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MaxDepth Aquatics, Inc.

Benthic Macroinvertebrates in Diamond Lake, 2007

Prepared for the
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By
Joseph Eilers

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ABSTRACT

Benthic macroinvertebrates were sampled at 23 sites monthly from June to October, 2007. The results show a rapid recovery of benthic organisms in Diamond Lake following the eradication of tui chub. Biomass of benthic invertebrates increased from an average of 17.6 lbs/ac from 2004-2006 to 200 lbs/ac in October, 2007. The total number of individuals in the lake-wide sample increased from an average of about 200 individuals to over 6,000 organisms in October 2007. The number of organisms per 23 sites in 2007 ranged from 75 up to 719 organisms. A number of taxa not present (or only rarely present) in Diamond Lake for years returned to the lake in 2007 including, mayflies, dragonflies, damselflies, amphipods, snails, and fingernail clams. One of the most noteworthy increases was for the amphipod, *Hyalella*, in which only 2 individuals were sampled during 2004-06; in October 2007, 678 individuals were sampled at 12 sites. The rate of increase in benthic biomass from August 2006 to October 2007 followed a well defined monotonic increase. Shoreline samples of benthic organisms were collected using a D-frame net to provide additional information regarding the benthic macroinvertebrate community. The shoreline sampling showed a much high proportion of non-dipteran insects, especially mayflies, along with a higher proportion of snails.

Cover Photo: Courtesy of Justin Miles, ODFW. Image taken on June 11, 2007 at the Diamond Lake weir. The dragonflies emerging are genus *Epitheca* (Cordulidae)

INTRODUCTION

Sampling of benthic macroinvertebrates has been conducted in Diamond Lake by several organizations since 1946 (Eilers 2003; Truemper 2007). The primary purpose of the sampling has been to determine the food base available for the trout that have been stocked. In years when tui chub have been present, the sampling has also served to document the impact of the chub on the benthic invertebrates. In the years leading up to the first rotenone treatment in 1954, benthic biomass declined precipitously. This pattern was repeated with the second introduction of tui chub circa the late 1980s (Eilers et al. 2007a).

Benthic sampling was continued in 2007 to determine the nature of benthic invertebrate response following the rotenone treatment in September 2006. It is intended that some of the data from the benthic sampling will be used in the stocking index to help guide the Oregon Department of Fish & Wildlife with trout stocking approaches in subsequent years (Eilers et al. 2007b).

METHODS

The methods in 2007 followed those for years 2004-2006 as described in Truemper (2007). This consisted of sampling 23 sites (Table 1), pooling triplicate Petite PONAR samples that were sieved through a #30 wire mesh. The benthic sampling in 2007 was conducted monthly from June through October. The October sample is the primary sample used to compare with previous years' production and community composition.

Additional information on the benthic macroinvertebrates was obtained by conducting kick-net sampling using a D-frame net in the near-shore area (Table 2). Sites were surveyed by kicking the substrate and swinging the net thought the disturbed area. The intensity of the survey was gauged by the duration of effort, distance sampled, site depth, and habitat type. Sites were sampled on seven days from June 20 – August 7, 2007. The samples were sorted into major taxonomic groups. Both the shoreline surveys and the traditional PONAR sampling conducted in 2007 were carried out by ODFW staff.

Table 1. Locations and characteristics of 23 sample sites.

Site #	Lat	Long	Depth (ft)	Substrate	Weeds	Comments
01	43 10.913	122 10.228	4	Hard	No	Pumice bottom - No mud
02	43 10.748	122 09.958	18	Soft/Veg	3 ft	*Elodea* and *Potamogeton*
03	43 10.532	122 09.637	29	Soft	No	
04	43 10.679	122 08.805	35	Soft	No	
05	43 09.974	122 09.862	3	Sand	No	Patches of short macrophytes
06	43 10.192	122 09.138	50	Soft	No	
07	43 10.063	122 09.072	50	Soft	No	
08	43 10.318	122 08.559	39	Soft	No	
09	43 10.323	122 08.311	34	Soft	No	
10	43 09.896	122 08.262	34	Soft*	No	Pumice in sample
11	43 09.490	122 09.104	33	Soft	No	
12	43 09.089	122 09.624	19	Soft/Veg	6 ft	*Nitella* and *Potamegeton*
13	43 09.089	122 09.781	15	Soft/Veg*	6 ft	Large pieces of pumice
14	43 09.105	122 09.850	6	Soft/Veg	6 ft	Dense macrophytes; pumice gravel
15	43 08.715	122 08.925	18	Soft/Veg	1 ft	*Ceratophylum*
16	43 08.331	122 08.364	4	Soft*/Veg	1 ft	Fine pumice with organic material
17	43 08.445	122 08.734	11	Soft/Veg	1 ft	*Elodea*
18	43 08.477	122 09.101	13	Soft/Veg	4 ft	*Ceratophylum*
19	43 09.963	122 09.145	48	Soft	No	EPA center
20	43 10.536	122 08.378	17	Veg	Yes	EPA NE (resort)
21	43 08.741	122 08.503	13	Veg	Yes	EPA SE
22	43 08.769	122 09.641	14	Veg	Yes	EPA SW
23	43 09.956	122 09.708	~22	Soft/veg	Yes	“Shrimp Beds”

