Clowhom Project Water Use Plan

Clowhom Lake Littoral Zone Productivity Study

Implementation Year 7

Reference: COMMON-3

Validation of the Effective Littoral Zone Performance Measure

Study Period: 2006-2012

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August 9, 2018

CLOWHOM WATER USE PLANNING
Littoral Primary Production (COMMON 3)
Monitor Review and Meta-Analysis

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Technical Report

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Monitor Review and Meta-Analysis

August 2018

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Executive Summary

The purpose of this study was to summarize and analyze periphyton biomass data collected at depth in Clowhom Lake Reservoir over a four-year monitoring program (2007, 2008, 2009, and 2010). Periphyton were grown on artificial substrate consisting of vertically oriented, Plexiglas plates that were roughed on each side to promote adhesion and colonization. The plates were placed every 2 m to a depth of 22 m below the normal maximum reservoir elevation (El 53.34 m). Three such sets of plates, referred to as arrays, were installed in the reservoir consisting of two static treatment arrays (plates stay fixed relative to reservoir elevation) and a single dynamic array (plates moved with water surface elevation). The dynamic plates served as the control treatment for the study. The static arrays were designed to mimic the effect of fluctuating reservoir elevations on periphyton growth, while the dynamic array mimicked periphyton growth under stable reservoir elevation conditions. The objective of this experimental design was to validate a conceptual Effective Littoral Zone (ELZ) model used during the Clowhom Lake Water Use Planning (WUP) process to quantify the response of littoral habitat to alternative reservoir operating strategies.

A strong growth response was expected as photosynthetically active radiation (PAR) intensities varied with plate depth, however this did not occur. Though statistically significant differences were observed between plates near the surface compared to deep in the water column, the magnitude of variation was small compared to Stave Lake Reservoir, where a similar more intensive study was carried out. Periphyton growth exponents averaged 0.02 d^{-1} across all light intensities, which was comparable to the growth exponents in Stave Lake Reservoir when PAR intensities were at their lowest. The vertical orientation of plates was hypothesised to be the main cause for this slow growth, allowing the periphyton to slough off the plate when reaching a critical mass. This was seen as confounding the periphyton growth dataset, and therefore could not be used to validate (or update if possible) the ELZ model. All ELZ modelling therefore made direct use of the Stave Lake Reservoir model which was empirically derived from similar periphyton biomass studies. The light extinction coefficients and Clowhom reservoir bathymetry data were incorporated into the model, but light intensity and water temperature data relied on a standardized yearly pattern developed for the Stave Lake system.

A comparison of depth integrated periphyton biomass (DIPB) data found that values were highest when there were no deep drawdowns during the Mar 31 to Oct 31 growing period. Single reservoir drawdowns (needed for annual facility maintenance and repairs) that were carried out in the spring had the least impact of periphyton growth, while two drawdowns in a single year had the greatest impact, resulting in the lowest DIPB values. Drawdowns carried out only in the fall had a similar impact to years with two drawdowns. The outcome validates the WUP recommendation to limit drawdowns to the spring period to maximize littoral periphyton production. The expected gains in periphyton production however, were not fully realized in most study years. ELZ modelling showed that in most years, short term fluctuations in reservoir elevation negated the potential gains by repeatedly dewatering periphyton growth in the upper elevations of the reservoir. These short-term fluctuations became more prominent following WUP due to changes in turbine operations, which was limited to operating at full capacity or taken off line due to reliability concerns (BC Hydro 2013).

Results of this study work led to a rejection of impact hypothesis $H_0$1, showing that periphyton biomass at the static arrays, and by inference in littoral areas, do vary annually as a function of reservoir operations. However, impact hypothesis $H_0$2 concerning validation of the ELZ model (as it relates to the Clowhom Lake Reservoir) could not be addressed in this study due to concerns with how well the periphyton were able to adhere to the colonization plates. Because the ELZ model could not be validated, the two management questions related to this study work, both related to ELZ model accuracy, could not be addressed. However, the ELZ model developed for the Stave Lake reservoir, which was empirically derived (Bruce and Beer 2016), was adapted to the Clowhom Lake Reservoir setting and can be used to calculate *relative* changes in ELZ metrics (e.g., depth integrated biomass, upper and lower boundary elevations, or depth of maximum biomass) between reservoir operating alternatives.

