PORTLAND STATE UNIVERSITY

Diamond Lake water quality during 2009:

Fish stocking index parameter final report

Prepared for the Partnership for Umpqua Rivers and the USDA Umpqua National Forest

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Contents

Introduction 1
Fingerling trout stocking rates 3
Primary consumer FSI parameters 4
Large *Daphnia* and "edible" zooplankton 4
Benthic macroinvertebrates 5
Primary producer FSI parameters 6
Chlorophyll-a and phytoplankton biovolume 6
Anabaena sp. cell density and phytoplankton composition 8
Secchi disc transparency 10
Chemical FSI parameters 11
Surface water dissolved oxygen 12
Surface water pH 12
Hypolimnetic dissolved oxygen 13
Water quality FSI parameter summary and discussion 14
References 17

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Figures

Figure 1. Example of boxplots used in this document. Circles represent individual data points, the middle lines represent median values, boxes represent interquartile ranges, and whiskers represent ranges of non-outlier data points. 3
Figure 2. Annual Diamond Lake fingerling trout stocking. 4
Figure 3. Large *Daphnia spp.* population density at site DLA. Boxes are interquartile ranges, whiskers are ranges of non-outlier data points, horizontal lines are median values, and circles are data points. 5
Figure 4. "Edible" zooplankton population density at site DLA. 5
Figure 5. Average benthic macroinvertebrate biomass measured during annual October surveys. Data were provided by ODFW. No data were collected during 1947, 1952-1953, 1980-2001, and 2003. 6
Figure 6. Surface water chlorophyll a concentration at site DLA. 7
Figure 7. Surface water phytoplankton biovolume at site DLA 8
Figure 8. Surface water *Anabaena sp.* density at site DLA. The dotted line is the TMDL upper limit of 15000 cells/mL. 9
Figure 9. Surface water phytoplankton composition by biovolume at site DLA. 9
Figure 10. Secchi transparency in Diamond Lake after the 2006 rotenone treatment. 10
Figure 11. Secchi disc transparency in Diamond Lake from 1962 through 2009. 11
Figure 12. Summertime surface water dissolved oxygen percent saturation. 12
Figure 13. Summertime Diamond Lake surface water pH values. Dotted lines are the DEQ pH criteria values. The dashed line is the approximate pH equilibrium value. 13
Figure 14. Summertime hypolimnetic dissolved oxygen concentrations at 13 m. 13
Figure 15. "Fish Stocking Index" values for water quality parameters. 16

Tables

Table 1. Count of dates with available data at Diamond Lake site DLA. 2
Table 2. Chlorophyll-a concentration by depth at Diamond Lake site DLA in 2009. 7
Table 3. 2009 Diamond Lake phytoplankton species list and percent of total 2009 density. 10
Table 4. Relationships between water quality parameter values and Fish Stocking Index values (Eilers et al. 2008). 14
Table 5. Fish Stocking Index values (values in bold) and water quality parameter values used to derive the index values (values in italics) for the period from 2006 through 2009. 15

Introduction

Diamond Lake is a large productive lake located in the headwaters of Oregon's Umpqua River. Since the early 1900s fishing for stocked trout and other related recreational activities has been an integral part of the local economy (USDA 2004). During the 1940s and 1990s the health of the fishery, water quality, and consequently, the local economy declined as the population of the introduced bait fish species tui chub (*Gila bicolor*) increased (Eilers et al. 2007). In both cases, the health of the trout fishery and water quality improved dramatically following removal of tui chub with the piscicide Rotenone (Eilers et al. 2008; Eilers et al. 2009; Sytsma and Miller 2008; Sytsma and Miller 2009).

Two food-web based theories have been proposed to explain the influence of tui chub on water quality in Diamond Lake (Eilers et al. 2007):

1. the top-down theory states that tui chub consumed herbaceous zooplankton to such a degree that the phytoplankton population was allowed to grow unchecked, and

2. the nutrient recycling theory states that the tui chub altered the food web resulted in higher nutrient recycling rates, and consequently, more available nutrients for phytoplankton growth.

Although tui chub are no longer present in the lake, there is concern that excessive stocking of zooplanktivorous fingerling trout may also have a negative impact on water quality (USDA 2004). As a result of this concern, the Diamond Lake Restoration Project Final Environmental Impact Statement (FEIS) proposed ODFW and ODEQ to develop ecologically sustainable fish stocking strategies and for ODFW to monitor the resulting fisheries and along with USFS, the water quality health (USDA 2004).

The purpose of this report is to summarize water quality conditions in Diamond Lake in response to the Oregon Department of Fish and Wildlife's (ODFW's) fingerling trout stocking strategies that were implemented following the 2006 rotenone treatment. Water quality conditions will be evaluated in comparison to data collected since 1962. The water quality parameters evaluated in this report are part of Diamond Lake Fish Stocking Index (FSI) (Eilers 2003; Eilers et al. 2008). Diamond Lake FSI parameters were selected based on their sensitivity to fingerling trout stocking levels and include:

- secondary consumer parameters: trout growth, condition and survival
- primary consumer parameters: large *Daphnia sp.* density, benthic macroinvertebrate biomass, and amphipod density
- primary producer parameters: chlorophyll a, *Anabaena sp.* density, and Secchi disc transparency, and
- chemical parameters: surface water pH, surface water dissolved oxygen concentration, and hypolimnetic dissolved oxygen concentration.

Zooplankton, primary producer, and chemical FSI parameters are included in this report using all data available through the 2009 season. Additional data were collected by other organizations between

2004 and 2009, but was not available to Portland State University for this report and was therefore not included in this assessment. Secondary consumer and benthic parameters have been evaluated by the ODFW (Holly Truemper, ODFW, pers. comm.). Benthic macroinvertebrate data collected by ODFW will be briefly summarized. Data collection and analysis during 2009 was funded through EPA's 319 Non-Point Source Pollution grant program. Field data and samples were collected June 30th, July 21st, and August 19th of 2009. Additional Secchi transparency data were provided by the Diamond Lake Lodge and USFS personnel. Water chemistry analysis was conducted by the Cooperative Chemical Analytical Laboratory established by memorandum of understanding no. PNW-82-187 between the U.S. Forest Service Pacific Northwest Research Station and the Department of Forest Ecosystems and Society, Oregon State University. Phytoplankton analysis was conducted by Aquatic Analysts, and zooplankton by ZP's Taxonomic Service. Historical data included in this report (Table 1) are from Systma and Miller (2009), Eilers (2009) Sytsma and Miller (2008), Sytsma et al. (2007), Eilers (2003), Lauer (1979), ODEQ, ODFW, Salinas and Larson (1995), and Salinas (1996; 1997; 1998; 1999; 2000; 2001; 2002; 2003; 2004; 2005).

Table 1. Count of dates with available data at Diamond Lake site DLA.

