Lake Tahoe Water Quality Investigations

Algal Growth Potential assays•
Phytoplankton• Periphyton

<u>Annual Report:</u>

July 1, 2013– June 30, 2014

Agreement No. 13-038-160

<u>Submitted to</u>:

State Water Resources Control Board
Lahontan Regional Water Quality Control Board

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Overview

This document provides a report of work completed by the U.C. Davis – Tahoe Environmental Research Center (TERC) between July 1, 2013 and June 30, 2014 under Agreement No. 13-038-160: Lake Tahoe Water Quality Investigations.

The objective of this project is to continue the long-term collection and reporting of high-quality water quality data in Lake Tahoe. The primary research and monitoring tasks addressed in this project include: (1) Algal growth potential assays, (2) phytoplankton identification and enumeration, and (3) quantification of attached algae in the littoral zone. More details on each of these tasks are provided below.

Algal Growth Potential Assays (Task 3).

The purpose of the Algal Growth Potential (AGP) assay is to compare levels of algal growth in the nearshore to identify emerging problem areas. Lahontan has an existing water quality standard which states that mean annual nearshore AGP at a site will not be greater than two times the mean annual AGP at a mid-lake reference station. The Algal Growth Potential (AGP) assay test was conducted as part of the California-Nevada-Federal Joint Water Quality Investigations in the late 1960's and early 1970's (California Department of Water Resources "DWR", 1970-75) to assess the maximum amount of algal growth supported by available nutrients in sampled waters. The assay uses changes in the concentration of chlorophyll, as a measure of biomass increase during laboratory incubations. Results are generally used to reflect the ability of phytoplankton to grow in ambient water.

AGP assays are performed four times per year (in spring, summer, fall and winter). Samples of lake water containing phytoplankton are collected from surface water (0.5-2m) at 10 nearshore sites: near Tahoe City, Kings Beach, Crystal Bay, Glenbrook, Zephyr Cove, Timber Cove, Tahoe Keys nearshore, Camp Richardson, Rubicon Bay and Sunnyside. Many of these sites are in proximity to sites sampled by DWR in its study of Lake Tahoe in the 1960's and 1970's. This presents an opportunity to compare recent results with historical values back in the 1970's for some sites. An additional nearshore site at Emerald Bay was added in December 2013, following the first experiment. Two open-water reference sites are also sampled, one near mid-lake north (U.C. Davis's MLTP station) and a mid-lake south site (similar to that used by DWR). The water is returned to the lab at TERC, divided into duplicate flasks and incubated under controlled light and temperature conditions over a 6-10 day period. Algal biomass accumulation as measured by changes in *in vivo* chlorophyll *a* fluorescence and extracted chlorophyll *a* is tracked throughout the assay. The peak chlorophyll *a* value achieved during the assay is considered the algal growth potential.

Enumeration and Identification of Phytoplankton (Task 4).

Characterization of phytoplankton species and abundance in Lake Tahoe provides important data with regard to nearshore condition. Change in the number and biodiversity of phytoplankton are indicators of nutrient loading, eutrophication and trophic status. Additionally, data and information generated through this task helps managers to determine if new and undesirable species (e.g. bloom-forming organisms, taste and odor species, or species that indicate a move away from the lake's current ultra-oligotrophic status) are colonizing the lake. Furthermore, these organisms influence lake clarity and there is some evidence that species composition and organism size can be a sentinel for climate change effects in Lake Tahoe (Winder et al., 2009).

At least 48 samples (four times per year from 10 nearshore AGP sites, and four times per year from the 2 mid-lake sites) are collected, in coordination with collection of water for the AGP bioassays. Samples are preserved with an iodine preservative and counted within 2 months of collection. A complete taxonomic breakdown to the species level, when feasible, is compiled for all samples following established TERC protocol (e.g. Hunter et al., 1990; Hunter et al., 1993). Results are reported as cell numbers and biovolume for each species or taxon.

<u>Quantification of Attached Algae or Periphyton in the Littoral Zone (Task 5).</u>

The purpose of this task is to assess levels of nearshore attached algae (periphyton) biomass around the lake. Excessive attached algae biomass coats the rocks in the spring in many areas around the lake and bright green filamentous algae occur along portions of the shoreline in the summer. The rate of periphyton growth is an indicator of local nutrient loading and long-term environmental changes. Monitoring trends in periphyton biomass is important in assessing local and lake-wide nutrient loading trends. The nearshore periphyton can substantially impact the aesthetic, beneficial use of the shore zone in areas where thick growth develops.

Samples of periphyton biomass are to be taken at nine shoreline locations around the lake (Rubicon Point, Sugar Pine Point, Pineland/Sunnyside, Tahoe City, Dollar Point, Incline West, Sand Point, Deadman Point, Zephyr Point), five times per year. These are the same sites that comprise the historical data base for periphyton monitoring in Lake Tahoe (e.g. Hackley et al., 2013). Three of the samplings are completed between January and June when attached algal growth in the eulittoral zone (0.5m) is greatest; the remaining two samplings are completed between July and December. Biomass measurement during the typical period of lower growth is desirable in that it allows for an evaluation of the extent to which growth may be extending in time. Higher than expected growth during a seasonal low period would indicate a change in nearshore condition. Duplicate biomass samples will be taken from the natural substrate at each site during sampling. Biomass is to be reported as chlorophyll *a* concentration. In addition, the relative abundance and distribution of periphyton will be assessed at 40-45 individual locations around the lake perimeter during the spring period of maximum growth. During this spring synoptic sampling, periphyton abundance will be determined using the Periphyton Biomass Index (Hackley et al., 2013) with concomitant chlorophyll *a* samples collected at select locations for calibration.

The additional tasks associated with this project include: project management (Task 1), quality assurance (Task 2), and reporting of data (Task 6). The summary of percent work completed based on a three-year granting period is shown in Table 1.

Table 1. The summary of percent work completed (based on a 3 year granting period) for the period July 1, 2013 – June 30, 2014 for each task is listed below:

Task	**Percent Completion in First Year** (for full 3 yr. granting period)
1 – Project Management	33%
2 – Quality Assurance	33%
3 – Algal Growth Potential Bioassays	33%
4 – Phytoplankton Enumeration and ID	33%
5 – Quantification of Periphyton	33%
6 – Reporting	34%

Task 1. Project Management and Administration

1.1. Project oversight – Entailed sampling coordination, overall project coordination, discussions with staff, assist in data evaluation, coordination and communication with agency staff, and incorporation of data into other Basin research/monitoring projects.
1.2. Quarterly invoicing – Entails ensuring that contract requirements were met through the timely preparation and submission of quarterly status reports. Ensure that invoicing is properly carried out.

Task 2. Project Quality Assurance

Standardized QA/QC practices for algal growth potential assays and phytoplankton identification and enumeration were followed as specified in the TRG QA/QC Manual (Janik et al., 1990). For QA/QC applied to periphyton monitoring see “Periphyton Quality Assurance Project Plan” in Hackley et al. (2004). QA/QC applied to the AGP bioassays was similar to methods used for QA/QC in algal nutrient bioassays, see: “Lake Tahoe Algal Bioassay Procedure” in Hackley et al., (2007). Information on QA/QC during the reporting period is included in the AGP Assay and Periphyton Task sections of the report.

Task 3. Algal Growth Potential Assays

With increasing focus on the environmental health of the nearshore, beginning in August 2013, the AGP test was reinstituted to compare algal growth potential from different nearshore and offshore stations around Lake Tahoe. The purpose of these experiments is to compare levels of algal growth in the nearshore to potentially identify emerging problem areas. Availability of the nutrients nitrogen (N) and phosphorus (P) in the water and levels of nutrients previously taken up by the algae (known as luxury uptake), are important factors which contribute to growth.

The Algal Growth Potential (AGP) assay test was conducted as part of the California-Nevada-Federal Joint Water Quality Investigations (DWR, 1970-75) in the late 1960’s and early 1970’s to compare potential levels of algal growth supported by waters from the lake and tributaries. Samples of nearshore, offshore and tributary water were collected during those studies and incubated under standard light and temperature conditions to compare maximum levels of phytoplankton growth achieved. Increases in *in vivo* fluorescence and chlorophyll *a* were tracked as measures of biomass change. Results largely reflected the ability of phytoplankton to grow in ambient water. The data from those studies provided information on some of the more productive nearshore areas in that period. Lahontan has an existing water quality standard which states that mean annual nearshore AGP at a site will not be greater than two times mean annual AGP at a mid-lake reference station. In the early 1970's, mean AGP from some sites did exceed the Lahontan standard, but no sites consistently exceeded the standard year-to-year (DWR, 1972-1975).

Methods:

AGP assay tests are performed four times per year (in spring, summer, fall and winter). Samples of lake water (usually from a depth between 0.5-1.5m) are collected from a boat, using a Van Dorn water sampler. Figure 1 shows a map of nearshore AGP sites along with periphyton monitoring locations. Table 2 provides the names, coordinates and some descriptive information for all sites sampled during the first year. Many of these sites are in proximity to sites sampled by DWR in their study of Lake Tahoe in the 1970's (DWR, 1970-1975). Two open-water reference sites are also sampled, one near mid-lake north (U.C. Davis's MLTP station) and a mid-lake south site (similar to that used by DWR). A sample for phytoplankton identification and enumeration is also collected directly from the Van Dorn sampler and treated with Lugol's reagent at the time water is collected for the AGP assay. Lake water from each site for the AGP assay is filtered through an 80 µm size mesh netting to remove large zooplankton, and collected in 4 liter HDPE bottles. The samples are kept near lake temperature in the dark in a cooler and returned to the lab at TERC where the experiment is usually started the same day[1].

In the AGP experiment, lake water from each site is divided into duplicate flasks and incubated under controlled light (CW fluorescent light with intensity ~ 74 μ E m^{-2} sec^{-1} for all assays except one assay done 12/13/14 in which light was from High Output T5 fluorescent light with intensity ~120 μ E m^{-2} sec^{-1}), standard light cycle (i.e. 16 hour light, 8 hour dark cycle used in all assays except the 2/20/14 bioassay in which a 14 hour light cycle was used) and at ambient lake temperature.[2] Algal biomass changes are measured by tracking *in vivo* chlorophyll *a* fluorescence in water from the flasks throughout the experiment using a Turner Designs 10AU fluorometer (configured for *in vivo* and extractable chlorophyll *a* measurement). On one or more days of the experiment, typically near the growth peak, subsamples are also filtered for later chlorophyll *a* extraction and analysis. Equations relating *in vivo* fluorescence measurements to extracted chlorophyll *a* are determined. The equations may then be used to calculate chlorophyll *a* on days when *in vivo* fluorescence peaks and extracted chlorophyll *a* was not measured. The peak chlorophyll *a* value achieved during the assay is considered the Algal Growth Potential (AGP).

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[1] In one assay done using water collected 12/12/13, a larger scale experiment was run, necessitating set-up the day following water collection.

[2] These methods differ slightly from the early DWR studies with respect to: lighting (DWR used a light intensity of 700 foot candles or ~91 μ E m^{-2} sec^{-2}) and temperature (DWR used a constant temperature of 20° C, we felt incubation at 20C might adversely affect some cold water species represented in the winter community).

Extracted chlorophyll *a* is analyzed fluorometrically using a Turner Designs 10AU fluorometer, calibrated with pure chlorophyll a from *Anacystis nidulans* algae. Frozen sample filters containing algae are thawed and extracted overnight at 4°C, in 100% methanol, then fluorescence before and after acidification with 0.05ml of 0.3N HCl is measured. Chlorophyll *a* and pheophyton concentrations are determined using the following equations:

Chlorophyll *a* (µg/l) = $(r/(r-1)) \times (R_b - R_a) \times V_{ex}/V_{fil}$
Pheophyton (µg/l) = $(r/(r-1)) \times (rR_a - R_b) \times V_{ex}/V_{fil.}$

R_b= Fluorescence of sample extract before acidification (minus) fluorescence of filter blank
R_a= Fluorescence of sample extract after acidification (minus) fluorescence of filter blank
V_{fil}= Volume of lake water filtered (Liters), usually 0.1 L
V_{ex} = Volume of methanol used for extraction (Liters), usually 0.005L
r = mean of R_b/R_a values for a range of pure chlorophyll standards.
(r = 2.369 for current calibration)

Additional field and lab data collected for these experiments includes: lake surface water temperature at time of collection; background fluorescence of the initial water collected (fluorescence of GF/F filtered water); and results of chemical analysis of N and P in the initial lake water (not part of contracted work, this was done for 8/15/13 and 6/9/14 AGP assays to provide supplementary information).

AGP Assay Results:

Site to site differences in AGP were apparent in 3 of 4 of the assays done during 2013-2014. Here we summarize the results of the individual assays, then look at whether there were any consistent patterns for nearshore sites and finally look at site annual means relative to the Lahontan standard for AGP.

AGP Assay #1 (8/15/13)

Initial chlorophyll *a* (chlorophyll *a* in lake samples at the start of the AGP assay - also representative of chlorophyll *a* in the lake at the time of collection) was relatively low at nearly all nearshore and mid-lake sites on 8/15/13 (Table 3; Figure 2 below). The highest initial chlorophyll *a* was observed at the Tahoe City site (0.43 µg/l), the other nearshore sites ranged from 0.20-0.31 µg/l and the mid-lake sites ranged from 0.18-0.20 µg/l. Samples of initial lake water for chemistry were also collected for this experiment, levels of NO_3-N, NH_4-N, SRP and TP were all very low (Table 4), with little obvious differences site-to-site. Surface temperature ranged from 18-20°C.

In the Algal Growth Potential assay, highest AGP levels occurred at 3 sites along the northwest shore (Sunnyside, Kings Beach and Tahoe City) where AGP ranged from 0.84-0.99 µg/l and 4 sites on the south shore (Bijou, C.R/Taylor Cr., Zephyr Cove and Tahoe Keys) where AGP ranged from 0.81-1.15 µg/l (Table 3, Figure 2). AGP at the Mid-lake reference stations ranged from 0.50 µg/l at Mid-lake South to 0.64 µg/l at Mid-lake North. Based on the initial chemistry of the water samples from all sites, very low (but not zero) amounts of nutrients were available at the sites, and there were no obvious associations between initial nutrient levels and AGP.

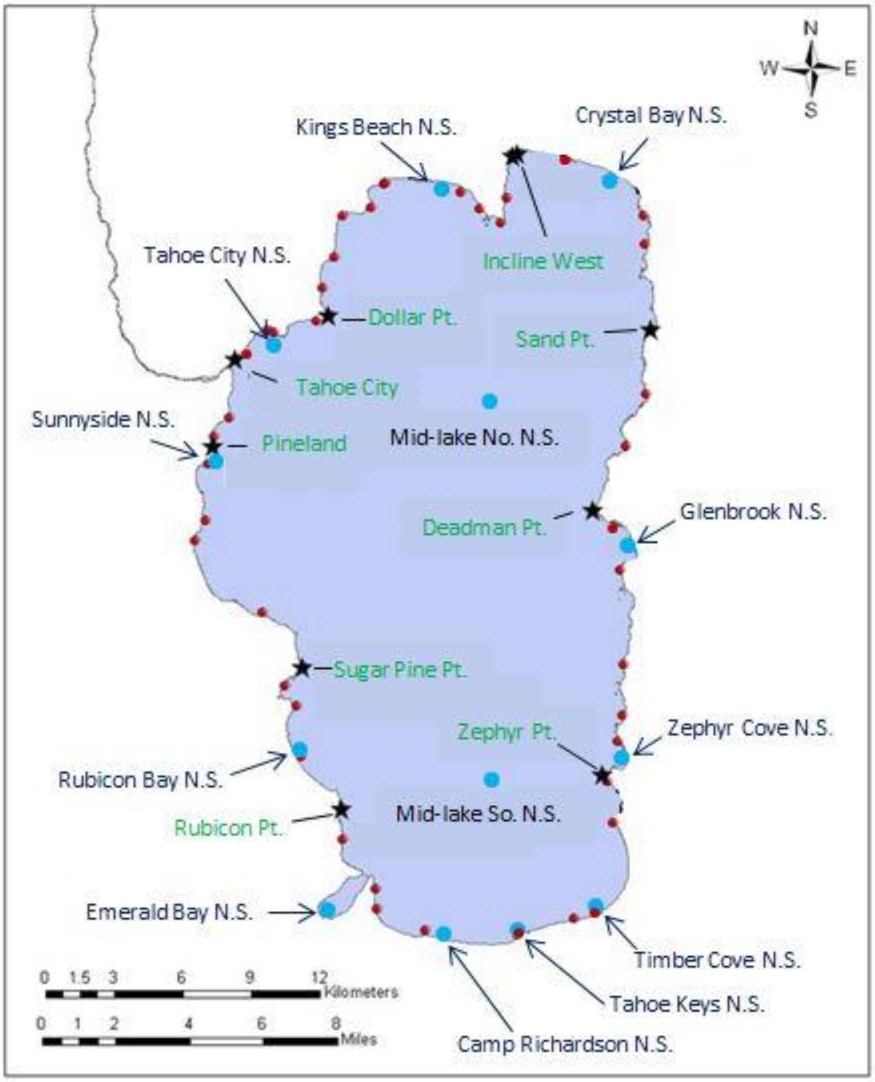

Figure 1. Map showing locations of AGP nearshore stations (light blue dots), routine periphyton monitoring stations (green text, black stars) and spring synoptic periphyton stations (red dots).

Table 2. Description of AGP and phytoplankton monitoring sites.

Site	Coordinates	Site Description	Water Depth
<u>Nearshore Sites</u>			
Sunnyside	N39 07.805 W120 09.216	~ 14-18 m from first pier just north of Ward Cr.	~ 3m
Tahoe City	N39 10.808 W120 07.173	~18-27 m outside of entrance to Tahoe City Boat Ramp area and pier	~2.5-3m
Kings Beach	N39 14.179 W120 02.207	~ 70 m from shore, offshore of "Lake Point Pier" slightly east of "Heritage Cove" condominiums	~ 1.5m
Crystal Bay	N39 14.258 W119 56.798	~45 m offshore of mouth of Incline Cr., Crystal Bay	~2m
Glenbrook	N39 05.371 W119 56.489	~ 15 m from right side "T" of old pilings, near piling at boundary of swim area,~70 m from shore, Glenbrook	~2m
Zephyr Cove	N39 00.512 W119 56.993	Off first set of beach stairs north of Zephyr Cove pier, ~27 m outside of swim area boundary, ~90 m from shore.	~2.5m
Timber Cove	-	~45-70 m northwest of end of Timber Cove pier	~2m
Bijou	N38 56.963 W119 58.480	At edge of shallow shelf ~1100 m offshore of steps near Rufus Allen Dr. (Note-site was discontinued and replaced with Timber Cove site closer to shore)	~ 3m
Tahoe Keys Nearshore	N38 56.423 W120 00.574	~70 m offshore of lake-side pier at Tahoe Keys, (Note-site for AGP#1 was ~115 m further offshore)	~1m
Taylor Cr./Camp Richardson	N38 56.531 W120 03.383	Near Piling "D" marking edge of restricted no boat area near Taylor Cr. (Note-Site was discontinued and replaced with Camp Richardson site)	~2.5m
Camp Richardson	N38 56.531 W120 03.383	Adjacent to end of Camp Richardson pier	1.5-2m
Emerald Bay	N38 57.187 W120 06.367	Adjacent to either the pier or near north edge of swim area boundary, both near Vikingsholm	~2.5m
Rubicon Bay	N39 00.875 W120 06.840	~70 m offshore of pier in shallow area	~2.5m
<u>Mid-lake Sites</u>			
Mid-lake North	N39 09.255 W120 00.478	Location of TERC MLTP station in north mid-lake, approx. 10.5 km east of Tahoe City	>450m
Mid-lake South	N38 59.641 W120 00.080	South mid-lake approximately 6.5 km north of Pope Beach.	>400m

Interestingly, even though nutrient levels were very low, all sites showed substantial increases in chlorophyll *a* during the bioassay (Table 3; Figure 2). One possible reason for this increase was that phytoplankton in the incubator were not exposed to high light intensity and UV radiation, as they are near the lake surface during the summer. Photosynthetically Active Radiation (PAR), UV-A and UV-B wavelengths of solar irradiance in the lake can cause inhibition of phytoplankton production in the short-term (Huovinen and Goldman, 2000). PAR at 2m in August can be very intense, near 1000 µ E m^{-2} sec^{-1} (TERC unpublished data) and surface UV radiation would be expected to be highest in the summer in June and July, when the sun is at or near its zenith in the northern hemisphere. Lighting in the incubator under cool white (CW) fluorescent lights was shown to have a PAR of 74 µ E m^{-2} sec^{-1} with very little light in UV bands (Shohei Watanabe personal communication). UV-B radiation has been shown to strongly inhibit (39-66% reduction) in situ phytoplankton production in the upper 2m of Lake Tahoe (Huovinen and Goldman, 2000). UV-A also can cause inhibition of phytoplankton (Huovinen and Goldman, 2000). Algal production and algal biomass in water samples in the incubator could have increased when the inhibitory effect of high PAR and UV radiation were removed. Nutrients in the water (although measurements were very low) and already incorporated in the cells (luxury uptake) were sufficient to support this increase. In some lakes phytoplankton acclimatize to high UV (Huovinen and Goldman, 2000). It would be desirable to know more about interactions between AGP, UV and PAR along with degree of acclimatization of algae to UV in the nearshore zone.

AGP Assay #1 Quality Assurance

The magnitude of growth responses showed moderate to high variation in replicates of water from some of the sites in the first AGP assay (done in August, 2013). The coefficient of variation (std. dev. /mean of replicates) was ≥ 0.20 for water collected from 3 sites, and one site (T. Keys outer channel) had a coefficient of variation > 0.40. Phytoplankton identification of water collected at the nearshore AGP sites showed that samples were quite diverse with variable contributions of benthic species. This diversity and variable contribution of benthic species was thought to create the potential for more variability *within* subsamples of water from a nearshore site. The results were not thought to be due to contamination of flasks. The data were used. However, to improve the ability to detect site differences, the number of replicates per site was increased to three in the second assay.

Table 3. Summary of field and experimental data collected for Algal Growth Potential (AGP) experiment done on Lake Tahoe water collected from nearshore and mid-lake sites on 8/15/13. Data for date of collection from various sites is shown in upper left (Date, Time, Surface Temp., Depth collected, chlorophyll *a*, selected observations). On selected dates, extracted chlorophyll *a* was measured, these values are summarized under the heading "Extracted Chlor. *a*". Final AGP results are shown at top right of table (in bold). Initial background fluorescence (i.e. fluorescence of filtered lake water) and mean daily *in vivo* fluorescence readings during the AGP experiment are shown along the bottom of the table.