The relationship between the ELZ model and fish production in Clowhom Lake Reservoir (COMMON2) could not be fully evaluated. The only fish metric suitable for comparison was the condition factor for rainbow and cutthroat trout. Though there was a 10-fold difference in ELZ across the three years with suitable fish data (2006, 2008 and 2010), there was no significant difference in the condition factors of either trout species. It would appear that littoral periphyton production had little effect on fish condition. This is consistent with the recent radio isotope study in Lower Campbell Lake Reservoir that showed leaf litter and phytoplankton production to be far greater sources of basal nutrients to the system. Terrestrial insects were also an important source. Littoral periphyton production however, only played a negligible role.

Wildlife studies at the wetland habitat immediately upstream of the Upper Clowhom Lake Reservoir have identified a risk to successful amphibian reproduction by the spring maintenance drawdowns designed to improve littoral periphyton production (Evelyn et al. 2016). One suggested mitigative measure was to move the spring drawdown recommended in the WUP to another time of year; in particular in the fall. Given how present turbine operations limit the expected benefits of spring drawdowns (relative to other times of the year) and that there appears to be little relation between littoral periphyton production and fish production, such a shift in timing may indeed be a feasible mitigation option. However, there may be other “watershed values” that conflict with such a change. A reservoir operations model based on the one used during the WUP (BC Hydro 2005) was developed as part of this study to allow such trade-off analyses, which includes an ELZ performance measure. Use of this model however, cannot be done in isolation and is therefore not considered part of the scope for this study. Changes to WUP operations will require follow-up monitoring, particularly considering the uncertainties that remain regarding the use of ELZ in Clowhom Lake Reservoir and its relationship to fish production.

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Introduction

1.1 Background

A Water Use Planning (WUP) process for BC Hydro's Clowhom hydroelectric facility was initiated May 2002 and completed May 2003. During the process, a Consultative Committee (CC) comprising of key stakeholders in the Clowhom Lake watershed (including representatives from BC Hydro, BC Ministry of Water, Land and Air Protection, Fisheries and Oceans Canada, Sechelt First Nation and Sunshine Coast Regional District) worked collaboratively to identify potential operating strategies for the Clowhom hydroelectric facility that attempt to balance the various environmental, social and economic interests in the area. At its conclusion, the CC recommended three key operational changes that had the potential to impact the fish and wildlife interests in the Clowhom watershed (BC Hydro 2005a):

1. Raise the minimum reservoir normal operating elevation from the historical level of El 47 m to El 49 m, except for special maintenance requirements (to be done in March if possible), emergencies, or dam safety concerns;
2. Limit annual maintenance-related drawdowns to the month of March, where minimum reservoir elevation can be as low as El 47 m; and
3. Increase the current diversion licence of 82.18 m^3s^{-1} to 100 m^3s^{-1}

When recommending these operational changes, the CC acknowledged that the impacts on fish and wildlife in the Clowhom watershed were uncertain, despite meta-analysis of available data, the performance measure modelling that was done, and the limited studies that were carried out at the time. Thus, in addition to the operational changes above, the CC recommended that monitoring studies be carried out to address the following three uncertainties (BC Hydro 2005b):

1. Operational impacts to obligate and facultative aquatic wildlife (study reference COMMON 1)

   The effects of reservoir operation on aquatic wildlife in the wetland habitat at the upper end of the reservoir could not be fully evaluated at the time of the WUP due to insufficient available information at the time. For decision-making purposes, it was assumed that there were no operational impacts. The true extent of impacts, if any, was uncertain.