Year	Chl-a	Zooplankton	Secchi	Phytoplankton	pH	Bottom DO	Surface DO
1962	0	0	9	0	0	0	0
1963	0	0	7	0	0	0	**0**
1964-1970	0	0	0	0	0	0	0
1971	8	0	5	0	5	3	4
1972	5	0	5	0	5	2	6
1973	4	0	6	1	6	2	6
1974	5	0	6	6	6	2	5
1975	5	0	9	6	6	2	6
1976	6	0	6	6	4	2	4
1977	7	0	7	7	7	2	7
1978-1991	0	0	0	0	0	0	0
1992	4	0	4	4	4	2	4
1993	6	0	4	5	6	3	6
1994	2	3	3	3	4	2	4
1995	3	3	3	2	0	1	3
1996	3	3	3	3	3	1	3
1997	3	3	3	3	3	1	3
1998	0	7	7	7	7	4	7
1999	4	4	3	3	5	2	5
2000	3	3	3	3	2	1	2
2001	8	5	13	13	8	4	10
2002	10	5	77	39	9	3	10
2003	4	5	35	23	15	8	15
*2004	0	6	24	NA	NA	NA	NA
*2005	0	4	29	22	NA	NA	NA
*2006	5	5	24	5	5	2	5
*2007	3	3	27	3	3	3	3
2008	11	13	31	13	13	13	13
*2009	3	3	23	3	3	3	3

* Some data collected after 2004 are not available. NA = no data available.

Much of the data in this report is presented as annual boxplots which summarize median values, the 25th through 75th percentiles of the data (the interquartile ranges (IQR)), and the range of non-outlier data points (Figure 1). The range of non-outlier data points is defined as the range of data that lie within 1.5 times the IQR outside the IQR. Individual data points including outlier points are superimposed on the boxplots to make it clear how many data points are used to create the boxplots.

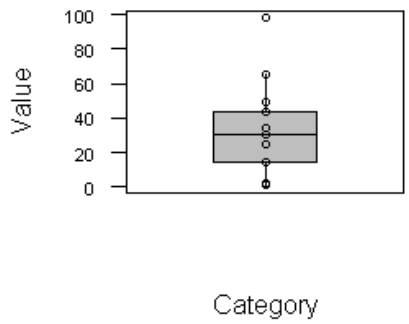

Figure 1. Example of boxplots used in this document. Circles represent individual data points, the middle lines represent median values, boxes represent interquartile ranges, and whiskers represent ranges of non-outlier data points.

Fingerling trout stocking rates

Annual fingerling stocking rates in Diamond Lake ranged from 300,000 to 500,000 from 1962 through 1999 (Figure 2). Stocking rates was reduced to less zero by 2003 due to poor growth rates associated with dense tui chub populations and poor water quality conditions After the removal of tui chub in 2006, ODFW implemented a conservative, adaptive, fingerling trout stocking strategy designed to minimize the impact on water quality and maintain a productive fishery (USDA 2004). This strategy resulted in 100,010 fingerlings stocked in 2007 and 200,100 in 2008 (ODFW 2009a). Fingerlings were stocked during mid June each year with the intent that populations of large herbaceous zooplankton, important grazers on phytoplankton, would reach high population densities prior to stocking.

An unusually cold spring in 2008 resulted in a short period between ice-off and mid June stocking, thus reducing the time period for zooplankton population growth free from the constraints of fingerling trout grazing pressure. To adapt to annual variation in climate and keep to the intent of stocking timing, the 2009 Diamond Lake Management Plan gives final decision for stocking of stocking fingerlings 4-6 weeks post ice off (ODFW 2009a). Ice off during 2009 was on May 19, stocking started 38 days later on June 25, and ended on July 7. A total 346,578 fingerlings were stocked during 2009; 10,000 of which were stocked before the first water quality sampling event on June 30, 2009 (ODFW pers. comm.).

Correlations between fingerling trout stocking rates and water quality are complicated by the unintentional introduction of golden shiners (*Notemigonus crysoleucas*). The influence of golden shiners on Diamond Lake's water quality is not known; however, ODFW implemented a golden shiner removal program and has stocked piscivorous trout to minimize any potential impacts on water quality and the fishery.

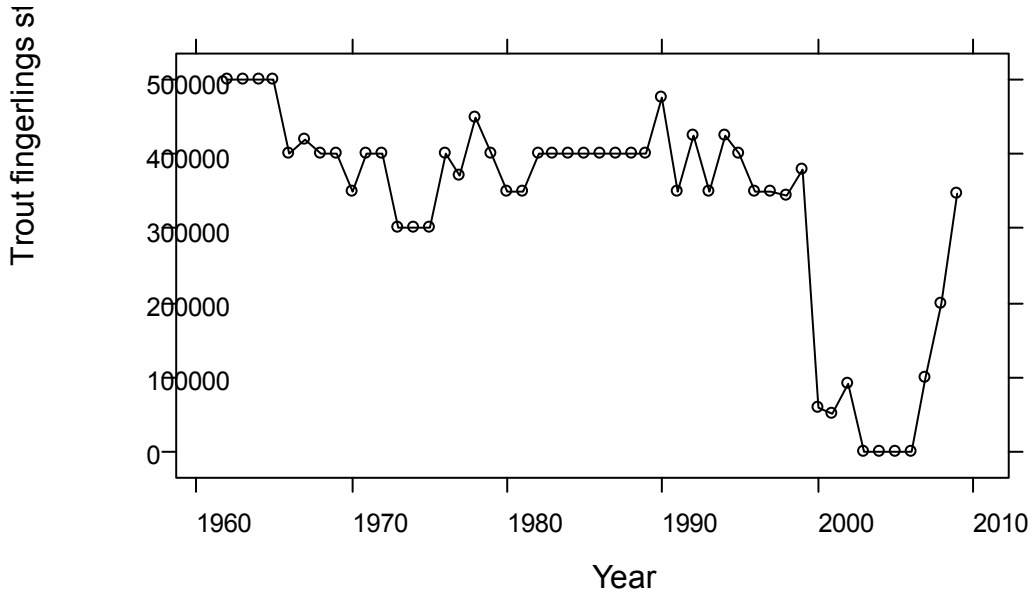

Figure 2. Annual Diamond Lake fingerling trout stocking.

Primary consumer FSI parameters

Primary consumers are organisms that feed on phytoplankton, benthic algae, and bacteria. Primary consumers are also a food source for secondary consumers such as trout, tui chub, and golden shiners. The abundance, composition, and production rates of primary consumers in a lake are a reflection of grazing pressure, food resources, competition, and environmental conditions. Measures of primary consumer status included in the FSI are large *Daphnia* species density, benthic macroinvertebrate biomass, and percent of the benthic community composed of amphipods.