Table 2. Shoreline sample sites sampled in 2007 using a D-frame net.

Date	Site	UTM	UTM	Depth (ft)	Habitat	distance sampled (ft)
6/20/2007	1S	567659	4780249	1.5-3	rush, sand	36
6/20/2007	2S	567642	4780380	2 to 4	rush, sand	25
6/20/2007	3L	567679	4780519	9	veg, sand	NA
6/20/2007	4S	567578	4780737	0.5 - 4	veg, sand	27
6/20/2007	5S	567568	4780815	2 to 4	rush, cattails, sand	60
6/20/2007	6S	567497	4780935	1 to 3.5	sand, lilly pads, rush	55
6/20/2007	7L	567397	4781145	5	lilly pads, sand, veg	NA
6/20/2007	8S	568056	4781637	0.5 to 3.5	rocks	20
6/20/2007	9S	568056	4781617	0.5 to 4	rocks	20
6/20/2007	10L	568423	4781522	8	rocks, mud	NA
7/26/2007	10L	568423	4781522	8	rocks, mud	NA
7/26/2007	wetland 1	567579	4780710	2	macrophytes	15
7/26/2007	wetland 2	567574	4780754	2	macrophytes	25
7/31/2007	A	570299	4780340	3	cobble, pebbles, log	30
7/31/2007	B	570297	4777239	3	cobble, sand	30
8/1/2007	C	570159	4776648	3	sand, potamegoton, undercut grass bank	55
8/2/2007	D	568198	4776412	4	potamegoton, grass	25
8/3/2007	E	567825	4777747	3	potamegoton, sand, silt grass, rocks	30
8/7/2007	1	567479	4780985	2.5"-3'	lily pads, rushes, detritus	30
8/7/2007	2	567739	4780075	1.5-3'	sand, vegetation	25
8/7/2007	3	567845	4778980	3	sand, pumice, floating macrophytes	40
8/7/2007	4	570307	4779125	2.75'	cobble, along log	30
8/7/2007	5	569570	4780939	3	rocks	25
8/7/2007	6	567921	4777107	3	macrophytes	35
8/7/2007	7	568134	4776583	3	potamegoton, sand, rushes	25
8/7/2007	8	569258	4776293	6"-5'	soft dirt, sand	40
8/7/2007	9	570174	4776674	3"-2.75'	sparse grass, sandy pebble, undercut bank	50
8/7/2007	10	567318	4781330	3	dense rushes, grass, dead veg with silt	25

RESULTS

The benthic biomass recovered rapidly in 2007 following the removal of the tui chub with the rotenone treatment in September 2006 (Figure 1). The degree of the recovery is not only impressive with respect to the recovery since 2004 when the systematic benthic monitoring was re-instituted (Figure 2), but also when compared to the long-term data available for the lake (Figure 3).