2. Role of littoral zone in governing the productive capacity of the reservoir (study reference COMMON 2)

   There were two competing (and possibly synergistic) hypotheses discussed at the time of the WUP that could explain the decline in fish productivity observed since impoundment in 1958. The first was that reservoir operations had caused a significant loss of littoral productivity, which in turn impacted all fish species, including those residing in open waters. The second was that impoundment blocked a historical run of sockeye salmon from returning to Clowhom Lake, and hence removed an important source of nutrients to the system. For decision making purposes, it was assumed the first hypothesis was most probable, and that restoring littoral productivity through operational changes would improve productivity levels 'near' to pre-impoundment levels.

3. Validity of the ELZ Performance Measure (study reference COMMON 3)

   An effective littoral zone (ELZ) model was developed to predict relative changes in littoral productivity around the shoreline of Clowhom Lake Reservoir for a given reservoir operating alternative. The model was conceptually new and had not been validated, though it was used in other WUP processes. For the purposes of decision making, it was assumed that the model was valid and accurately predicted relative changes in littoral productivity.

The focus of this study is on the collation and analysis of monitoring studies associated with the ELZ performance measure (PM). ELZ monitoring was initiated in 2006 with the first set of data collected in 2007. These data however, were confounded by apparatus design issues and could not be used. Following a change in apparatus design, ELZ related data were collected in 2008, 2009 and 2010. Separate data reports were written for each year of study with no attempt to link the data sets or to analyses them with respect to ELZ PM performance. The primary objective of this study is to carry out these analyses and develop a more empirically-based ELZ model suitable for tracking changes in littoral development in response to changes in reservoir hydrology. Output of this modelling exercise was then used to compare the consequences of pre-WUP operations to the benefits expected by the CC from their recommended operational changes. Of direct concern is the effect on the reservoir's littoral habitat where a slight gain in production was expected.

The CC hypothesized that gains in littoral production could lead to improved fish production (COMMON2). Three years of fish productivity data have been collected as part of the COMMON2 study, which have already been summarized into a single report by Bates and Coombes (2012). The summary however, did not include analyses that relate fish production to the ELZ metric; a key requirement of COMMON2 study work. Thus, included in this report is an analysis of the Bates and Coombes (2012) data to determine if fish production is indeed linked to littoral production as measured by the ELZ metric.

The wildlife (COMMON1) studies are still ongoing and are not expected to be completed until 2026 (BC Hydro 2005a). However, a proponent-driven, species-at-risk study of the reservoir has identified a significant stranding risk to amphibian eggs and larvae by the WUP requirement to limit maintenance drawdowns to the month of March (Evelyn et al. 2016). A shift in the timing of this maintenance-related drawdown has been proposed as a means to mitigate this impact, but the consequences to littoral productivity could not be assessed without completion of COMMON 3 analyses. This analysis is included in this report as well.

1.2 ELZ Performance Measure

A reservoir's littoral zone is defined as the area of shoreline that remains wetted and receives sufficient light for aquatic plant life to grow. This includes periphyton; a mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces. In the case of Clowhom Lake Reservoir, which is an ultra-oligotrophic system with very low nutrient availability (Bruce 2003), periphyton was assumed to be the dominant form of plant life in the littoral zone.

Growth rates of these organisms have been shown to vary considerably as a function of available light intensity (e.g., Bruce et al. 2011, Perrin et al. 2016). Because light intensity tends to decline exponentially with water depth, so does periphyton growth, creating a complex growth profile over time. This is further complicated by shifts in day length and maximum solar intensity as seasons change. In a reservoir setting where water levels fluctuate, this photic zone that allows for periphyton growth also fluctuates, sometimes leaving communities that have been established at depth with insufficient light to maintain growth. In newly watered areas, periphyton have the opportunity to recolonize if given sufficient time but, can rapidly perish when dewatered, particularly in the summer when exposed to intense sunlight (Bruce et al. 2011).