AGP #1 H_2O Collection 8/15/13	Date Collected	Time Collected	Lake Surface T (°C)	Collection Depth (m)	Lake Chl. *a* (µg/l)	Observations	**Extracted Chlor. *a*** AGP D4 8/19/13	**Extracted Chlor. *a*** AGP D6 8/21/13	**Final AGP Results Chl. *a* ± s.d. (µg/l)**
Nearshore:									
Sunnyside	8/15/13	14:24	18.5	1-1.5	.25	Mod. SW wind	.82 ± .16	.57 ± .18	**.84 ± .21**
Tahoe City	8/15/13	09:05	18.0	1-1.5	.43	Least clear site	.91 ± .05	.73 ± .07	**.99 ± .01**
Kings Beach	8/15/13	10:40	18.0	1-1.5	.28		.79 ± .06	.69 ± .08	**.85 ± .05**
Crystal Bay	8/15/13	11:00	19.5	1-1.5	.26		.64 ± .13	.48 ± .08	**.64 ± .13**
Glenbrook	8/15/13	11:40	18.5	1-1.5	.27		.62 ± .03	.58 ± .02	**.64 ± .04**
Zephyr	8/15/13	12:00	18.5	1-1.5	.22		.85 ± .12	.70 ± .01	**.89 ± .02**
Bijou	8/15/13	13:00	20.0	1-1.5	.27	NE wind	.67 ± .06	.51 ± .04	**.81 ± .08**
Tahoe Keys	8/15/13	13:20	19.5	1-1.5	.27	Mod. SW wind	1.15 ± .48	.87 ± .28	**1.15 ± .48**
CR/Taylor	8/15/13	13:30	19.0	1-1.5	.31	Light SW wind	.73 ± .08	.59 ± .04	**.85 ± .12**
Rubicon Bay	8/15/13	13:53	19.0	1-1.5	.20		.55 ± .10	.56 ± .04	**.55 ± .10**
Mid-Lake:									
Mid-lk No.	8/15/13	09:35	18.5	1.5	.20		.64 ± .04	.58 ± .01	**.64 ± .04**
Mid-lk So.	8/15/13	12:45	18.5	1.5	.18		.48 ± .13	.50 ± .13	**.50 ± .15**

Experiment Daily Fluorescence	Backgrd. Fluor. GF/F Fil.	D0 Fluor. 8/15/13 21:00	D1 Fluor. 8/16/13 12:45	D2 Fluor. 8/17/13 15:30	D3 Fluor. 8/18/13 17:45	D4 Fluor. 8/19/13 14:30	D5 Fluor. 8/20/13 15:35	D6 Fluor. 8/21/13 13:10
Nearshore:								
Sunnyside	.000	.135± .004	.196±.004	.258± .016	.308± .066	.285± .057	.268± .064	.214± .053
Tahoe City	.000	.210± .002	.247±.004	.314± .001	.356± .001	.328± .006	.306± .014	.253± .007
Kings Beach	.000	.135± .005	.179± .005	.216± .005	.301± .019	.305± .019	.311± .017	.251± .043
Crystal Bay	.000	.147± .001	.176± .008	.226± .034	.250± .047	.252± .056	.229± .037	.179± .034
Glenbrook	.000	.138± .011	.185± .013	.208± .013	.247± .013	.236± .013	.231± .007	.210± .006
Zephyr	.000	.113± .006	.172± .017	.250± .007	.324± .007	.321± .018	.312± .001	.256± .008
Bijou	.000	.161± .008	.208± .006	.254± .008	.300± .025	.288± .027	.255± .009	.204± .003
Tahoe Keys	.007	.163± .001	.213± .006	.298± .090	.390± .134	.386± .123	.358± .105	.303± .098
CR/Taylor	.004	.186± .013	.250± .000	.288± .016	.312± .036	.286± .017	.277± .014	.233± .003
Rubicon Bay	.000	.113± .002	.144± .007	.181± .025	.208± .031	.216± .039	.219± .031	.202± .032
Mid-Lake:								
Mid-lk No.	.000	.108± .007	.144± .011	.202± .002	.238± .008	.236± .006	.226± .005	.198± .020
Mid-lk So.	.000	.105± .002	.135± .023	.163± .046	.190± .057	.181± .049	.202± .047	.173± .042

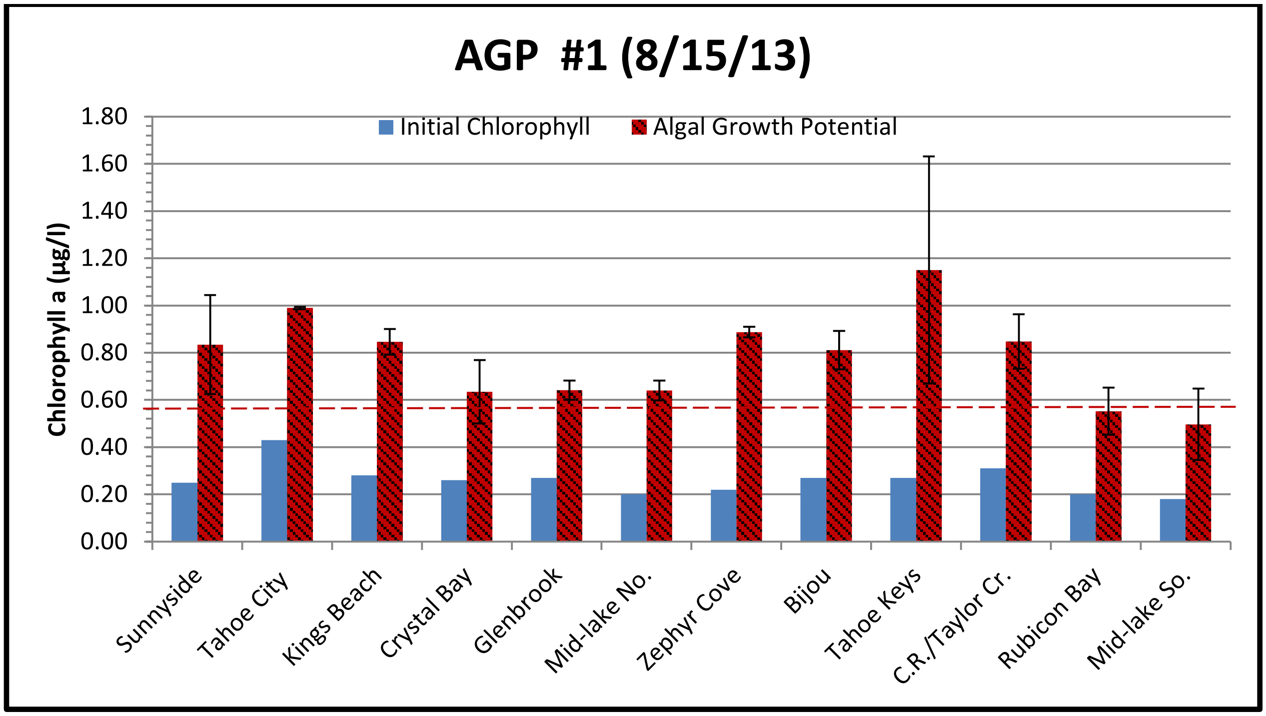

Figure 2. Chlorophyll *a* (extracted) in water collected 8/15/13 and Algal Growth Potential (maximum algal chlorophyll *a* achieved during incubation) at nearshore and mid-lake sites. Red dashed line is the mean AGP of Mid-lake North and South reference sites for the assay.

Table 4. Nutrient concentrations sites in initial lake water collected 8/15/13 from AGP sites.

AGP#1 8/15/13	Initial NO_3-N (µg/l)	Initial NH_4-N (µg/l)	Initial SRP (µg/l)	Initial TP (µg/l)
Nearshore:				
Sunnyside	1	5	1	2
Tahoe City	2	5	2	4
Kings Beach	1	4	2	4
Crystal Bay	2	3	1	4
Glenbrook	1	4	2	4
Zephyr	1	4	2	5
Bijou	1	5	2	3
Tahoe Keys	1	4	1	3
Camp Rich/Taylor	1	4	1	3
Rubicon	1	3	1	NA
Mid-Lake:				
Mid-lk No.	1	4	2	4
Mid-lk So.	1	4	2	2

Note- "NA" = analysis not done for this sample.

AGP Assay #2 (12/12/13)

Initial chlorophyll *a* in nearshore and offshore near-surface water collected 12/12/13 was slightly higher than levels observed 8/15/14 (Table 5; Figure 3). Highest initial chlorophyll *a* was observed at a new site in Emerald Bay (0.69 µg/l), Rubicon Bay was next highest (0.58 µg/l). Chlorophyll *a* at the other nearshore sites ranged from 0.34-0.44 µg/l and the mid-lake sites ranged from 0.49-0.55 µg/l. Both mid-lake and nearshore chlorophyll *a* had generally increased relative to levels observed in the summer; however, the level of chlorophyll *a* at the mid-lake stations, had increased higher than levels at many of the nearshore sites. Initial lake chemistry was not analyzed in this bioassay. Lake surface temperature ranged from 6-8°C.

This Algal Growth Potential assay was run in a larger incubator, set-up with higher intensity lights than used in the previous bioassay. The larger incubator was used to accommodate an increase in the number of replicates per treatment. The light intensity in the incubator was increased to expose phytoplankton to higher light levels than used in the first experiment. High output T5 fluorescent lights were used for the first time, which boosted, PAR to ~ 120 μ E m^{-2} sec^{-1} with very little UV, (compared to ~74 μ E m^{-2} sec^{-1} in the standard incubator). It should be noted however, a light level of ~ 120 μ E m^{-2} sec^{-1} was still much less than the 643 μ E m^{-2} sec^{-1} PAR present in the lake at 1.5m in December, with some of the light in the UV wavelength in the lake at 1.5m in Dec. We could not boost the light intensity higher than 120 μ E m^{-2} sec^{-1} due to increased heat output over the flasks at higher light levels with this light system. The experiment was also started the day following water collection due to the large scale of the experiment.

The results for this December AGP assay showed general declines in biomass. In Table 5, note the large drop in *in vivo* fluorescence between Day 0 and Day 1 of the assay. *In vivo* fluorescence levels, which relate to chlorophyll *a* content of the algae, dropped between Day 0 and Day 1 and remained relatively low and fairly similar at sites through the rest of the assay. Differences in biomass between sites were only readily apparent among initial chlorophyll *a* levels (Figure 3). Initial chlorophyll *a* was highest at Emerald Bay, followed by Rubicon Bay and the two mid-lake sites. The remaining nearshore sites were lower than the mid-lake sites.

Interpretation of the results from this assay is less straight forward compared with the previous assay, as a result of the substantial decline in biomass from initial levels observed for all sites. In the 1970's DWR AGP studies, they occasionally would also record such declines and report the initial lake concentration of chlorophyll *a* as the Algal Growth Potential for the sample(s) on the date. They assumed that the algae in such cases were depleted of nutrients and therefore there was no growth potential. In standard nutrient bioassays, done at TERC through the years, we have also occasionally observed declines from initial fluorescence in lake control samples to which no nutrients had been added. However, the declines in those bioassays were generally moderate (declines averaging around 18% but ranging to 37% for 10 of 31 bioassays showing the pattern in one period examined (June 1999 to October 2004), TERC unpublished data). Whereas the declines observed with AGP assay #2 were quite substantial (39% decline from initial fluorescence), which is at the upper end of the range for the past nutrient bioassays.

A comparison of AGP results from the two different incubators used in the AGP tests, along with phytoplankton analysis post-decline of algae in the experiment, may shed some light on the causes of these declines. Lake water from the (12/12/13) Mid-lake South site was incubated in both the smaller incubator with CW light and the larger incubator with High Output light, to see if similar results would be obtained in the AGP experiment. The sample in the standard incubator (lower light intensity) showed much less of an initial depression in growth (15% decline from initial fluorescence) compared with that seen in the large incubator under higher light intensity (39% decline from initial fluorescence). This indicated a possible impact associated with the higher light intensity. Phytoplankton counts for the Mid-lake South sample incubated under high intensity lighting, (after the biomass decline), showed that a die off of one phytoplankton species, *Gymnodinium fuscum* contributed substantially to the decline. *Gymnodinium fuscum* initially was the biomass dominant species in most of the December nearshore and mid-lake samples. In the south mid-lake sample Gymnodinium accounted for 44% of total biovolume when collected, but dropped to 3% of the total biovolume 5 days after collection. This species is known to be sensitive to heat and light intensity (reported to be minimally tolerant of examination under light microscope (Bold and Wynne, 1978)). It is possible either high intensity or some unusual spectral peaks at certain wavelengths observed for the High Output lights, caused the die off of the *Gymnodinium fuscum.* Another phytoplankton species *Rhodomonas lacustris* also declined substantially during assay in the mid-lake south sample analyzed dropping from 10% of total biovolume to 0%. Algal biomass of the surviving algae under High Output lights, remained low and relatively similar at all sites through the rest of the assay.

Since the initial decline in algae fluorescence was substantial in the large incubator (39% decline) used in this AGP test, whereas results for the standard incubator showed a small decline (15% decline), the results from the two incubators were not strictly comparable. We decided not to use data from this AGP assay in comparison with other AGP assays run in the standard incubator. In Figure 3, we show the algal growth potential as the same as the initial chlorophyll *a*. However, since such large declines from initial fluorescence occurred, it is difficult to say with certainty that the initial chlorophyll levels represent the algal growth potential. Under more favorable light conditions in an incubator, it is possible algae from some sites may have experienced a rebound or growth response following the decline.

AGP Assay #2 Quality Assurance

In the second AGP assay, replication of results was improved using triplicate samples per site. The coefficients of variation were generally low <0.10 for this second assay. However, a drawback of increasing the number of replicates was the increased time needed for both set-up of the experiment and fluorescence measurements and chlorophyll filtrations throughout the course of the experiment. Due to the large scale of the second assay, set-up was done the day following sample collection (similar to experiments done by DWR in the 1960’s and 1970’s). A draw-back of this delay was that samples were held for a longer period in the dark, with the possibility of physiological responses to prolonged dark conditions. In addition a new lighting system with higher intensity lighting than used in the first assay was used. The results of this assay showed a substantial decline in algae with an undesirable impact of the high output lighting a likely the cause as discussed above. Due to the large algae decline in AGP #2, the results were not included in calculation of site mean annual values.

Table 5. Summary of field and AGP experimental data collected: Lake Tahoe water collected 12/12/13. Note- This experiment was run using increased replicates per treatment (triplicates) and to accommodate the increased number of flasks, a walk-in incubator w/ High Output T5 fluorescent lighting was used; typically a Percival incubator "PI", with cool white fluorescent lighting is used; one duplicate set of flasks "Mid-lk So. PI" was also run in the Percival Incubator.

AGP #2 H_2O Collection 12/12/13	Date Collected	Time Collected	Lake Surface T (°C)	Collection Depth (m)	Lake Chl. *a** (µg/l) 12/13/13	Observations	**Extracted Chlor. *a*** AGP D0 12/13/13	**Extracted Chlor. *a*** AGP D6 12/19/13	**Final AGP Results Chl. *a* (µg/l)**
Nearshore:									
Sunnyside	12/12/13	15:12	8.0	1.5	0.44		0.44	.24 ± .02	**0.44**
Tahoe City	12/12/13	10:00	6.5	0.5	0.39		0.39	.27 ± .02	**0.39**
Kings Beach	12/12/13	10:50	6.8	0.5	0.41		0.41	.22 ± .02	**0.41**
Crystal Bay	12/12/13	11:10	7.8	1.0	0.45		0.45	.19 ± .02	**0.45**
Glenbrook	12/12/13	11:48	7.5	1.0	0.34		0.34	.23 ± .01	**0.34**
Zephyr	12/12/13	12:12	7.5	1.0	0.34		0.34	.21 ± .01	**0.34**
Timber Cove	12/12/13	12:55	6.2	1.5	0.41		0.41	.25 ± .03	**0.41**
Tahoe Keys	12/12/13	13:00	6.5	0.5	0.41		0.41	.27 ± .01	**0.41**
Camp Rich.	12/12/13	13:20	8.0	1.0	0.42		0.42	.24 ± .02	**0.42**
Emerald Bay	12/12/13	14:00	6.5	1.5	0.69		0.69	.39 ± .04	**0.69**
Rubicon Bay	12/12/13	14:40	-	1.0	0.58		0.58	.32 ± .04	**0.58**
Mid-Lake:									
Mid-lk No.	12/12/13	10:29	7.8	1.5	0.49		0.49	.23 ± .01	**0.49**
Mid-lk So.	12/12/13	12:28	8.0	1.5	0.55		0.55	.27 ± .02	**0.55**
Mid-lk So. PI							0.55	.54 ± .08	**0.55**

Experiment Daily Fluorescence	Backgrd. Fluor. GF/F Fil.	D0 Fluor. 12/13/13 ~14:30	D1 Fluor. 12/14/13 12:15	D2 Fluor. 12/15/13 12:30	D3 Fluor. 12/16/13 13:50	D4 Fluor. 12/17/13 14:00	D5 Fluor. 12/18/13 13:40	D6 Fluor. 12/19/13 14:45
Nearshore:								
Sunnyside	.057	.292± .001	.187±.009	.169± .013	.137± .007	.147± .017	.159± .012	.136± .006
Tahoe City	.065	.257± .003	.164±.015	.166± .003	.155± .006	.168± .007	.179± .011	.167± .007
Kings Beach	.056	.260± .013	.176± .001	.167± .007	.150± .021	.144± .005	.138± .002	.131± .005
Crystal Bay	.059	.262± .003	.176± .010	.169± .008	.141± .002	.153± .005	.135± .007	.136± .008
Glenbrook	.064	.276± .006	.165± .002	.156± .003	.137± .004	.142± .003	.138± .004	.139± .007
Zephyr	.061	.239± .004	.152± .005	.152± .006	.140± .005	.148± .002	.155± .011	.135± .005
Timber Cove	.042	.280± .001	.176± .014	.174± .003	.153± .009	.164± .012	.158± .015	.141± .010
Tahoe Keys	.057	.284± .001	.181± .013	.180± .008	.161± .010	.173± .002	.162± .013	.158± .010
Camp Rich.	.062	.281± .003	.174± .004	.171± .002	.154± .016	.142± .006	.144± .006	.127± .006
Emerald Bay	.078	.342± .013	.226± .018	.213± .005	.188± .004	.195± .011	.190± .008	.179± .012
Rubicon Bay	.057	.327± .008	.210± .012	.200± .009	.172± .016	.190± .013	.184± .003	.174± .016
Mid-Lake:								
Mid-lk No.	.070	.283± .005	.186± .007	.175± .003	.153± .004	.170± .003	.149± .009	.152± .007
Mid-lk So.	.063	.312± .002	.192± .001	.185± .014	.157± .011	.169± .014	.156± .010	.146± .011
Mid-lk So. PI	.063	.312± .002	.265± .006	.264± .002	.263± .003	.256± .016	.257± .025	.260± .030

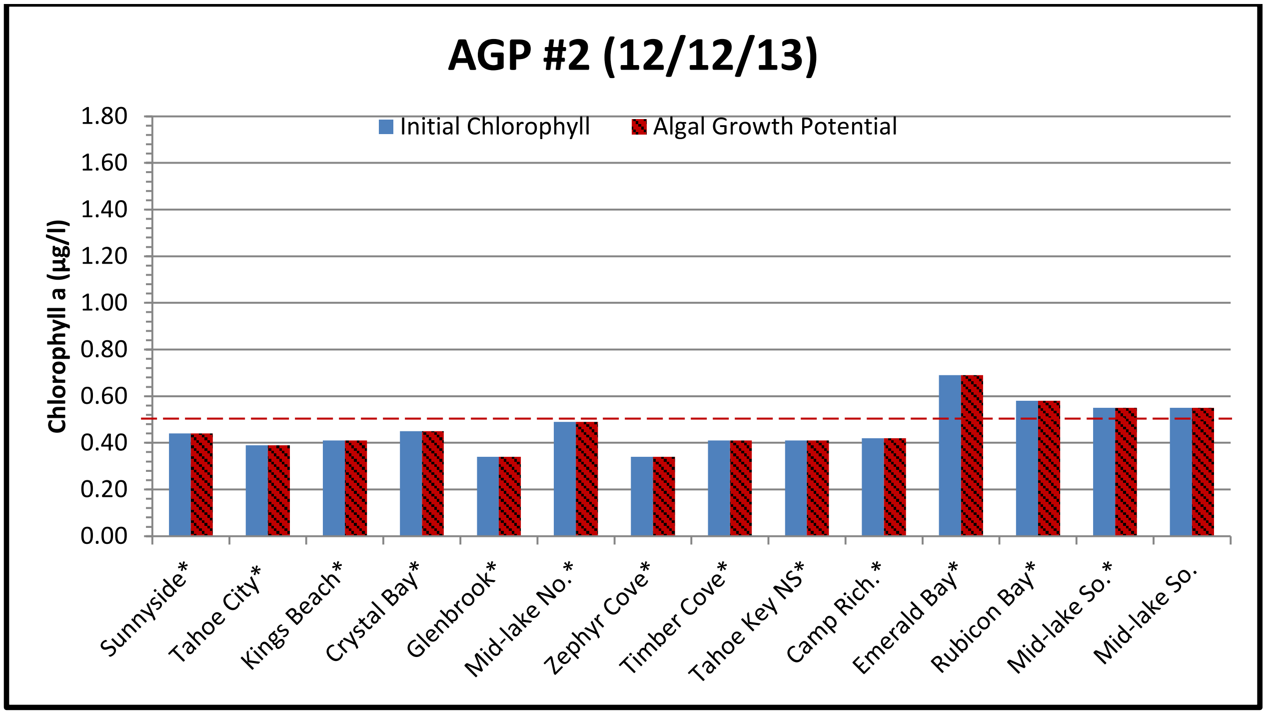

Figure 3. Chlorophyll a (extracted) in water collected 12/12/13 (filtered on 12/13/13) and Algal Growth Potential (maximum algal chlorophyll a achieved during incubation) at nearshore and mid-lake sites. Red dashed line is mean AGP of Mid-lake North and South reference sites for the bioassay. *- Indicates samples incubated in incubator with High Output fluorescent lights (used only in this experiment); Mid-lake So. (no star) incubated in standard incubator.

AGP Assay #3 (2/20/14)

Initial chlorophyll *a* in water collected from nearshore and mid-lake sites 2/20/14 showed quite a range in values (Table 6; Figure 4). Zephyr Cove along the southeast shore had the overall highest chlorophyll *a* (0.96 µg/l). Chlorophyll *a* levels at the other south shore sites ranged from 0.41 µg/l at Rubicon Bay to 0.67 µg/l at Camp Richardson, while Emerald Bay chlorophyll was 0.74 µg/l. In the north portion of the lake, chlorophyll *a* ranged from 0.24 µg/l at Tahoe City to 0.81 µg/l in Crystal Bay. Initial chlorophyll *a* at the North and South Mid-lake reference sites was relatively high (0.87 µg/l). Initial lake water for chemistry was not collected for this bioassay. Lake surface temperature ranged from 4.5-6°C.

This was likely a dynamic period in the lake as a strong storm had recently occurred 2/8/14-2/10/14, with substantial rainfall and runoff at lake level and significant south- southwest wind events occurring on 2/8/14 and 2/15/14. Nearshore sites likely experienced different amounts of input of runoff water containing sediments and nutrients as well as experienced different degrees of wind-driven mixing and circulation of surface waters as a result of these events. Offshore chlorophyll *a* in the lake typically goes through a seasonal progression with chlorophyll levels increasing in the upper water column in late fall and winter as mixing of algae and nutrients from deeper in the euphotic zone with surface water occurs. The differences in chlorophyll *a* observed among nearshore sites and the mid-lake on 2/20/14 may to some extent reflect varying degrees of mixing with offshore or mid-lake water, as well as differences in input of water and nutrients in the nearshore and possibly changes in the algal community. Under some conditions, algae populations at a site can be in a state of transition, resulting in temporarily reduced algae numbers as the community shifts (Debbie Hunter, personal communication).