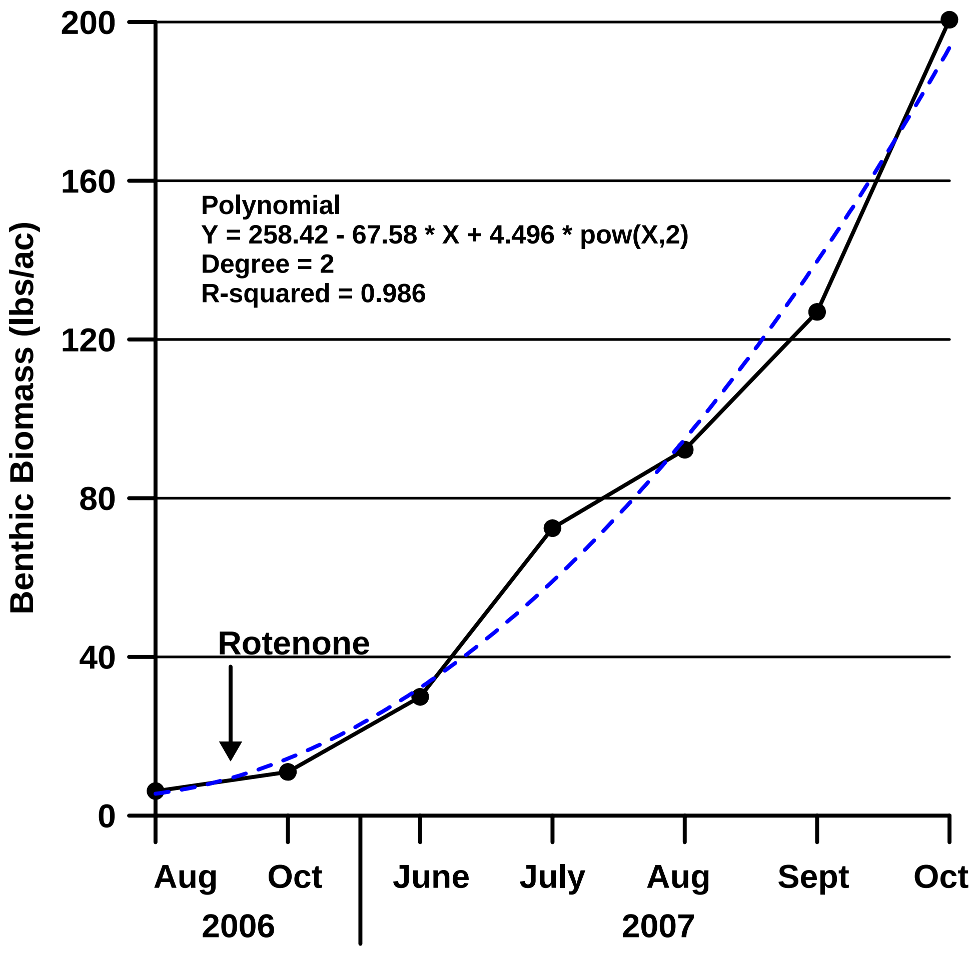

Figure 1. Benthic biomass in Diamond Lake from August 2006 to October 2007.