To capture these exponential relationships and related time effects, an Effective Littoral Zone metric was developed to track the biomass of periphyton as it grows over time at different depths, taking into account the effects of available light (both intensity and duration of daylight hours) on the rate of periphyton growth at each depth interval, as well as whether the periphyton remain submerged. 100% mortality is assumed when periphyton are dewatered. Areas that are newly watered are assigned a nominal biomass value, representing the starting point for new growth (i.e., recolonization). At the end of a specified growing period (assumed to be March 1 to October 31 in this study), a periphyton biomass (PB) is derived for each depth interval, which is multiplied by the interval's areal extent to account for the reservoir's bathymetry. The result is a PB depth-profile for the reservoir that can be summarised in terms of a depth integrated periphyton biomass (DIPB) where periphyton biomass is summed across all depth intervals or by the boundary elevations that define a given DIPB percentile range. Greater detail on how these values are calculated is found in Section 2.5.

1.3 Management Questions

When identifying uncertainties, the CC expressed them in terms of management questions that had associated impact hypotheses. Thus, the overarching objective of this report was to test the impact hypotheses using the summarised data collected in the past 10 years of monitoring and in turn, address the companion management questions. With respect to the COMMON 3 studies, the management questions were identified as follows:

1. How accurate is the ELZ model and corresponding performance measure (PM) in predicting changes in littoral zone productivity as a function of reservoir operations?
2. Are there changes in model parameters or in the model algorithm that could improve predictive capability and reliability for future WUP processes, including those at other BC Hydro facilities?

Because the outcome of the COMMON 3 monitoring study was unavailable to Bates and Coombs (2012) for their 5-year review of fish productivity data, the following management question associated with the COMMON2 studies was also addressed in this study:

3. If a change [in fish productivity metrics] is observed, is it correlated with changes in littoral area as measured by the ELZ performance measure?

Finally, because a link has been identified between WUP reservoir operations and amphibian reproductive success (Evelyn et al. 2016), the following management question associated with COMMON 1 was also addressed:

4. If [wildlife species] diversity and use is low [in the wetland habitat] and the [reservoir] operational linkage high, what [additional or new] constraints would have to be put in place to ensure protection of that habitat, and possibly improve these values? Does the implementation of the WUP satisfy these criterions?

1.4 Impact Hypotheses

The Clowhom WUP CC identified the following impact hypotheses to be addressed in relation to the management questions 1 and 2 listed above:

$H_0$1: Depth-integrated periphyton biomass of the littoral zone ($DIPB_{Lit}$), relative to that offshore ($DIPB_{Pel}$), does not vary annually as a function of (i.e. is correlated to) reservoir operations.

$H_0$2: Measured ratio of $DIPB_{Lit}$ to $DIPB_{Pel}$ is correlated with that predicted by the ELZ model.

In the study terms of reference (BC Hydro 2005b), the term $DIPB_{Lit}$ referred to littoral production under the variable water level conditions, while $DIPB_{Pel}$ was the same, but under stable water level conditions. The reference to offshore or pelagic DIPB was related to the location of the study apparatus used to mimic stable water surface elevation (WSE) condition is the reservoir. In this study, $DIPB_{Pel}$ was more appropriately defined as DIPB under dynamic conditions ($DIPB_{Dyn}$); where the apparatus used to monitor periphyton growth was allowed to move with WSE. Conversely $DIPB_{Lit}$, was more appropriately defined as DIPB under static conditions ($DIPB_{Stat}$); where the apparatus used to monitor periphyton growth was fixed relative to varying WSE.

Methods

2.1 General Approach

The periphyton biomass data (measured as Ash Free Dry Weight, AFDW in units of g/m^2) used in this study were obtained from the annual monitoring study reports of Bates 2007, 2008; Bates and Staat 2009, and Bates et al. 2010, 2011, 2012. These were all entered into a single common database containing 635 records of data (excluding records with missing data). The periphyton biomass data were scanned for outlier values, of which only one was found and therefore was left unchanged, and growth rate calculated for each record. The procedure for calculating growth rate and other data treatments are presented in the sections that follow.

