Turbidity Storm Maxima Continuous Monitoring Data





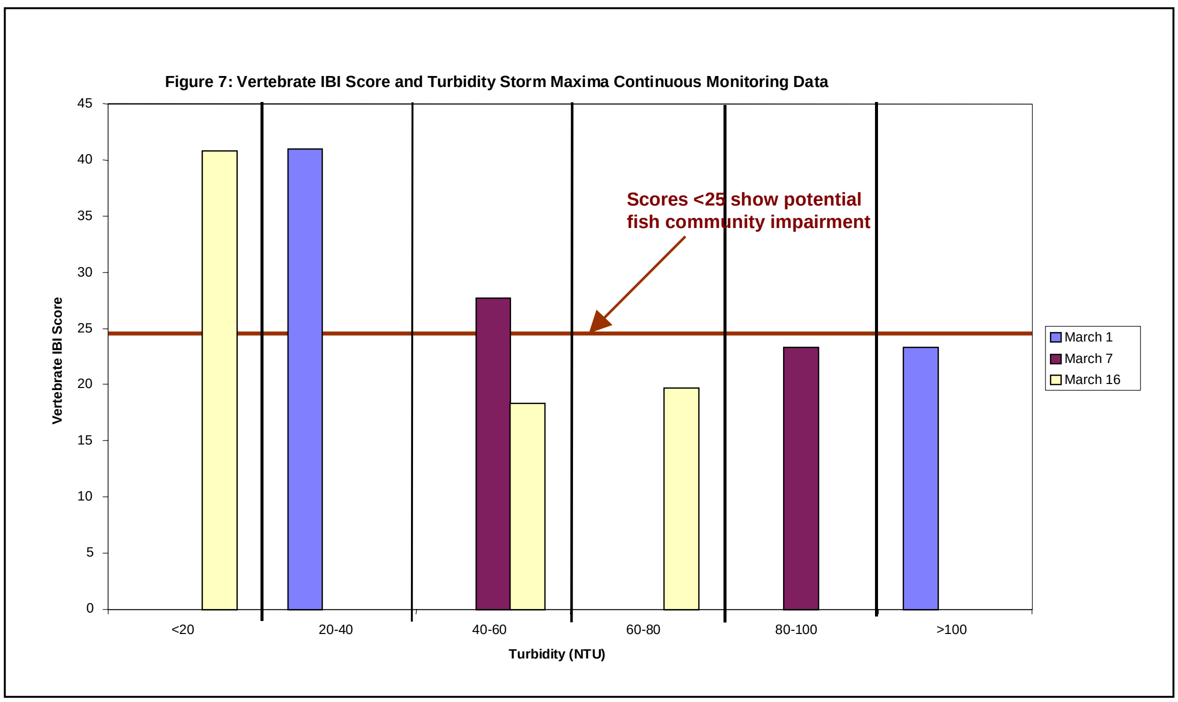
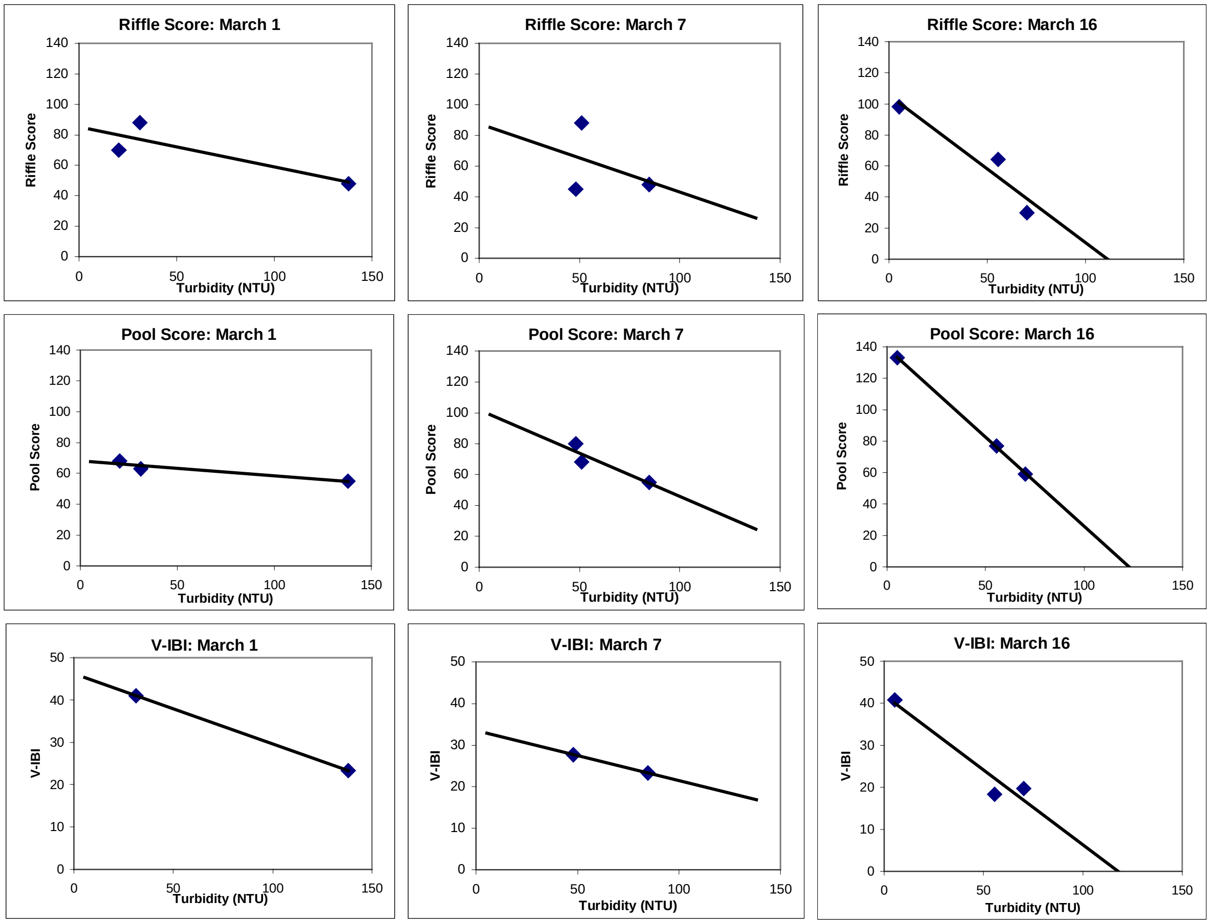