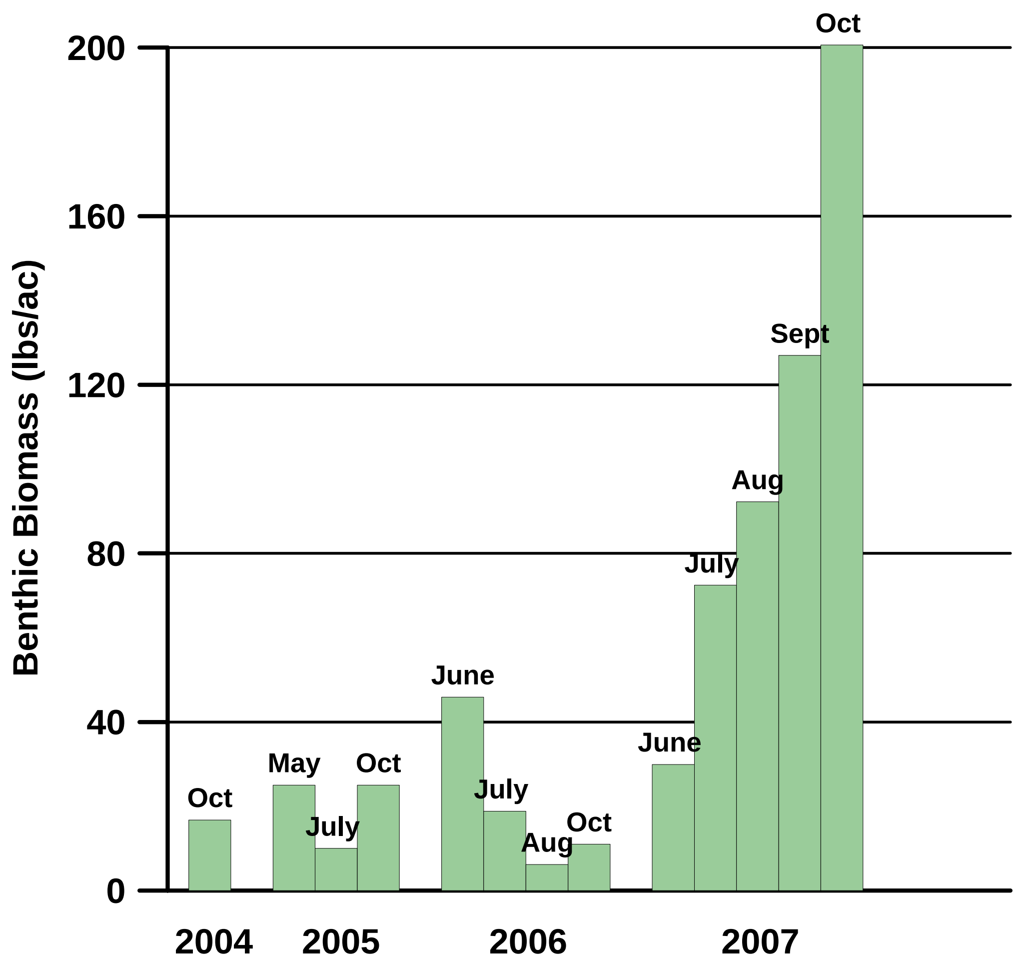

Figure 2. Benthic biomass in Diamond Lake from October 2004 to October 2007.