This Algal Growth Potential assay was run in the same incubator used in the first AGP test (CW fluorescent lighting). Two replicates per site were used in the AGP assay and the assay was started the same day of collection. Fluorescence measurements were collected through Day 13 of the experiment, however, after Day 9, the volumes of water in the flasks were so depleted that results beyond Day 9 were of questionable reliability and not used.

In the Algal Growth Potential test, highest AGP levels occurred at two sites along the south shore, Tahoe Keys and Timber Cove where AGP was 1.09 µg/l and 1.08 µg/l respectively (Table 6, Figure 4). Algae at both these sites showed significant growth during the assay and final chlorophyll *a* levels were approximately twice that of the initial levels. Next highest AGP was at Zephyr Cove (0.96 µg/l), however, this was the initial chlorophyll level and subsequent levels were lower there. Next highest AGP levels were the mid-lake references sites (AGP=0.87 µg/l) and several nearshore sites (Emerald Bay, Crystal Bay, Glenbrook, Kings Beach, Camp Richardson) with AGP levels close to mid-lake levels (ranging from 0.77-0.87 µg/l). Of these sites, Emerald Bay, Kings Beach and Camp Richardson showed slight to moderate increases in chlorophyll *a* relative to their initial levels, while chlorophyll *a* declined relative to initial levels at the mid-lake stations, Crystal Bay and Glenbrook.

Lowest AGP was observed for three sites along the west shore: Rubicon Bay (0.61 µg/l), Sunnyside (0.62 µg/l) and Tahoe City (0.69 µg/l). Of these sites, Tahoe City however, showed a very strong growth response with a substantial increase in chlorophyll *a* from a low (0.24 µg/l) initial level and was still increasing on Day 9 of the assay. This may indicate significant availability of nutrients to support additional growth there, and higher AGP than reported here. Rubicon Bay showed a modest increase in chlorophyll *a* from initial levels, while Sunnyside showed only a small additional increase in chlorophyll *a*.

There were some similarities among the three sites that showed very significant increases in biomass in this assay. Timber Cove and Tahoe Keys, which had the highest AGP levels and an approximate doubling of chlorophyll from initial levels, are located in the extensive shallow shelf area adjacent to South Lake Tahoe. These sites are potentially impacted by surface runoff and nutrient inputs from the Upper Truckee River and Trout Creek, as well as urban runoff from nearby upland development. The Tahoe Keys nearshore site is also between the entrance areas to the Tahoe Keys. The Tahoe City site is also located on a shallow "shelf" area, but off of the Tahoe City region. The entrance to Star Harbor is nearby and Star Harbor receives inflow from Polaris and Burton Creeks. The fact that these sites are all near sources of nutrients may have contributed to their AGP growth responses observed in this assay. It's possible that the location of the sites in shallow shelf areas may indicate a role of the shelves in the distribution of inflow and nearshore water, and the extent of mixing with offshore lake water.

Table 6. Summary of field and experimental data collected for Algal Growth Potential (AGP) experiment done on Lake Tahoe water collected from nearshore and mid-lake sites on 2/20/14. Experiment run in Percival incubator, two replicates per treatment. Note- “Zoopl” = zooplankton.

AGP #3 H_2O Collection 2/20/14	Date Collected	Time Collected	Lake Surface T (°C)	Collection Depth (m)	Lake Chl. *a** (µg/l)	Observations	**Extracted Chlor. *a*** AGP D1 2/21/14	**Extracted Chlor. *a*** AGP D6 2/26/14	**Extracted Chlor. *a*** AGP D9 3/1/14		**Final AGP Results Chl. *a* (µg/l)**
Nearshore:											
Sunnyside	2/20/14	15:00	5.5	1.0	0.63		.54 ± .04	.57 ± .09	.59 ± .05		**.63**
Tahoe City	2/20/14	09:36	5.0	0.5	0.24		.24 ± .02	.45± .00	.69± .01		**.69 ± .01**
Kings Beach	2/20/14	10:50	5.0	0.5	0.58		.55 ± .01	.68 ± .02	.87 ± .06		**.87 ± .06**
Crystal Bay	2/20/14	11:20	5.0	0.5	0.81		.65 ± .08	.67 ± .03	.71 ± .02		**.81**
Glenbrook	2/20/14	11:45	5.0	0.5	0.79		.69 ± .03	.70 ± .04	.73 ± .09		**.79**
Zephyr	2/20/14	12:09	5.0	0.5	0.96		.90 ± .04	.66 ± .03	.70 ± .02		**.96**
Timber Cove	2/20/14	12:51	5.0	0.5	0.50		.45 ± .01	.87 ± .00	1.09± .15		**1.09±.15**
Tahoe Keys	2/20/14	13:05	5.0	0.5	0.60		.55 ± .02	.93 ± .02	1.08± .04		**1.08± .04**
Camp Rich.	2/20/14	13:20	6.0	0.5	0.67		.61 ± .01	.63 ± .04	.83 ± .02		**.83 ± .02**
Emerald Bay	2/20/14	13:52	4.5	1.0	0.74	many Zoopl.	.70 ± .03	.77 ± .02	.75 ± .13		**.77 ± .02**
Rubicon Bay	2/20/14	14:20	5.2	1.0	0.41		.36 ± .02	.55 ± .04	.61 ± .01		**.61 ± .01**
Mid-Lake:											
Mid-lk No.	2/20/14	10:05	5.0	1.0	0.87		.79 ± .02	.65 ± .02	.60 ± .04		**.87**
Mid-lk So.	2/20/14	12:23	5.0	1.0	0.87		.79 ± .00	.76 ± .01	.72 ± .08		**.87**

Experiment Daily Fluorescence	Backgrd. Fluor.	D0 Fluor. 2/20/14 19:35	D1 Fluor. 2/21/14 12:25	D2 Fluor. 2/22/14 11:45	D3 Fluor. 2/23/14 11:50	D4 Fluor. 2/24/14 12:00	D5 Fluor. 2/25/14 12:05	D6 Fluor. 2/26/14 12:10	D7 Fluor. 2/27/14 12:25	D8 Fluor. 2/28/14 13:13	D9 Fluor. 3/1/14 14:15
Nearshore:											
Sunnyside	.064	.371± .008	.317±.004	.314± .016	.313± .014	.322± .002	.325± .000	.354± .015	.330± .016*	.324± .020*	.385± .012
Tahoe City	.074	.218± .004	.188±.001	.196± .003	.200± .004	.219± .001	.251± .001	.280± .001	.346± .022*	.352± .010*	.418± .001
Kings Beach	.062	.403± .001	.347± .008	.331± .008	.329± .003	.331± .009	.348± .006	.364± .016	.389± .018*	.364± .020*	.441± .023
Crystal Bay	.075	.490± .001	.383± .007	.374± .010	.368± .011	.355± .001	.380± .018	.357± .005	.353± .016*	.347± .004*	.381± .011
Glenbrook	.074	.483± .010	.378± .013	.380± .015	.372± .009	.359± .004	.380± .008	.365± .004	.373± .012*	.356± .020*	.406± .007
Zephyr	.068	.527± .018	.410± .012	.395± .001	.392± .001	.364± .022	.370± .027	.363± .008	.362± .020*	.337± .018*	.401± .025
Timber Cove	.118	.402± .017	.371± .005	.415± .002	.434± .018	.473± .004	.507± .002	.549± .006	.544± .000*	.572± .004*	.623± .030
Tahoe Keys	.105	.425± .008	.381± .002	.425± .008	.457± .004	.490± .000	.513± .013	.547± .004	.538± .008*	.555± .016*	.621± .014
Camp Rich.	.071	.416± .001	.372± .011	.378± .016	.387± .016	.379± .003	.390± .004	.418± .002	.421± .000*	.384± .024*	.476± .010
Emerald Bay	.126	.361± .004	.316± .006	.330± .006	.337± .001	.338± .002	.333± .001	.356± .006	.332± .006*	.313± .004*	.378± .029
Rubicon Bay	.062	.292± .000	.257± .020	.268± .007	.274± .001	.298± .001	.315± .007	.345± .012	.327± .008*	.333± .004*	.420± .008
Mid-Lake:											
Mid-lk No.	.070	.484± .019	.364± .008	.358± .014	.347± .005	.339± .006	.320± .004	.332± .003	.333± .024*	.320± .002*	.357
Mid-lk So.	.066	.486± .008	.382± .006	.375± .004	.379± .016	.359± .001	.368± .016	.366± .006	.376± .021*	.364± .024*	.401± .001

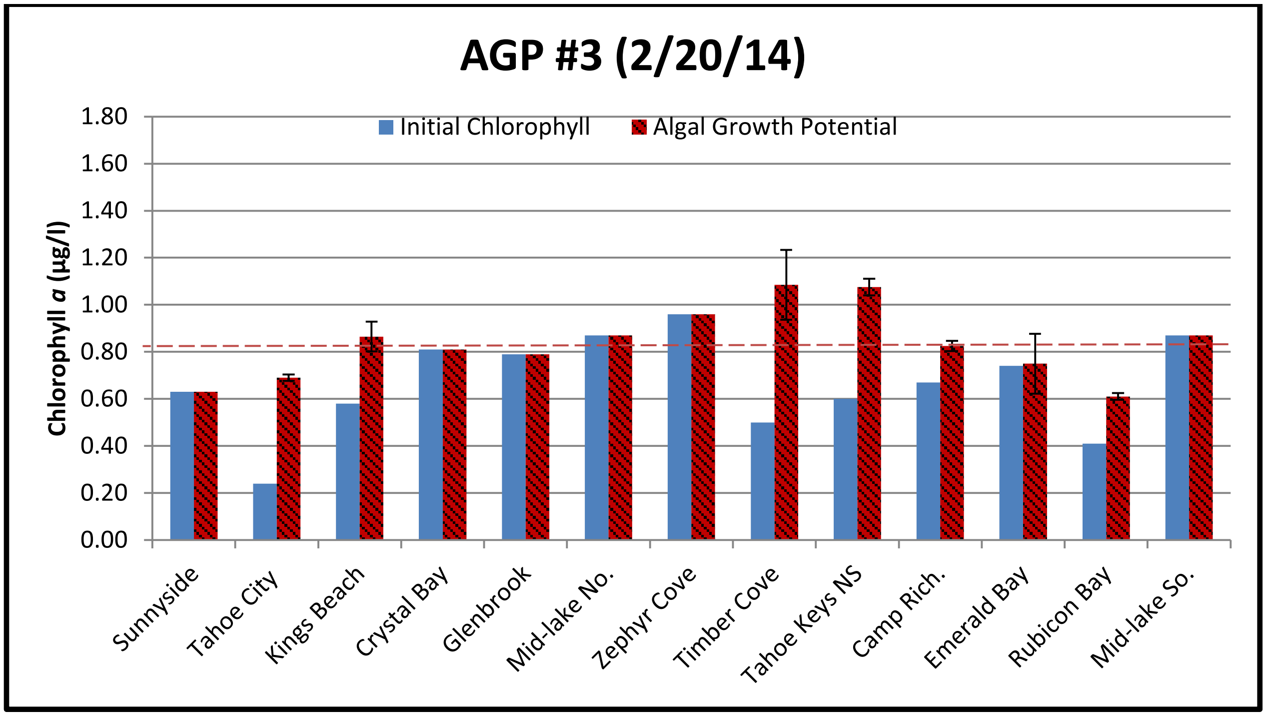

Figure 4. Chlorophyll a (extracted) in water collected 2/20/14 and Algal Growth Potential (maximum algal chlorophyll a achieved during incubation) at nearshore and mid-lake sites. Red dashed line is mean AGP of Mid-lake North and South reference sites for the bioassay.

AGP Assay #3 Quality Assurance

We returned to use of duplicate treatments and incubation under CW fluorescent lighting in AGP assay #3 (Feb. 2014), and observed improved results. The coefficients of variation for duplicates in AGP Bioassay #3 were generally low (< 0.10 for a majority of treatment replicates). The highest coefficient of variation observed was 0.17 for Day 9 Emerald Bay replicates. The results from this bioassay were good and they were included in determination of site annual mean AGP levels.

AGP#4 (6/9/14)

Initial lake chlorophyll *a* was extremely low at all nearshore and mid-lake sites on 6/9/14 (Table 7; Figure 5). The highest initial chlorophyll *a* levels were observed in the nearshore at Emerald Bay (0.42 µg/l), Tahoe City (0.31 µg/l) and Tahoe Keys nearshore (0.30 µg/l). Initial chlorophyll *a* at the other nearshore sites ranged from 0.12-0.24 µg/l and the mid-lake sites ranged from 0.12-0.17 µg/l. Levels of NO_3-N, NH_4-N, SRP and TP were all very low (but not zero), with very subtle differences if any among sites (Table 8). Tahoe City and Sunnyside appeared to have slightly more SRP than other sites.

In the Algal Growth Potential test, Camp Richardson along the south shore had the highest AGP (0.83 µg/l), next highest in the south portion of the lake were Emerald Bay (0.69 µg/l) and Tahoe Keys (0.65 µg/l) (Table 7; Figure 5). In comparison, the Mid-lake South reference site AGP was

0.58 µg/l. In the north portion of the lake, highest AGP levels were Sunnyside (0.69 µg/l) and Tahoe City (0.61 µg/l). While the Mid-lake North reference site AGP was quite low (0.26 µg/l). Rubicon Bay had the lowest AGP (0.26 µg/l) among nearshore sites. The very low initial concentrations of chlorophyll *a* at most nearshore sites around the lake, was likely a consequence of overall low availability of nutrients following another year of drought and light spring input of nutrients associated with the snowmelt. However, similar to AGP assay #1 all sites showed significant increases in chlorophyll *a* relative to the initial lake levels during the AGP incubation. Again, this may have been a consequence of the reduction in light intensity and absence of inhibitory UV radiation during in the AGP assay. Algal production and algal biomass in water samples in the AGP test may have increased as a consequence of removing the inhibitory effects of high PAR and UV radiation when samples were placed in the incubator.

AGP #4 Assay Quality Assurance

The results from AGP bioassay #4 (done in June 2014) were also good and usable for calculation of annual means. The coefficients of variation (std. dev. /mean of replicates) for replicates in the bioassay were generally low. However, as volumes in flasks were drawn down significantly by Day 9, coefficients of variation increased for some treatments. Results after Day 9 were not included in determination of AGP for this bioassay, due to the small volumes left in flasks and potential for non-representative results.

Table 7. Summary of field and experimental data collected for Algal Growth Potential (AGP) experiment done on Lake Tahoe water collected from nearshore and mid-lake sites on 6/9/14. Experiment run in Percival incubator, two replicates per treatment. Notes- "Meta."= metaphyton present; Surface oil sheen observed at surface at Tahoe City; metaphyton and plants observed along bottom at sites indicated (not in samples).

AGP #4 H_2O Collection 6/9/14	Date Collected	Time Collected	Lake Surface T (°C)	Collection Depth (m)	Lake Chl. *a** (µg/l)	Observations	**Extracted Chlor. *a*** AGP D4 6/13/14	**Extracted Chlor. *a*** AGP D6 6/15/14	**Extracted Chlor. *a*** AGP D9 6/18/14	**Final AGP Results Chl. *a* (µg/l)**
Nearshore:										
Sunnyside	6/9/14	13:45	16.0	1.5	0.14		.52 ± .04	.58 ± .01		**.69 ± .06**
Tahoe City	6/9/14	09:00	14.0	1.5	0.31	Surf. Oil sheen	.61 ± .01	.39(n=1)		**.61 ± .01**
Kings Beach	6/9/14	09:45	14.5	0.75	0.17		.32 ± .01	.37 ± .04		**.37 ± .04**
Crystal Bay	6/9/14	10:10	15.0	1.5	0.18		.35 ± .02	.36 ± .04	.39 ± .04	**.39 ± .04**
Glenbrook	6/9/14	10:40	15.0	1.0	0.11		.31 ± .04	.35 ± .04	.33 ± .04	**.44 ± .06**
Zephyr	6/9/14	11:05	15.5	0.75	0.21		.44 ± .05	.48 ± .01		**.50 ± .03**
Timber Cove	6/9/14	11:35	16.0	0.5	0.13	Metaphyton	.43 ± .01	.50 ± .03		**.50 ± .03**
Tahoe Keys	6/9/14	11:50	16.5	0.5	0.30	Plants & Meta.	.46 ± .08	.41 ± .01	.65 ± .19	**.65 ± .19**
Camp Rich.	6/9/14	12:00	16.5	1.5	0.24		.51 ± .01	.57 ± .01	.83 ± .04	**.83 ± .04**
Emerald Bay	6/9/14	12:32	17.0	1.5	0.42		.69 ± .04	.61 ± .03		**.69 ± .04**
Rubicon Bay	6/9/14	13:00	17.0	1.0	0.12		.26 ± .01	.18 ± .01		**.26 ± .02**
Mid-Lake:										
Mid-lk No.	6/9/14	09:25	15.0	1.5	0.12		.26 ± .03	.20 ± .01	.23 ± .08	**.26 ± .03**
Mid-lk So.	6/9/14	11:20	15.5	1.5	0.17		.31 ± .01	.34 ± .01	.58 ± .01	**.58 ± .01**

Experiment Daily Fluorescence	Backgrd. Fluor.	D0 Fluor. 6/9/14 19:30	D1 Fluor. 6/10/14 14:40	D2 Fluor. 6/11/14 15:34	D3 Fluor. 6/12/14 15:20	D4 Fluor. 6/13/14 16:00	D5 Fluor. 6/14/14	D6 Fluor. 6/15/14 10:30	D7 Fluor. 6/16/14 14:50	D8 Fluor. 6/17/14	D9 Fluor. 6/18/14 15:20
Nearshore:											
Sunnyside	.024	.183± .006	.209±.005	.261± .006	.340± .008	.397± .011		.421± .016	.436± .035		.252± .018
Tahoe City	.049	.256± .007	.356±.021	.361± .012	.387± .011	.395± .022		.305± .026	.262± .008		.202± .037
Kings Beach	.037	.178± .001	.208± .001	.215± .007	.244± .005	.242± .001		.228± .002	.249± .013		.242± .012
Crystal Bay	.051	.201± .001	.235± .001	.254± .003	.262± .004	.256± .005		.243± .021	.255± .007		.258± .008
Glenbrook	.036	.176± .005	.210± .002	.223± .004	.258± .002	.270± .012		.263± .015	.293± .037		.241± .022
Zephyr	.031	.212± .011	.235± .003	.258± .001	.299± .003	.330± .001		.323± .001	.327± .014		.262± .006
Timber Cove	.050	.190± .006	.205± .019	.232± .001	.277± .010	.295± .006		.289± .008	.265(n=1)		.223(n=1)
Tahoe Keys	.076	.260± .013	.281± .008	.281± .006	.287± .004	.296± .010		.289± .006	.323± .001		.352± .058
Camp Rich.	.043	.290± .005	.283± .004	.269± .011	.277± .001	.291± .002		.277± .003	.330± .004		.413± .005
Emerald Bay	.057	.327± .009	.322± .025	.351± .010	.391± .018	.394± .005		.360± .000	.356± .014		.307± .004
Rubicon Bay	.030	.169± .001	.170± .011	.195± .004	.210± .011	.211± .013		.172± .003	.185± .003		.215± .008
Mid-Lake:											
Mid-lk No.	.036	.157± .001	.195± .001	.175± .007	.218± .009	.224± .007		.180± .008	.180± .003		.203± .021
Mid-lk So.	.037	.212± .005	.220± .001	.198± .004	.203± .014	.220± .004		.226± .001	.265± .011		.313± .029

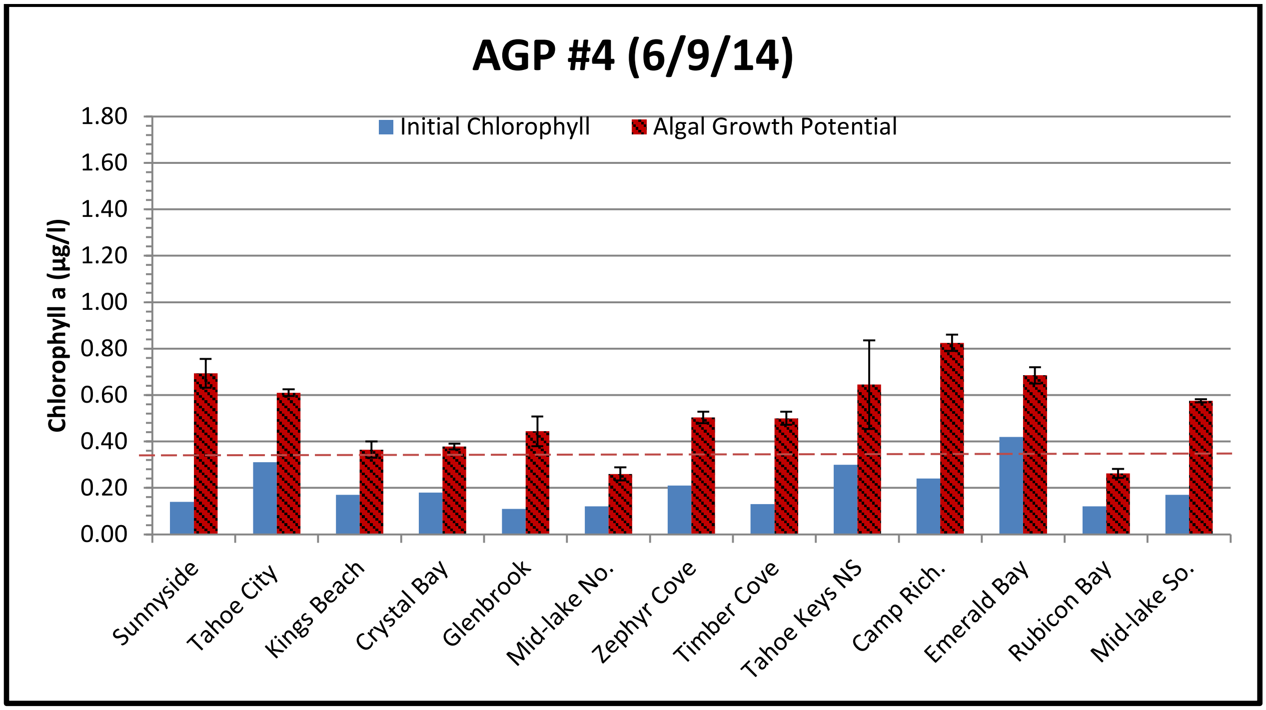

Figure 5. Chlorophyll a (extracted) in water collected 6/9/14 and Algal Growth Potential (maximum algal chlorophyll a achieved during incubation) at nearshore and mid-lake sites. Red dashed line is mean AGP of Mid-lake North and South reference sites for the bioassay.

Table 8. Nutrient concentrations sites in lake water collected 6/9/14 from AGP sites.