As indicated in Section 1.2, key to the ELZ calculation is the premise that periphyton growth varies as a function of water depth. As reservoir elevations drop, the photic zone shifts downward triggering and/or accelerating growth among lower elevation periphyton communities, which partially offset losses due to the dewatering of higher elevation communities. The first analytical task was to assess whether such a relationship was present in the data, and in doing so assess the relative success with which the field methods could mimic periphyton growth patterns in variable and stable water level conditions. The outcome of this initial assessment determined how subsequent analyses were carried out.

The ELZ model developed for the Stave Lake Reservoir was to initially serve as the starting point for model development in Clowhom Lake Reservoir, as it was empirically derived from a 10-year, more comprehensive dataset. The data from the Clowhom Lake Reservoir was used as a calibration dataset, from which the Stave Lake model could be modified so that it was specific to the Clowhom Lake watershed. The modified model would then be used to address the management questions outlined in Section 1.3 and their associated impact hypotheses. As discussed in Sections 3.1 and 4.1, the growth response of Clowhom Lake periphyton on the array apparatus appeared to have been compromised by the vertical orientation of the Plexiglas substrate used. As a result, the Stave Lake model could not be modified as planned. The Stave Lake ELZ model was therefore used in its largely unmodified form to address the studies management questions. This does raise some concerns regarding model accuracy however, because the comparison of all model outputs is relative to one another, these accuracy concerns do not necessarily impact the conclusions of this study.

In the sections that follow, the study design, field techniques and laboratory methods used for each monitoring year are summarised. Data handling methods are also described. This is then followed by a description of the Stave Lake Reservoir ELZ modeling algorithm and the data inputs that were used for each simulation year. Model inputs specific to the Clowhom reservoir that were incorporated in the ELZ model included the light extinction coefficients and the slope area of the reservoir at 0.1 m intervals (both obtained from Bruce 2003).

2.2 Study Design

In situ sampling of periphyton can be cumbersome and difficult to standardize, particularly at depth. As an alternative, artificial substrate was used to attract colonization and growth of periphyton for sampling. The substrate consisted of 5 mm thick Plexiglas squares that measured 15 x 20 cm in size. Both sides of each plate were roughened using coarse sand paper to promote adhesion. Grooves were also cut on both sides of the plates to help guide a 5 cm wide scraper down a 10 cm long path to collect a 50 cm^2 sample. Two samples were collected from each plate for a given sampling period, one on each side, which were in turn combined to form a single 100 cm^2 sample for biomass measurement. Both 50 cm^2 samples were scraped directly into a single glass jar and place on ice in a cooler for transport to the laboratory.

In total, there were 33 such periphyton growth plates used each monitoring year. These were grouped into three treatments of 11 plates each. The plates in each group were arranged 2 m apart in a vertically oriented linear array where the deepest plate was approximately 22 m below the maximum normal operating elevation of El 53.34 m. Two of these arrays were anchored to the reservoir bottom so that they remained stationary as the reservoir water surface varied over time (these are referred to as the static arrays). These arrays mimicked the conditions periphyton would experience along the reservoir's shoreline. The third array was hung from a large buoy on the water surface, so that the plates always moved in unison with the water surface (i.e., a dynamic array). This setup was designed to mimic a more lake like setting where water levels are relatively stable and periphyton growth occurs with seasonally maximum lighting conditions and without the risk of dewatering. This was considered the ideal state for periphyton growth and therefore served as the study's control group. The other two arrays were considered treatment groups; one located midway up the Lower Clowhom Lake, the other mid-way up the Upper Clowhom Lake. The control array was located adjacent to the Upper Clowhom Lake treatment array. All arrays were installed along the northern shore and were similarly exposed to the sun's daily cycle. A more detailed description of the periphyton growth apparatus, along with their precise locations, is provided by Bates et al. (2012).

The Periphyton growth arrays were generally installed in early spring and sampled every 4 to 6 weeks until late fall. Actual sampling dates and incubation periods varied considerably each study year. These are summarised in Table 1. It should be noted that in the study's first year (2007), the array apparatus did not function as well as expected, leading to treatment errors. As a result, periphyton samples collected in this first year were largely excluded from analysis unless otherwise specified (the 2007 control group data were still usable).