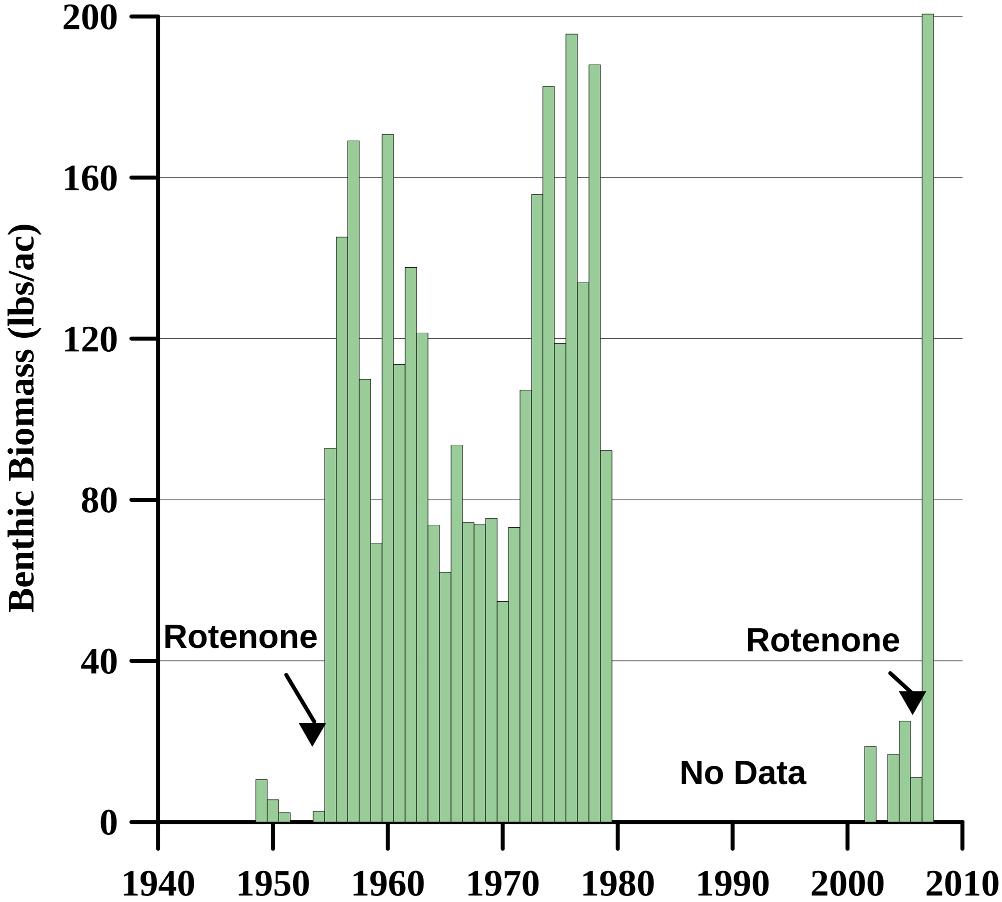

Figure 3. Benthic biomass in Diamond Lake from October 1949 to October 2007.