Figure 8 is a matrix of graphs showing the Data Sonde turbidity maxima and biotic integrity scores plotted separately for each storm event. Graphs for the same storm event are in columns in the matrix while graphs for the same biological indicator are in rows. Generally, all indicators show a decrease of biotic integrity with increasing storm event turbidity. The Mid Coast sites surveyed during the March 16 storm had the greatest difference in biotic integrity and also the greatest difference in turbidity between sites.

Figure 8: Storm Turbidity Maxima and Biotic Integrity Scores, Continuous Monitoring Data



Figures 9, 10, and 11 plot the maximum measured turbidity from grab sample with the scores for the three indicators of stream biotic condition. These data also indicate an overall trend of decreasing biological integrity with increasing turbidity, although not as clearly as the continuous monitoring storm turbidity peaks. Appendix A contains the grab sample data.

These graphs should be interpreted with some caution since we do not know where the turbidity grab sample is relative to the turbidity peak for a particular storm and a particular stream. Some of these points represent only one grab sample. Low turbidity values with low bio integrity score could mean that grab sampling did not capture the peak storm turbidity. When continuous monitoring equipment is not used, storm event monitoring for ephemeral effects like turbidity spikes should probably focus on collecting more frequent grab samples from fewer sites rather than maximizing the number of sites by collecting fewer samples, as we did in this study.

