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DEPARTMENT OF FISH AND WILDLIFE
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May 31, 2011

Jonathan Jennings
Aquatic Pesticide Program
Department of Ecology
P.O. Box 47600
Olympia, Washington 98504-7600

NPDES Permit WA0041009
Annual Report

Dear Mr. Jennings:

Enclosed is the 2009-2010 and 2010-2011 Zooplankton Monitoring Report as required by NPDES Waste Discharge Individual Permit Number WA0041009. This packet is reported separately from the Post-Treatment Discharge Monitoring Reports because zooplankton monitoring spans a full year after lake treatments and cannot be completed by the annual reporting due date.

Please feel free to contact me at 360-902-2738 or email james.uehara@dfw.wa.gov with any questions.

Sincerely,

Jim Uehara
Inland Fish Program Manager

Enclosures

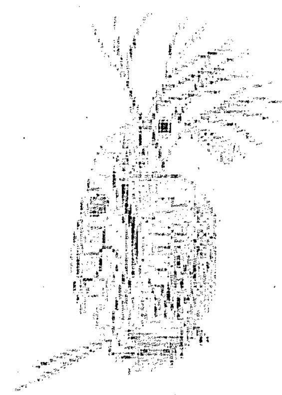
cc: Craig Burley, WDFW Olympia
Chris Donley, WDFW Spokane

I certify under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

ZOOPLANKTON MONITORING REPORT

WDFW FISH MANAGEMENT PERMIT
NPDES PERMIT No. WA0041009

For the years 2009-2010 through 2010-2011



MAY 2011

Prepared for:
Department of Ecology
Water Quality Program

By: Jon Anderson
Washington Department of Fish and Wildlife
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and

Chris Donley
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Introduction

With their gill-like tracheae, aquatic invertebrates are theoretically as susceptible to the toxic effects of rotenone as fish or amphibian larvae (Bradbury 1986). After laboratory based tests, Chandler and Marking (1982) concluded that, apart from an ostracod (*Cypridopsis sp.*), aquatic invertebrates are generally more tolerant of rotenone than most fishes and amphibian larval stages. In their study the most resistant organisms exposed were a snail (*Helisoma sp.*) and the Asiatic clam (*Corbicula manilensis*) for which the LC_{50} 96h concentrations were 50 times greater than those Marking and Bills (1976) reported for the Black bullhead (*Ictalurus melas*), one of their most resistant fishes. Sanders and Cope (1968) also conducted lab tests examining the effect of rotenone to the nymph or naiad stage of a stonefly (*Pteronarcys californica*). They found that the LC_{50} 24h was 2,900 µg/L and the LC_{50} 96h was 380 µg/L. These values are greater by an order of magnitude to those found by Marking and Bills (1976) for the black bullhead (*Ictalurus melas*), indicating that some aquatic invertebrates are much less sensitive to rotenone than fish. Larger, later instar naiads were less susceptible to given concentrations of toxin than were smaller, earlier instars of the same species (Sanders and Cope, 1968).

The immediate effect of rotenone on zooplankton communities can be catastrophic (Bradbury 1986), and we expect that at least 50% of the cladocerans and copepods present would die from exposure to rotenone concentrations (0.5 to 4.0 ppm) commonly used in fisheries management projects. There is general agreement that the planktonic crustaceans, especially cladocerans, are the group most affected, and rotifers are deemed more resistant to rotenone. Bradbury (1986) estimated that zooplankton would be reduced to non-measurable levels for a period from two to twelve weeks. Once plankters reappear, the community begins to rebuild, eventually returning to pre-treatment levels and diversity.

The Washington Department of Fish and Wildlife obtained National Pollutant Discharge Elimination System (NPDES)/Waste Discharge Individual Permit No. WA0041009 in July, 2002 to apply rotenone, an aquatic pesticide used to manage fish populations in lakes and streams in the State of Washington. The safe and effective treatment of populations of undesirable fish species improves aquatic and riparian fish and wildlife habitats, establishes conditions favorable for the growth of desirable game fish species, and promotes the social and economic benefits of a healthy recreational fishery in the lakes that have been treated.