2.3 Laboratory Methods

Once in the laboratory, all the periphyton samples were flushed out of the sampling jars using distilled water and filtered at low vacuum pressure into a pre-weighed, pre-ashed, 0.45 µm, 47 mm glass fibre filter (GFF). The filter samples were placed in an aluminium weigh boat and dried in an oven at 100°C for 12-24 hours to ensure all moisture was eliminated from the filter sample. The oven-dried filter samples were then weighed and recorded as dry-weight (DW_{Oven}). The oven-dried filter samples were

Table 1. Summary of periphyton sampling dates for each study year and corresponding incubation periods that periphyton were given to grow.

Sample	2008		2009		2010	
	Date	**Incubation**	**Date**	**Incubation**	**Date**	**Incubation**
1	11-Jun	35	08-May	29	03-Jun	29
2	09-Jul	28	12-Jun	34	07-Jul	34
3	22-Aug	43	15-Jul	26	24-Aug	48
4	18-Sep	27	13-Aug	29	22-Sep	29
5	16-Oct	28	08-Sep	26	27-Oct	35
6	26-Nov	41			23-Nov	27

then ashed at 500°C in a muffle furnace for a minimum of 5 hours and then re-weighed (DW_{Muff}). Ash free dry weight (AFDW) was calculated as the difference between the DW_{Oven} and DW_{Muff} and expressed in terms of the mass of organic matter per unit area (g/m^2).

2.4 Data Analysis

2.4.1 Periphyton Growth Rates

Periphyton biomass tends to follow an exponential trajectory with time (Bruce and Beer 2012). As a result, growth (b) was estimated using the following equation:

$$b = \ln((x_t + x_o)/x_o)/t \qquad \text{(Eq. 1)}$$

where x_t is the AFDW biomass of periphyton at the end of a growth period lasting *t* days, and x_o is the starting biomass at time t = 0. It should be noted that 'b' represents the intrinsic biomass growth rate of the periphyton community being measured and has units of proportion per day. Unfortunately, the methods used in this monitoring program did not include a provision to directly measure a starting biomass 'x_o'. It was however, assumed to be 100 $\mu g/m^2$ based on the periphyton study of Bruce et al. (2011), which showed that starting biomass on similarly treated artificial substrate typically ranged from 50 to 160 $\mu g/m^2$. This value was also added to x_t to account for the fact that the starting biomass was generally comprised of residual organisms trapped on the roughened surface of the growth plate after it was scraped clean of periphyton. It was assumed that the starting biomass was the same for all plates and all sampling periods. Finally, the transformation was only done on those AFDW samples where the corresponding sampling plates were continuously submerged during the growth period. This avoided the confounding effects of substrate-dewatering that sometimes resulted from fluctuations in reservoir elevation. The outcome of this transformation process was a dataset of periphyton growth estimates (d^{-1}) that could be directly compared between sites and years, as well as a function of water depth.

Between year and site comparisons were done using a two-way ANOVA procedure on the growth rate data that were depth-averaged for each sampling period. These were considered independent measurements within each study year and site. Checks were carried out to ensure the data were normally distributed and homoscedastic between groups. Transformations were used to correct for non-normality and heteroscedasticity if required. Multiple comparisons were done using the Student Neuman-Kuels (SNK) test with the Bonferroni correction procedure.

Similar two-way ANOVA's were used to evaluate growth differences as a function of plate depth and study year. These were done separately for each study site. Growth rates were not depth averaged in this case. Between-site differences in growth depth profiles were assessed subjectively, relying on the outcome of the between-year and site ANOVA to help guide that assessment.