Figure 9: Turbidity Maximum Grab Samples and Riffle Macroinvertebrate Score

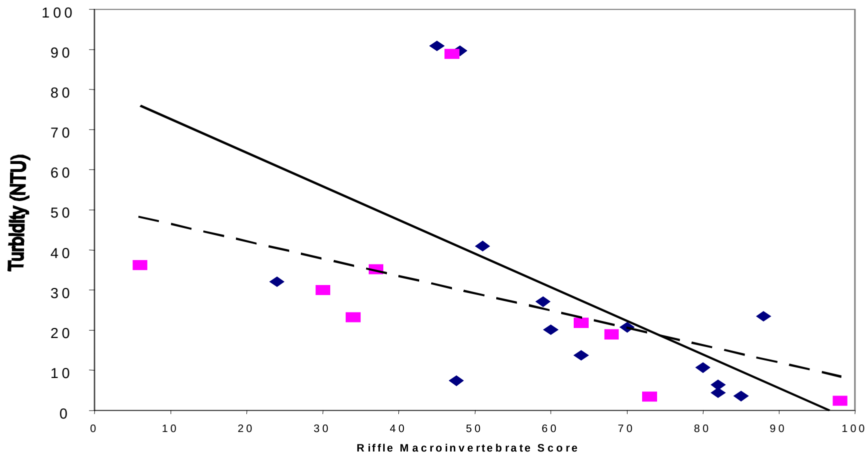


Figure 10: Turbidity Maximum Grab Samples and Pool Macroinvertevbrate Scores

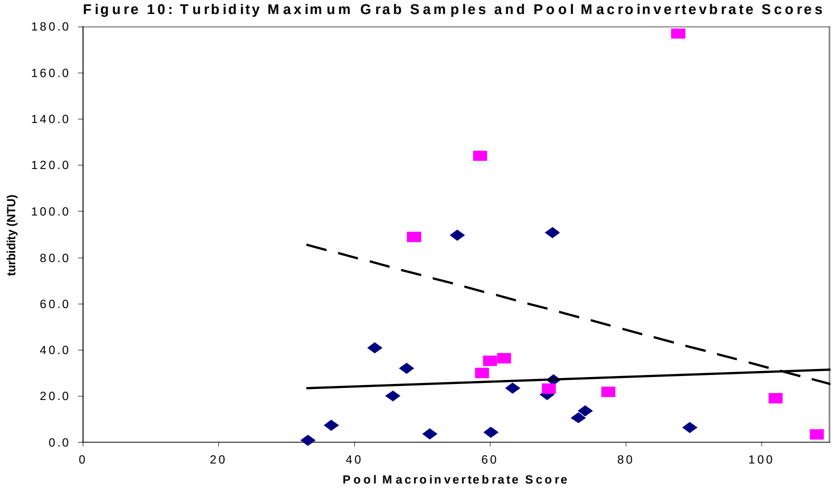
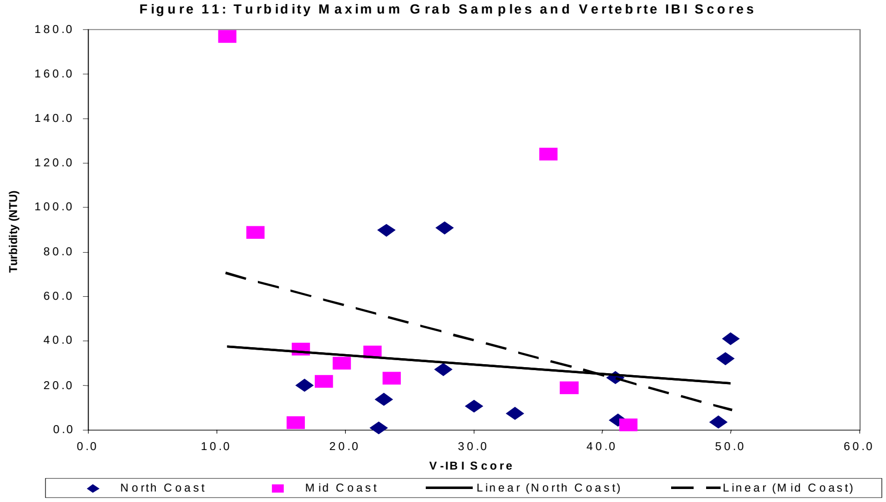


Figure 11: Turbidity Maximum Grab Samples and Vertebrte IBI Scores



Cabin Creek in the Umpqua basin had very high turbidity during the March 16 storm. Field turbidity was unmeasurable at greater than 1000 NTU and laboratory measured turbidity was 760 NTU, by far the highest turbidity measured in this study. Since this site was an outlier it was not plotted on the graphs. The pool macroinvertebrate, riffle macroinvertebrate, and vertebrate scores of 44, 33, and 27, respectively, indicate moderate to severe impairment, and agree with the pattern of low biotic integrity and high storm turbidity observed in this study.

Figure 12 is a plot of the field-measured turbidity and total solids. It shows that as turbidity increases so does total solids. .

Figures 13 and 14 are comparisons of Data Sonde turbidity measurements with field and laboratory audit measurements. For most measurements, the field grab measurement is higher than the laboratory measured turbidity. This is not unexpected since the substances that cause turbidity tend to settle out or precipitate out of the sample with time (Raeanne Haynes, DEQ QA chemist, personal communication). When compared to the field audits, the Data Sondes frequently appear to over measure turbidity, especially at low levels. Probably stream particulate material is depositing on the turbidity meter optics causing higher turbidity measurements.