AGP#1 6/9/14	Initial NO_3-N (µg/l)	Initial NH_4-N (µg/l)	Initial SRP (µg/l)	Initial TP (µg/l)
Nearshore:				
Sunnyside	1	3	2	4
Tahoe City	1	4	3	5
Kings Beach	1	3	1	3
Crystal Bay	1	2	1	3
Glenbrook	1	3	1	2
Zephyr	1	4	1	2
Timber Cove	1	5	1	4
Tahoe Keys	1	3	1	6
Camp Rich/Taylor	1	3	1	4
Emerald Bay	1	3	1	4
Rubicon	1	3	1	3
Mid-Lake:				
Mid-lk No.	1	3	1	3
Mid-lk So.	1	3	1	3

Patterns of AGP in 2013-2014

This was the first year we have used the AGP method. With data from only 3 comparable bioassays so far, observations on patterns in the data are very limited. The only consistent patterns seen so far are:

- Tahoe Keys Nearshore AGP has consistently been among the higher nearshore site levels. This site had the highest AGP in assay #1 done in August, 2013 (although there was high treatment variability) and highest AGP in assay #3 done in February, 2014. It had the third highest AGP in the bioassay in June, 2014.
- Rubicon Bay, had the lowest AGP in the 3 comparable bioassays among nearshore sites.

Generally, quite a range of AGP responses has been observed for individual sites in different assays. For example Crystal Bay AGP levels varied from 0.64 µg/l (Aug. 2013) to 0.81 µg/l (Feb. 2014) to 0.39 µg/l (June, 2014). Tahoe City has been among the sites with higher levels of AGP. The AGP at Tahoe City was second highest in the Aug. 2013 assay and it was the fourth highest AGP in June, 2014 assay. It along with Tahoe Keys and Timber Cove were also sites that showed substantial chlorophyll *a* increases in the February, 2014 bioassay.

Levels of AGP in 2013-2014 and the Lahontan AGP Standard

The Lahontan standard for AGP states that mean annual AGP at a site should not be greater than two times the mean annual AGP at a mid-lake reference station. Since our use of the AGP test began with the August 2013 bioassay, there was not a full calendar year of data in 2013 to make a determination of whether any of the sites violated the standard. Beginning with the next annual report, we will present the results relative to the standard based on a full calendar year of data. However, to gain insight on the data collected so far with respect to the standard, we examined the data for the reporting year (July1, 2013- June 30, 2014) to see whether any violations occurred[3]. Table 9 presents the results for mean annual AGP for the three comparable bioassays (August 2013, February 2014 and June 2014) along with the site annual mean AGP (denoted by "A" in Table 9) divided by the mid-lake reference sites annual mean AGP (denoted by "B" in Table 9). No station exceeded the Lahontan standard during this annual period. The highest level for "A"/"B" was 1.55 at Tahoe Keys. Next highest level was observed for nearby Camp Richardson area (1.35). Rubicon Bay had the lowest level (0.76), indicating mean annual AGP there was actually less than mean annual AGP at the Mid-lake reference sites.

[3] Note, for several years in the DWR's 1970's AGP studies, evaluation relative to the Lahontan standard for the calendar year were based on the mean of data from AGP bioassays done in May and August. We included bioassays in Aug. 2013, June 2014 along with a February 2014 test. We should eventually be collecting data for 4 seasons in a year and will need to evaluate whether inclusion of all seasonal data provides potentially different results relative to the Lahontan Standard compared with using only late spring and late summer AGP results.

Table 9. Summary of individual AGP assay results for sites, Mean annual AGP and Mean Annual AGP divided by Mid-lake Mean Annual AGP for assays done 7/1/13 – 6/30/14. There were no violations relative to the Lahontan Standard for AGP during the reporting period (i.e. no annual mean for a site was more than twice the annual mean at the mid-lake reference sites.

	AGP 8/15/2013	AGP 2/20/2014	AGP 6/9/2014	(A) Mean Annual	Std. Dev.	n	(A/B) Site Mean/ Mid-lake-Mean AGP
							NO VIOLATIONS
Nearshore:							
Sunnyside	0.84	0.63	0.69	0.72	0.11	3	1.16
Tahoe City	0.99	0.69	0.61	0.76	0.2	3	1.23
Kings Beach	0.85	0.87	0.37	0.7	0.28	3	1.12
Crystal Bay	0.64	0.81	0.39	0.61	0.21	3	0.99
Glenbrook	0.64	0.79	0.44	0.62	0.18	3	1.01
Zephyr	0.89	0.96	0.5	0.78	0.25	3	1.26
Bijou	0.81			0.81		1	1.31
Timber Cove		1.09	0.5	0.8	0.42	2	1.28
Tahoe Keys	1.15	1.08	0.65	0.96	0.27	3	1.55
a-C.R./Taylor	0.85			0.85		1	1.37
b-Camp Rich.		0.83	0.83	0.83	0	2	1.34
(Mean a,b)	0.85	0.83	0.83	0.84	0.01	3	1.35
Emerald Bay		0.77	0.69	0.73	0.06	2	1.18
Rubicon Bay	0.55	0.61	0.26	0.47	0.19	3	0.76
Mid-Lake:							
Mid-lk No.	0.64	0.87	0.26	0.59	0.31	3	0.95
Mid-lk So.	0.5	0.87	0.58	0.65	0.19	3	1.05
(Mean Mid-lake)	0.57	0.87	0.42	(B)0.62	0.23	3	1

Note- Camp Richardson/ Taylor and Camp Richardson sites were relatively close to each other, for data analysis, data was combined to determine an regional annual average.

Summary Points for Algal Growth Potential Assays

1. **The purpose of these experiments is to compare levels of algal growth in the nearshore to potentially identify emerging problem areas. The AGP test provides an indication of the potential for algal growth in water collected from the various sites. Availability of the nutrients nitrogen (N) and phosphorus (P) in the water and levels of nutrients previously taken up by the algae (known as luxury uptake), are important factors which contribute to growth. In the lake, natural conditions may exist which prevent the full growth potential from being realized (i.e. if a physical, chemical or biological factor negatively impacts growth).**

2. **Comparable data was collected from 3 of 4 AGP assays. One assay, done in Dec. 2013 however, experimented with incubation under higher intensity lights with different light spectrum). A substantial decline in algal biomass occurred under these lights. In comparison, a small decline in biomass occurred with incubation of the same water in an incubator which used less intense cool white fluorescent lighting. Results from the Dec. assay were not included in comparisons of site results and comparisons of mean annual AGP.**

3. **No station exceeded the Lahontan AGP standard during this reporting period. The highest level for (Site Annual Mean AGP)/ (Mid-lake Mean Annual AGP) was 1.55 at Tahoe Keys. Next highest level was observed for nearby Camp Richardson area (1.35). Rubicon Bay had the lowest level (0.76), indicating mean annual AGP there was actually less than mean annual AGP at the Mid-lake reference sites.**

4. **With data from only 3 comparable assays so far, observations on patterns in the data are very limited. Tahoe Keys Nearshore AGP has consistently been among the higher nearshore site levels. This site had the highest AGP in assay #1 done in August, 2013 (although there was high treatment variability) and highest AGP in assay #3 done in February, 2014. It had the third highest AGP in the bioassay in June, 2014. In contrast, Rubicon Bay, consistently had the lowest AGP in the 3 comparable bioassays among nearshore sites.**

5. **Tahoe City has been among the sites with higher levels of AGP. The AGP at Tahoe City was second highest in the Aug. 2013 assay and it was the fourth highest AGP in June, 2014 assay. It along with Tahoe Keys and Timber Cove were also sites that showed substantial chlorophyll *a* increases in the February, 2014 bioassay.**

6. **Interestingly, even though nutrient levels were very low in the assays done in summers of 2013 and 2014, all sites showed substantial increases in chlorophyll *a* during the assays. One possible reason for this increase was that phytoplankton in the incubator were not exposed to high light intensity and UV radiation, as they are near the lake surface during the summer. Photosynthetically Active Radiation (PAR), UV-A and UV-B wavelengths of solar irradiance in the lake can cause inhibition of phytoplankton production. Algal production and algal biomass in water samples in the incubator could have increased when the inhibitory effect of high PAR and UV radiation experienced in the lake near the surface, were removed.**

Nutrients in the water (although measurements were very low) and already incorporated in the cells (luxury uptake) were sufficient to support this increase. It would be desirable to know more about interactions between AGP, UV and PAR along with degree of acclimatization of algae to UV in the nearshore zone.

Task 4. Enumeration and Identification of Phytoplankton

High quality environments can be sustained only by adequate public awareness, scientific monitoring and protection measures to ensure that areas will maintain that quality. Phytoplankton, being the first link in the aquatic food chain, represent a sensitive biological indicator that swiftly responds to environmental change (Smol, 2008). Scientific monitoring, using phytoplankton as the key component, has been common for the last 50 years with varying degrees of success (Hall & Smol, 2010, Kristiansen, 1986). Chemical and physical factors can impact the phytoplankton community. In the case of Lake Tahoe, different nearshore sites offer different chemical and physical conditions; however, the differences between stations are subtle. If it is possible to define unique characteristics at some or all of the sites, then an opportunity exists to track regional differences. These results could provide information useful in making management decisions.

There is historical precedent for the use of phytoplankton as an environmental indicator. In Lake Tahoe during the 1960's phosphorus and nitrogen concentrations increased due to increased inputs associated with wastewater treatment and disposal practices (use of septic systems and land-disposal of treated wastewater from treatment plants), as well as from increased nutrients from disturbance of land, soils and vegetation associated with rapid development around the Tahoe basin. This change in nutrient loading influenced the phytoplankton community composition. A colonial diatom, *Fragilaria crotonensis*, became abundant and a bio-volume dominant. Twenty years after its first appearances in Lake Tahoe, *Fragilaria crotonensis* disappeared from the phytoplankton community. The discontinued use of septic systems and exporting all sewage from the basin played a significant role in limiting the nutrient loading beginning in the early 1970's. The disappearance of *Fragilaria crotonensis* from the community was directly linked to the decrease in nutrient inputs (Bradbury, 1975, Reavie & Smol 2001). In this case, *Fragilaria crotonensis* was an environmental indicator. The current nearshore study is designed to identify species and communities of phytoplankton that can serve a similar role.

In the past year (2013-2014), twelve near-shore sites and two open water (mid-lake) stations have been sampled on four dates for phytoplankton identification and enumeration. Phytoplankton was identified to species level and enumerated at 630X total magnification. Gross parameters such as sample bio-volume and abundance by taxon group were determined, as well as detailed information about phytoplankton community composition and diversity. Bio-volume is a common descriptor used in phytoplankton studies. It is an individual cell metric which requires calculation of cell volume from 3-dimensional geometric forms. Total bio-volume of a sample is the collective individual cell volume calculations added together, weighted by population abundance. It can lead to an estimation of phytoplankton biomass.

Phytoplankton bio-volume (by taxonomic group and total per sampling station) was calculated for each of the four sampling events in water year 2014 (Figure 6). Algal bio-volume was greatest during the summer season. Within each graph differences between stations were distinct. The greatest total bio-volume was observed at Tahoe City during June 2014 with dinoflagellates comprising 89% of the total. However, this station fluctuated throughout the year with the lowest total bio-volume also observed at Tahoe City in February. Stations with consistently high summer bio-volume were Tahoe City, Tahoe Keys, Camp Richardson, and Emerald Bay. In Figure 6b and 6c (December and February) there were less pronounced differences between stations. This was probably a consequence of lake turbulence and mixing during the winter maintaining a more homogeneous community lake-wide.

Phytoplankton taxonomic groups (orders) that comprised the total bio-volume for each station are represented by various colors. Seasonal periodicity is reflected by the color change between individual graphs. Community composition in December and February was similar (Figure 6b &6c). Seasonal succession between these sampling dates was apparent when dinoflagellate dominance (December) gave way to a mixed chrysophyte/cryptophyte dominance in February. A more dramatic comparison was the community composition during the two summer sampling dates (August and June). Diatoms dominated in August 2013 (Figure 6a) and dinoflagellates dominated in June 2014 (Figure 6d). The June community assemblage was indicative of nutrient limitation based on the type of dominant phytoplankton taxa. *Peridinium spp.* (dinoflagellate) *and Dinobryon spp.* (chrysophyte) are symptomatic of phosphorus limitation (C.S. Reynolds, 1984).

Comparison of stations within the same sampling date indicated different bio-volume values even though the stations shared a similar palette of color. On August 2013 all stations were dominated by the small centric diatom, *Cyclotella gordonensis* and Sunnyside had the greatest total bio-volume. The greatest diversity was seen at Tahoe Keys and Tahoe City because both stations had significant populations of green algae (chlorophytes), although the diversity values might have been partly influenced by benthic re-suspension. Comparing that graph to the summer of 2014, once again the variability between stations was distinct. In June 2014 *Peridinium inconspicuum* (dinoflagellate) was dominant at most of the stations. Tahoe City had the greatest total bio-volume. The most impressive result from this graph, however, was the community composition and diversity at Emerald Bay and Tahoe Keys. Those sites were entirely different from the phytoplankton communities at other nearshore stations and the mid-lake. This information would support the idea that some of the nearshore stations are quite unique and can be characterized using only phytoplankton community descriptions based on samples from those sites.

Initially there was concern that sampling close to shore at shallow depths would increase the incidence of benthic (periphyton and metaphyton) species in the plankton due to re-suspension. Indeed, benthic cells were present at all nearshore stations. These cells were predictably large in size but relatively rare. Only a couple of nearshore stations (Tahoe City and Tahoe Keys during the summer months) were substantially impacted by their abundance. Re-suspended benthic algae can impact total bio-volume, chlorophyll, and diversity numbers, leading to a complicated interpretation when comparing nearshore sites.

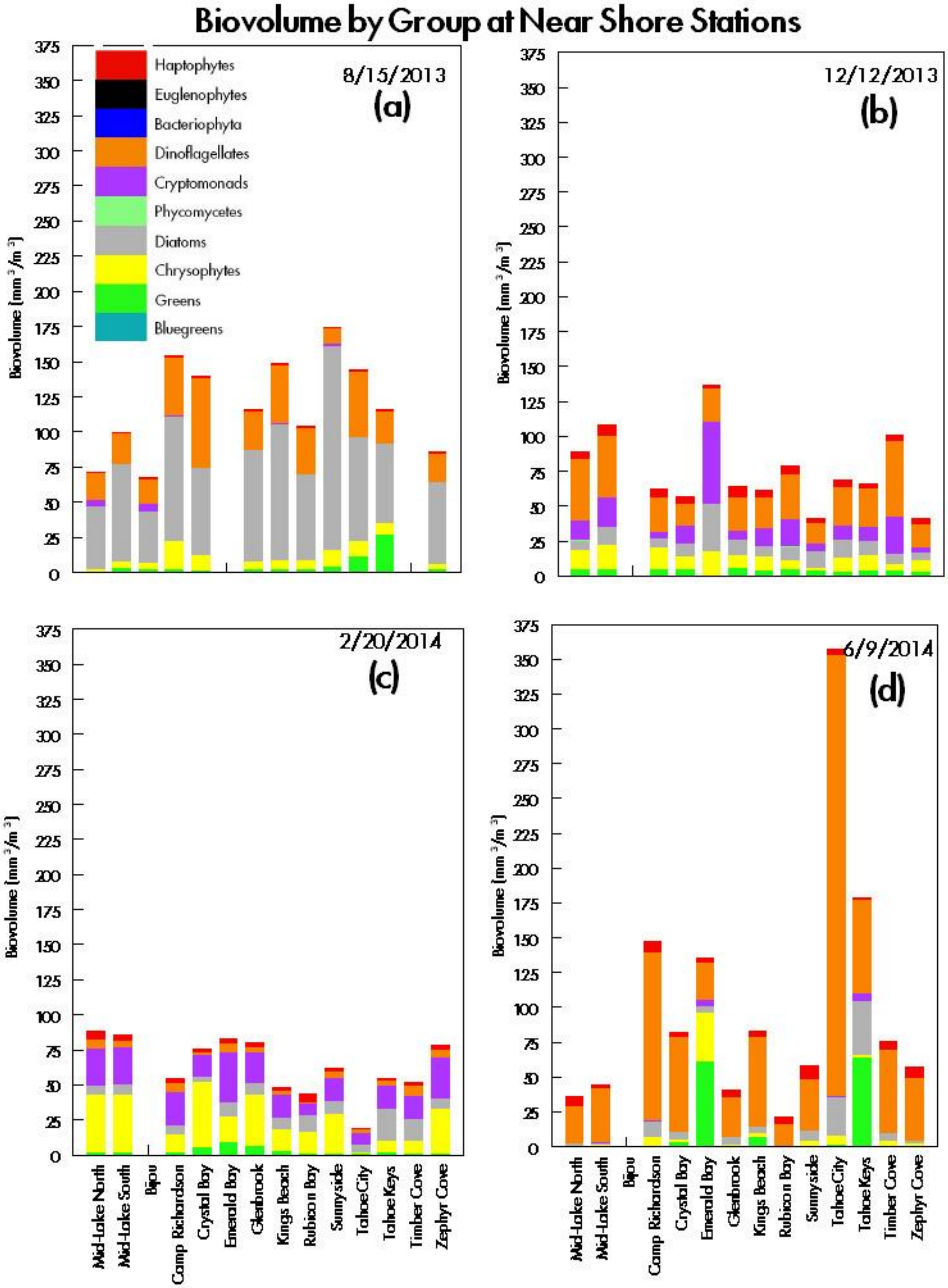

Figure 6. Lake Tahoe phytoplankton biovolume at nearshore and mid-lake sites on 2013-2014. Lake samples were from near-surface water (usually from a depth of between 0.5-2m).

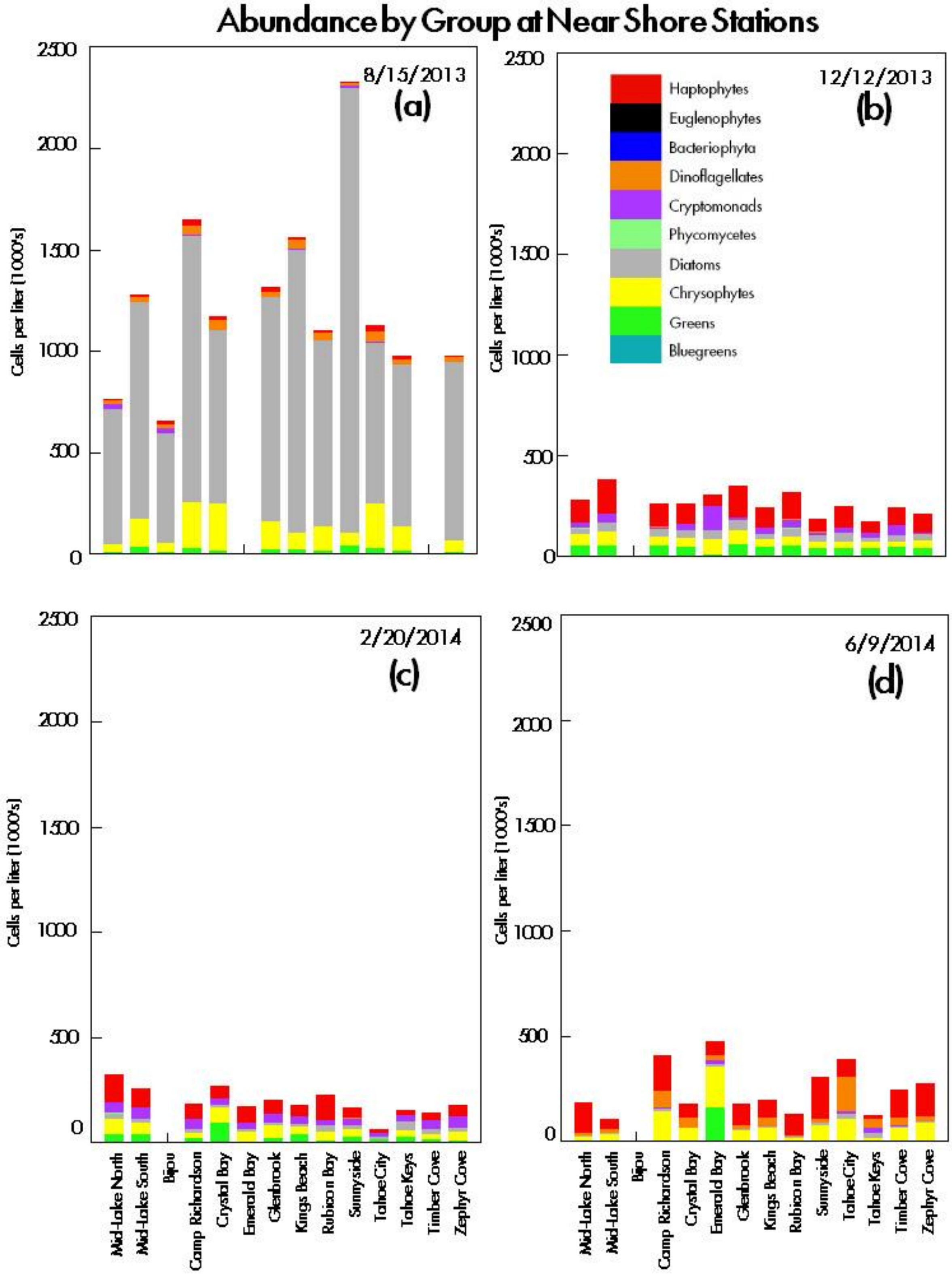

Figure 7. Lake Tahoe phytoplankton abundance at nearshore and mid-lake sites 2013-2014.

Total abundance (cells/l) was presented in Figure 7 with taxonomic groups represented by different colors, categorized by station, on each sampling date. The highest total abundance of cells at all near-shore sites was in August 2013 (Figure 7a). This particular graph followed the abundance patterns seen in previous summers for the last decade with summer being the season of highest annual phytoplankton abundance, lowest diversity, and generally dominated by diatoms. On the other hand, in June 2014 total abundances at all stations were exceptionally low. The June 2014 results (Figure 7d) broke the typical summer pattern and were an unusual occurrence. Phytoplankton growth was limited, possibly by low nutrient availability in the water column associated with a prolonged drought and/or incomplete lake turn-over. The limitation impacted all locations around the lake. Winter samples (Figure 7b & 7c) had generally low abundance but high diversity. The lake was more homogeneous during the winter because of mixing so differences between stations were more difficult to discern.

Phytoplankton taxonomic groups in Figure 7 were similar at all locations on any individual sampling date. Seasonal change in the phytoplankton community was generally controlled (numerically) by one species in each successional period. The abundance results, therefore, reflected the success or failure of that one species at each of the nearshore stations. For example, diatoms (gray color, Figure 7a) were the most abundant taxon in August 2013. The diatom category was dominated by a single species, *Cyclotella gordonensis*. Sunnyside had the greatest quantity of this diatom. Camp Richardson and Kings Beach had the second and third most abundant population. During the un-stratified months of December and February (Figure 7b & 7c) all stations shared a strong taxonomic commonality with the deeper mid-lake stations. The winter-time low abundance and also the taxonomic similarity make this data less informative. In June 2014 (Figure 7d) distinct differences between some nearshore sites and mid-lake phytoplankton were apparent. Although low in total abundance, a single dinoflagellate species, *Peridinium inconspicuum* was dominant at many stations. Emerald Bay had the greatest total abundance compared to other near-shore stations. More importantly, however, was the proportion of taxonomic groups which comprised that total. Emerald Bay and Tahoe Keys had the highest diversity, followed by Tahoe City and Camp Richardson. These stations, based on abundance and diversity of phytoplankton, differed most from the mid-lake control stations.