Not only has the biomass of benthic macroinvertebrates increased dramatically, but the number and types of taxa returning to the lake has shown a substantial improvement (Table 3). The most abundant organisms in Diamond Lake continue to be the chironomids, especially *Dicrotendipes* and *Chironomus*. However, some non-dipteran taxa have shown impressive recoveries, most notably the amphipod, *Hyalella*, which increased from a total of two individuals sampled throughout the lake from 2004-2006 (Truemper 2007) to 678 individuals found at 12 sites in October 2007. Site #23 which was added to the sampling design in 2004 because of its location in what is commonly referred to as the "Shrimp Beds" yielded only two amphipods in October 2007. Most of the amphipods (578) were instead found at site 17.

Other noteworthy recoveries include the return of three taxa of snails, including 258 individuals of *Gyraulus parvus*. The fingernail clam, *Psidium*, was also found, but only at one site (#16). Two species of mayflies, *Callibaetis sp.* and *Caenis amica,* also returned in substantial numbers, totaling 257 organisms. Two individuals of the order Odonata, a damselfly and the dragonfly, *Epitheca* (shown on the cover), also were reasonably abundant. Two species of caddisflies were also present, but were uncommon in theses PONAR samples. There were three sites sampled in 2007 that were exposed (dry) during the drawdown in 2006. These three sites (1, 14, 16) had abundant numbers of individuals present in 2007 (244-465) and had diverse faunas (15-19 taxa). Curiously, all fingernail clams sampled in the survey were found at site 16.

Table 3. Number of organisms present at the 23 sites sampled in October 2007 and the number of sites at which they were found.

PHYLUM	**CLASS**	**Order**	**FAMILY**	**GENUS**	**ASSIGNED NAME**	Total	# Sites
ANNELIDA	HIRUDINEA	Rhynchobdellida	Glossiphoniidae	Helobdella	*Helobdella stagnalis*	198	8
ANNELIDA	HIRUDINEA	Rhynchobdellida	Erpobdellidae		*Erpobdella punctata*	22	7
ANNELIDA	OLIGOCHAETA				OLIGOCHAETA	211	16
NEMATA					NEMATA	10	3
ARTHROPODA	ARACHNOIDEA	Trombidiformes			Trombidiformes	2	2
ARTHROPODA	INSECTA	Ephemeroptera	Baetidae	Callibaetis	*Callibaetis*	118	15
ARTHROPODA	INSECTA	Ephemeroptera	Caenidae	Caenis	*Caenis amica*	139	5
ARTHROPODA	INSECTA	Brachycera			Brachycera	1	1
ARTHROPODA	INSECTA	Diptera	Chironomidae		*Chironomini*	4	4
ARTHROPODA	INSECTA	Diptera	Chironomidae	Ablabesmyia	*Ablabesmyia*	5	3
ARTHROPODA	INSECTA	Diptera	Chironomidae	Chironomus	*Chironomus*	1704	21
ARTHROPODA	INSECTA	Diptera	Chironomidae	Cladopelma	*Cladopelma*	4	1
ARTHROPODA	INSECTA	Diptera	Chironomidae	Cladotanytarsus	*Cladotanytarsus*	32	7
ARTHROPODA	INSECTA	Diptera	Chironomidae	Cryptochironom	*Cryptochironomus*	12	7
ARTHROPODA	INSECTA	Diptera	Chironomidae	Dicrotendipes	*Dicrotendipes*	2064	22
ARTHROPODA	INSECTA	Diptera	Chironomidae	Diplocladius	*Diplocladius*	1	1
ARTHROPODA	INSECTA	Diptera	Chironomidae	Endochironomus	*Endochironomus*	1	1
ARTHROPODA	INSECTA	Diptera	Chironomidae	Orthocladius/Cri	Orthocladius/Cricotop	1	1
ARTHROPODA	INSECTA	Diptera	Chironomidae	Paratanytarsus	*Paratanytarsus*	1	1
ARTHROPODA	INSECTA	Diptera	Chironomidae	Phaenopsectra	*Phaenopsectra*	8	5
ARTHROPODA	INSECTA	Diptera	Chironomidae	Procladius	*Procladius*	327	21
ARTHROPODA	INSECTA	Diptera	Chironomidae	Psectrocladius	*Psectrocladius*	29	6
ARTHROPODA	INSECTA	Diptera	Chironomidae	Pseudochironon	*Pseudochironomus*	2	1
ARTHROPODA	INSECTA	Diptera	Chironomidae	Tanytarsus	*Tanytarsus*	98	16
ARTHROPODA	INSECTA	Odonata	Coenagrionidae	Coenagrion/Ena	*Coenagrion/Enallagma*	22	4
ARTHROPODA	INSECTA	Odonata	Cordullidae	Epitheca	*Epitheca*	20	4
ARTHROPODA	INSECTA	Trichoptera	Leptoceridae	Oecetis	*Oecetis*	1	1
ARTHROPODA	INSECTA	Trichoptera	Leptoceridae	Mystacides	*Mystacides*	2	2
ARTHROPODA	CLADOCERA	Cladocera			Cladocera	103	14
ARTHROPODA	MALACOSTRACA	Amphipoda		Hyalella	*Hyalella*	678	12
MOLLUSKA	BIVALVA		Pisidiidae	Pisidium	*Pisidium*	38	1
MOLLUSKA	GASTROPODA		Lymnaeidae	Lymnaea	*Lymnaea*	2	2
MOLLUSKA	GASTROPODA		Planorbidae	Gyraulus	*Gyraulus parvus*	258	13
MOLLUSKA	GASTROPODA		Valvatidae	Valvata	*Valvata*	1	1
						6119	