Figure 12: Turbidity and Total Solids Grab Samples

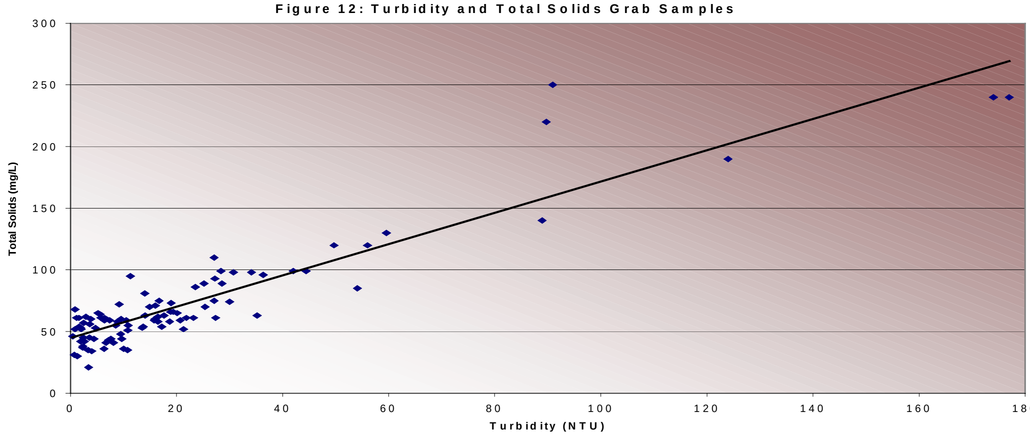
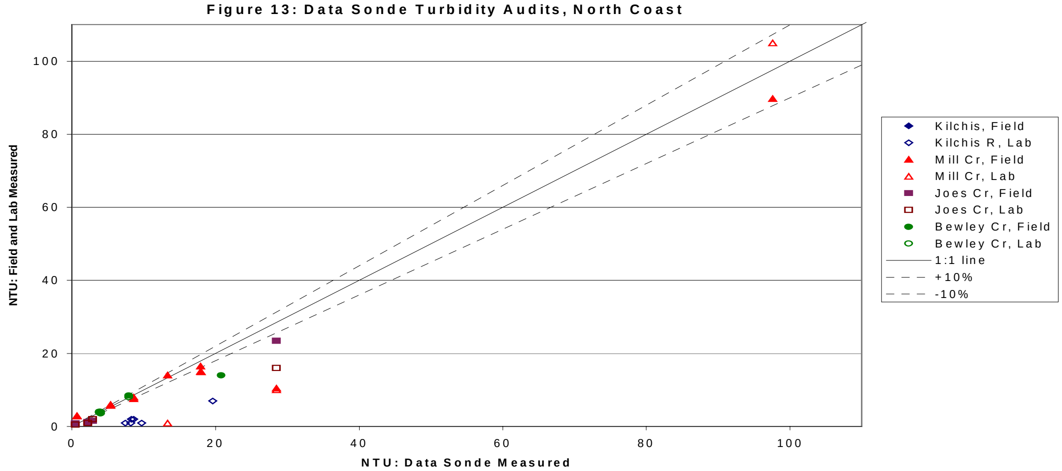
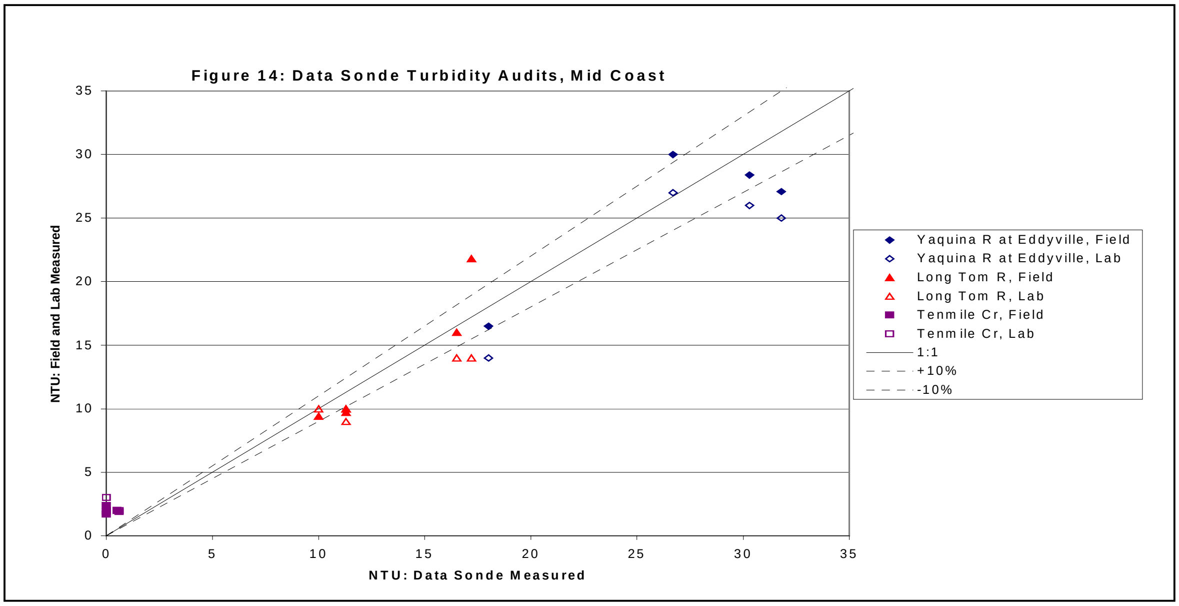


Figure 13: Data Sonde Turbidity Audits, North Coast





CONCLUSIONS

A clear relationship was shown between stream biological integrity and winter turbidity. Streams with lower biological integrity had higher turbidity during winter storm events.