Large *Daphnia* and "edible" zooplankton

Large *Daphnia* are efficient consumers of phytoplankton; therefore, high densities can suppress algal biomass and associated problems such as high pH and toxigenic algal blooms (Sarnelle and Knapp 2005). Large *Daphnia* are also preferred prey for fingerling trout and tui chub. Two large *Daphnia* species, *D. pulicaria*, and to a lesser extent *D. rosea*, have dominated the "edible" zooplankton community in Diamond Lake since zooplankton population monitoring began in 1994. Low densities of large *Daphnia* and other "edible" zooplankton were observed from 1995 through 2006 when tui chub were abundant in the lake (Figure 3; Figure 4). Densities increased dramatically following the 2006 rotenone treatment. Median densities were higher in 2009 than the previous two years; however, there were only three sampling events in 2009. High densities were observed on June 30, 2009 sampling event, 5 days after 10,000 fingerling trout were stocked; and on August 19, 2009, 43 days after the last of the 346,578 fingerlings were stocked. The lowest density was observed on July 21, 2009, 14 days after stocking ceased which suggests that fingerling stocking rates may have had an impact on the population; however, the density of 5602 large *Daphnia* per cubic meter was still very high in a historical context. The high densities observed during 2009 indicates that the 2009 fingerling trout stocking regime did not have an appreciable effect on large *Daphnia spp.* or "edible" zooplankton densities.

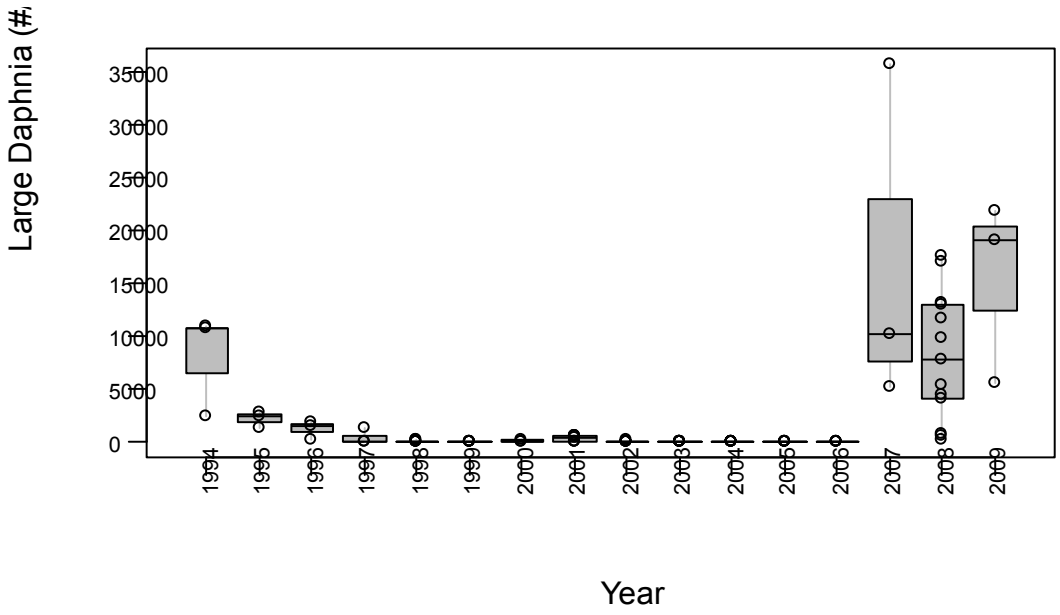

Figure 3. Large *Daphnia spp.* population density at site DLA. Boxes are interquartile ranges, whiskers are ranges of non-outlier data points, horizontal lines are median values, and circles are data points.

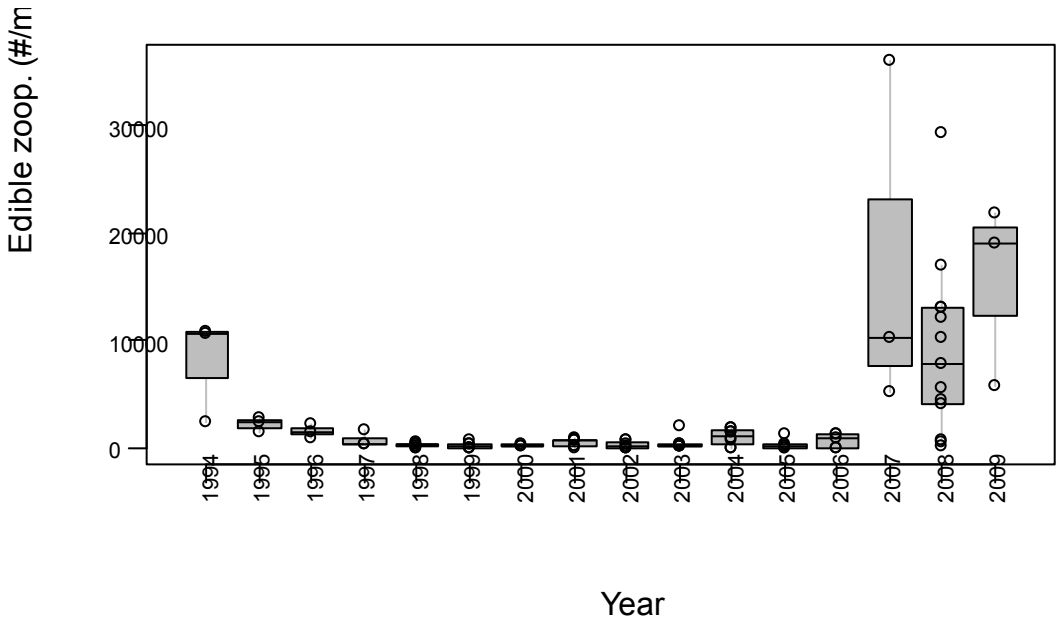

Figure 4. "Edible" zooplankton population density at site DLA.

Benthic macroinvertebrates

Benthic macroinvertebrates are a food source for fingerling trout, larger trout, tui chub, and golden shiners. Benthic macroinvertebrate surveys have been conducted intermittently by ODFW during the fall since 1948 (Figure 5). Excessive grazing pressure from tui chub resulted in low benthic macroinvertebrate densities prior to rotenone treatments in 1954 and 2006 (Eilers 2008). Density increased dramatically after treatments in both instances. The highest density recorded in Diamond

Lake, 342 lbs/acre, was observed during October, 2009 (Holly Truemper, ODFW, pers. comm.) which also indicates that 2009 fingerling stocking rates were not excessive.