Each of the measurable parameters, bio-volume, abundance and taxonomic grouping have hinted that phytoplankton could be used to uniquely characterize some of the near-shore stations. Unfortunately those parameters do not measure the stations with enough discernment to define what exactly is causing the 'uniqueness'. The level of detail needed requires a knowledge of phytoplankton at the species taxonomic level.

Fortunately, phytoplankton samples were identified and enumerated to the species level. After one year of sampling 13 different stations, 155 individual species were identified. Many of those species were common between all stations, including the mid-lake. The goal in data analysis, however, was to identify only those species which were pre-dominantly seen in the nearshore. To accomplish this a threshold criterion was assigned where a species abundance had to occur 90% of the time at a near-shore station to be characterized as a 'near-shore' species. For example, if a species had an abundance of 100, then 90 of those individuals had to be found at near-shore stations and only 10 individuals or less at the mid-lake. Using this criterion, the original list of 155 individual species was reduced by >60% to approximately 50 unique 'nearshore' species per sampling date. Potentially any species listed in this subset could have been a candidate for an environmental indicator. However, the initial goal was more conservative, hoping only to identify a unique community associated with each station.

Table 10 and Table 11 display a matrix of the cell abundance (cells/l) of pre-dominantly nearshore species collected at all stations on either August 15, 2013 or June 9, 2014. Each table aggregates the individual species by taxonomic grouping. The columns represent species which formed the unique phytoplankton community at that station. The horizontal rows represent the commonality or uniqueness of that species among stations. Distribution patterns were seen both vertically and horizontally. For example, in Table 11, Emerald Bay had a grouping of *Dinobryon spp*. which could not be found at any other nearshore station. Contrast that with the diatom *Achnanthes minutissima* which was found at nearly all stations. Because the species are listed alphabetically within their group, it was possible to spot diversity within the group or even within a genera. Additional information can be gleaned from the summation of pre-dominantly nearshore species at the bottom of the table. Stations with the highest totaled numbers represent regions with the highest diversity.

Patterns begin to develop which discern one station from another based solely on their phytoplankton community. These patterns were only visible in the two summer sampling dates. Tahoe City, Tahoe Keys and Emerald Bay had the greatest diversity in pre-dominantly nearshore phytoplankton. The community assemblage at Emerald Bay had the most unique taxa. There were several species which might serve as site-specific indicators: *Rhodomonas lacustris, Stephanodiscus hantzschii, Oocystis borgei, & Kephyrion spirale*. Data from the winter phytoplankton community had only a few pre-dominantly nearshore species. Since the stations were mostly homogeneous very few of the counted species could meet the 90% criteria outlined above. Additional sampling, especially when the lake is stratified, will give more opportunity to solidify plankton community patterns or alter them appropriately.

Summary

Phytoplankton community structure has the potential to characterize individual nearshore stations. After one year of sample collection the data is still limiting. The stations have only been sampled four times and inter-annual and seasonal fluctuations in the phytoplankton community have been dramatic. Characterization of a station based on the phytoplankton community will happen over time with repeated sampling. Added data during the next two years will yield conclusions with more merit. Armed with the knowledge of total bio-volume, abundance, diversity, and phytoplankton taxa within the community, it will be possible to evaluate each nearshore station for trophic status. The definition of oligotrophic versus mesotrophic categories is somewhat fluid therefore assigning a trophic status to each station may be problematic. However, it will be possible to say that one station is more productive, more diverse and has more unique species compared with another station. This information can then be used to make management plans on a regional basis.

Recommendations

1) Sample more during the stratified period. This is the seasonal window when differences between stations are accentuated. Capturing ‘snapshots’ throughout this timeframe will help in understanding of the dynamics of community formation at the nearshore stations.
2) Re-suspension of benthic plankton into the pelagic at near-shore stations is common. Benthic cells can have a substantial impact on sample bio-volume, chlorophyll, and community diversity. Comparison of near-shore stations based on these parameters makes data interpretation difficult when benthic phytoplankton are abundant. Sampling days should be selective, based on weather, wind, and boat traffic with greatest care given to avoid times when re-suspension is likely.
3) Maintain sampling of the mid-lake station. It is important to have a control station so that unusual seasonal occurrences can be reasonably interpreted. For example, the phytoplankton community in the summer of 2014 is so unique that it might be considered an indicator of some major catastrophic event. Fortunately the historical data set from the mid-lake station (30+ years) helps put this data into context. This situation has happened in the past and it is indicative of nutrient depletion in the euphotic zone (C.S. Reynolds, 1984 and D. Hunter, personal communication). The impact is seen throughout the lake. If the mid-lake station had not been sampled, one would not be able to make this conclusion and data interpretation could be less accurate, even erroneous.
4) Anthropogenic sources of nutrient input which might influence nearshore biota should be identified and chemically quantified. Some phytoplankton species respond predictably to these variables and can be used as bio-indicators.

Table 10 - Biovolume by Taxonomic Group and Station (8/15/2013)

Date	Specie	Group	Bijou	CampRichardson	CrystalBay	EmeraldBay	Glenbrook	KingsBeach	RubiconBay	Sunnyside	TahoeCity	TahoeKeys	TimberCove	ZephyrCove
08/15/13	Leptolyngbya sp.	BLUEGR	0	870	7548	0	21334	0	0	0	1673	0	0	3274
08/15/13	Microcystis aeruginosa	BLUEGR	0	11605	0	0	0	0	0	0	0	0	0	0
08/15/13	Nostoc sp.	BLUEGR	0	0	0	0	0	0	0	0	0	509	0	0
08/15/13	Oscillatoria sp.	BLUEGR	0	0	384	0	0	0	0	0	0	0	0	0
08/15/13	Phormidium sp.	BLUEGR	0	0	0	0	0	966	0	0	0	0	0	0
08/15/13	Cladophora sp.	CHLORO	0	0	0	0	0	0	0	0	278	0	0	0
08/15/13	Closterium gracile	CHLORO	0	0	0	0	0	48	0	0	0	0	0	0
08/15/13	Cosmarium bioculatum	CHLORO	0	926	0	0	0	2315	0	0	0	0	0	871
08/15/13	Cosmarium contractum	CHLORO	0	0	0	0	0	48	0	0	0	0	0	0
08/15/13	Cosmarium laeve	CHLORO	0	0	0	0	0	0	0	0	0	50	0	0
08/15/13	Cosmarium phaseolus	CHLORO	0	0	0	0	0	0	50	0	0	0	0	0
08/15/13	Monoraphidium minutum	CHLORO	0	0	0	0	0	0	0	0	0	814	0	0
08/15/13	Mougeotia parvula	CHLORO	539	0	48	0	0	48	100	288	557	6935	0	491
08/15/13	Oocystis elliptica	CHLORO	0	0	0	0	0	0	0	0	167	0	0	0
08/15/13	Pediastrum duplex	CHLORO	0	0	0	0	0	0	0	0	55	0	0	0
08/15/13	Pediastrum tetras	CHLORO	49	116	0	0	0	0	0	0	0	0	0	0
08/15/13	Peduastrum integrum	CHLORO	0	0	0	0	0	0	0	57	110	0	0	0
08/15/13	Scenedesmus ellipticus	CHLORO	0	0	0	0	0	0	0	0	0	203	0	0
08/15/13	Scenedesmus quadricauda	CHLORO	0	290	0	0	0	0	0	0	0	0	0	0
08/15/13	Sphaerocystis schroeteri	CHLORO	0	0	0	0	2136	386	0	3231	669	2039	0	436
08/15/13	Spirogyra sp.	CHLORO	0	0	0	0	0	0	0	0	55	0	0	0
08/15/13	Tetradesmus wisconsinensis	CHLORO	0	116	0	0	0	193	0	0	0	0	0	0
08/15/13	Bitrichia ollula	CHRYSO	0	0	0	0	0	0	0	0	0	0	0	871
08/15/13	Chrysococcus rufescens	CHRYSO	0	0	0	0	0	0	0	921	0	0	0	0
08/15/13	Dinobryon sociale v. americanu	CHRYSO	0	0	0	0	853	0	0	115	1782	0	0	0
08/15/13	Epipyxis sp.	CHRYSO	0	0	0	0	1706	0	0	0	0	0	0	0
08/15/13	Gloeobotrys limneticus	CHRYSO	3131	3707	2304	0	5120	4630	6419	11059	891	203	0	2615
08/15/13	Kephyrion cupliforme	CHRYSO	0	926	0	0	853	0	0	0	0	0	0	0
08/15/13	Kephyrion globosa	CHRYSO	0	0	0	0	1706	0	0	0	0	0	0	0
08/15/13	Pseudopedinella sp.	CHRYSO	2348	5561	0	0	0	3858	1604	2764	1782	2443	0	0
08/15/13	Synura sp.	CHRYSO	0	7415	0	0	0	0	0	8294	0	0	0	0
08/15/13	Cryptomonas sp.	CRYPTO	0	0	0	0	160	0	0	0	111	101	0	0
08/15/13	Achnanthes gibberula	DIATOM	0	0	0	0	0	0	0	0	891	0	0	0
08/15/13	Achnanthes lanceolata	DIATOM	0	0	0	0	4266	771	0	0	0	0	0	871
08/15/13	Achnanthes minutissima	DIATOM	0	0	0	0	3413	0	0	0	0	0	0	0
08/15/13	Amphora ovalis	DIATOM	0	0	0	0	53	0	0	0	55	0	0	0
08/15/13	Cymbella ventricosa	DIATOM	0	0	0	0	0	0	0	115	0	50	0	0
08/15/13	Diploneis smithii var. pumila	DIATOM	0	58	0	0	0	0	0	57	0	0	0	0
08/15/13	Epithemia sorex	DIATOM	0	116	96	0	0	338	0	173	669	0	0	0
08/15/13	Epithemia zebra	DIATOM	0	0	0	0	0	0	0	0	0	50	0	0
08/15/13	Fragilaria capucina	DIATOM	0	0	96	0	0	96	100	288	0	0	0	0
08/15/13	Gomphonema sp.	DIATOM	0	0	0	0	53	0	0	0	0	0	0	0
08/15/13	Mastogloia smithii	DIATOM	0	0	48	0	160	289	0	115	55	0	0	0
08/15/13	Navicula bacillum	DIATOM	0	0	96	0	0	0	0	0	0	0	0	0
08/15/13	Navicula gastrum	DIATOM	0	0	336	0	0	241	0	0	0	0	0	0
08/15/13	Navicula pupula	DIATOM	0	0	0	0	106	0	0	57	55	0	0	0
08/15/13	Navicula radiosa	DIATOM	0	0	48	0	0	0	0	0	223	0	0	0
08/15/13	Nitzschia acicularis	DIATOM	0	0	192	0	0	48	0	0	0	0	0	0
08/15/13	Nitzschia palea	DIATOM	0	0	0	0	0	0	0	0	1782	0	0	0
08/15/13	Pinnularia sp.	DIATOM	0	0	96	0	0	144	0	0	111	0	0	0
08/15/13	Rhopalodia gibba	DIATOM	0	0	48	0	53	96	0	57	223	0	0	0
08/15/13	Staurosira construens	DIATOM	196	406	3029	0	1175	386	251	230	4183	968	0	0
08/15/13	Staurosirella pinnata	DIATOM	0	1740	528	0	0	0	0	1788	0	0	0	0
08/15/13	Surirella linearis	DIATOM	0	58	0	0	0	0	0	0	0	0	0	0
08/15/13	Surirella linearis var. helvet	DIATOM	0	0	0	0	0	0	0	0	55	101	0	0
08/15/13	Synedra acus	DIATOM	0	0	48	0	0	48	0	0	0	50	0	0

Table 10 (cont) - Biovolume by Taxonomic Group and Station (8/15/2013)

Date	Specie	Group	Bijou	CampRichardson	CrystalBay	EmeraldBay	Glenbrook	KingsBeach	RubiconBay	Sunnyside	TahoeCity	TahoeKeys	TimberCove	ZephyrCove
08/15/13	Synedra capitata	DIATOM	0	0	0	0	0	0	0	0	0	50	0	0
08/15/13	Synedra ulna	DIATOM	0	0	96	0	53	0	0	57	390	50	0	0
08/15/13	Gymnodinium eurytopum	DINOFL	0	0	12981	0	0	0	0	0	0	0	0	0
08/15/13	Gymnodinium lantzschii	DINOFL	0	0	0	0	1335	0	0	0	0	0	0	0
Number of predominantly near-shore species sampled at station:			5	15	18	0	18	19	6	18	24	16	0	7

Table 11 - Biovolume by Taxonomic Group and Station (6/9/2014)

Date	Specie	Group	Bijou	CampRichardson	CrystalBay	EmeraldBay	Glenbrook	KingsBeach	RubiconBay	Sunnyside	TahoeCity	TahoeKeys	TimberCove	ZephyrCove
06/09/14	Leptolyngbya sp.	BLUEGR	0	0	0	0	0	0	0	0	0	0	0	1858
06/09/14	Phormidium sp.	BLUEGR	0	0	0	0	0	1507	0	0	0	1330	0	619
06/09/14	Schizothrix muelleri	BLUEGR	0	0	0	0	0	0	0	0	1394	0	0	0
06/09/14	Cladophora sp.	CHLORO	0	0	413	0	0	803	0	0	0	5140	0	0
06/09/14	Closterium moniliferum	CHLORO	0	0	0	0	0	0	0	0	0	413	0	0
06/09/14	Cosmarium bioculatum	CHLORO	0	827	0	0	0	0	0	0	0	0	0	0
06/09/14	Elakatothrix gelatinosa	CHLORO	0	0	0	4481	0	0	0	0	0	0	0	0
06/09/14	Monoraphidium contortum	CHLORO	0	827	0	0	0	0	0	0	0	733	0	0
06/09/14	Mougeotia parvula	CHLORO	0	0	0	0	187	0	0	0	223	0	0	0
06/09/14	Nephrocytium sp.	CHLORO	0	0	0	0	0	0	0	0	891	0	0	0
06/09/14	Oocystis borgei	CHLORO	0	0	0	34154	0	0	0	0	0	0	0	0
06/09/14	Oocystis naeglii	CHLORO	0	51	0	0	0	0	0	0	0	0	0	0
06/09/14	Oocystis parva	CHLORO	0	0	0	2215	0	0	0	0	891	0	0	0
06/09/14	Pediastrum boryanum	CHLORO	0	51	0	0	0	0	0	0	110	0	0	0
06/09/14	Pediastrum tetras	CHLORO	0	0	0	0	0	0	0	0	0	733	0	0
06/09/14	Planktonema lauterbornii	CHLORO	0	414	0	0	0	0	0	0	0	0	0	557
06/09/14	Planktosphaeria gelatinosa	CHLORO	0	0	0	122613	0	0	0	0	0	0	0	0
06/09/14	Scenedesmus quadricauda	CHLORO	0	0	0	0	0	0	0	0	55	0	108	0
06/09/14	Bitrichia chodati	CHRYSO	0	0	0	51	0	0	0	0	0	0	0	0
06/09/14	Bitrichia ollula	CHRYSO	0	0	0	822	0	0	0	0	0	0	0	0
06/09/14	Chromulina sp.	CHRYSO	0	0	0	0	0	802	0	0	0	0	867	0
06/09/14	Chrysolykos planctonicus	CHRYSO	0	0	0	2468	0	802	0	0	0	0	0	0
06/09/14	Dinobryon bavaricum	CHRYSO	0	0	0	822	0	0	0	0	0	0	0	0
06/09/14	Dinobryon cylindricum	CHRYSO	0	0	0	103	0	0	0	0	0	0	0	0
06/09/14	Dinobryon divergens var. schau	CHRYSO	0	0	0	11520	0	0	0	0	0	0	0	0
06/09/14	Dinobryon eurystoma	CHRYSO	0	4962	0	0	0	0	0	1966	10693	0	5202	4947
06/09/14	Dinobryon sociale v. americanu	CHRYSO	0	0	0	83936	0	0	0	0	0	0	0	0
06/09/14	Epipyxis sp.	CHRYSO	0	1654	0	23041	0	0	0	0	0	0	0	0
06/09/14	Flagellates (5-10um)	CHRYSO	0	0	0	0	0	0	0	0	0	0	1734	0
06/09/14	Kephyrion cupliforme	CHRYSO	0	0	0	822	0	0	0	0	891	0	0	0
06/09/14	Kephyrion globosa	CHRYSO	0	0	0	2468	0	0	0	0	891	0	0	0
06/09/14	Kephyrion spirale	CHRYSO	0	0	0	9052	0	0	0	983	0	0	0	0
06/09/14	Monas coronifera	CHRYSO	0	0	0	822	0	0	0	0	0	0	0	0
06/09/14	Pseudopedinella sp.	CHRYSO	0	0	0	4114	0	0	0	0	0	0	0	0
06/09/14	Synura sp.	CHRYSO	0	827	0	13166	0	0	0	0	2673	733	867	0
06/09/14	Cryptomonas sp.	CRYPTO	0	0	0	0	0	0	0	0	0	2199	0	0
06/09/14	Kathablepharis ovalis	CRYPTO	0	2481	0	2468	0	2407	0	0	7128	733	1734	1979
06/09/14	Rhodomonas lacustris	CRYPTO	0	0	0	16458	0	0	0	0	0	0	0	0
06/09/14	Rhodomonas minuta	CRYPTO	0	0	0	0	0	0	0	0	2673	19794	867	0
06/09/14	Achnanthes affinis	DIATOM	0	0	0	0	0	0	0	0	0	0	1734	0
06/09/14	Achnanthes gibberula	DIATOM	0	0	0	0	750	0	0	0	891	0	0	0
06/09/14	Achnanthes lanceolata	DIATOM	0	0	0	0	0	0	0	0	0	91	0	0
06/09/14	Achnanthes minutissima	DIATOM	0	0	1466	822	0	802	0	983	1782	733	867	0
06/09/14	Amphipleura pellucida	DIATOM	0	0	0	0	0	0	0	61	0	0	0	0
06/09/14	Amphora ovalis	DIATOM	0	0	0	0	0	0	0	0	55	0	0	0
06/09/14	Asterionella formosa	DIATOM	0	0	0	206	46	0	0	0	55	91	0	0
06/09/14	Aulacoseira islandica	DIATOM	0	0	0	0	0	0	0	0	0	321	0	0
06/09/14	Aulacoseira italica	DIATOM	0	880	0	0	0	0	0	0	111	1698	0	0
06/09/14	Cocconeis placentula var. line	DIATOM	0	51	0	0	0	0	0	0	0	0	0	0
06/09/14	Cyclotella bodanica	DIATOM	0	0	0	412	0	0	0	0	0	0	0	0
06/09/14	Cyclotella glomerata	DIATOM	0	0	0	0	0	0	790	0	0	0	0	0
06/09/14	Cymbella amphicephala var. her	DIATOM	0	0	45	0	0	0	0	0	0	137	0	0
06/09/14	Cymbella ventricosa	DIATOM	0	103	0	0	0	802	0	983	278	0	0	61
06/09/14	Diatoma hiemale var. mesodon	DIATOM	0	0	0	0	0	0	0	0	111	0	54	0
06/09/14	Epithemia sorex	DIATOM	0	0	45	0	187	100	0	0	1171	0	0	0
06/09/14	Epithemia zebra	DIATOM	0	0	0	0	0	0	0	0	55	183	54	0

Table 11 (cont): Biovolume by Taxonomic Group and Station (6/9/2014)

Date	Specie	Group	Bijou	CampRichardson	CrystalBay	EmeraldBay	Glenbrook	KingsBeach	RubiconBay	Sunnyside	TahoeCity	TahoeKeys	TimberCove	ZephyrCove
06/09/14	Eunotia arcus	DIATOM	0	0	0	0	0	0	0	0	0	917	0	61
06/09/14	Fragilaria capucina	DIATOM	0	207	45	0	46	50	98	0	167	917	108	0
06/09/14	Fragilaria crotonensis	DIATOM	0	517	0	0	0	0	0	0	0	0	0	0
06/09/14	Gomphoneis herculeana	DIATOM	0	0	0	0	0	0	0	123	0	0	0	0
06/09/14	Gomphonema constrictum	DIATOM	0	0	0	0	0	0	0	0	0	45	0	0
06/09/14	Gomphonema sp.	DIATOM	0	0	45	0	0	0	0	0	0	0	0	0
06/09/14	Mastogloia smithii	DIATOM	0	0	0	51	46	50	0	61	0	0	0	61
06/09/14	Navicula aurora	DIATOM	0	51	0	0	0	0	0	0	0	917	0	61
06/09/14	Navicula cryptocephala	DIATOM	0	0	45	0	0	50	0	61	55	91	54	0
06/09/14	Navicula decussis	DIATOM	0	0	0	0	0	0	0	61	0	0	0	0
06/09/14	Navicula pupula	DIATOM	0	0	0	0	0	50	0	0	167	504	0	0
06/09/14	Nitzschia acicularis	DIATOM	0	0	0	0	0	100	0	0	0	413	54	0
06/09/14	Nitzschia linearis	DIATOM	0	0	0	0	0	0	0	0	891	0	0	0
06/09/14	Pinnularia sp.	DIATOM	0	0	0	51	0	50	0	0	0	0	0	0
06/09/14	Rhopalodia gibba	DIATOM	0	51	0	0	46	0	0	0	223	45	0	0
06/09/14	Staurosira construens	DIATOM	0	2951	0	1957	0	1105	0	246	7475	13906	271	123
06/09/14	Staurosirella pinnata	DIATOM	0	0	0	3291	0	0	0	0	3564	367	0	0
06/09/14	Stephanodiscus alpinus	DIATOM	0	0	0	0	0	0	0	0	55	0	108	0
06/09/14	Stephanodiscus hantzschii	DIATOM	0	1654	0	0	0	0	0	0	0	0	0	0
06/09/14	Surirella linearis	DIATOM	0	0	0	0	0	0	0	0	0	45	0	0
06/09/14	Synedra acus	DIATOM	0	51	0	0	0	50	0	0	0	0	0	0
06/09/14	Synedra acus var. angustissima	DIATOM	0	0	0	0	0	0	0	123	0	0	0	0
06/09/14	Synedra acus var. radians	DIATOM	0	0	0	0	3000	0	0	0	5346	2932	0	0
06/09/14	Synedra ulna	DIATOM	0	0	413	0	93	100	0	61	167	229	54	0
06/09/14	Tabellaria fenestrata	DIATOM	0	51	0	0	0	0	0	0	0	45	0	0
06/09/14	Tabellaria flocculosa	DIATOM	0	51	0	0	0	0	0	0	0	0	0	0
06/09/14	Gymnodinium fuscum	DINOFL	0	414	0	0	0	0	0	0	0	0	0	0
06/09/14	Peridinium cyst	DINOFL	0	2481	596	0	0	0	0	0	891	0	0	0
06/09/14	Peridinium inconspicuum	DINOFL	0	0	0	0	0	0	0	0	162182	0	0	0
06/09/14	Euglena sp.	EUGLEN	0	0	0	0	0	0	0	0	0	45	0	0
06/09/14	Bodo angustus	PHYCOM	0	0	0	0	0	0	0	0	0	733	0	0
Number of predominantly near-shore species sampled at station:			0	23	9	27	9	17	2	12	33	32	17	10

Task 5. Periphyton

The purpose of the periphyton monitoring task is to assess the levels of nearshore attached algae (periphyton) growth around the lake. As with phytoplankton, nutrient availability plays a large role in promoting periphyton growth. The amount of periphyton growth can be an indicator of local nutrient loading and long-term environmental changes. Periphyton biomass is considered an important indicator, which together with nearshore chlorophyll, phytoplankton and macrophyte metrics provide information on the trophic status of the Lake Tahoe nearshore zone. Trophic status in turn, along with nearshore clarity, community structure and conditions for human health are considered primary indicators of nearshore condition or health as outlined in the Lake Tahoe nearshore monitoring framework (Heyvaert et al., 2013).