Continuous monitoring data are more useful than grab samples in identifying turbidity patterns of streams during storm events. Continuous turbidity monitoring during storm events shows that grab sampling for turbidity can easily miss peak turbidities during storm events. When collecting grab samples to capture storm turbidity maxima it is better to collect samples more frequently at fewer sites rather than collect fewer samples at more sites.

Data Sondes are effective monitoring tools but require diligent quality assurance checks to ensure high data quality. New continuous turbidity monitors with self-cleaning optics should be an improvement over the design of monitors used in this study.

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Appendix A: Water Chemistry Data

Code: J = Estimated value, analyzed after holding time

405041 OR822S
AGENCY CREEK AT RM 0.2

INITIAL DATE	97/03/01	97/03/03	97/03/03	97/03/06
INITIAL TIME	1037	1730	1740	1515
WATER TEMP CENT		6.6	6.6	8.1
WATER TEMP FAHN		43.9	43.9	46.6
FIELD TURB NTU	6.4	19.4	20.1	18.9
LAB TURB NTU	5	17	18	17
CNDUCTVY FIELD MICROMHO		54	54	53
CNDUCTVY AT 25C MICROMHO			53	
RESIDUE TOTAL MG/L	59	66	65	66
RESIDUE TOT NFLT MG/L	6	17	16	18

412212 OR798S
BEWLEY CREEK AT RM. 0.3

INITIAL DATE	97/03/01	97/03/03	97/03/04	97/03/05	97/03/06	97/03/07
INITIAL TIME	1337	1420	1345	1040	1231	1220
WATER TEMP CENT		7.9	8.3	7.5	9	9.2
WATER TEMP FAHN		46.2	46.9	45.5	48.2	48.6
FIELD TURB NTU	90.9	6.68	3.86	3.53	8.5	14
LAB TURB NTU	66	6	4	4	8	16
CNDUCTVY FIELD MICROMHO		48	49	50	49	45
DO MG/L			11.1	11.5	11.1	10.9
DO SATUR PERCENT			94	95	96	94
PH SU			6.6	6.6	6.5	6.5
RESIDUE TOTAL MG/L	250	41	60	45	55	81
RESIDUE TOT NFLT MG/L	210	8	10	4	9	56

405098 OR818S
BIG CREEK AT RM 2.9

INITIAL DATE	97/03/03	97/03/06	97/03/06
INITIAL TIME	1320	1206	1420
WATER TEMP CENT	6.9	8	8
WATER TEMP FAHN	44.4	46.4	46.4
FIELD TURB NTU	5.2	6.4	6.4
LAB TURB NTU	6	6	6
CNDUCTVY FIELD MICROMHO	51	50	50
RESIDUE TOTAL MG/L	65	61	60
RESIDUE TOT NFLT MG/L	10	10	8

405289 OR043S
CABIN CREEK AT RM 5.6

INITIAL DATE	97/03/16	97/03/17	97/03/18
INITIAL TIME	1525	1525	945
WATER TEMP CENT	11.6	11.4	9.3
WATER TEMP FAHN	52.9	52.5	48.7
FIELD TURB NTU	>1000	54.1	42
LAB TURB NTU	760	48.0J	38
CNDUCTVY FIELD MICROMHO	116	79	81
RESIDUE TOTAL MG/L	720J	85J	99J
RESIDUE TOT NFLT MG/L	700	26J	20

405273 OR007S
CEDAR CREEK AT RM 0.6

INITIAL DATE	97/03/01	97/03/03	97/03/06
INITIAL TIME	1115	1715	1500
WATER TEMP CENT		7.3	8.9
WATER TEMP FAHN		45.1	48
FIELD TURB NTU	27.1	13.5	15.9
LAB TURB NTU	21	13	14
CNDUCTVY FIELD MICROMHO		55	57
RESIDUE TOTAL MG/L	75	53	60
RESIDUE TOT NFLT MG/L	23	8	9

405036 OR850S
COX CREEK AT RM 0.3

INITIAL DATE	97/03/16	97/03/17	97/03/18
INITIAL TIME	1620	1435	1030
WATER TEMP CENT	10.3	10.4	9.5
WATER TEMP FAHN	50.5	50.7	49.1
FIELD TURB NTU	124	44.4	25
LAB TURB NTU	104	38.0J	24
CNDUCTVY FIELD MICROMHO	53	44	55
RESIDUE TOTAL MG/L	190J	99J	70J
RESIDUE TOT NFLT MG/L	130	24J	11