Special condition S.2 of the NPDES requires sampling of zooplankton in treated lakes according to the protocols set forth in "Water Quality Assessments of Selected Lakes within Washington State 1998", Department of Ecology, December 2000, Publication No. 00-03-039, (NPDES Appendix B). Sampling frequency was set at pre-treatment, six months post-treatment, and one year post-treatment. Samples were to be analyzed for relative abundance of cladocerans and copepods, and their mean length, and tabulated as the ratio of total cladocerans: total copepods.

Sampling Results

Table 1 represents the lakes treated with rotenone during the years 2009-2010 through 2010-2011.

Table 1. Locations and dates for zooplankton samples taken to comply with NPDES Permit No. WA0041009 from 2009-10 through 2010-11.

LAKES TREATED	TREATMENT DATE	PRE-TREATMENT	SIX MONTHS	ONE YEAR
2009-10				
BUCK LAKE	10/29/2009	10/28/09	5/01/10	10/15/10
FISHTRAP LAKE	10/15/2009	10/14/09	5/03/10	10/14/10
FOURTH OF JULY LAKE	10/13/2009	10/12/09	5/03/10	10/14/10
HOG CANYON LAKE	10/14/2009	10/14/2009	5/03/10	10/14/10
HOG SWAMP	10/16/2009	10/16/2009	5/03/10	10/14/10
WEST MEDICAL LAKE	10/27/2009	10/27/2009	5/03/10	10/14/10
2010-11				
BEDA LAKE	9/15/2010	9/15/10	4/04/11	TO BE COLLECTED
DUNE LAKE	9/15/2010	9/15/10	3/30/11	TO BE COLLECTED
HARRIS LAKE	9/15/2010	9/15/10	4/04/11	TO BE COLLECTED
SEDGE/TERN LAKES	9/15/2010	9/15/10	4/04/11	TO BE COLLECTED
WINDMILL LAKE	10/03/2010	10/03/10	NOT ANALYZED	TO BE COLLECTED
NORTH WINDMILL LAKE	10/05/2010	10/05/10	NOT ANALYZED	TO BE COLLECTED
N.-N. WINDMILL LAKE	10/05/2010	10/05/10	NOT ANALYZED	TO BE COLLECTED
CANAL LAKE	10/03/2010	10/03/10	NOT ANALYZED	TO BE COLLECTED
PIT LAKE	10/03/2010	10/03/10	NOT ANALYZED	TO BE COLLECTED
HEART LAKE	10/03/2010	10/03/10	NOT ANALYZED	TO BE COLLECTED
LYLE LAKE	10/13/2010	10/13/10	NOT ANALYZED	TO BE COLLECTED
NORTH TEAL LAKE	10/12/2010	10/12/10	NOT ANALYZED	TO BE COLLECTED
SOUTH TEAL LAKE	10/12/2010	10/12/10	NOT ANALYZED	TO BE COLLECTED
HERMAN LAKE	10/12/2010	10/12/10	NOT ANALYZED	TO BE COLLECTED
JUNE LAKE	10/05/2010	10/05/10	NOT ANALYZED	TO BE COLLECTED
LOWER CALICHE LAKE	10/25/2010	10/25/10	NOT ANALYZED	TO BE COLLECTED
UPPER CALICHE LAKE	10/25/2010	10/25/10	NOT ANALYZED	TO BE COLLECTED
MARTH LAKE	10/25/2010	10/25/10	NOT ANALYZED	TO BE COLLECTED
WEST CALICHE	10/25/2010	10/25/10	NOT ANALYZED	TO BE COLLECTED

Disposition of Samples

Since 2006, the Washington Department of Fish and Wildlife's, Large Lakes Research Team (LLRT) has been conducting the analysis of all samples taken in the lake rehabilitation program. Methods, analysis and the LLRT's report to the lake rehabilitation program is included in this document as Attachment 1.