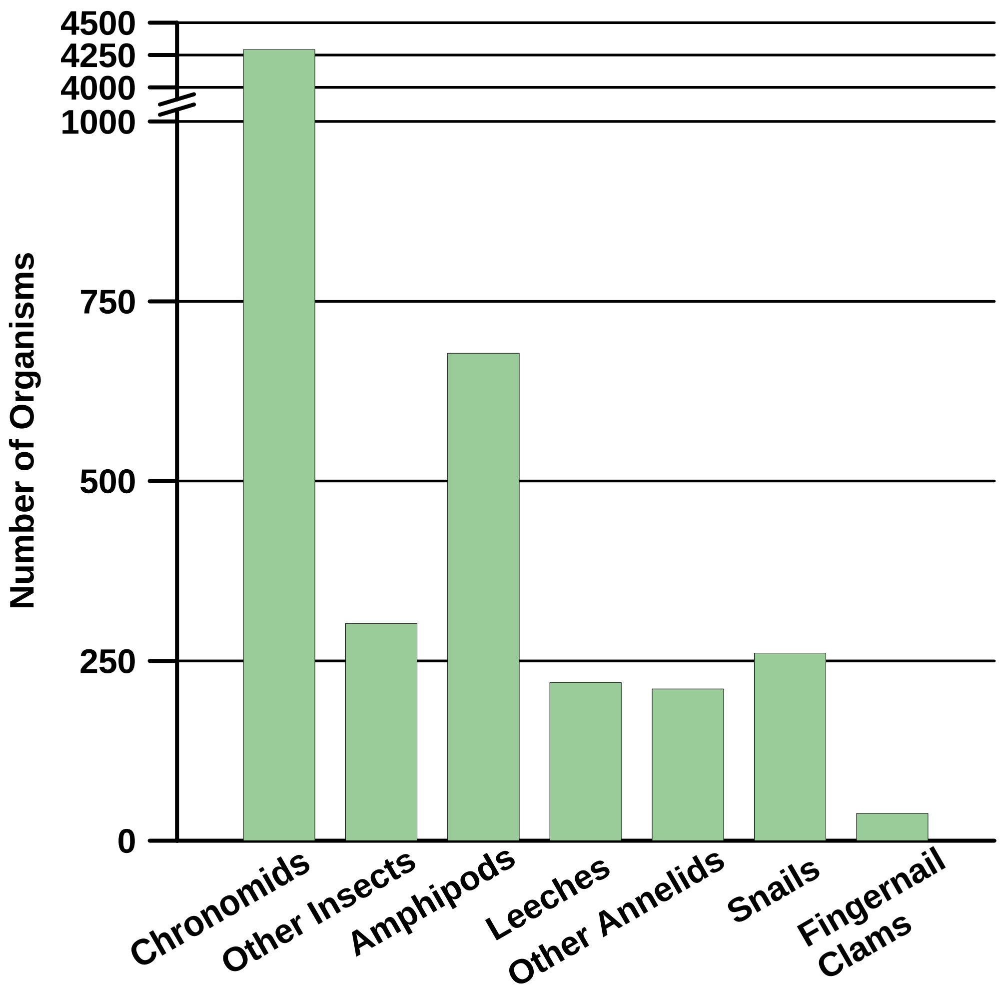

Figure 4. Number of benthic organisms sampled in Diamond Lake, October 2007 based on major groups collected with PONAR samples.

The results of the D-frame net shoreline sampling efforts are shown in Table 3. The major groups of organisms shows that the majority of organisms sampled were non-dipteran insects, primarily mayflies, and snails (Figure 5). Amphipods showed similar numbers encountered in the October 2007 PONAR samples, although the results from the different methods are difficult to compare quantitatively. Nevertheless, the shoreline sampling provides some important insights to a more complex benthic community that is only partially represented by the PONAR sampling.

Table 4. Sample results from shoreline sampling in 2007. The last line represents the total number of individuals.

Site	Annelids	Midges	Damselfly	Dragonfly	Caddisfly	Mayfly	Notonectidae	Corixidae	Amphipod	Snails
1S		4	23			1	1	12		3
2S	1	39	5					1		
3L		11								
4S	1	10	5					3		1
5S		15	4							2
6S	12	334						2		1
7L		36	3							
8S	2	6								
9S		9								
10L		0								
10L	0	0		0					0	
wetland 1		8	8	1		13		2	54	35
wetland 2	1	65	7			7		3	24	21
A	64	14				21			164	26
B	26	182			2	133			35	29
C		17	4			333		21	2	280
D	10	193	6			290	2	15	121	171
E		5	8		12	17			31	105
1		153	264		1	2		5		117
2		57	3	5	2	35		1	5	105
3	4	11				6	1		5	19
4	80	12				33			25	44
5	6	9				52			24	10
6		11	3			30		1	10	130
7	1	42	69		1	115	3	12	9	264
8		93				28		3	27	60
9		31	24		1	238		29		275
10	4	31	286			8	1	2	10	257
	212	1398	722	6	19	1362	8	112	546	1955