405027 OR796S
DART CREEK AT RM 3.7

INITIAL DATE	97/03/03	97/03/06
INITIAL TIME	1105	1535
WATER TEMP CENT	7.4	8.5
WATER TEMP FAHN	45.3$	47.3$
FIELD TURB NTU	13.7	8.1
LAB TURB NTU	14	8
CNDUCTVY FIELD MICROMHO	40	40
RESIDUE TOTAL MG/L	54	41
RESIDUE TOT NFLT MG/L	12	3

405282 OR027S
DRIFT CREEK AT RM 7.3

INITIAL DATE	97/03/15	97/03/16	97/03/17	97/03/18
INITIAL TIME	1450	1400	1350	1300
WATER TEMP CENT	9.6	9.6	9.6	10.7
WATER TEMP FAHN	49.3	49.3	49.3	51.3
FIELD TURB NTU	3.4	3.37	2.6	2.3
LAB TURB NTU	4	3	3	2
CNDUCTVY FIELD MICROMHO	48	59	52	55
RESIDUE TOTAL MG/L	21J	35J	42J	37J
RESIDUE TOT NFLT MG/L	10	10J	7J	3

405035 OR851S
ELK CREEK AT RM 34.2

INITIAL DATE	97/03/16	97/03/16	97/03/17	97/03/18
INITIAL TIME	1550	1551	1450	1015
WATER TEMP CENT	10.9	10.9	9.8	9.1
WATER TEMP FAHN	51.6	51.6	49.6	48.4
FIELD TURB NTU	174	177	49.7	30.7
LAB TURB NTU	138	143	43.0J	26
CNDUCTVY FIELD MICROMHO	87	87	71	76
CNDUCTVY AT 25C MICROMHO	-	85	-	-
RESIDUE TOTAL MG/L	240	240	120	98
RESIDUE TOT NFLT MG/L	160	160	44J	22

405021 OR831S
FALL CREEK AT RM 0.7

INITIAL DATE	97/03/01	97/03/03	97/03/06
INITIAL TIME	1630	1125	1008
WATER TEMP CENT		5.2	7.3
WATER TEMP FAHN		41.4	45.1
FIELD TURB NTU	2.5	1.67	3.6
LAB TURB NTU	2	2	4
CNDUCTVY FIELD MICROMHO		64	63
RESIDUE TOTAL MG/L	57	54	56
RESIDUE TOT NFLT MG/L	5	<1	6

405073 OR826S
FISHHAWK CREEK AT RM 1.7

INITIAL DATE	97/03/03	97/03/03	97/03/06
INITIAL TIME	1445	1446	1104
WATER TEMP CENT	6.4	6.2	6.4
WATER TEMP FAHN	43.5	43.2	43.5
FIELD TURB NTU	7.2	7.4	4.7
LAB TURB NTU	7	8	5
CNDUCTVY FIELD MICROMHO	34	34	35
CNDUCTVY AT 25C MICROMHO		33	
RESIDUE TOTAL MG/L	43	59	53
RESIDUE TOT NFLT MG/L	12	14	10

405033 OR790S
FOX HOLLOW CREEK AT RM 1.3

INITIAL DATE	97/03/16	97/03/17	97/03/18
INITIAL TIME	1020	1145	1255
WATER TEMP CENT	9.8	9.1	9.8
WATER TEMP FAHN	49.6	48.4	49.6
FIELD TURB NTU	56	88.9	59.6
LAB TURB NTU	54	67.0J	51
CNDUCTVY FIELD MICROMHO	71	66	69
RESIDUE TOTAL MG/L	120	140	130
RESIDUE TOT NFLT MG/L	48	48J	41

405093 OR839S
HONEY GROVE CREEK AT RM 1.2

INITIAL DATE	97/03/16	97/03/17	97/03/18
INITIAL TIME	1055	1045	1550
WATER TEMP CENT	9.6	9.4	10.8
WATER TEMP FAHN	49.3	48.9	51.4
FIELD TURB NTU	19	16.7	9.2
LAB TURB NTU	17	17	10
CNDUCTVY FIELD MICROMHO	57	58	64
RESIDUE TOTAL MG/L	73J	75J	72J
RESIDUE TOT NFLT MG/L	18J	19J	14