2.4.2 Depth Integrated Periphyton Biomass

Depth integrated periphyton biomass (DIPB) was calculated for each sampling date (Table 1) and the static array (treatment) data were compared to the dynamic array (control) data as $DIPB_{Stat}/DIPB_{Dyn}$ ratios. This is equivalent to the $DIPB_{Lit}/DIPB_{Pel}$ ratios used in the impact hypothesis statements (Section 1.3), which represents the proportional retention of periphyton biomass (PB_R) following exposure to variable WSE conditions. The proportional loss of periphyton biomass is derived simply as $1 - PB_R$. Negative ($1 - PB_R$) values indicated a net proportional gain in periphyton biomass. In addition to the ratios calculated for each static array, a 'theoretical' ratio was calculated directly from the dynamic array where depth integration only incorporated thee same fully submerged plates as each static array site. This represented the expected proportional loss (or gain) in biomass based solely on the effects of dewatering, and does not account for the effects of shifts in the photic zone. Finally, a modelled $DIPB_{Stat}/DIPB_{Dyn}$ ratio was calculated based on ELZ modelling outcomes (See the following section) where ELZ is calculated using the recorded water levels during a given incubation period and is compared to an ELZ if WSE was kept stable at El 53 m.

2.5 ELZ Modelling

For the WUP, the ELZ modelling algorithm assumed a "fixed layer" of periphyton would be added to an existing population on each day of simulation. This additive approach simplified the model, but was found to create incorrect outcomes when compared to empirical periphyton growth curves (Bruce and Beer 2016). Rather than continue with the additive growth approach to ELZ modelling, a revised model of periphyton growth was used which took into account it's exponential trajectory. The revised model was developed from the ELZ studies completed in Stave Lake Reservoir, which not only highlighted the importance of this exponential growth, but also revised the relationship of this growth to light. Analysis of the Stave Lake Reservoir periphyton growth data found that growth rates did indeed increase exponentially with light intensity, but over the range of available light conditions, growth rates tended to reach a maximum well before maximum light intensity was reached. This indicated that growth rates could become light saturated and that the relationship could be described using a hyperbolic saturation equation of the form Ax/(B + x) where A is considered the maximum rate of periphyton production and the B coefficient is the light intensity where the growth rate is 50% of maximum. Furthermore, it was found that production never slowed to near zero values. Rather it continued at very low light intensities and in one study, in near darkness (Bruce and Beer 2014). It was hypothesised that chemosynthesis driving that growth rather than photosynthesis and that the periphyton community was likely comprised of at least a few mixotrophic species (Bruce and Beer 2015a). Such periphyton growth rate curves were derived at four sites in Stave Lake system, with the following equation being chosen to be representative:

$$P_z = 0.024 + (0.046 + 0.0023*T)\cdot PAR_z/(PAR_{A50} + PAR_z) \qquad \text{(Eq. 2)}$$

Where;

P_z = Periphyton production rate at depth 'z'
T = Depth-averaged water temperature
PAR_z = Photosynthetically Active Radiation concentration at depth 'z'
PAR_{A50} = Photosynthetically Active Radiation level at which production is 50% of maximum

It should be noted that in Eq. 2 that maximum growth rate is derived as a function of water temperature is that the constant "0.024" represents the base level growth rate that is driven by chemosynthesis. The PAR term in this equation is defined as the hourly sum of photosynthetically active radiation concentrations (μmole/m^2/d) measured each day. The PAR intensity at which growth is 50% of maximum was found to vary with PAR at the water surface:

$$PAR_{50} = 55 + 0.41\cdot PAR_{Surface}^{0.65} \qquad \text{(Eq.4)}$$

and is likely the result of a changing periphyton community structure as available PAR changes over the course of the growing season.