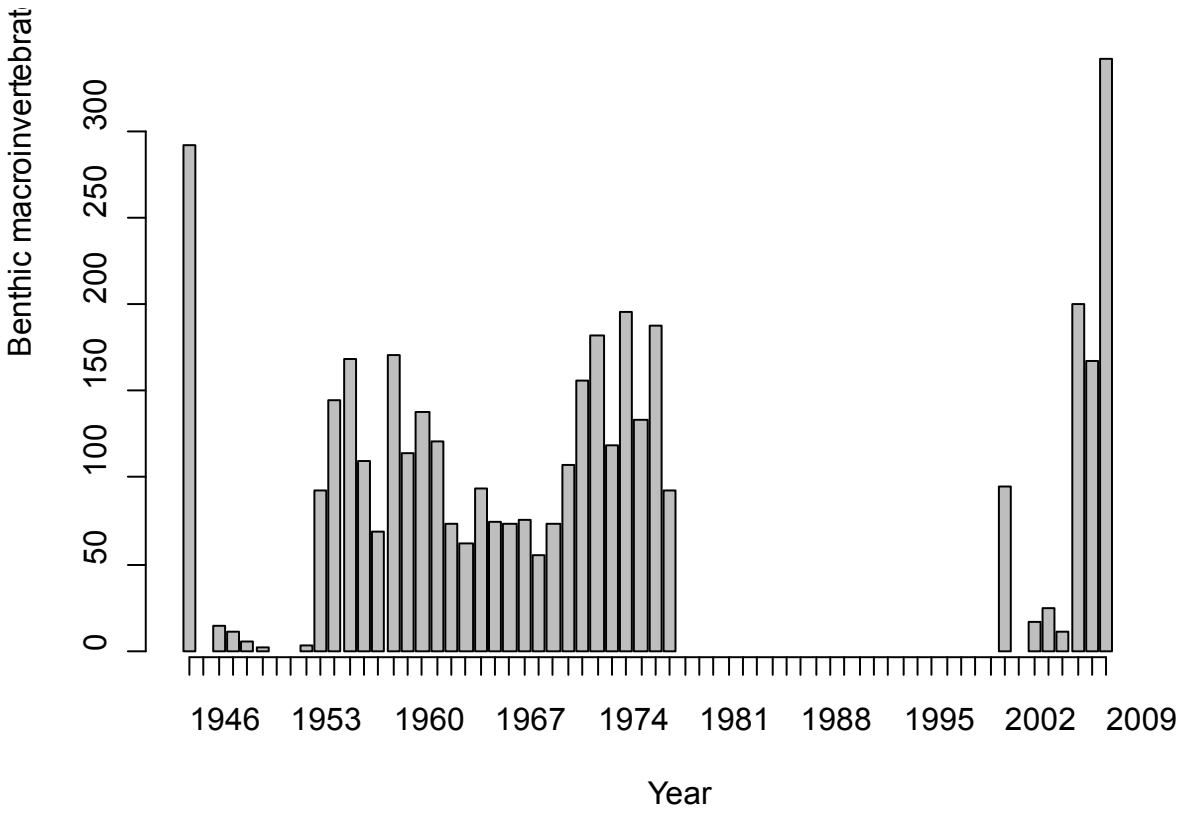

Figure 5. Average benthic macroinvertebrate biomass measured during annual October surveys. Data were provided by ODFW. No data were collected during 1947, 1952-1953, 1980-2001, and 2003.

Primary producer FSI parameters

Three primary producer parameters are included in the FSI to characterize the impact of grazing pressure by trout and tui chub: chlorophyll-a concentration, Secchi disc transparency, and *Anabaena* species cell density (Eilers et al. 2008).

Chlorophyll-a and phytoplankton biovolume

Chlorophyll-a is a photosynthetic pigment common to all phytoplankton and is used as a surrogate for phytoplankton biomass. In comparison to historical measurements, surface water chlorophyll-a concentrations were extremely low during the three 2009 sampling events in 2009 (Figure 6). All surface water concentrations were less than 2 µg/L which is well below TMDL target of 10 µg/L (Turner et al. 2006). Concentrations in the meta- and hypoliminia were slightly higher than surface water concentrations, but still below the TMDL target concentration (Table 2).

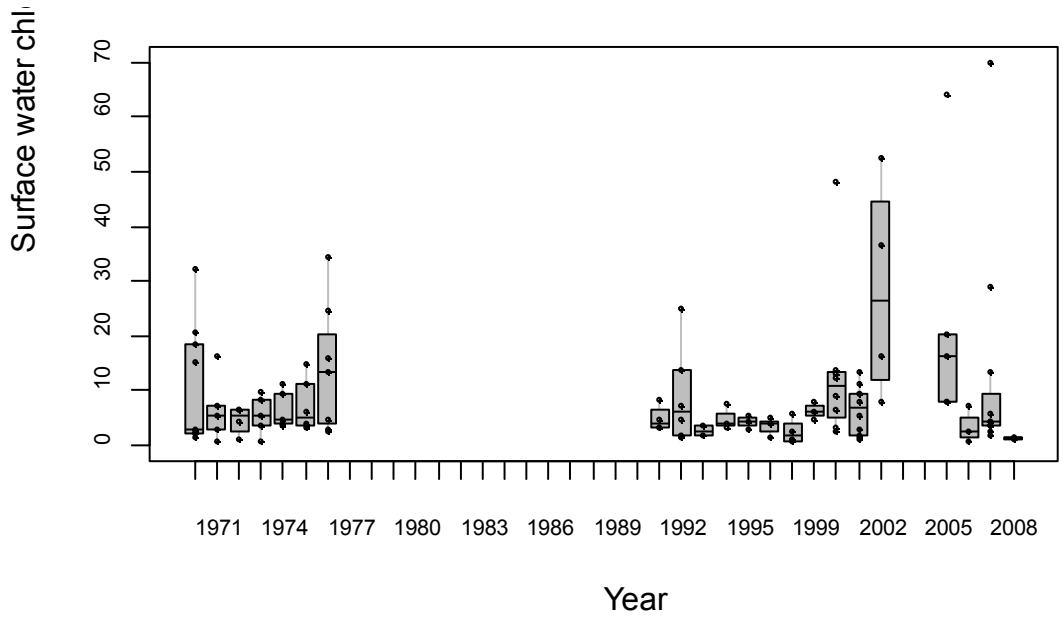

Figure 6. Surface water chlorophyll a concentration at site DLA.

Table 2. Chlorophyll-a concentration by depth at Diamond Lake site DLA in 2009.

Depth strata	6/30/2009	7/21/2009	8/19/2009
Epilimnion (1m)	1.5	1.4	1.0
Metalimnion	2.0	2.4	1.5
Hypolimnion (13m)	2.4	7.3	2.9

Phytoplankton biovolume is a more direct, but more time consuming and expensive estimate of phytoplankton biomass. Phytoplankton biovolume has been measured using consistent and comparable methods since 1989. Median surface water phytoplankton biovolume estimates in 2009 were the lowest observed during the period of record and ranged from 7,307 to 35,940 μm^3/mL during 2009 (Figure 7). Biovolume estimates in the meta- and hypolimnion were also extremely low in a historical context ranging up to 22,694 μm^3/mL.