405279 OR019S
JOES CREEK AT RM 0.5

INITIAL DATE	97/02/28	97/03/01	97/03/02	97/03/03	97/03/06
INITIAL TIME	1310	1230	1045	1525	1340
WATER TEMP CENT	7.2		6.5	6.2	7.4
WATER TEMP FAHN	45		43.7	43.2	45.3
FIELD TURB NTU	0.83	23.5	1.55	1.17	5.54
LAB TURB NTU	<1.0	16	2	1	5
CNDUCTVY FIELD MICROMHO	92		78	83	75
DO MG/L	11.6		11.5	11.8	
DO SATUR PERCENT	97		95	96	
PH SU	7.9		7.9	7.9	
RESIDUE TOTAL MG/L	68	86	61	61	64
RESIDUE TOT NFLT MG/L	1	21	2	1	8

405022 OR829S
KILCHIS RIVER AT RM 8.5

INITIAL DATE	97/02/28	97/03/01	97/03/02	97/03/03	97/03/04	97/03/05	97/03/06	97/03/07
INITIAL TIME	1605	1520	1335	1225	1136	1214	1105	1129
WATER TEMP CENT	7.9		6.9	5.6	7.3	6.7	7.7	7.7
WATER TEMP FAHN	46.2		44.4	42.1	45.1	44.1	45.9	45.9
FIELD TURB NTU	0.44	10.8	2.32	1.3	0.83	0.68	1.95	20.7
LAB TURB NTU	1.0K	7	2	1	1	1	2	19
CNDUCTVY FIELD MICROMHO	46		41	42	44	44	41	37
DO MG/L	11.8		11.7	12.8	12.1	12.4	12.1	12
DO SATUR PERCENT	99		96	101	100	100	100	100
PH SU	7.7		7.6	7.4	7.5	7.4	7.7	7.5
RESIDUE TOTAL MG/L	46	51	38	30	52	31	42	59
RESIDUE TOT NFLT MG/L	<1	23	2	2	<1	<1	2	28

405271 OR003S
LONG TOM RIVER AT RM 48.5

INITIAL DATE	97/03/16	97/03/17	97/03/17	97/03/18	97/03/18
INITIAL TIME	920	931	1045	925	926
WATER TEMP CENT	9.4	8.6	8.6	9.1	9.3
WATER TEMP FAHN	48.9	47.5	47.5	48.4	48.7
FIELD TURB NTU	9.43	21.8	16	10	9.7
LAB TURB NTU	10	14	14.0J	10	9
CNDUCTVY FIELD MICROMHO	37	45	37	43	43
CNDUCTVY AT 25C MICROMHO	-	-	-	-	38
RESIDUE TOTAL MG/L	48J	61J	71J	36J	44J
RESIDUE TOT NFLT MG/L	11	19J	17J	10	13

405096 OR832S
MILL CREEK AT RM 1.0

INITIAL DATE	97/02/28	97/03/01	97/03/02	97/03/03	97/03/04	97/03/05	97/03/06	97/03/07
INITIAL TIME	1445	1355	1200	1355	1308	1105	1201	1245
WATER TEMP CENT	7.9		7.6	7.6	8	7.4	9.1	9.4
WATER TEMP FAHN	46.2		45.7	45.7	46.4	45.3	48.4	48.9
FIELD TURB NTU	2.91	89.7	10.5	14.1	5.79	7.61	16.5	14.9
LAB TURB NTU	3	105	10	13	6	8	15	15
CNDUCTVY FIELD MICROMHO	77		63	63	68	68	64	60
DO MG/L	11.6		11	11.5	11.2	11.6	11.1	10.8
DO SATUR PERCENT	97		91	95	94	96	96	94
PH SU	7.4		6.7	6.6	6.9	6.8	6.9	6.8
RESIDUE TOTAL MG/L	62	220	59	63	61	44	58	70
RESIDUE TOT NFLT MG/L	1K	180	8	12	5	9	12	24

405023 OR823S
ROCK CREEK AT RM 1.4
41053 OREGON POLK

INITIAL DATE	97/03/01	97/03/03	97/03/06
INITIAL TIME	1015	1755	1523
WATER TEMP CENT		5.2	6.8
WATER TEMP FAHN		41.4	44.2
FIELD TURB NTU	6.3	3.95	10.7
LAB TURB NTU	6	4	10
CNDUCTVY FIELD MICROMHO		33	27
RESIDUE TOTAL MG/L	36	34	35
RESIDUE TOT NFLT MG/L	4	2	9

405038 OR846S
SMITH RIVER AT RM 81.3

INITIAL DATE	97/03/16	97/03/17	97/03/17	97/03/18
INITIAL TIME	1300	1310	1311	1130
WATER TEMP CENT	9.7	8.8	8.8	8.9
WATER TEMP FAHN	49.5	47.8	47.8	48
FIELD TURB NTU	17.6	23.2	17.2	11.3
LAB TURB NTU	16	18.0J	17.0J	13
CNDUCTVY FIELD MICROMHO	37	37	37	37
CNDUCTVY AT 25C MICROMHO	-	-	36	-
RESIDUE TOTAL MG/L	63J	61J	54J	95J
RESIDUE TOT NFLT MG/L	1	16J	19J	9