Results of Analyses

The response of zooplankton to the effects of the rotenone treatments was variable in each of the lakes sampled. In general, the ratio of cladocerans to copepods tended to decline significantly after six months post-treatment, then was found to have returned to near pre-treatment levels at one year post-treatment. The average length of cladocerans showed an inconsistent response at six months post-treatment, and generally was slightly larger at one year post-treatment. Copepod average lengths also showed inconsistent response at six months post-treatment, and tended to increase in size or remain the same at one year post-treatment (Table 2).

Table 2. Locations and dates for zooplankton samples taken to comply with NPDES Permit No. WA0041009 from 2009-10 and 2010-11. Cladoceran to copepod ratios, and average lengths in millimeters.

2009-10 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
BUCK LAKE				
Pre-Treatment	10/28/2009	19.51:1	1.01	0.63
Six Month Post-Treatment	5/01/2010	3.50:1	.086	0.60
One Year Post-Treatment	10/15/2010	166.7:1	.973	.957
FISHTRAP LAKE				
Pre-Treatment	10/14/2009	1:1.53	0.68	0.79
Six Month Post-Treatment	5/03/2010	1:6.11	0.77	1.01
One Year Post-Treatment	10/14/2010	3.25:1	0.89	1.11
FOURTH OF JULY LAKE				
Pre-Treatment	10/12/2009	1.84:1	0.45	0.73
Six Month Post-Treatment	5/03/2010	14.44:1	0.39	0.65
One Year Post-Treatment	10/14/2010	3.62:1	1.61	1.12
HOG CANYON LAKE				
Pre-Treatment	10/14/2009	1:4.08	0.97	1.19
Six Month Post-Treatment	5/03/2010	2.35:1	0.44	0.60
One Year Post-Treatment	10/14/2010	3.34:1	1.02	1.86
HOG SWAMP				
Pre-Treatment	10/16/2009	1:1.20	0.62	0.84
Six Month Post-Treatment	5/08/2010	1:1.17	0.42	0.63
One Year Post-Treatment	10/14/2010	1:2.38	0.94	1.56
WEST MEDICAL LAKE				
Pre-Treatment	10/27/2009	11:1	1.08	0.80
Six Month Post-Treatment	5/03/10	3.22:1	1.22	0.68
One Year Post-Treatment	10/14/2010	7.77:1	1.45	1.36

Table 2. (cont.) Locations and dates for zooplankton samples taken to comply with NPDES Permit No. WA0041009 from 2009-10 and 2010-11. Cladoceran to copepod ratios, and average lengths in millimeters.

2010-11 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
BEDA LAKE				
Pre-Treatment	9/15/2010	1:1.50	0.15	0.68
Six Month Post-Treatment	4/04/11	1:8.74	0.46	0.70
One Year Post-Treatment	NOT COLLECTED			
DUNE LAKE				
Pre-Treatment	9/15/2010	1:1.36	0.24	1.14
Six Month Post-Treatment	3/30/2011	1:15.57	0..40	1.2
One Year Post-Treatment	NOT COLLECTED			
HARRIS LAKE				
Pre-Treatment	9/15/2010	1:19.45	0.27	1.10
Six Month Post-Treatment	4/04/11	1.07:1	0.42	0.80
One Year Post-Treatment	NOT COLLECTED			
SEDGE/TERN LAKE				
Pre-Treatment	9/15/2010	4.72:1	0..20	0.87
Six Month Post-Treatment	4/04/11	1:2.00	0.50	0.84
One Year Post-Treatment	NOT COLLECTED			
WINDMILL LAKE				
Pre-Treatment	10/03/2010	4.21:1	1.10	1.10
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
NORTH WINDMILL LAKE				
Pre-Treatment	10/05/2010	7.26:1	0.38	0.76
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
NORTH-NORTH WINDMILL LAKE				
Pre-Treatment	10/05/2010	1:8.60	0.41	0.84
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
CANAL LAKE				
Pre-Treatment	10/03/2010	1.94:1	1.0	0.96
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			

Table 2. (cont.) Locations and dates for zooplankton samples taken to comply with NPDES Permit No. WA0041009 from 2009-10 and 2010-11. Cladoceran to copepod ratios, and average lengths in millimeters.