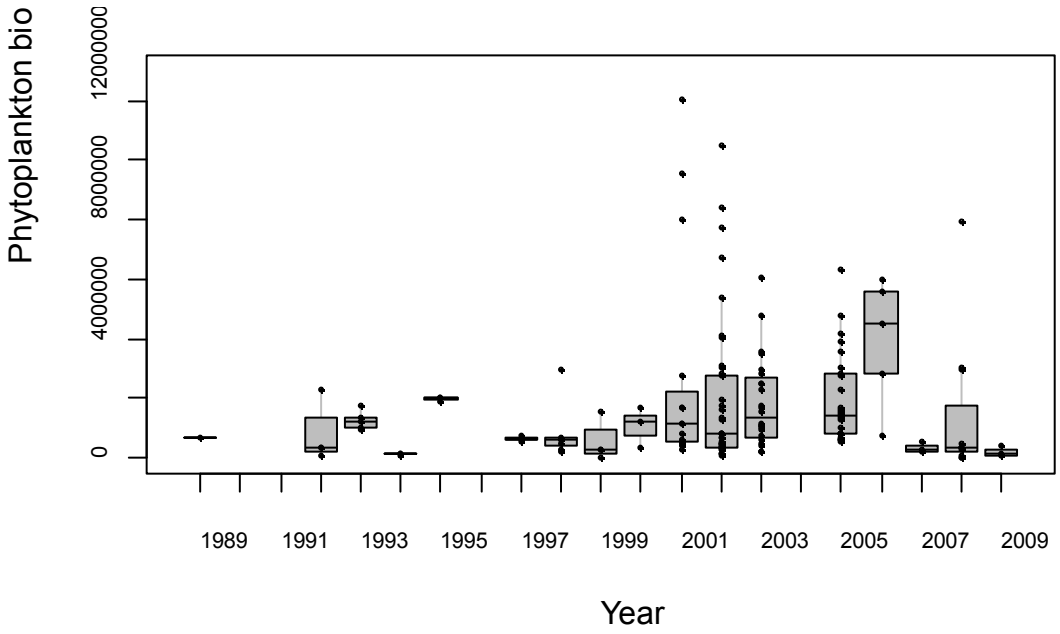

Figure 7. Surface water phytoplankton biovolume at site DLA

Anabaena sp. cell density and phytoplankton composition

Two species of *Anabaena, A. flos aquae and A. planctonica,* were identified in samples collected in 2009. *A. flos aquae* was present during all three sampling events and A*. planctonica* was present during the June and July sampling event. *Anabaena spp.* densities, however, were very low in comparison to historical data and substantially less than the 15000 cell/mL criterion recommended by the Diamond Lake TMDL (Figure 8; Turner et al. 2006). The highest cell density observed at the DLA site during 2009 was 5243 cells/mL in a 1m sample collected by the USFS on the August 3, 2009. Less than 516 *Anabaena spp.* cells/mL were observed in each of the metalimnetic samples and no cells were encountered in any of the hypolimnetic samples. The low values indicate that the 2009 fingerling trout stocking rates did not lead to conditions that favored dense *Anabaena spp.* blooms.

Although *Anabaena spp.* cell densities were low during 2009, they made up a considerable portion of phytoplankton biomass because total phytoplankton biomass was low. *Anabaena* species, the only species of cyanobacteria enumerated in Diamond Lake during 2009, constituted 81% of the total surface water biomass on July 21, 37% on August 19, and 17% on June 30, 2009 (Figure 9). Diatoms, primarily *Tabellaria fenestrata* dominated the biovolume during the June sampling event while Cryptophyte species, primarily *Cryptomonas erosa* dominated the August sampling event. A total of 33 phytoplankton species were encountered in the nine primary field samples and three field split samples collected and submitted to Aquatic Analysts during 2009 (Table 3).

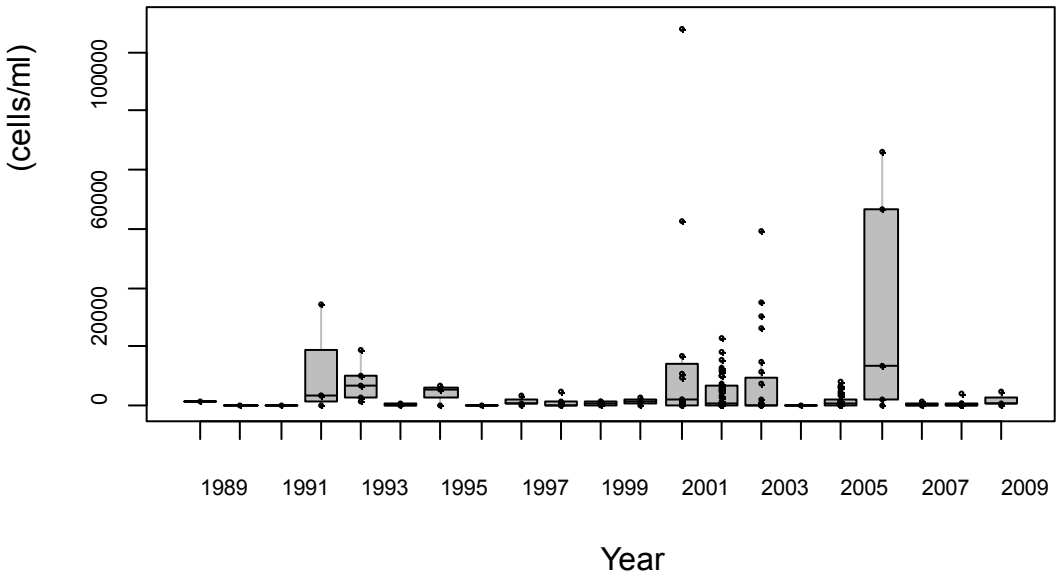

Figure 8. Surface water *Anabaena sp.* density at site DLA. The dotted line is the TMDL upper limit of 15000 cells/mL.

Figure 9. Surface water phytoplankton composition by biovolume at site DLA.

Table 3. 2009 Diamond Lake phytoplankton species list and percent of total 2009 density.

Species name	% density		Species name	% density
Cryptomonas erosa	23.37		*Fragilaria construens venter*	0.30
Rhodomonas minuta	18.71		*Dinobryon sertularia*	0.26
Ankistrodesmus falcatus	15.28		*Nitzschia acicularis*	0.23
Tabellaria fenestrata	10.87		*Fragilaria crotonensis*	0.21
Anabaena flos-aquae	10.34		*Melosira ambigua*	0.16
Chromulina sp.	4.39		*Kephyrion littorale*	0.16
Chlamydomonas sp.	3.52		*Mallomonas sp.*	0.14
Sphaerocystis schroeteri	2.43		*Achnanthes minutissima*	0.10
Anabaena planctonica	2.12		*Nitzschia palea*	0.10
Melosira granulata	1.93		*Nitzschia capitellata*	0.08
Staurastrum gracile	1.00		*Synedra rumpens*	0.08
Synedra radians	1.00		*Gymnodinium sp.*	0.08
Asterionella formosa	0.72		*Gloeocystis ampla*	0.07
Cryptomonas ovata	0.64		*Oocystis lacustris*	0.07
Nitzschia frustulum	0.61		*Schroderia sp.*	0.07
Glenodinium sp.	0.46		*Fragilaria construens*	0.07
Stephanodiscus hantzschii	0.40			

Secchi disc transparency

Secchi disc transparency in Diamond Lake is primarily determined by phytoplankton biomass and their size and depth distributions. Since phytoplankton species and chlorophyll a were only monitored during three sampling events during 2009, the additional Secchi monitoring dates were critical for providing context to the less frequent measurements. Secchi transparency was observed during 23 sampling events during 2009: three by PSU, three by USFS, and 17 by Diamond Lake Lodge.