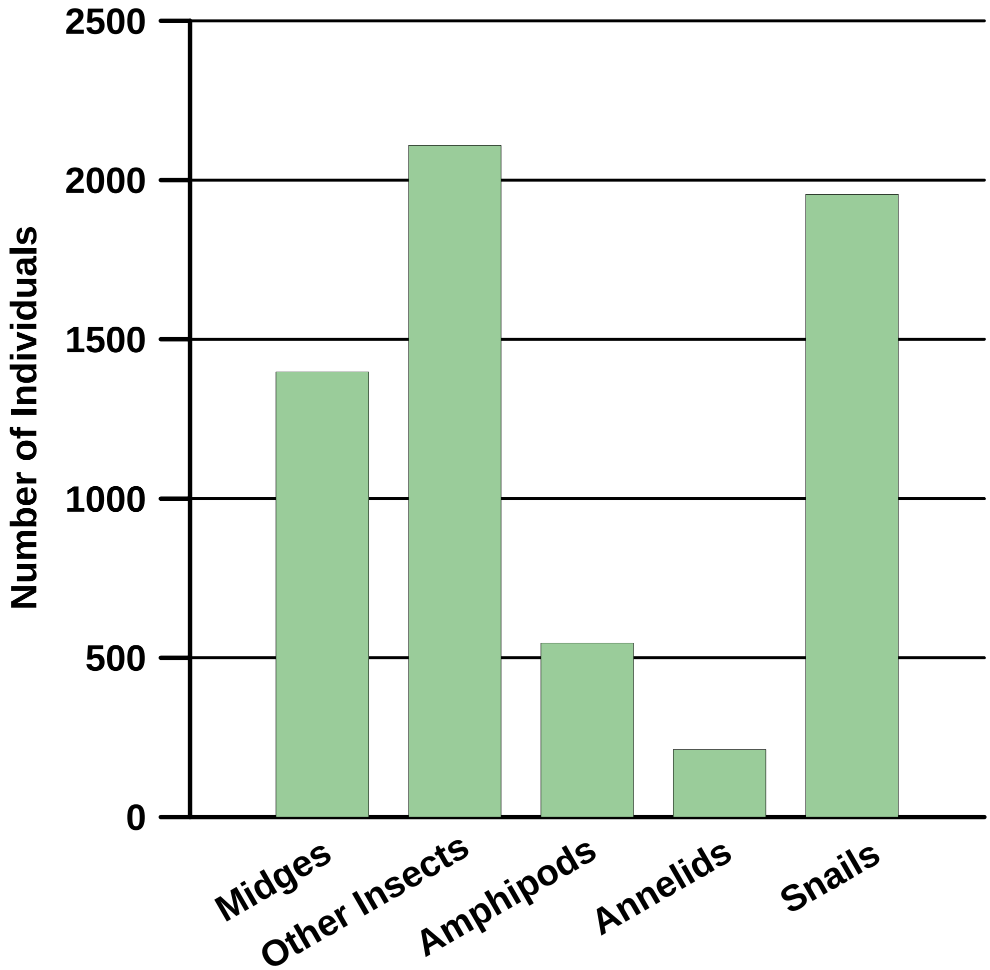

Figure 5. Number of benthic organisms sampled in the near-shore environment of Diamond Lake from June – August, 2007 using a D-Frame net sampler.

DISCUSSION

The rapid recovery of both benthic biomass and a reasonable diversity of aquatic invertebrates were impressive based on comparison with the historical data. Chironomids continue to remain the most abundant organisms in Diamond Lake, but a number of other taxa are also recovering nicely. It is unclear whether the relatively low percentage of amphipods present in October 2007 can be compared directly with the Oregon Game Commission (OGC) data from 1957-60 or whether the data in recent years (2004-07) represents a different level of sorting of the invertebrate samples. For example, the 1957-60 OGC data show that over 60 percent of the individuals in the samples were amphipods compared to only 11.1 percent in the 2007 samples. Thus, there may be some methodological differences between how the samples are currently processed compared to the historical samples that preclude a one-to-one comparison.

A second issue that has become apparent in 2007 is that there are a number of benthic taxa present in Diamond Lake that are not well represented in the current (and historical) sampling protocol. The sampling strategy has always been focused towards assessing the biomass of macroinvertebrates that are available to trout. This is systematically acquired using the PONAR samples that provide a quantitative sample of a known area. Unfortunately, the PONAR samples are not efficient for sampling highly vegetated sites, particularly in near-shore areas. Staff with ODFW evaluated the macroinvertebrate community in the near-shore zone by collecting kick-net samples in selected areas. The results showed the presence of a large of number of Hemiptera and other taxa that were not being sampled with the PONAR survey. These other taxa include species within the Notonectidae, Belostomatidae (Figure 6), Gerridae, and Corixidae. To some extent, this group of insects found in the macrophyte/near-shore habitat will be sampled using the blacklight trap that was deployed in 2006 and 2007. The data from 2006 have been compiled and the data from 2007 are due to be completed in early 2008 and will be reported elsewhere.

Figure 6. A *Lethocerus* sampled using a D-frame kick net along the northwest shore of Diamond Lake, summer 2007.

Another component of the benthic macroinvertebrates that are not reflected in the PONAR samples is the crayfish. There was a large population of signal crayfish (*Pacifasticus leniusculus leniusculus*) present in Diamond Lake prior to the drawdown and rotenone treatment. A large number of these organisms were killed during the over-winter drawdown that exposed the individuals to freezing conditions. We presume that another large portion of the population was killed during the rotenone treatment. Some sampling of crayfish was conducted during summer 2006 using baited crayfish traps, but none was conducted in 2007.

The return of large numbers of aquatic insects to Diamond Lake was evident in the large hatches of insects that occurred throughout the summer (Figures 7 and 8). Most of these hatches appeared to be chironomids (midges), although hatches of mayflies and caddisflies (2200 hr, July 9, 2007) were noted. The drawdown appeared to have little effect on the recruitment of aquatic macroinvertebrates as evidenced by the results from the shoreline surveys and the three sites that were dry in 2006.

Figure 7. Insect exuviae on Diamond Lake, Aug 6, 2007.

Figure 8. An aerial view of insect exuviae following a major hatch on Diamond Lake, September 11. 2007. (Photo courtesy of Mari Brick, ODFW).

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