2010-11 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
PIT LAKE				
Pre-Treatment	10/03/2010	1:1.03	1.10	1.23
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
HEART LAKE				
Pre-Treatment	10/03/2010	1:1.01	0.90	1.02
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
LYLE LAKE				
Pre-Treatment	10/13/2010	5.46:1	0.46	1.03
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
NORTH TEAL LAKE				
Pre-Treatment	10/12/2010	6.53:1	1.64	0.99
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
SOUTH TEAL LAKE				
Pre-Treatment	10/12/2010	1.35:1	0.75	0.82
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
HERMAN LAKE				
Pre-Treatment	10/12/2010	1.04:1	0.59	0.95
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
JUNE LAKE				
Pre-Treatment	10/05/2010	1.58:1	0.93	0.96
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
UPPER CALICHE LAKE				
Pre-Treatment	10/25/2010	1:13.6	0.53	0.98
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			

Table 2. (cont.) Locations and dates for zooplankton samples taken to comply with NPDES Permit No. WA0041009 from 2009-10 and 2010-11. Cladoceran to copepod ratios, and average lengths in millimeters.

2010-11 Lakes Treated	DATE	Ratio of Cladocerans:Copepods	Cladocerans Avg. Length (mm)	Copepods Avg. Length (mm)
LOWER CALICHE LAKE				
Pre-Treatment	10/25/2010	4.13:1	0.18	0.76
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
MARTHA LAKE				
Pre-Treatment	10/25/2010	2.12:1	0.61	0.75
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			
WEST CALICHE LAKE				
Pre-Treatment	10/25/2010	26.23:1	0.47	0.61
Six Month Post-Treatment	NOT ANALYZED			
One Year Post-Treatment	NOT COLLECTED			

Discussion

Changes in the abundance and/or structure of the plankton community by the use of chemicals like rotenone can have marked effects on subsequent fish populations that depend on plankton either directly or indirectly for nutrition. Hoffman and Olive (1961) conducted an experiment to document the effect of rotenone on the zooplankton community in a Colorado reservoir from 1954-1955. They observed a complete kill of protozoans and Entomostracans and a major reduction in the Rotifer population following the treatment. Their finding agreed with previous research (Hooper, 1948; Brown and Ball, 1943; Hamilton, 1941) and more recent findings have demonstrated that rotenone is indeed variably toxic to zooplankton communities (Melaas et al., 2001; Beal and Anderson, 1993; Neves, 1975; Anderson, 1970; Kiser et al, 1963), especially in acidic conditions (Kiser et al. 1963).

Unlike many benthic invertebrates, which may escape the immediate effects of rotenone by burrowing into sediment, zooplanktons are exposed to rotenone for the full duration of its activity in the water column. However, populations may recover from resistant life-stages and or eggs (Kiser et al. 1963). A full recovery of the zooplankton community may take longer however. Beal and Anderson (1993) demonstrated that some populations make take up to 8 months to recover following rotenone treatment, while Anderson (1970) noted a 3-year recovery period in two mountain lakes.

Therefore, when rotenone is used in a fisheries management program where future restocking and growth of game fish depends on naturally produced food items, consideration must be given for an adequate amount of time for the zooplankton communities to re-establish themselves, before fish are re-introduced into the lake.

Field studies examining the effect of rotenone on aquatic macroinvertebrate communities have provided varied results. Whereas some workers noticed dramatic, long-term effects (Mangum and Madrigal 1999; Binns 1967), others observed rotenone has a negligible effect on most aquatic macroinvertebrates (Demong, 2001; Melaas, 2001). Most researchers would agree, however, that the effects of rotenone are less pronounced and more variable to macroinvertebrates than the effects of the chemical on zooplankton. Similar to the range of sensitivities demonstrated by various fish species to rotenone, different species of aquatic macroinvertebrates exhibit a range of tolerances (Mangum and Madrigal, 1999; Chandler and Marking, 1982; Engstrom-Heg et al., 1978) likely based on their oxygen requirements.