Periphyton grows in the littoral (shore) zone of Lake Tahoe, which may be divided into the eulittoral zone and the sublittoral zone, each with distinct periphyton communities. The eulittoral zone is the shallow area between the low and high lake level and is substantially affected by wave activity. Substrata within this region desiccate as the lake level declines, and periphyton must recolonize this area when lake level rises. The sublittoral zone extends from the bottom of the eulittoral to the maximum depth of photoautotrophic growth. The sublittoral zone remains constantly submerged and represents the largest littoral benthic region of Lake Tahoe.

The algal community in the eulittoral zone is typically comprised of filamentous green algae (i.e., *Ulothrix sp., Zygnema sp.*) and stalked diatom species (i.e., *Gomphoneis herculeana*). The attached algae in the eulittoral zone display substantial growth resulting in rapid colonization of suitable areas. These algae are able to take advantage of localized soluble nutrients, and can establish a thick coverage over the substrate within a matter of months. Similarly, this community rapidly dies back as nutrient concentrations diminish and shallow nearshore water temperatures warm with the onset of summer. The algae can slough from the substrate and disperse into the open water, or washed onto the shore. In areas where biomass is high, the slimy coating over rocks and sloughed material accumulated along shore can be a nuisance. The eulittoral zone periphyton plays an important role in the aesthetic, beneficial use of the shorezone. It is the rapid response of eulittoral periphyton to localized nutrient inputs that lends particular value to monitoring this community as an indicator of localized differences in nutrient loading.

The sublittoral zone is made up of different algal communities down through the euphotic zone. Cyanophycean (blue-green) algal communities make up a substantial portion of the uppermost sublittoral zone. These communities are slower growing and more stable than the filamentous and diatom species in the eulittoral zone.

<u>Stations and Methods</u>

Nine routine stations were monitored during Nov. 2013- July, 2014 (Rubicon Pt., Sugar Pine Pt., Pineland, Tahoe City, Dollar Pt., Zephyr Pt., Deadman Pt., Sand Pt and Incline West). These nine sites are located around the lake (Figure 1 presents a map of locations and Table 12 provides coordinates of locations) and represent a range of backshore disturbance levels from relatively undisturbed land (Rubicon Point and Deadman Point) to a developed urban center (Tahoe City).

Table 12. Locations of Routine Periphyton Monitoring Stations

SITE NAME	LOCATION
Rubicon	N38 59.52; W120 05.60
Sugar Pine Point	N39 02.88; W120 06.62
Pineland	N39 08.14; W120 09.10
Tahoe City	N39 10.24; W120 08.42
Dollar Point	N39 11.15; W120 05.52
Zephyr Point	N39 00.10; W119 57.66
Deadman Point	N39 06.38; W11957.68
Sand Point	N39 10.59; W119 55.70
Incline West	N39 14.83; W119 59.75

A detailed description of the sample collection and analysis procedures is given in Hackley et al. (2004). Briefly, the method entails collection while snorkeling of duplicate samples of attached algae from a known area of natural rock substrate at a depth of 0.5m, using a syringe and toothbrush sampler. These samples are transported to the laboratory where the samples are processed and split, with one portion of the sample analyzed for Ash Free Dry Weight (AFDW) and the other portion frozen for later analysis of chlorophyll *a* concentration (both AFDW and chlorophyll *a* are used as measures of algal biomass). We also measure average filament length, percent algal coverage, and estimate the visual score in field observations. The visual score is a subjective ranking (1-5) of the level of algal growth viewed underwater (as well as above water for a portion of the data), where 1 is least offensive appearing (usually natural rock surface with little or no growth) and 5 is the most offensive condition with very heavy growth.

Results

Monitoring at Routine Sites

In this report we summarize the data collected during the period November, 2013 to July, 2014. Nine routine sites were sampled. All sites were sampled five times during the period. Three of the five samplings were made during the spring when growth typically peaks (March-May), with additional sampling circuits made during low growth in the summer (late June/ early July) and fall (November). Table 13 presents the results for biomass (chlorophyll *a* and Ash Free Dry Weight (AFDW)) and field observations (visual score, average filament length, percent algal coverage, biomass index and basic algal types) at the nine routine periphyton sites for the period November 2013 through July, 2014. The results for periphyton chlorophyll *a* biomass are also presented graphically in Figures 8 (a-i) together with earlier data collected since 2000. Figure 9 presents a graph of lake surface elevation and 0.5m sampling elevation Jan. 2000-August, 2014.

During 2013-2014, certain patterns for biomass were apparent at the routine sites. Comparing the data by water year, the following patterns were observed.

Water Year 2014 Patterns of Periphyton Biomass

WY 2014 was characterized by generally low periphyton biomass at the routine monitoring sites, with only modest spring increases at two sites in the NW portion of the lake and little or no increases at the other routine sites. Early in WY 2014 (in November), biomass was relatively low at all sites with Tahoe City having the highest chlorophyll *a* biomass (26 mg/m^2) and biomass at the other sites near or below 20 mg/m^2. By March 2014, slight to modest increases in biomass were observed at Pineland and Tahoe City in the NW portion of the lake. At Pineland, biomass peaked at a modest 40 mg/m^2, down substantially from the extremely high peak biomass of 242 mg/m^2 observed in spring 2013. Tahoe City had the highest highest peak biomass (65 mg/m^2), which was down from the 126 mg/m^2 peak observed in 2013. The remaining sites showed small to no increases in the spring 2014.

Biomass at routine sites during lower growth periods (i.e. November 2013, late June/early July 2014) was generally similar to measurements made during the same periods in previous years (Figs. 8a-h). At most sites, chlorophyll a was slightly elevated (near or below 20 mg/m^2). At Tahoe City, chlorophyll was slightly elevated in Nov. 2013 (Chl.=26.34 mg/m^2) relative to most years since 2000 and Deadman Pt. biomass was slightly elevated in late June/early July (Chl.=30.84 mg/m^2).

Several factors may have contributed to the low biomasses observed in WY 2014. Among these factors, lower precipitation, lower nutrient inputs associated with runoff, less frequent storms, and possibly wind events may have played a role. WY 2014 was the third WY in a row of lower than average precipitation (see TERC, 2014) for precipitation trends at Tahoe City through WY 2013. There were no substantial runoff events until early February 2014 when a substantial storm with rain at lake level and higher elevation snow occurred. Also, a relatively small snowpack developed through the winter of 2014 which contributed to a relatively low spring runoff. Overall, runoff-associated nutrients contributed to the nearshore, were likely much reduced in 2014. With fewer storms in 2014, the degree of wind-mixing and potential upward mixing of nutrients may have been reduced. One other factor which may also have had an impact, from November 21-23 there was a strong north to northeast wind event. The waves generated were opposite the south or southwest wind direction typically occurring with winter storms. During this wind event, substantial wave activity resulted on the northwest and west shores of Lake Tahoe. It is possible this wave activity had some detrimental impact on early algal growth along the west and northwest shore through algal loss from wave action.

Table 13 . Summary of eulittoral periphyton chlorophyll <u>a</u> (Chlor.<u>a</u>), Ash Free Dry Weight (AFDW), visual score from above and below water, average filament length, percent algal coverage, and predominant algal types estimated visually underwater (where SD= stalked diatoms; FG= filamentous greens; CY= blue-green algae) for routine periphyton monitoring sites during November, 2013-July, 2014. Note for chlorophyll *a* and AFDW, n=2 unless otherwise indicated (i.e. two replicate samples were taken and analyzed). Visual score is a subjective ranking of the aesthetic appearance of algal growth ("above" viewed above water; "below" viewed underwater) where 1 is the least offensive and 5 is the most offensive. Biomass Index is Filament Length times % Algal Cover. Also,"NA" = not available or not collected; "NES" = not enough sample for analysis; "Var." = variable amount of cover. Sampling depth and corresponding sampling elevation are also indicated.

Site	Date	Sampling Depth/Elev (m/ ft)	Chlor. *a* (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (g/m^2)	Above Visual Score	Below Visual Score	Avg. Fil. Length (cm)	Algal Cover (%)	Biomass Index	Algal Type
Rubicon Pt.	11/14/13	0.5/6222.34	15.07	3.61	15.91	2.01	3	3	0.8	85	0.68	SD,CY,FG
	3/4/14	0.5/6222.49	19.99	4.60	17.47	3.19	3	4	0.7	80	0.56	CY,FG
	4/11/14	0.5/6222.60	19.39	0.63	21.80	6.49	3	3.5	0.8	68	0.54	CY,FG
	5/21/14	0.5/6222.75	11.36	2.24	14.45	0.92	3	4	1.5	60	0.9	CY,FG
	7/2/14	0.5/6222.42	6.99	2.31	20.02	1.32	3.5	3	1.0	70	0.7	CY,FG
Sugar Pine Pt.	11/14/13	0.5/6222.34	18.95	2.40	18.83	2.77	NA	2	0.2	80	0.16	CY,FG
	3/4/14	0.5/6222.49	4.29	1.46	NES	NES	NA	1	<0.1	<5	<0.005	-
	4/11/14	0.5/6222.60	9.74	2.52	NES	NES	NA	2	<0.1	70	<0.07	CY,SD
	5/21/14	0.5/6222.75	7.11	1.02	11.13	2.91	NA	3	0.3	80	0.24	CY,FG
	7/2/14	0.5/6222.42	9.57	1.18	NES	NES	NA	2	<0.1	20	0.02	FG
Pineland	11/14/13	0.5/6222.34	20.74	1.09	21.84	2.84	2	2	0.1	73	0.07	CY
	3/4/14	0.5/6222.49	39.89	6.99	31.90	1.37	3	3.5	1.4	90	1.26	SD
	4/11/14	0.5/6222.60	31.96	10.70	32.26	4.44	3	4	1.5	65	0.98	SD,CY
	5/21/14	0.5/6222.75	11.76	7.18	10.23	5.94	2	4	1.0	80	0.80	SD,CY
	7/2/14	0.5/6222.42	21.18	2.06	31.85	0.03	2	3	0.5/0.1	30/70	0.22	SD,CY
Tahoe City	11/14/13	0.5/6222.34	26.34	4.59	25.55	5.39	2	2	0.1	60	0.06	SD,FG
	3/10/14	0.5/6222.54	38.45	5.54(n=3)	39.96	5.42(n=3)	3	3	1.7	70	1.19	SD
	4/11/14	0.5/6222.60	65.18	22.92(n=3)	70.15	14.69(n=3)	4	4	1.8	60	1.08	SD
	5/21/14	0.5/6222.75	16.49	0.46	17.60	3.64	NA	2	0.2	50	0.10	SD
	6/27/14	0.5/6222.45	11.74	2.27	13.48	0.89	2	2	0.1	70	0.07	SD

Site	Date	Sampling Depth/Elev (m/ ft)	Chlor. *a* (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (g/m^2)	Above Visual Score	Below Visual Score	Avg. Fil. Length (cm)	Algal Cover (%)	Biomass Index	Algal Type
Dollar Pt.	11/14/13	0.5/6222.34/	19.96	6.40	13.41	3.32	2	2	<0.1	60	<0.06	CY
	3/4/14	0.5/6222.49	8.99	5.12	9.28	(n=1)	2	2	0.1	80	0.08	SD
	4/11/14	0.5/6222.60	23.52	11.45	11.64	2.77	2	2.5	0.3	65	0.20	SD
	5/21/14	0.5/6222.75	16.14	NA**	18.68	5.31	2	2	0.2	80	0.16	SD,CY
	6/27/14	0.5/6222.45	12.09	2.81	13.94	2.84	2	2	0.3	60	0.18	SD
Incline West	11/14/13	0.5/6222.34	11.70	4.70	17.40	8.41	2	3	0.2	70	0.14	CY
	3/4/14	0.5/6222.49	17.93	3.74	24.59	6.66	3	3	0.3	90	0.27	CY,FG
	4/11/14	0.5/6222.60	16.31	2.66	23.30	1.99	3	3	0.6	70	0.42	CY,FG
	5/21/14	0.5/6222.75	22.12	2.96	32.81	7.24	3	3.5	1.2/0.3	50/80	0.69	CY,FG
	7/2/14	0. 5/6222.42	21.40	3.59	33.19	8.02	3	3	0.5/0.1	30/70	0.22	CY,FG
Sand Pt.	11/14/13	0.5/6222.34	21.24	0.55	32.86	1.32	2	3	0.3	60	0.18	CY
	3/4/14	0.5/6222.49	20.13	3.99	33.81	1.46	3	3	0.3	85	0.26	CY,FG
	4/11/14	0.5/6222.60	24.87	1.92	40.10	5.98	NA	2	0.3	80	0.24	CY,FG
	5/21/14	0.5/6222.75	14.25	2.28	31.49	10.90	3	3	0.7/0.1	30/80	0.26	CY,FG
	7/2/14	0.5/6222.42	13.83	1.36	20.79	3.24	3	3	0.5/0.1	30/70	0.22	CY,FG
Deadman Pt.	11/14/13	0.5/6222.34	14.48	1.96	24.09	2.01	3	3	0.3	70	0.21	CY
	3/4/14	0.5/6222.49	23.17	0.76	27.96	0.41	2	3	0.3	80	0.24	CY
	4/11/14	0.5/6222.60	12.59	3.75	19.91	2.98	2	2	0.2	50	0.10	CY
	5/21/14	0.5/6222.75	19.18	6.02	28.62	7.83	2	3	0.7/0.1	30/80	0.26	CY,FG
	7/2/14	0. 5/6222.42	30.84	3.25	36.08	5.50	3	3	0.7/0.1	50/80	0.43	CY/FG
Zephyr Pt.	11/14/13	0.5/6222.34	10.38	4.85	10.74	4.73	2	2	0.2	70	0.14	SD,CY
	3/4/14	0.5/6222.49	11.01	2.14	13.62	0.09	2.5	2	0.1	80	0.08	SD,CY
	4/11/14	0.5/6222.60	3.36	0.53	NES	NES	2	2	<0.1	10	<0.01	
	5/21/14	0.5/6222.75	15.81	2.62	25.30	2.83	3	3	0.4	70	0.28	FG,CY
	7/2/14	0.5/6222.42	6.45	0.60	10.47	3.31	3	3	0.3	50	0.15	FG,CY

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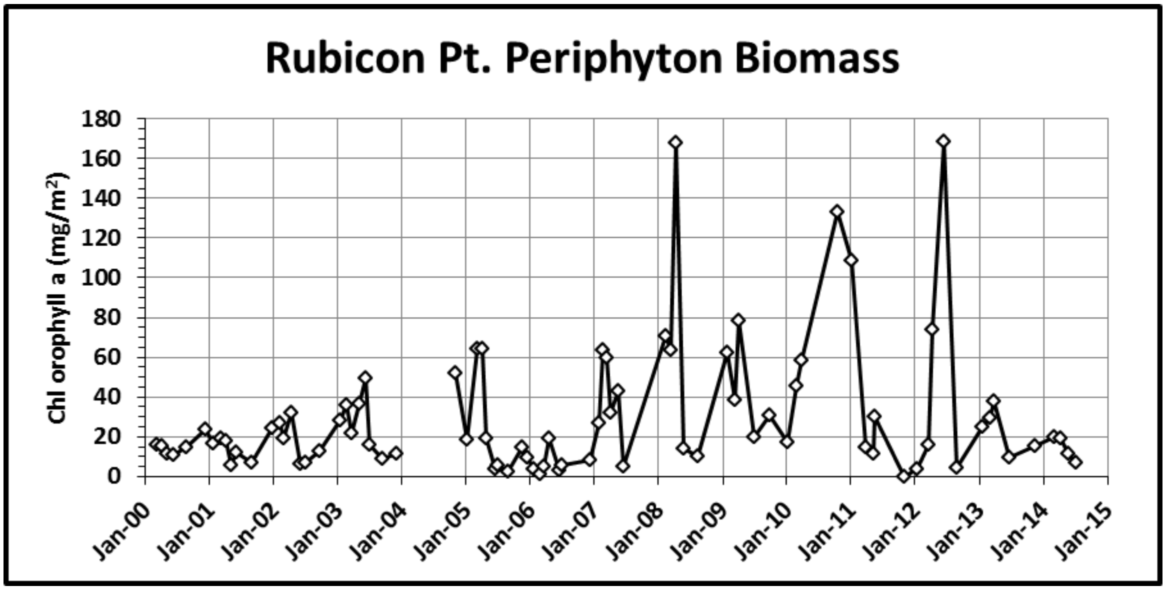

Figure 8 a. Rubicon Pt. periphyton biomass (chlorophyll *a*) 2000-2014.

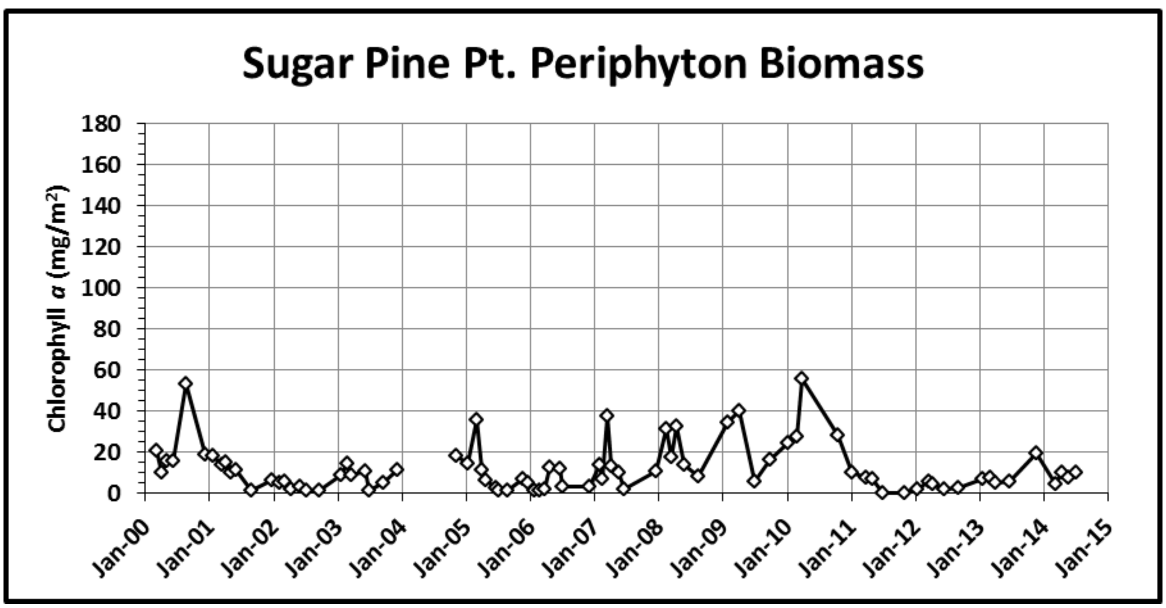

Figure 8 b. Sugar Pine Pt. periphyton biomass (chlorophyll *a*) 2000-2014.

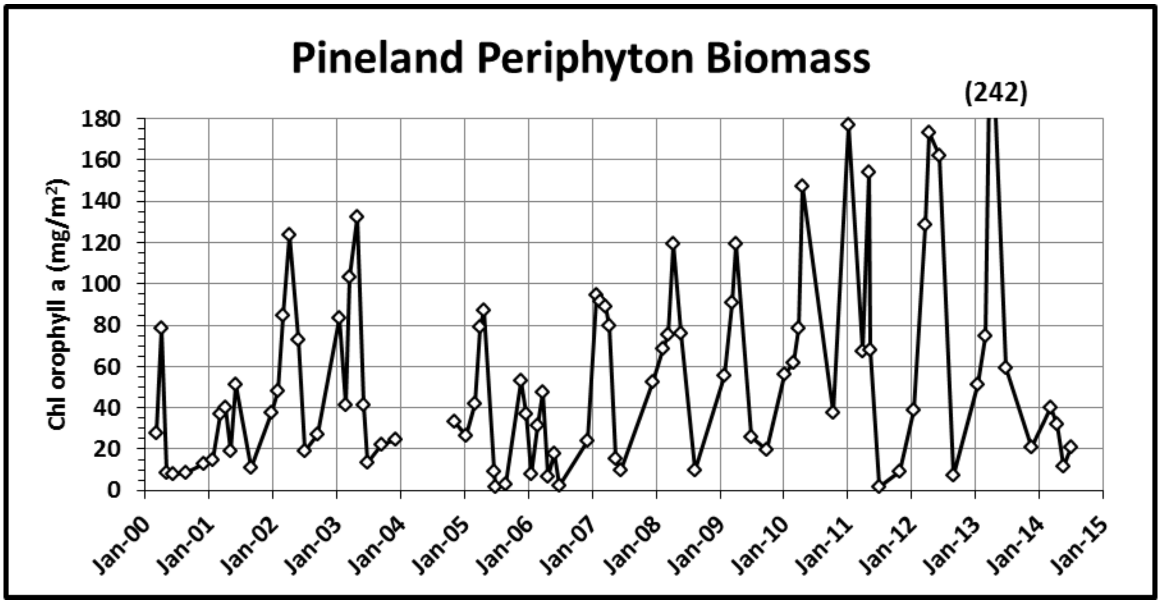

Figure 8 c. Pineland periphyton biomass (chlorophyll *a*) 2000-2014.