Transparency measurements ranged from 4.5 m on September 16 to 10.2 m on August 19, 2009 (Figure 11). The two lowest measurements, 4.5 and 4.7 m, were observed late in the summer after destratification of the water column and the associated flux of nutrients to surface waters. All other measurements were 6 m or greater. The median value of 7.2 m was the deepest observed since the 2006 rotenone treatment and among the deepest recorded since 1962 (Figure 11).

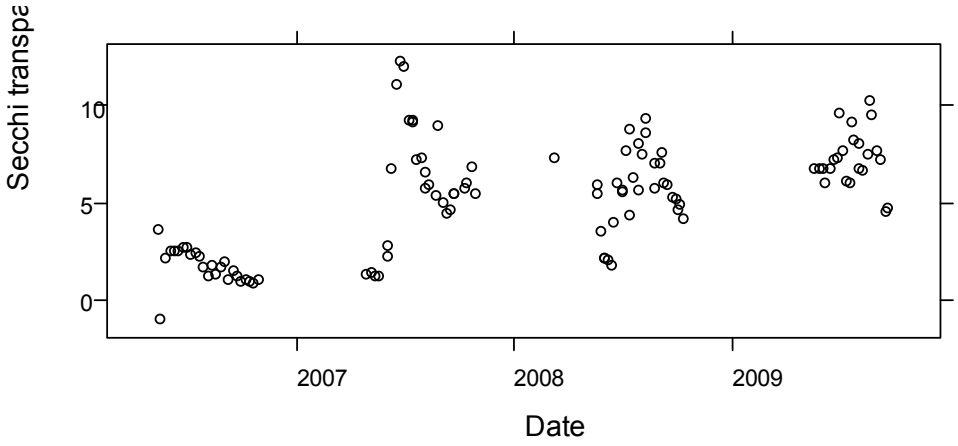

Figure 10. Secchi transparency in Diamond Lake after the 2006 rotenone treatment.

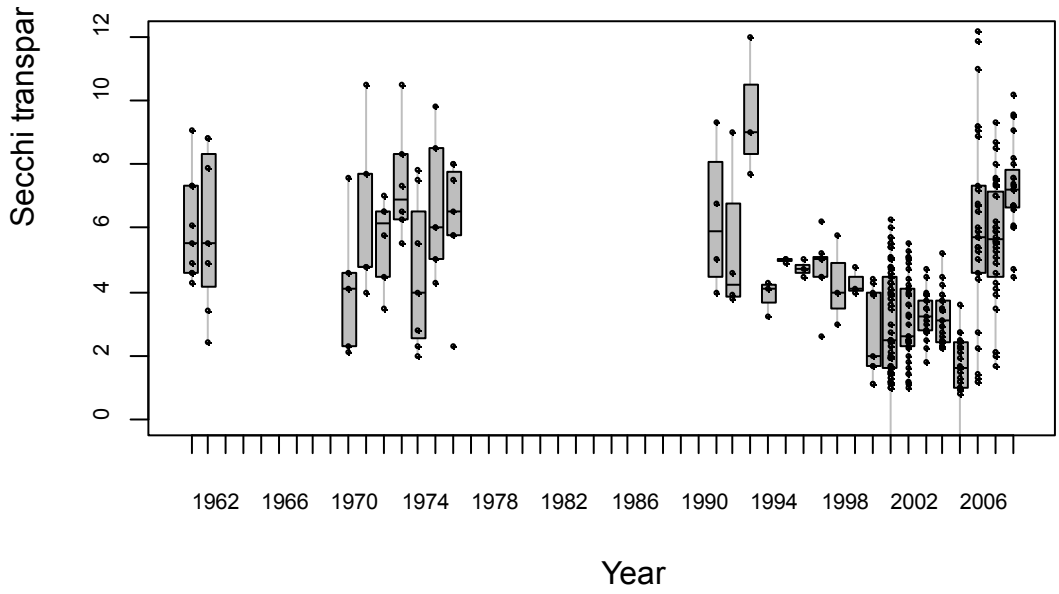

Figure 11. Secchi disc transparency in Diamond Lake from 1962 through 2009.

Chemical FSI parameters

Three chemical parameters are included in the FSI: surface water pH, surface water dissolved oxygen (DO), and the depth to anoxic water. Equilibrium DO (or saturated) concentrations in water are primarily determined by temperature and elevation. Equilibrium summertime DO concentrations at Diamond Lake's elevation range from 9.4 mg/L to 7.5 mg/L depending on temperature. Equilibrium pH values in water are determined by air equilibrated aqueous carbon dioxide (CO_2) concentrations, carbonate alkalinity concentrations, and temperature (Hofmann et al. 2010). Diamond Lake's equilibrium pH is approximately 7.8.

Deviations from equilibrium DO and pH are determined by a balance between the rates of processes that move the DO and CO_2 concentrations away from equilibrium with the atmosphere (photosynthesis, respiration, and decomposition) and rates of physical re-equilibration of DO and CO_2 with the atmosphere. Since the balance between photosynthesis and respiration change on a daily cycle, pH and DO values are generally higher before sunset and lower values before sunrise. In addition, since wind speed determines the rates of CO_2 and DO flux across the air-water interface, deviations from equilibrium can be greater during periods with calm winds. Finally, since Diamond Lake has low alkalinity, small deviations from equilibrium CO_2 concentrations result in large deviations in pH from equilibrium.

The presence of density stratification prevents re-equilibration of hypolimnetic DO and CO_2 with the atmosphere; therefore, DO concentrations in the hypolimnion decrease and CO_2 concentrations increase during the period of stratification. The depth to anoxic water in the hypolimnion depends on two primary factors: the supply of organic material to the hypolimnion to fuel oxygen consumption, and the length of time the lake has been stratified. The first factor is determined by the biological productivity of the system and the second factor is determined by annual variations in climate.

The result of these all these factors, and the justification for including the parameters in the FSI, is that higher productivity increases the probability of high pH and DO values in surface waters, and shallower depths to anoxia.

Surface water dissolved oxygen

Surface water dissolved oxygen concentrations in Diamond Lake during 2009 ranged from 104 to 112% of saturation. All measurements were conducted at least 4.5 hours after sunrise to allow time for algal production to increase concentrations; however, concentrations may have increased later each day. The median value and range observed during 2009 was similar to historical data (Figure 12).