The results of monitoring the zooplankton in lakes treated with rotenone under Permit No. WA0041009 reveals a similar variability. The short-term effects appear to be temporary, with most taxa or groups of taxa recovering to pre-treatment levels, or re-establishing populations and relative abundances of cladocerans and copepods that reflect a modified predatory assemblage.

It is expected that rotenone will reduce overall populations of zooplankton immediately subsequent to treatment of the lake, but that zooplankton communities will fully recover in almost all cases (Bradbury 1986). Following an autumn treatment, zooplankton recovery will be slow due to low water temperatures through the winter months. As the water warms and primary production results in growth of phytoplankton, the remaining zooplankton populations respond positively and proportionally.

The zooplankton populations at the time of treatment were influenced by the predatory effects of populations of fish deemed undesirable for the game fish management plan of the individual lake. It is expected that, subsequent to rotenone treatment and the re-stocking of desirable game fish, the zooplankton populations will re-establish themselves at levels somewhat different to the pre-treatment state. A variety of temporary shifts in zooplankton community structure occur during the post-treatment period, with the most common shift being toward larger-sized cladocerans while fish are absent (Bradbury 1986). When fish are reintroduced, the zooplankton community returns to a structure, level of abundance, and diversity more closely resembling that observed pre-treatment.

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Attachment 1.

Zooplankton Identification and Analysis

Washington Department of Fish and Wildlife

February 25, 2010

Prepared for:

Fish Management Division

By:

Rochelle Shipley

Large Lakes Research Team

Introduction

In 2009, the Fish Management Division of the Washington Department of Fish and Wildlife (WDFW) solicited the WDFW Large Lakes Research Team to conduct analyses on zooplankton samples collected during lake rehabilitations from 2008 to 2009. Samples were collected from 16 lakes with multiple samples from each lake, equating to 54 samples.

Methods and Results for Zooplankton Analyses

Preserved zooplankton samples were identified and enumerated (Washington Department of Ecology 2002). For zooplankton samples with less than 500 individuals, the entire sample was enumerated, whereas, samples with more than 500 individuals of any one species were sub-sampled. Prior to sub-sampling, the sample was reduced into a 100 mL beaker using an open-ended nytex mesh cup and diluted ethanol. Using a Hensen-Stempel pipette, 10 mL were removed from the stirred sample to assure a homogenous distribution of zooplankton throughout. The process of sub-sampling was repeated if the initial sub-sample contained more than 500 individuals. Based on the total number of individuals in the sub-sample, the entire sample was estimated.

Relative abundance and mean length (mm) were determined for cladocerans and copepods for each zooplankton sample and sub-sample. Relative abundance was estimated using a Leica 0.8-3.5 x-dissecting microscope. Lengths for copepods and cladocerans (up to 20 individuals of each type) were measured to the nearest 0.02 mm using an ocular micrometer (Table 1). The results were reported as a ratio of total cladocerans: total copepods (Table 2).

Table 1. Average zooplankton length (nearest 0.02 mm) ± 2 SE.