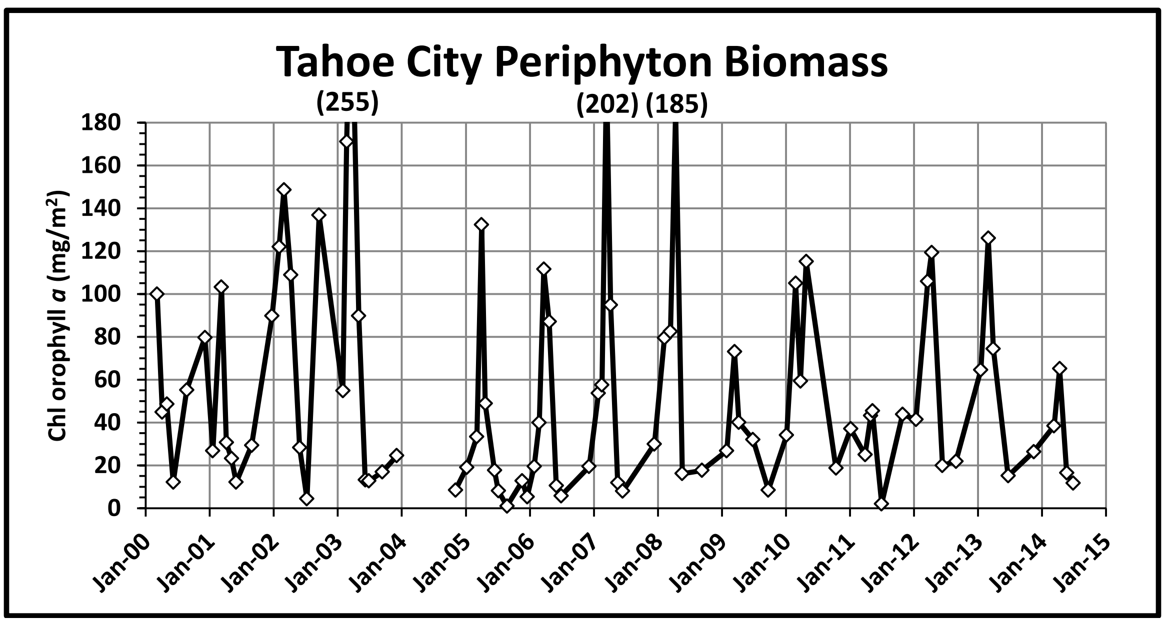

Figure 8 d. Tahoe City periphyton biomass (chlorophyll *a*) 2000-2014.

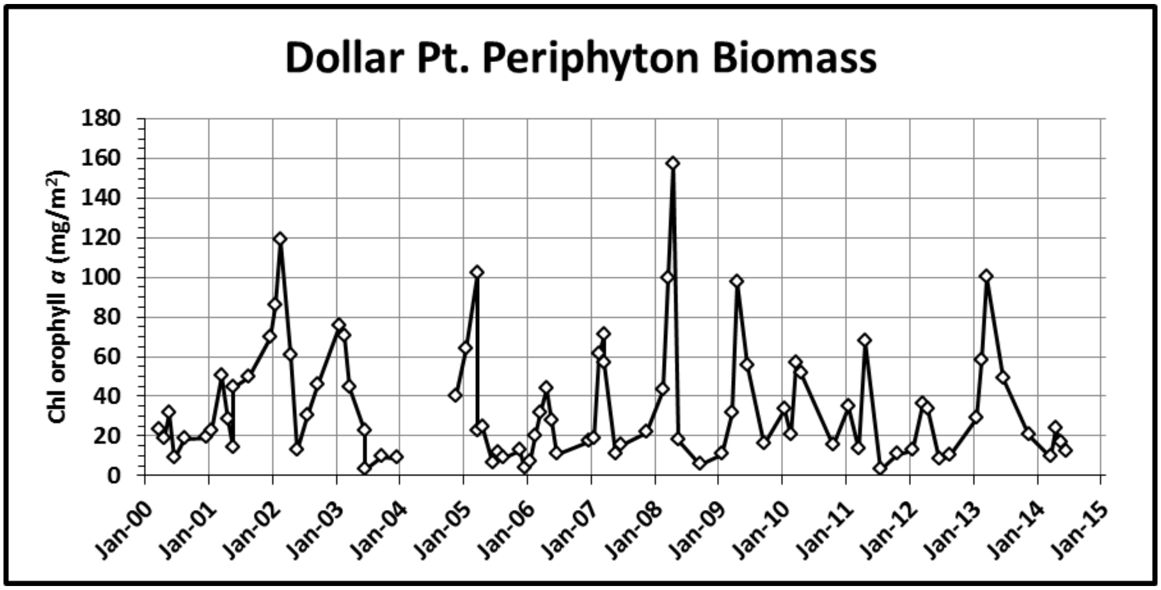

Figure 8 e. Dollar Pt. periphyton biomass (chlorophyll *a*) 2000-2014.

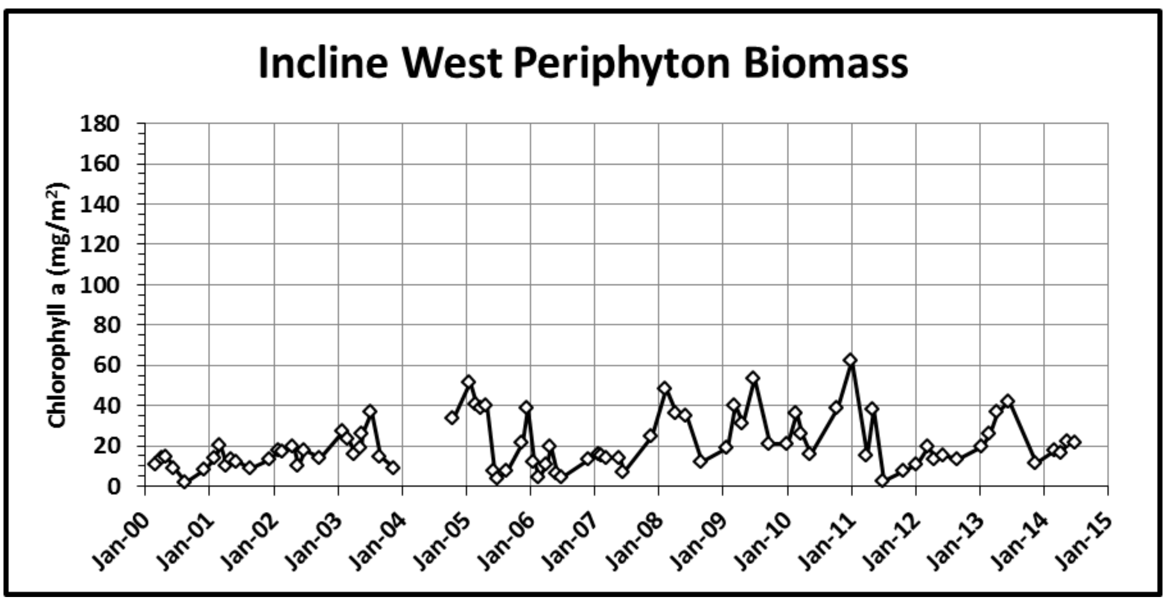

Figure 8 f. Incline West periphyton biomass (chlorophyll *a*) 2000-2014.

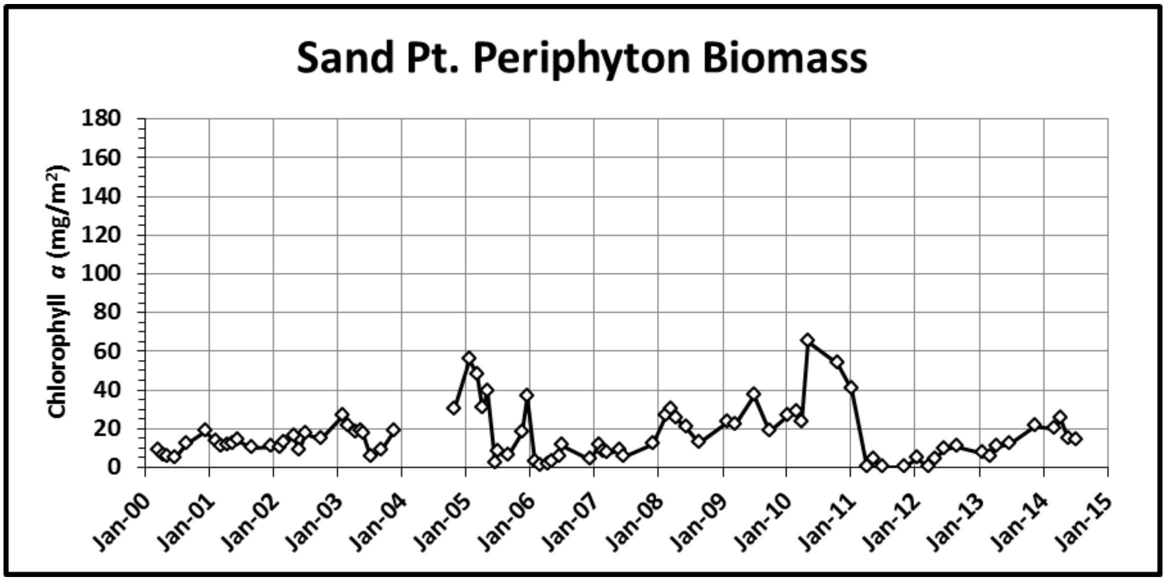

Figure 8 g. Sand Pt. periphyton biomass (chlorophyll *a*) 2000-2014.

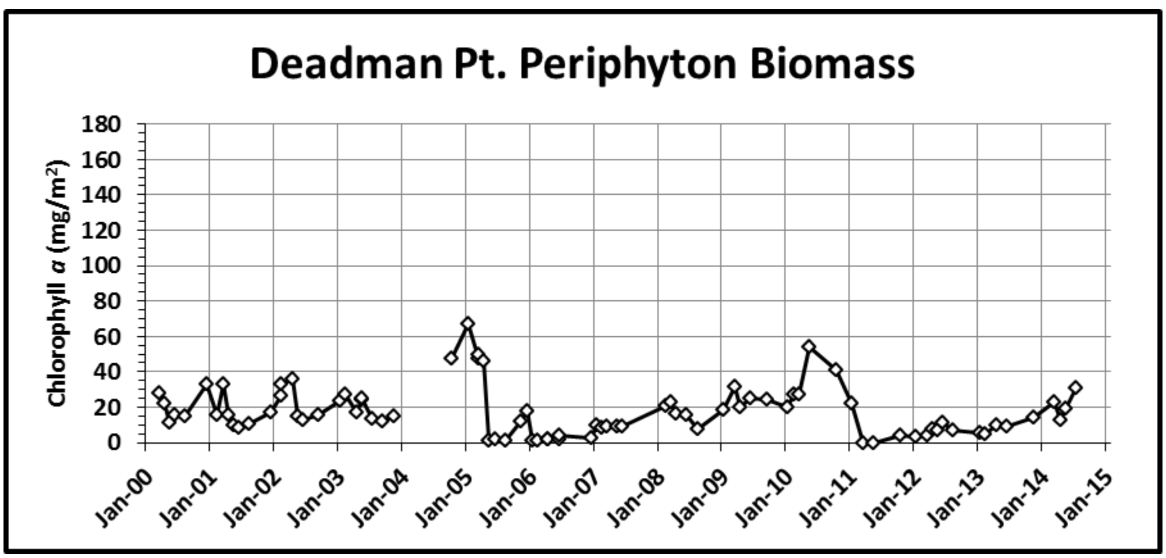

Figure 8 h. Deadman Pt. periphyton biomass (chlorophyll *a*) 2000-2014.

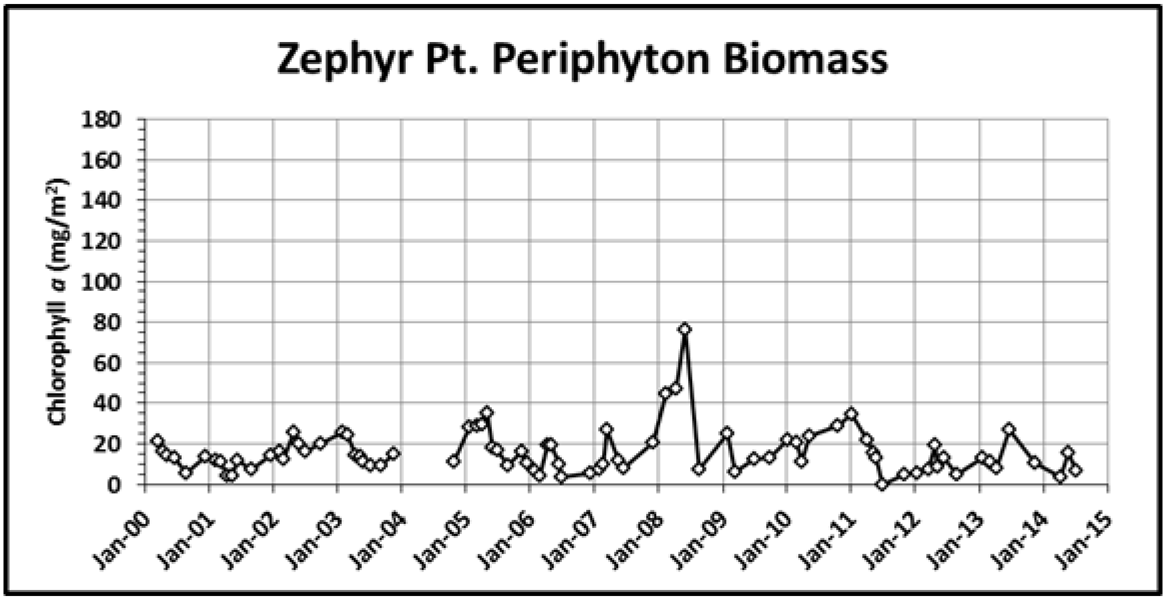

Figure 8 i. Zephyr Pt. periphyton biomass (chlorophyll *a*) 2000-2014.

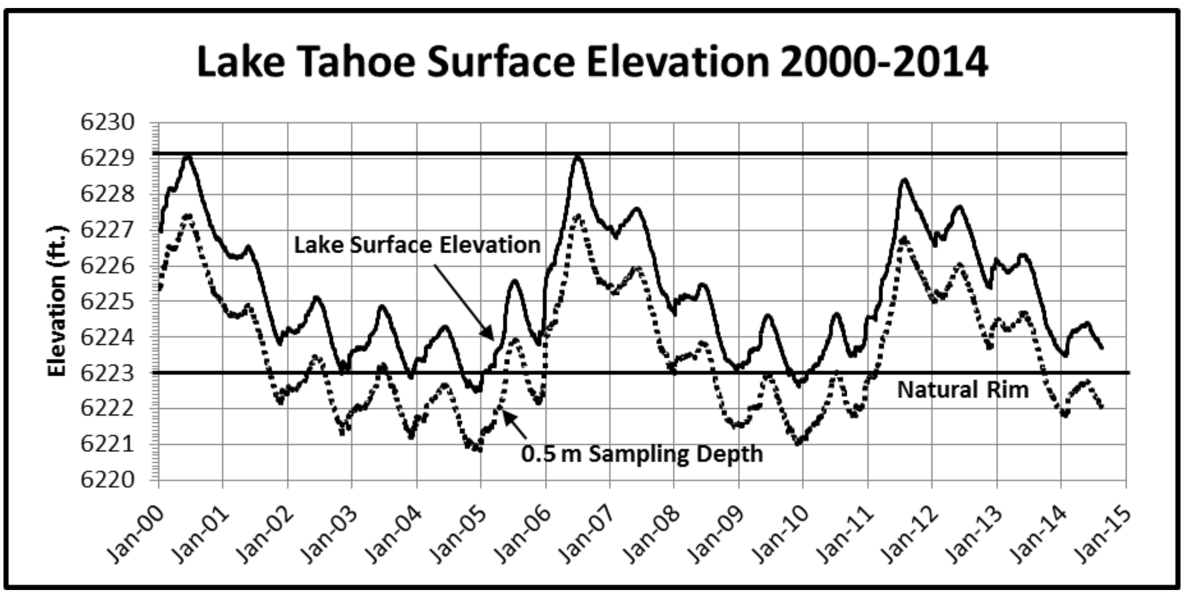

Figure 9. Fluctuation in Lake Tahoe surface elevation 1/1/00-8/19/14. Periphyton samples were typically collected during the period from natural rock substrata at a depth of 0.5m below the water surface. The 0.5m sampling depth (shown as a dotted line) fluctuates with the lake surface elevation. The elevation of the natural rim of Lake Tahoe is 6223 ft. The top 6.1 ft. of the lake above the natural rim (to 6229.1 ft.) is operated as a reservoir. Lake level data is from USGS web site (http://nwis.waterdata.usgs.gov).

Annual Maximum Biomass

WY 2014 annual maximum biomass values as estimated by chlorophyll *a* (Figure 10), showed a substantial decline in 2014 from levels in 2013 at Pineland, Tahoe City and Dollar Pt. At Dollar Pt. peak spring biomass was only 24 mg/m^2 in 2014 compared to 100 mg/m^2 in 2013. At Pineland, biomass peaked at 40 mg/m^2 in 2014, while the annual maximum was very high in 2013 (242 mg/m^2). Pineland peak spring biomass had been near or greater than 100mg/m^2 consistently since WY 2007. At Tahoe City, the peak value was 65 mg/m^2 in 2014 compared to 126 mg/m^2 in 2013. The lower annual maximums in 2014 at these sites may be associated with the environmental factors characteristic of this year mentioned above (i.e., lower precipitation, lower nutrient inputs associated with runoff, less frequent storms, and possibly wind-related events).

Annual maximums at the other routine sites showed less dramatic changes in 2014 compared to the previous year. Slight to moderate decreases annual peak biomass in 2014 were observed at Incline West, Rubicon Pt. and Zephyr Pt. Slight increases were observed at Sand Pt. and Deadman Pt. along the east shore. These increases were likely a result the contribution of chlorophyll *a* associated with Cyanophycean or blue-green algae on the rocks. The Cyanophycean algae area are relatively slow-growing algae, which form stable growths more typically slightly deeper in the upper sublittoral zone. As a consequence of lower lake levels in 2014 however, they were closer to the surface, at the 0.5m sampling depth and contributed to total chlorophyll *a*. At Sugar Pine Pt. the annual maximum was low and similar to the previous year.

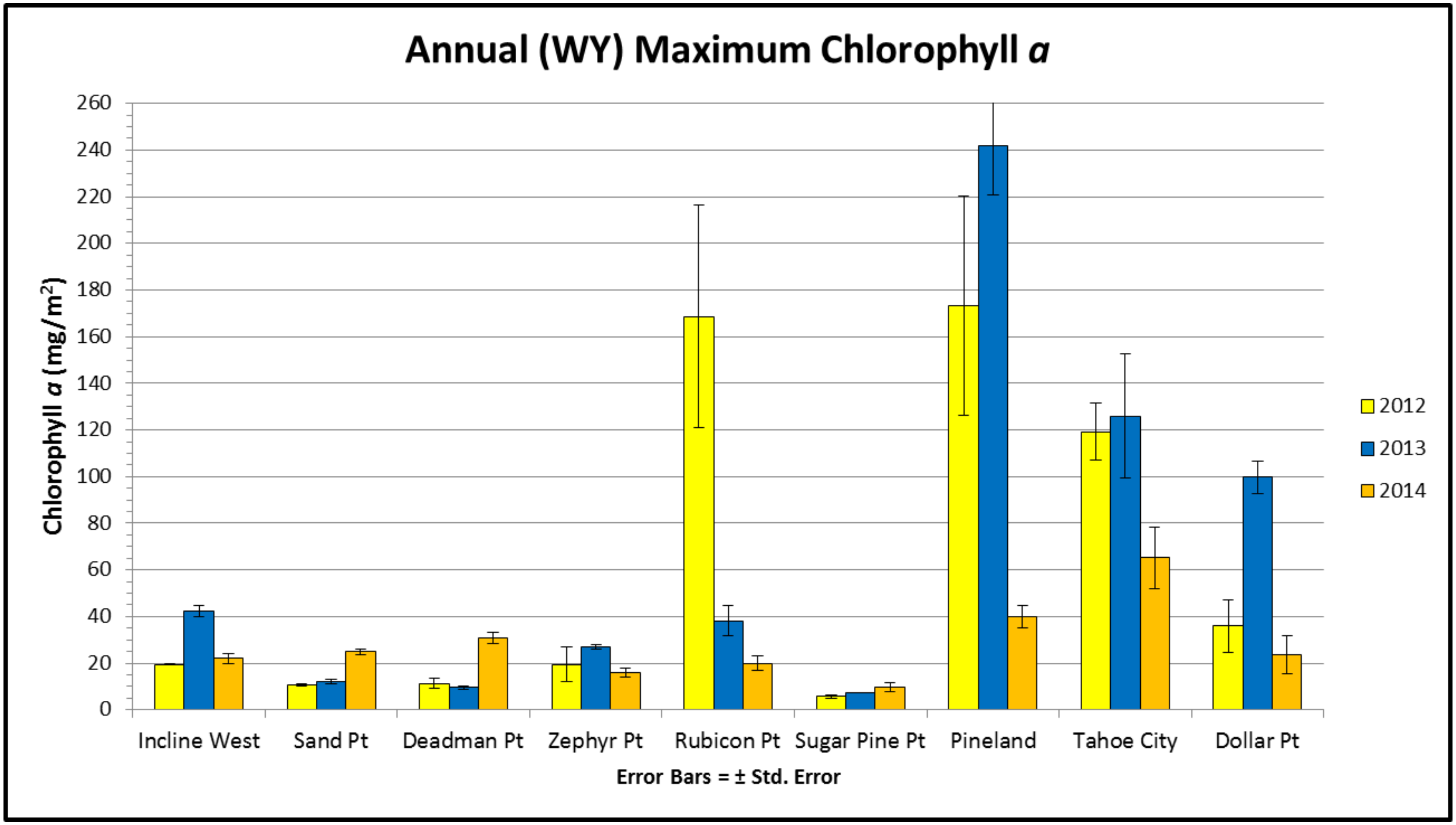

Figure 10. Maximum periphyton chlorophyll *a* for Water Years 2012-2014 at the nine routine periphyton monitoring sites at 0.5m.

Spring Synoptic Monitoring 2014

While the nine routine sampling sites provide data from many different locations around the lake with differing levels of backshore development and disturbance, the limited number of these sites does not provide enough resolution to determine nearshore periphyton biomass on a lake-wide scale. For this reason synoptic sampling was done in the spring of 2014, in which 45 sites in addition to the nine routine sites were assessed for the level of periphyton biomass. Table 14 presents the names and locations of these synoptic sites. This synoptic monitoring was timed as much as possible to correspond to peak periphyton growth in each region of the lake.

2014 Chlorophyll *a* to Periphyton Biomass Index Relationship

At all Spring Synoptic sites, a “Periphyton Biomass Index (PBI)” was calculated for each date to approximate the level of biomass present. The PBI provides a means to rapidly estimate the level of periphyton biomass without collection of samples at every site. Measurements of average algal filament length and percent coverage of algae over rocks at 0.5m were made while snorkeling. The Biomass Index was calculated by multiplying the average filament length (cm) of the periphyton by the estimate of percent coverage of algae over the rock. At a portion of the sites biomass samples were also collected for measurement of chlorophyll *a* and AFDW, to check the relationship between measured biomass and periphyton biomass index. Higher PBI should be associated with more material over the rock surface. TERC has been making measurements of PBI during spring synoptics since 2003.

The association between PBI and chlorophyll *a* was similar to the association for similar range spring values during 2011-2013. For the spring 2014 synoptic survey, the linear relation between chlorophyll *a* and Periphyton Biomass Index (Figure 11) had an R^2 value of 0.57 and the relation was described by the equation: Y=0.0191X+0.0072 where X is chlorophyll and Y is PBI. For values in a similar range (i.e. chlorophyll <82 mg/m^2) from 2011-2013 spring synoptic surveys, the R^2 was 0.52 and the linear equation was similar, Y=0.0215X+0.1403. The PBI generally appears to behave similarly to measured biomass and provides a means to rapidly assess levels of periphyton biomass at the synoptic sites.