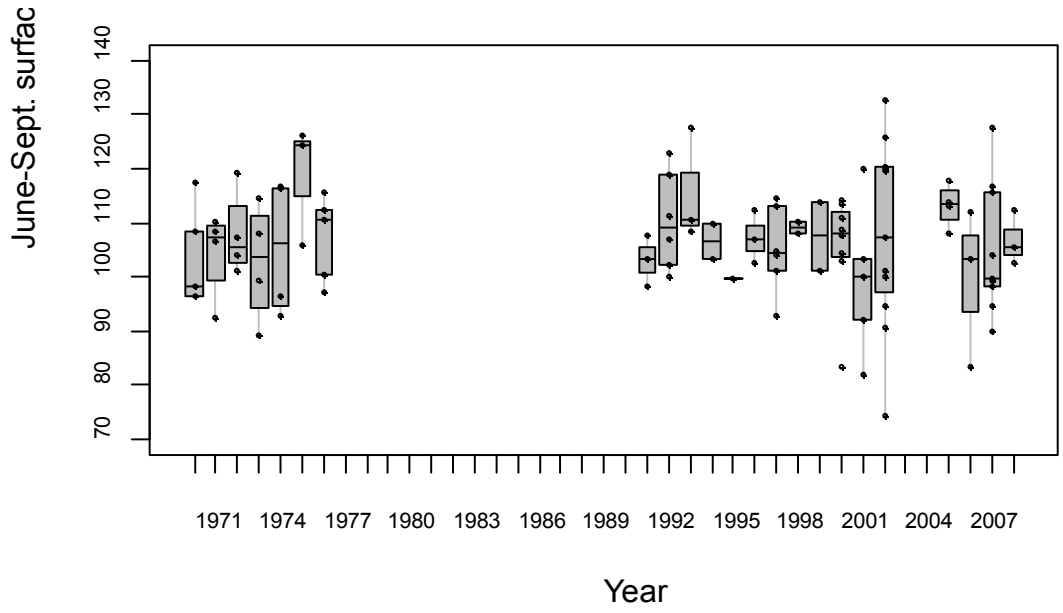

Figure 12. Summertime surface water dissolved oxygen percent saturation.

Surface water pH

Surface water pH values during 2009 were at or higher than equilibrium and ranged from 7.8 on June 30, 9.0 on July 21 and 8.5 on August 19. High pH values were also observed by MaxDepth Inc. during August (Joe Eilers, pers. comm.). Median pH values were considerably higher than the two years following the rotenone treatment, but similar to historical values (Figure 13).

There are two explanations for the high pH values observed in 2009. First, all three sampling events in 2009 were conducted during calm periods. Since rates of dissolved CO_2 equilibration with the atmosphere are low during calm periods and Diamond Lake is poorly buffered, even low productivity in could lead high pH values. Second, high productivity in combination with the calm winds could explain the high pH values. High productivity seems unlikely since chlorophyll- a and phytoplankton biovolume were at historical lows during 2009; however productivity by macrophytes may have increased due to the clear water.

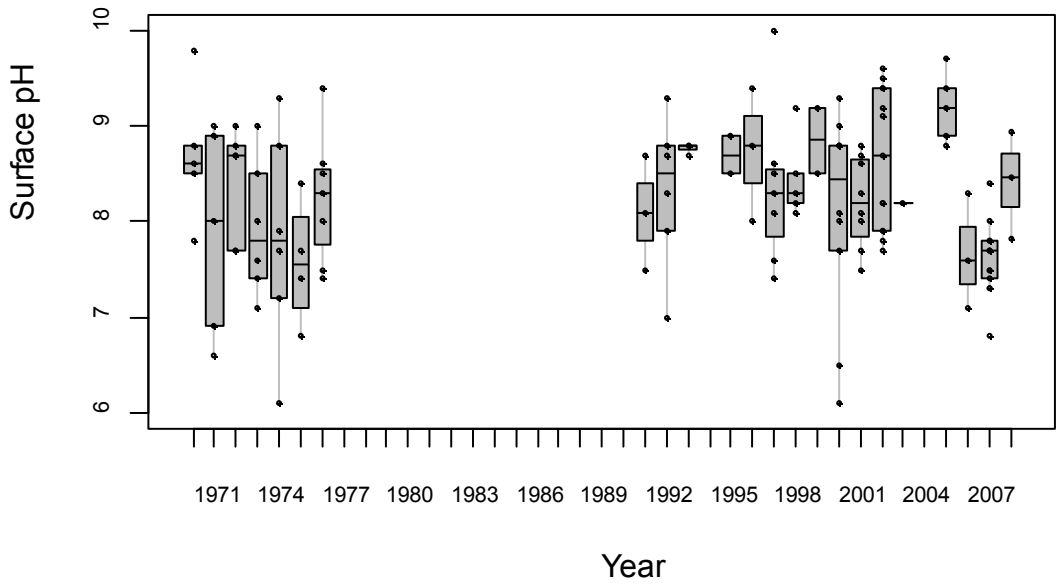

Figure 13. Summertime Diamond Lake surface water pH values. Dotted lines are the DEQ pH criteria values. The dashed line is the approximate pH equilibrium value.

Hypolimnetic dissolved oxygen

Hyplolimnetic dissolved oxygen has been measured at 13 m in Diamond Lake since 1971. Concentrations during 2009 increased compared to values observed during 2007 and 2008 and are similar to concentrations observed prior to the tui chub infestation (Figure 14). The lowest DO concentration in the water column during 2009 sampling events ranged from 2.26 mg/L at 15 m during the June 30 sampling event to less than 1 mg/L at 12 m during the August 19 sampling event. The increase in dissolved oxygen concentrations indicates that 1) the supply of organic material produced in the photic zone during 2009 was lower than during the tui chub infestation, and 2) the stores of organic material built up in the sediment during the tui chub infestation are being depleted.

Figure 14. Summertime hypolimnetic dissolved oxygen concentrations at 13 m.

Water quality FSI parameter summary and discussion

Since the Diamond Lake Fish Stocking Index was proposed by Eilers (2003), the selection of parameters used in the water quality component of the FSI and the scaling of the parameters been reevaluated and slightly changed. For instance, the original secondary production FIS parameter "percent edible zooplankton" was discontinued because there is no universally accepted definition of "edible". A less ambiguous parameter, median annual count of large *Daphnia* (*D. pulicaria* plus *D. rosea*), was used adopted as a measure of secondary production (Eilers 2008).

The scaling of the FSI in this report is based on values reported in Eilers 2008 report with one minor exception: median epilimnetic dissolved oxygen concentration (Table 4). Dissolved oxygen FSI parameter values in this report are scaled from 103% to 127% of saturation which correspond to FSI values of 10 to zero. Eilers (2008) scaled dissolved oxygen from 85% to 105% corresponding to FSI values of 10 to zero. The only difference between the two scales is the semantics of saturated dissolved oxygen and has no bearing the resulting FSI index values. Eilers notes the saturated dissolved oxygen at Diamond Lake's elevation is 83% of what it would be at sea level but does not adjust values so saturated dissolved oxygen at elevation is defined as 100%. Saturated dissolved oxygen in the FSI scaling used in this report is defined as 100% at Diamond Lake's elevation.

Table 4. Relationships between water quality parameter values and Fish Stocking Index values. Epilimnetic DO index values were adjusted from those proposed by Eilers et al. (2008) to reflect the percent of saturation at Diamond Lake's altitude.