Lake	Date	Treatment	Cladoceran Average TL	SE	*Copepod* Average TL	SE
Swamp	10/26/2009	PRE	0.62	0.22	0.84	0.07
Swamp	10/16/2009	PRE	0.43	0.11	-	-
Swamp	10/16/2009	PRE	0.53	0.34	0.69	0.10
4th of July	10/12/2009	PRE	0.45	0.04	0.73	0.08
4th of July	10/12/2009	PRE	0.51	0.04	0.63	0.07
4th of July	10/12/2009	PRE	0.47	0.05	0.63	0.05
Ellen Lake	5/8/2009	MID	0.69	0.16	0.91	0.47
Ellen Lake	5/8/2009	MID	-	-	0.96	-
Ellen Lake	5/8/2009	MID	1.45	-	1.85	-
West Lake	4/6/2009	UNK	0.48	0.08	2.13	0.45
West Lake	4/6/2009	UNK	0.38	0.02	2.61	0.86
West Lake	4/6/2009	UNK	0.38	0.02	2.02	0.40
TD2	4/6/2009	UNK	0.86	0.61	1.04	0.36
TD2	4/6/2009	UNK	1.05	0.43	0.87	0.21
TD2	4/6/2009	UNK	0.65	0.39	0.58	0.09
West Medical Lake	10/27/2009	PRE	1.08	0.19	0.80	0.26
West Medical Lake	10/27/2009	PRE	1.27	0.23	1.12	0.30
West Medical Lake	10/27/2009	PRE	1.21	0.16	-	-
Starzman Lake	11/12/2009	POST	1.36	0.33	1.19	0.09
Hog Canyon	10/14/2009	PRE	0.97	0.13	1.19	0.17
Hog Canyon	10/14/2009	PRE	0.91	0.15	1.29	0.17
Hog Canyon	10/14/2009	PRE	0.96	0.19	1.09	0.10
Hatch Lake	5/8/2009	MID	0.59	0.17	-	-
Hatch Lake	5/8/2009	MID	0.66	0.06	-	-
Hatch Lake	5/8/2009	MID	0.69	0.05	1.40	-
Hatch Lake	10/7/2009	POST	1.27	0.17	1.69	0.09
Hatch Lake	10/7/2009	POST	1.37	0.13	1.87	0.17
Hatch Lake	10/7/2009	POST	1.44	0.15	1.91	0.16
Frater Lake	5/1/2009	MID	0.77	0.42	0.86	0.21
Frater Lake	5/1/2009	MID	0.57	0.14	0.78	0.16
Frater Lake	5/1/2009	MID	0.71	0.68	0.75	-
Frater Lake	10/7/2009	POST	0.78	0.07	-	-
Frater Lake	10/7/2009	POST	0.53	0.05	-	-
Frater Lake	10/7/2009	POST	0.59	0.12	-	-
Ellen Lake	10/6/2009	POST	0.42	0.01	0.56	0.09
Ellen Lake	10/6/2009	POST	0.36	0.02	0.60	0.09
Ellen Lake	10/6/2009	POST	0.40	0.01	0.61	0.16
Fishtrap	10/14/2009	PRE	0.68	0.15	0.79	0.06
Fishtrap	10/14/2009	PRE	0.78	0.19	0.87	0.08
Fishtrap	10/14/2009	PRE	0.82	0.18	0.88	0.07
Williams Lake	5/8/2009	MID	0.72	0.14	0.65	0.09
Williams Lake	5/8/2009	MID	0.70	0.21	0.50	-
Williams Lake	5/8/2009	MID	0.60	0.10	-	-
Williams Lake	10/6/2009	POST	0.94	0.09	0.86	0.06
Williams Lake	10/6/2009	POST	1.01	0.14	0.99	0.06
Williams Lake	10/6/2009	POST	0.87	0.10	0.82	0.05
Buck Lake	10/28/2009	PRE	1.01	0.10	0.63	0.06
Dixon's Pond	10/24/2008	POST	0.69	0.28	-	-
Dixon's Pond	10/24/2008	POST	1.08	0.26	0.95	0.09
Little Hatch Lake	10/7/2009	POST	0.76	0.10	1.47	0.11
Little Hatch Lake	10/7/2009	POST	1.04	0.19	1.57	0.07
Little Hatch Lake	5/8/2009	MID	0.70	0.11	0.79	0.13
Little Hatch Lake	5/8/2009	MID	0.77	0.16	-	-

Little Hatch Lake	10/7/2009	POST	0.84	0.14	1.76	0.10

Table 2. Zooplankton total enumeration and sub-sample enumeration.