Table 14. Periphyton Spring Synoptic monitoring locations.

SITE DESIGNATION	WEST SHORE	LOCATION
A	Cascade Creek	N38 57.130; W120 04.615
B	S. of Eagle Point	N38 57.607; W120 04.660
C	E.Bay/Rubicon	N38 58.821; W120 05.606
D	Gold Coast	N39 00.789; W120 06.796
E	S. Meeks Point	N39 01.980; W120 06.882
F	N. Meeks Bay	N39 02.475; W120 07.194
G	Tahoma	N39 04.199; W120 07.771
H	S. Fleur Du Lac	N39 05.957; W120 09.774
I	Blackwood Creek	N39 06.411; W120 09.424
	Kaspian Pt.	(Point near Elizabeth Dr.)
J	Ward Creek	N39 07.719; W120 09.304
K	N. Sunnyside	N39 08.385; W120 09.135
L	Tavern Point	N39 08.806; W120 08.628
TCT	Tahoe City Tributary	(adjacent to T.C. Marina)
M	TCPUD Boat Ramp	N39 10.819; W120 07.177
N	S. Dollar Point	N39 11.016; W120 05.888
O	S. Dollar Creek	N39 11.794; W120 05.699
P	Cedar Flat	N39 12.567; W120 05.285
Q	Garwood's	N39 13.486; W120 04.974
R	Flick Point	N39 13.650; W120 04.155
S	Stag Avenue	N39 14.212; W120 03.710
T	Agatam Boat Launch	N39 14.250; W120 02.932
	EAST SHORE	
E1	South side of Elk Point	N38 58.965; W119 57.399
E2	North Side of Elk Point	N38 59.284; W119 57.341
E3	South Side of Zephyr Point	N38 59.956; W119 57.566
E4	North Zephyr Cove	N39 00.920; W119 57.193
E5	Logan Shoals	N39 01.525; W119 56.997
E6	Cave Rock Ramp	N39 02.696; W119 56.935
E7	South Glenbrook Bay	N39 04.896;W119 56.955
E8	South Deadman Point	N39 05.998; W119 57.087
E9	Skunk Harbor	N39 07.856; W119 56.597
E10	Chimney Beach	N39 09.044; W119 56.008
E11	Observation Point	N39 12.580; W119 55.861
	NORTH SHORE	
E12	Hidden Beach	N39 13.263; W119 55.832
E13	Burnt Cedar Beach	N39 14.680; W119 58.132
	Incline Condo	N39 14.90; W119 59.63
	Old Incline West	(100 yds No. Incline West)
E14	Stillwater Cove	N39 13.789; W120 00.020
E15	North Stateline Point	N39 13.237; W120 00.193
E16	Brockway Springs	N39 13.560; W120 00.829
E17	Kings Beach Ramp Area	N39 14.009; W120 01.401
	SOUTH SHORE	
S1	Tahoe Keys Entrance	N38 56.398; W120 00.390
S2	Kiva Point	N38 56.555; W120 03.203
	Timber Cove Rocks	Rocks west T. Cove Pier

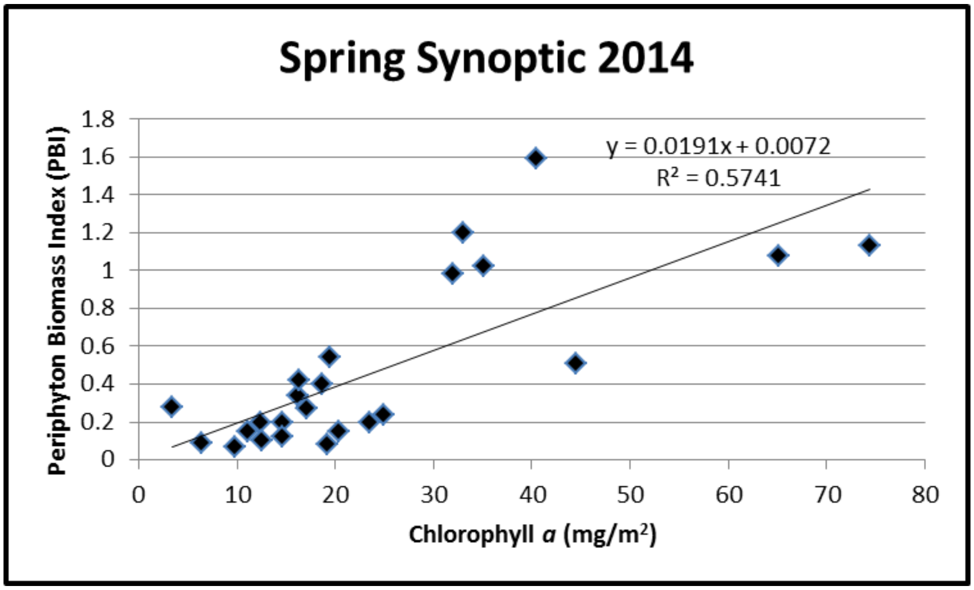

Figure 11. Relation between periphyton chlorophyll *a* and Periphyton Biomass Index for sites where both were measured during the 2014 spring synoptic survey.

Results of Spring Synoptic Monitoring 2014

The PBI values were used to prepare the map of synoptic biomass for spring 2014 (Figure 12). This map shows distribution of biomass around the lake during April 4 – April 18, 2014. 45 sites were monitored in addition to the 9 routine sites. Data collected for the 2014 spring synoptic survey are summarized in Table 15. This synoptic monitoring was timed as much as possible to correspond to peak spring periphyton growth in the lake. Based on a comparison of data throughout the year at routine sites and observations in the field, it appeared the synoptic survey occurred slightly after the peak at some sites (e.g., Pineland, and South Shore sites) and slightly before the peak at some north and east shore sites (e.g., Incline West, and Deadman Pt.).

Generally light biomass (indicated by the two shades of green, in the map) was observed along much of the shoreline around the lake during the 2014 spring synoptic survey. Growth was light along much of the north, east and south shore (with the exception of Timber Cove which had relatively heavy biomass). Regions of lighter biomass were also observed along the west shore including areas from north of Rubicon Bay to Tahoma, and much of the region north of Tahoe City to Kings Beach. When compared with previous spring synoptics done 2011-2013 (Hackley et al., 2013), the extent of shoreline with relatively light growth was greater in 2014. A combination of factors may have contributed to this widespread lighter growth including: lower precipitation, lower nutrient inputs associated with runoff, less frequent storms, and possibly wind-related events that may have disrupted algal growth early on.

Sites with moderate or heavier periphyton biomass also were observed in the Spring 2014 periphyton synoptic. Stretches of moderate biomass occurred along the west shore

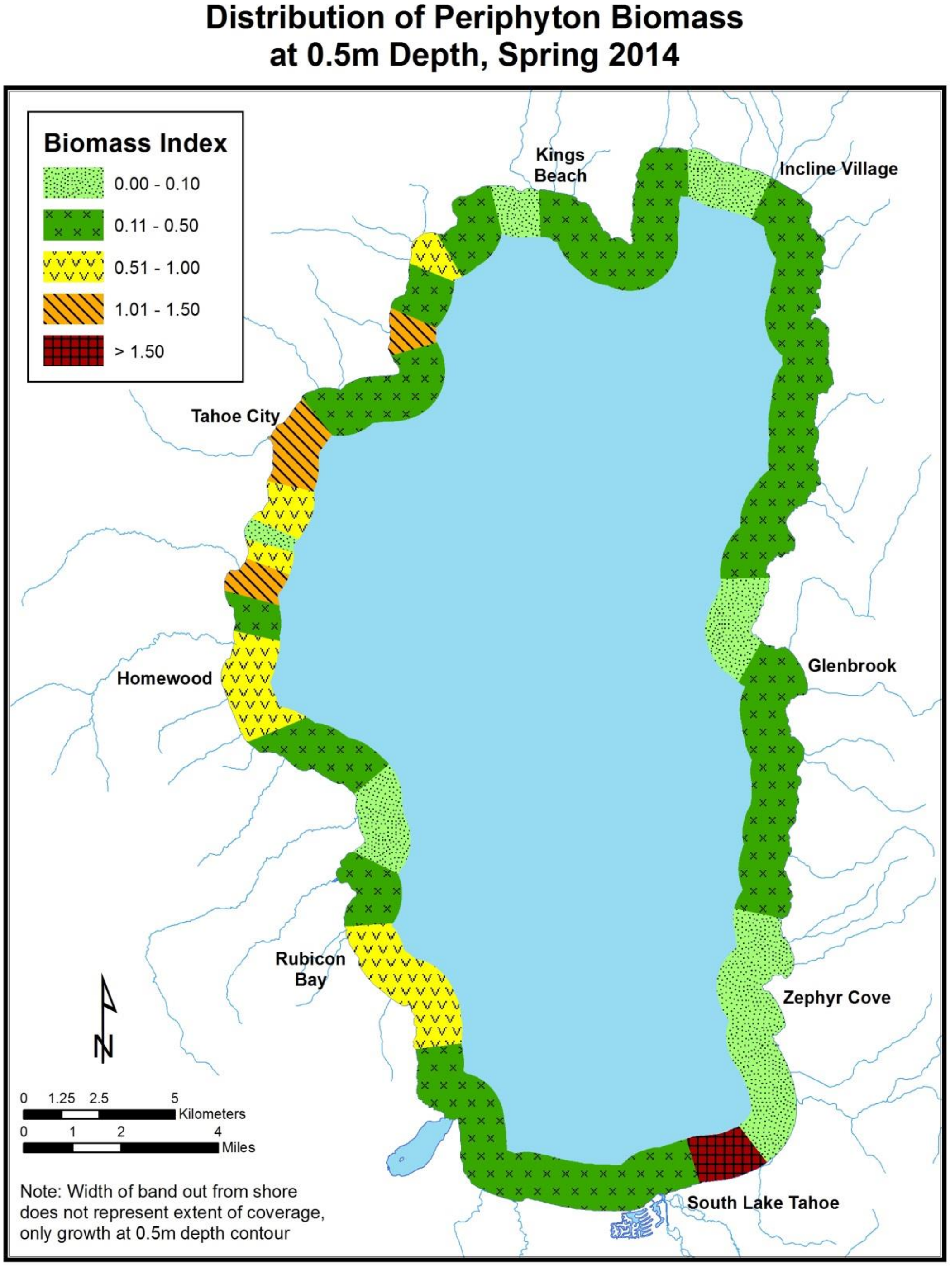

Figure 12. Extrapolated regional distribution of periphyton biomass measured as Biomass Index (Avg. Filament Length x % Area Covered with Algae) April 4-19, 2014.

Table 15. Summary of 0.5m periphyton chlorophyll *a*, Ash Free Dry Weight (AFDW), visual score, avg. filament length and percent algal coverage, predominant algae present based on visual observations while snorkeling (FG=filamentous greens; SD=stalked diatoms; CY= blue green algae), for routine sites (shaded) and Spring Synoptic survey sites during April 4-18, 2014. Note for chlorophyll *a* and AFDW, n=2 unless otherwise indicated. Visual score is a subjective ranking of the aesthetic appearance of algal growth (viewed underwater) where 1 is the least offensive and 5 is the most offensive. Biomass Index is filament length times percent algal cover. "NA" = not available or not collected; "NES" = not enough sample for analysis. Sampling depth and corresponding sampling elevation are also indicated.

Site	Site Name	Date	Sampling Depth/Elev (m/ ft)	Chl a (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (mg/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Cover. %	Biomass Index	Algal Type
A	Cascade Creek	4/14/14	0.5/6222.60	14.59	4.30	20.79	3.47	3	3	0.3	68%	0.20	CY,FG
B	S. of Eagle Point	4/14/14	0.5/6222.60					3	2.5	0.3	45%	0.14	CY,FG
C	E.Bay/Rubicon	4/14/14	0.5/6222.60					3	3	0.5	60%	0.30	CY,FG
	Rubicon Pt.	4/11/14	0.5/6222.60	19.39	0.63	21.80	6.49	3	3.5	0.8	68%	0.54	CY,FG
D	Gold Coast	4/14/14	0.5/6222.60	44.55	7.67	32.56	0.41	3	3	0.8	64%	0.51	SD,CY,FG
E	S. Meeks Point	4/14/14	0.5/6222.60					3	3	0.7	70%	0.49	SD,CY,FG
F	N. Meeks Bay	4/14/14	0.5/6222.60					3	3	0.5/0.1	50/75%	0.28	CY,FG
	Sugar Pine Pt.	4/11/14	0.5/6222.60	9.74	2.52	NES	NES	NA	2	<0.1	70%	<0.07	CY,SD
G	Tahoma	4/14/14	0.5/6222.60	20.41	3.27	21.98	4.35	3	2	0.3	50%	0.15	CY,SD
H	S. Fleur Du Lac	4/14/14	0.5/6222.60					3.5	3.5	1.2	67%	0.80	SD,CY,FG
I	Blackwood Creek	4/14/14	0.5/6222.60					2	3	1.8	30%	0.54	SD
	Kaspian Pt.	4/14/14	0.5/6222.60					NA	3	0.5	90%	0.45	SD,CY,FG
J	Ward Creek	4/14/14	0.5/6222.60	33.08	7.79(n=3)	22.53	0.80(n=3)	4	5	2.0	60%	1.20	SD
	Pineland	4/11/14	0.5/6222.60	31.96	10.70	32.26	4.44	3	4	1.5	65%	0.98	CY,SD
K	N. Sunnyside	4/14/14	0.5/6222.60					1	1	0.2	40%	0.08	SD
L	Tavern Pt.	4/14/14	0.5/6222.60					3	3	1.0	60%	0.60	SD
	Tahoe City	4/11/14	0.5/6222.60	65.18	22.92(n=3)	70.15	14.69(n=3)	4	4	1.8	60%	1.08	SD
TCT	Tahoe City Trib.	4/16/14	0.5/6222.62	74.44	4.76(n=3)	46.98	1.10(n=3)	4	4	1.5	75%	1.13	SD
M	TCPUD Boat Ramp	4/16/14	0.5/6222.62					3	3	0.7	25%	0.18	SD
	Lake Forest	4/16/14	0.5/6222.62					3	3	0.7	34%	0.24	SD,CY
N	S. Dollar Pt.	4/14/14	0.5/6222.62					2	2	0.3	60%	0.18	SD,CY
	Dollar Pt.	4/11/14	0.5/6222.60	23.52	11.45	11.64	2.77	2	2.5	0.3	65%	0.20	SD
O	S. Dollar Creek	4/16/14	0.5/6222.62	35.17	7.60(n=3)	25.87	7.58(n=3)	3	4	2.0/0.1	50/70%	1.02	SD,CY
P	Cedar Flat	4/16/14	0.5/6222.62					3	3	0.5	60%	0.30	SD,CY,FG
Q	Garwood's	4/16/14	0.5/6222.62					2	3	0.7	80%	0.56	SD,CY
R	Flick Point	4/16/14	0.5/6222.62	12.45	0.35	23.89	2.57	2	3	0.4/0.1	40/80%	0.20	CY,FG
S	Stag Avenue	4/16/14	0.5/6222.62					2	3	0.6	80%	0.48	SD,CY,FG

Site	Site Name	Date	Sampling Depth/Elev (m/ ft)	Chl a (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (mg/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Cover. %	Biomass Index	Algal Type
T	Agatam Boat R.	4/16/14	0.5/6222.62					1	2	<0.1	70%	<0.07	CY
E17	Kings Beach	4/16/14	0.5/6222.62					1	2	0.2	60%	0.12	SD
E16	Brockway Springs	4/16/14	0.5/6222.62	16.17	5.42	37.14	14.84	3	3	0.7/0.1	40/95%	0.34	SD,CY,FG
E15	No. Stateline Point	4/16/14	0.5/6222.62					2	2.5	0.3	60%	0.18	SD,CY,FG
E14	Stillwater Cove	4/16/14	0.5/6222.62					3	2.5	0.3	65%	0.20	SD,CY,FG
	Old Incline West	4/16/14	0.5/6222.62					3	3	1.0/0.1	50/75%	0.53	CY,FG
	Incline West	4/11/14	0.5/6222.60	16.31	2.66	23.30	1.99	3	3	0.6	70%	0.42	CY,FG
	Incline Condo	4/16/14	0.5/6222.62	18.72	1.87	36.46	3.60	2.5	3	0.5	80%	0.40	CY,FG
E13	Burnt Cedar Beach	4/18/14	0.5/6222.63					2	2	0.3	30%	0.09	CY,FG
E12	Hidden Beach offsh.	4/18/14	0.5/6222.63					1	2	0.2	50%	0.10	CY
	Hidden Beach insh.	4/18/14	0.5/6222.63	14.59	2.66	20.91	7.25	1	2	0.2	60%	0.12	SD,CY
E11	Observation Point	4/18/14	0.5/6222.63					3	3	0.5	50%	0.25	CY
	Sand Pt.	4/11/14	0.5/6222.60	24.87	1.92	40.10	5.98		2	0.3	80%	0.24	CY,FG
E10	Chimney Beach	4/18/14	0.5/6222.63					3	3	0.5	60%	0.30	CY,FG
E9	Skunk Harbor	4/18/14	0.5/6222.63	11.05	0.37	20.45	0.75	2	2	0.3	50%	0.15	CY,FG
	Deadman Pt.	4/11/14	0.5/6222.60	12.59	3.75	19.91	2.98	2	2	0.2	50%	0.10	CY
E8	So. Deadman Point	4/18/14	0.5/6222.63					3	3	0.6	50%	0.30	CY,FG
E7	So. Glenbrook Bay	4/18/14	0.5/6222.63					3	3	0.6	70%	0.42	CY,FG
E6	Cave Rock Ramp	4/18/14	0.5/6222.63	17.04	2.66	27.29	3.96	3	3	0.5/<0.1	50/70%	0.27	CY,FG
E5	Lincoln Park	4/18/14	0.5/6222.63					2	2	0.3	70%	0.21	CY,FG
E4	No. Zephyr Cove	4/18/14	0.5/6222.63					2.5	2	0.1	90%	0.09	CY,FG
E3	So. Zephyr Pt.	4/18/14	0.5/6222.63	19.17	6.79	16.53	7.51	2	2	<0.1	75%	<0.08	CY
	Zephyr Pt.	4/11/14	0.5/6222.60	3.36	0.53	NES	NES	2	2	<0.1	10%	0.28	CY,FG
E2	No. Elk Pt.	4/18/14	0.5/6222.63					1.5	1.5	<0.1	<1%	<0.01	CY,FG
E1	So. Elk Point	4/18/14	0.5/6222.63	6.43	1.34	NES	NES	3	3	0.1	90%	0.09	SD,FG
	Timber Cove Rock	4/4/14	0.5/6222.58	40.4	16.24(n=3)	29.40	6.80(n=3)		4	1.8	90%	1.59	SD,FG
S1	T. Keys Entrance	4/4/14	0.5/6222.58					3.5	3	0.5	60%	0.30	SD,FG
S2	Kiva Point	4/4/14	0.5/6222.58					3	3	0.5	50%	0.25	SD

interspersed with areas of lighter or heavier growth. Areas of moderate-heavy biomass occurred in several areas where heavier biomass has been observed in past synoptics. These sites included Ward Cr. mouth, Tahoe City, Tahoe City Tributary and South Dollar Cr, on the northwest shore and Timber Cove Rocks along the south shore. The Periphyton Biomass Index at these areas was lower in 2014 however than in 2013 (Table 16). Again, lower precipitation, lower nutrient inputs associated with runoff, less frequent storms, and possibly wind-related events that may have disrupted algal growth early on may have contributed to generally lighter biomass in 2014 compared to 2013.

Table 16. Comparison of Periphyton Biomass Index (PBI) at sites with heaviest biomass in 2014 with levels in 2013. Higher PBI was observed at the sites in 2013.

Site	2014 PBI	2013 PBI
Ward Cr. Mouth	1.20	5.00
Tahoe City	1.08	2.67
Tahoe City Trib.	1.13	2.38
South Dollar Cr.	1.02	2.70
Timber Cove	1.59	1.36

Predominant algal types in the periphyton around the lake during the spring synoptic survey showed some variation. A mix of Cyanophytes and filamentous green algae appeared to dominate the biomass along much of the north and east shore, as well as along the south west shore from Cascade Cr. to Rubicon Pt. A mix of Stalked diatoms and filamentous green algae dominated the biomass along the south shore. Stalked diatoms were predominant along the northwest shore from Blackwood to Dollar Pt.

Quality Assurance for Periphyton

The periphyton monitoring is designed to reflect the amount of attached algal biomass present in specific lake locations. There is no standard growth pattern that the collected samples can be compared to. Therefore it is assumed that the collected biomass is representative of the area in which it was collected. Assurances that collected samples are representative rely on replicate samples and expertise of the sampling personnel to place sampling tubes over sections of substrate that reflect the area's growth pattern. During periods of high standing biomass, when within site variability can be high, researchers may collect triplicate samples. The additional sample increases the statistical power of the analysis and can account for the presence of higher variability. Collection of the triplicate sample is left up to the discretion of the scientist. During the study period triplicate samples were collected for 2 of 45 routine site samples and 4 of 15 spring synoptic site samples.

Summary Points for Periphyton Monitoring

1. **The periphyton monitoring program continues to provide valuable data on levels of periphyton in the nearshore. This monitoring adds to a substantial historical data base on periphyton for Lake Tahoe, which can help to inform management decisions and future scientific investigations.**

2. **WY 2014 was characterized by generally low periphyton biomass at the routine monitoring sites, with only modest spring increases at two sites (Pineland and Tahoe City) in the NW portion of the lake and little or no increases at the other routine sites.**

3. **Several factors may have contributed to the low biomasses observed in WY2014. Factors considered most important include, lower precipitation, lower nutrient inputs associated with runoff, less frequent storms, and possibly atypical wind events.**

4. **Periphyton biomass at Pineland was reduced substantially relative to recent years. Pineland has consistently had high annual biomass (i.e., chlorophyll *a* near or above 100 mg/m^2) since 2007. However, in 2014 peak biomass was only 39.89 mg/m^2. In comparison, the spring peak the previous year, in 2013, was the heaviest in the last 11 years 242 mg/m^2.**

5. **During the 2014 spring synoptic survey, generally light biomass was present along much of the shoreline, including much of the north, east and south shore (with the exception of Timber Cove area along the south shore, which had fairly heavy biomass). Regions of lighter biomass were also found along the west shore including areas from north of Rubicon Bay to Tahoma, and much of the region north of Tahoe City to Kings Beach. When compared with previous spring synoptic survey done 2011-2013, the extent of shoreline with relatively light growth was greater in 2014.**

6. **Sites with moderate or heavier periphyton biomass also were observed in the spring 2014 periphyton synoptic. Stretches of moderate biomass occurred along the west shore interspersed with areas of lighter or heavier growth. Areas of moderate-heavy biomass occurred in several areas where heavier biomass has been observed in past spring synoptics. These sites included Ward Cr. mouth, Tahoe City, Tahoe City Tributary and South Dollar Cr, on the northwest shore and Timber Cove Rocks along the south shore. The Periphyton Biomass Index at these areas was lower in 2014 however than in 2013.**

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