405270 OR001S
SOUTH FORK GOBLE CREEK AT RM 0.9

INITIAL DATE	97/03/03	97/03/06
INITIAL TIME	1205	1520
WATER TEMP CENT	6.3	8
WATER TEMP FAHN	43.3	46.4
FIELD TURB NTU	10.9	9.5
LAB TURB NTU	11	9
CNDUCTVY FIELD MICROMHO	49	51
RESIDUE TOTAL MG/L	55	60
RESIDUE TOT NFLT MG/L	8	9

405034 OR841S
SOUTH FORK SIUSLAW RIVER AT RM 2.3

INITIAL DATE	97/03/16	97/03/17	97/03/18	97/03/18
INITIAL TIME	1115	1210	1230	1231
WATER TEMP CENT	9.8	8.9	9.3	9.3
WATER TEMP FAHN	49.6	48	48.7	48.7
FIELD TURB NTU	27.4	35.2	21.3	18.7
LAB TURB NTU	25	27.0J	17	17
CNDUCTVY FIELD MICROMHO	41	36	36	36
CNDUCTVY AT 25C MICROMHO	-	-	-	38
RESIDUE TOTAL MG/L	61J	63J	52J	58J
RESIDUE TOT NFLT MG/L	21	16J	11	10

405283 OR029S
TENMILE CREEK AT USFS TENMILE CREEK CAMP GROUND

INITIAL DATE	97/03/15	97/03/16	97/03/17	97/03/17	97/03/18
INITIAL TIME	1600	1240	1501	1502	1144
WATER TEMP CENT	9.8	9.7	9.9	10.1	10
WATER TEMP FAHN	49.6	49.5	49.8	50.2	50
FIELD TURB NTU	2.4	2.02	1.9	1.7	1.9
LAB TURB NTU	3	2	2	2	2
CNDUCTVY FIELD MICROMHO	45	52	53	53	53
RESIDUE TOTAL MG/L	29J	45J	45J	40J	35J
RESIDUE TOT NFLT MG/L	3	1J	1J	1J	2

405275 OR011S
UNAMED TRIB ENTERING NEHALEM R AT RM 70.5

INITIAL DATE	97/03/03
INITIAL TIME	1530
WATER TEMP CENT	6.2
WATER TEMP FAHN	43.2
FIELD TURB NTU	8.9
LAB TURB NTU	10
CNDUCTVY FIELD MICROMHO	32
RESIDUE TOTAL MG/L	58
RESIDUE TOT NFLT MG/L	8

405274 OR009S
WILLIAMS CANYON CREEK AT RM 1.8

INITIAL DATE	97/03/03	97/03/06
INITIAL TIME	1730	840
WATER TEMP CENT		7.6
WATER TEMP FAHN		45.7
FIELD TURB NTU	32.1	27.2
LAB TURB NTU		26
CNDUCTVY FIELD MICROMHO		65
RESIDUE TOTAL MG/L		93
RESIDUE TOT NFLT MG/L		8

405044 OR835S
YAQUINA RIVER AT EDDYVILLE

INITIAL DATE	97/03/15	97/03/16	97/03/17	97/03/18
INITIAL TIME	1330	1510	1150	1450
WATER TEMP CENT	9.1	10.1	9.5	10.6
WATER TEMP FAHN	48.4	50.2	49.1	51.1
FIELD TURB NTU	30	27.1	28.4	16.5
LAB TURB NTU	27	25	26	14
CNDUCTVY FIELD MICROMHO	55	62	60	66
RESIDUE TOTAL MG/L	74J	110J	99J	62J
RESIDUE TOT NFLT MG/L	44	49J	55J	19

405072 OR836S
YAQUINA RIVER U/S OF EDDYVILLE

INITIAL DATE	97/03/15	97/03/16	97/03/16	97/03/17	97/03/18
INITIAL TIME	1310	1531	1532	1205	1420
WATER TEMP CENT	10	9.7	9.8	9.5	10.7
WATER TEMP FAHN	50	49.5	49.6	49.1	51.3
FIELD TURB NTU	25.2	36.3	34.1	28.6	15.8
LAB TURB NTU	25	33	32	26	15
CNDUCTVY FIELD MICROMHO	55	63	60	61	66
RESIDUE TOTAL MG/L	89J	96J	98J	89J	59J
RESIDUE TOT NFLT MG/L	65	60J	49J	48J	21