Lake	Date	Treatment	Total Count Ratio Cladocerans	Total Count Ratio Copepods	Sub-Sample Ratio Cladocerans	Sub-Sample Ratio Copepods
Swamp	10/26/2009	PRE	350	420	1.00	1.20
Swamp	10/16/2009	PRE	31	45	1.00	1.45
Swamp	10/16/2009	PRE	7	27	1.00	3.86
4th of July	10/12/2009	PRE	395	215	1.84	1.00
4th of July	10/12/2009	PRE	580	450	1.29	1.00
4th of July	10/12/2009	PRE	560	310	1.81	1.00
Ellen Lake	5/8/2009	MID	17	3	5.67	1.00
Ellen Lake	5/8/2009	MID	0	1	0.00	1.00
Ellen Lake	5/8/2009	MID	1	1	1.00	1.00
West Lake	4/6/2009	UNK	1220	460	2.65	1.00
West Lake	4/6/2009	UNK	3500	900	3.89	1.00
West Lake	4/6/2009	UNK	2300	2300	1.00	1.00
TD2	4/6/2009	UNK	800	23800	1.00	29.75
TD2	4/6/2009	UNK	400	6900	1.00	17.25
TD2	4/6/2009	UNK	400	10400	1.00	26.00
West Medical Lake	10/27/2009	PRE	16170	1470	11.00	1.00
West Medical Lake	10/27/2009	PRE	15050	1190	12.65	1.00
West Medical Lake	10/27/2009	PRE	13000	500	26.00	1.00
Starzman Lake	11/12/2009	POST	262	352	1.00	1.34
Hog Canyon	10/14/2009	PRE	1010	4120	1.00	4.08
Hog Canyon	10/14/2009	PRE	1720	5550	1.00	3.23
Hog Canyon	10/14/2009	PRE	1930	4530	1.00	3.35
Hatch Lake	5/8/2009	MID	11	0	11.00	0.00
Hatch Lake	5/8/2009	MID	58	0	58.00	0.00
Hatch Lake	5/8/2009	MID	52	1	52.00	1.00
Hatch Lake	10/7/2009	POST	1950	560	3.48	1.00
Hatch Lake	10/7/2009	POST	2070	660	3.14	1.00
Hatch Lake	10/7/2009	POST	2630	1080	2.44	1.00
Frater Lake	5/1/2009	MID	14	8	1.75	1.00
Frater Lake	5/1/2009	MID	12	4	3.00	1.00
Frater Lake	5/1/2009	MID	2	1	2.00	1.00
Frater Lake	10/7/2009	POST	2400	0	240.00	0.00
Frater Lake	10/7/2009	POST	800	0	80.00	0.00
Frater Lake	10/7/2009	POST	1020	0	102.00	0.00
Ellen Lake	10/6/2009	POST	22800	900	25.33	1.00
Ellen Lake	10/6/2009	POST	23850	400	59.63	1.00
Ellen Lake	10/6/2009	POST	23300	400	58.25	1.00
Fishtrap	10/14/2009	PRE	19700	30200	1.00	1.53
Fishtrap	10/14/2009	PRE	24300	50500	1.00	2.08
Fishtrap	10/14/2009	PRE	21100	35200	1.00	1.67
Williams Lake	5/8/2009	MID	28	4	7.00	1.00
Williams Lake	5/8/2009	MID	4	1	4.00	1.00
Williams Lake	5/8/2009	MID	30	0	30.00	0.00
Williams Lake	10/6/2009	POST	8400	6300	1.33	1.00
Williams Lake	10/6/2009	POST	6950	4450	1.56	1.00
Williams Lake	10/6/2009	POST	5600	5100	1.10	1.00
Buck Lake	10/28/2009	PRE	683	35	19.51	1.00
Dixon's Pond	10/24/2008	POST	134000	11800	11.36	1.00
Dixon's Pond	10/24/2008	POST	24620	1700	14.48	1.00
Little Hatch Lake	10/7/2009	POST	1430	1570	1.00	1.10
Little Hatch Lake	10/7/2009	POST	1660	1620	1.02	1.00
Little Hatch Lake	5/8/2009	MID	15	0	15.00	0.00
Little Hatch Lake	5/8/2009	MID	391	2	195.50	1.00