Index value	pH (median @ 1m)	Epi. DO (median % sat)	Hypo. DO (min. m)	Chl-a (median µg/l)	Secchi disk (median m)	*Anabaena spp.* Density (max cells/m)	Benthic inverts. (October Lbs/ac)	Large *Daphnia spp.* (median #/m^3)
10	8.0	103	12	2	8	1000	250	15000
9	8.1	105	11	4	7	2000	200	12000
8	8.2	108	10	6	6.5	5000	175	10000
7	8.3	110	9.5	8	6	10000	150	8000
6	8.4	113	9	10	5.5	20000	125	6000
5	8.5	115	8.5	12	5	40000	100	4000
4	8.7	118	8	14	4.5	60000	75	2000
3	8.9	120	7.5	16	4	80000	50	1000
2	9.1	122	7	18	3	100000	25	100
1	9.3	125	6.5	20	2	500000	10	10
0	9.5	127	6	22	1	1000000	5	0

In addition to slight differences in the scaling of the FSI parameters used in this report, only data available to PSU were used in the assessment all data collected by PSU from 2006 through 2009, data collected by ODFW during 2008, and all Secchi transparency data for all years (Table 5). Data collected by ODFW during 2006, 2007, and 2009 were not available. This resulted in some slightly different index values than those calculated by ODFW, although the same conclusions can be drawn regardless of the dataset used.

Table 5. Count of dates with data collected at the Diamond Lake DLA site by PSU during 2006, 2007, and 2009 and by PSU and ODFW during 2008 that were used to calculate FSI parameters. Secchi data are from all available sources.

Year	pH	Dissolved oxygen	Chlorophyll-a	Secchi	Phytoplankton	Zooplankton
*2006	5	5	5	24	5	5
*2007	3	3	3	27	3	3
2008	13	13	11	31	13	13
*2009	3	3	3	23	3	3

All FSI parameters, with the exception of surface water pH, indicated good water quality conditions during 2009 and a considerable improvement from the most recent tui chub infestation (Table 6; Figure 15). As mentioned in previous sections, the decrease in the surface water pH FSI value during 2009 may have more to do with calm wind conditions and macrophyte production than an increase in phytoplankton production. Monitoring results suggest that the ODFW's stocking schedule for 346,578 fingerling trout during 2009 did not have had a significant negative impact on water quality. In addition, the invasive golden shiner population does not appear to be significantly affecting water quality.

Table 6. Fish Stocking Index values (values in bold) and water quality parameter values used to derive the index values (values in italics) for the period from 2006 through 2009.

Index parameter	2006	2007	2008	2009
Median surface pH	**3.0** *(8.9)*	**10** *(7.3)*	**10.0** *(7.4)*	**5.0** *(8.5)*
Minimum epilimnetic DO (mg/l)	**6.0** *(113)*	**9.8** *(103.4)*	**10.0** *(99.6)*	**9.0** *(105)*
Miniumum depth to anoxia (m)	**6.0** *(9)*	**9.0** *(11)*	**9.0** *(11)*	**10.0** *(12)*
Median chlorophyll-a (µg/L)	**3.0** *(16.1)*	**9.8** *(2.4)*	**8.8** *(4.4)*	**10.0** *(1.4)*
Median Secchi depth (m)	**0.2** *(1.65)*	**6.2** *(5.7)*	**6.2** *(5.6)*	**9.2** *(7.2)*
Maximum Anabaena spp. cells	**2.7** *(86448)*	**9.6** *(1321)*	**8.3** *(3827)*	**8.0** *(5243)*
Median Large *Daphnia spp. count*	**0.0** *(0)*	**8.0** *(10180)*	**6.9** *(7757)*	**10.0** *(19000)*
Benthic invertebrates (lbs/ac)	**1.1** *(11)*	**9.0** *(200.6)*	**7.7** *(167.7)*	**10.0** *(342)*

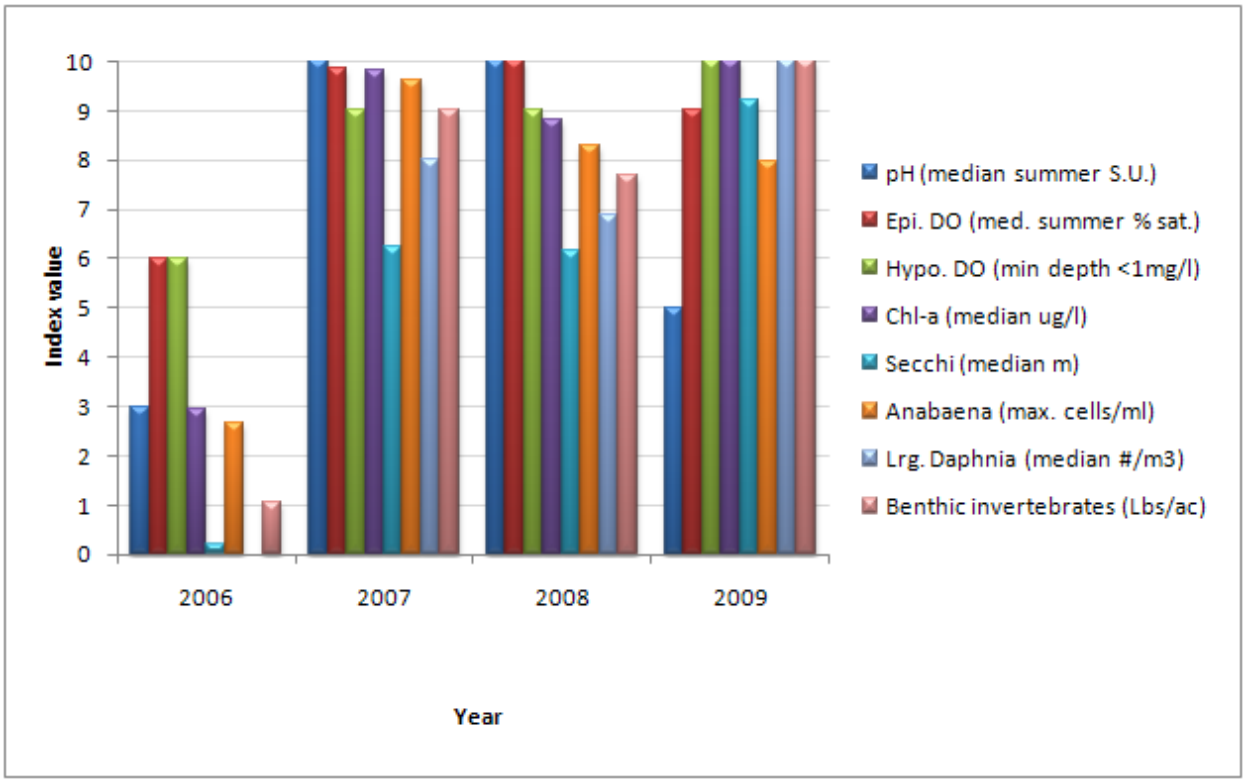

Figure 15. "Fish Stocking Index" values for water quality parameters.

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