Little Hatch Lake	5/8/2009	MID	626	6	104.67	1.00
Little Hatch Lake	10/7/2009	POST	1160	1470	1.00	1.27

Recommendations

Field Sampling:

Depth should be recorded to calculate the volume of water sampled. Zooplankton density can then be computed from the known volume in the sample and expanded to number/liter, which is useful when comparing data among water bodies. To reduce the error of overestimating zooplankton abundance, each sample should be taken from an anchored site, from the bottom of the lake straight up to the lake surface, rather than at an angle. If a sample contains benthic debris, the sample should be emptied and taken again. In addition, each sample should contain a label tag written in pencil on waterproof paper (e.g. "Rite in the Rain"®) for site identification. Some of the sample bottles were labeled in permanent ink, which dissolves in ethanol. Consequently, some of the sample bottles lacked pertinent information regarding area of collection and depth. The following information should be recorded on a label:

- Lake Name
- Location of Sample (description or coordinates)
- Date
- Time
- Depth
- Water Temperature

Preservation:

We recommend that the following preservation techniques, similar to those developed by Black and Dodson (2003), be used when collecting zooplankton samples. Immediately following a tow, each sample should be flushed into an open-ended nytex mesh cup designed to capture all zooplankton within the sample while allowing the water to pass through. Once the majority of water has drained from the sample, the nytex cup should be placed in a tray of 95% ethanol for approximately 10 seconds in order to fix the zooplankton. Once the sample is fixed it should be irrigated from the cup with 70% ethanol into a Whirl-Pak® or 125 mL plastic bottle. Samples should be stored in 70% ethanol until lab analysis. To prevent samples from drying, an adequate volume of ethanol should be used to fill the storage vessel. Other types of alcohol such as isopropyl should not be used as they can destroy cladoceran carapaces. During our zooplankton analysis, some cladocerans could not be measured because of carapace deterioration.

Analysis:

The zooplankton sampling protocol (Washington Department of Ecology 2002) requires a cladoceran/copepod ratio for each sample. Although this is the prescribed methodology, we feel an additional descriptive approach may be warranted. The identification of zooplankton to family would provide more information and be useful to temporally and spatially compare samples within and among systems. Furthermore, the descriptive approach may be useful to detect invasive species such as the zebra mussel (*Dreissena polymorpha*) larvae or veliger, which range in size from 97-228 μm depending on the ontogenetic stage (USACE 2007). However, it should be noted that the sampling efforts associated with the rehabilitation requirements could only supplement, not replace the existing efforts dedicated to detecting invasive species such as zebra mussels.

Conclusions:

We recommend that all future samples be analyzed shortly after they are collected to reduce the likelihood of damage to zooplankton carapaces. The methods that we recommended will reduce the volume of alcohol required while maintaining the integrity of zooplankton structures used for analysis. We have constructed all of the necessary equipment needed to follow our methodologies and will gladly supply WDFW staff with these material when needed. Thank you for using the Large Lakes Research Team to perform your mandated tasks and we look forward to becoming more involved in future Lake Rehabilitation Program efforts.

References:

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Abstract

Wapato Lake was surveyed by the Region Two Warmwater Team using a boat electrofisher, gill nets, and fyke nets. Largemouth bass *Micropterus salmoides* was the most abundant species collected followed by pumpkinseed sunfish *Lepomis gibbosus*, and yellow perch *Perca flavescens*. Water chemistry data (dissolved oxygen and pH) in the epilimnion were well within acceptable standards for fish growth and survival. Seven game fish species were collected during this survey and with the exception of rainbow trout *Oncorhyncus mykiss*, were collected with all gears. Stock density indices reflect that the yellow perch population contains mostly large fish, while the largemouth bass population is comprised mostly of fish less than twelve inches. Length at age for all species was at or above average for fish older than age two, but below average for age one and two fish.

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