For the Clowhom ELZ model, the periphyton growth rate equation was applied to depths ranging from El 53.4 m to El 22.9 m at 0.1 m intervals. PAR at depth was calculated using the simple exponential equation:

$$PAR_z = PAR_{Surface} \cdot e^{kz} \qquad \text{(Eq.3)}$$

where the light extinction coefficient k was set at 0.38 (Bruce 2003). The coefficient was assumed to be the same for the entire periphyton growing season. On any given day, shoreline areas that were above the water surface elevation were considered to have been dewatered and assigned a biomass value = 0, indicating that any periphyton that had grown at the elevation was now dead. Newly watered depths were assigned an initial starting biomass of 100 µg/m^2 (Bruce et al. 2011)

Unfortunately, the light intensity data collected during the WUP was found to be unsuitable for use in Eq. 2 and 3. The light was measured in lux units (Lumens/m^2), which was contains a much broader spectrum of light than PAR. Also for some years, there were significant gaps in the recorded data set. As an alternative, a standardized PAR dataset developed for the Stave Lake Reservoir ELZ model was used, which was based on a combination of *in situ* PAR observations at the Stave Lake Reservoir and light intensity data collected Metro Vancouver (Figure 1). Also unavailable was a daily time series of suitable water temperature data. These were simulated as well, using the algorithm developed for the Stave Lake Reservoir that uses daily PAR summed the previous 75 days as a predictor variable (Bruce and Beer 2016). This is also summarised in Figure 1.

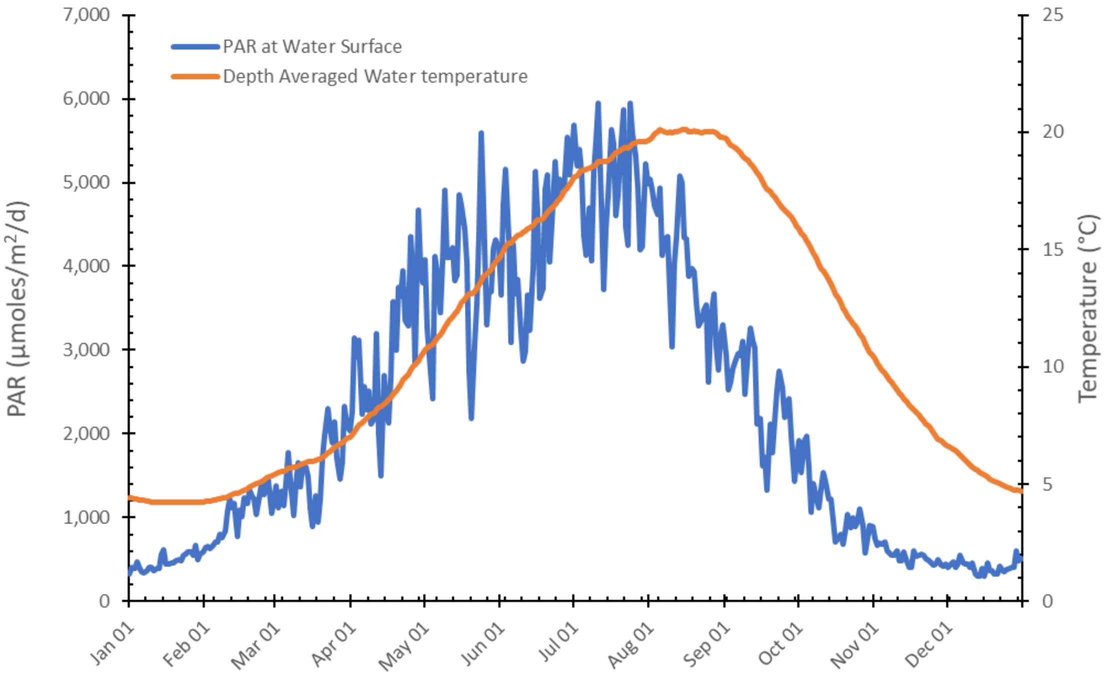


Figure 1. Plot of standardized PAR and depth integrated water temperatures for use in the ELZ model. These data were obtained from the Stave Lake Reservoir and were used repeatedly for each year of ELZ modelling.

The growing periphyton biomass was calculated for each day of the year between March 1 and October 31. This period was defined as the duration of the periphyton growing season for this study. The starting biomass of periphyton was arbitrarily set at 100 µg/m^2 at all water depths at the start of each simulation year. The number of years the ELZ algorithm was applied depended on the scenario being modelled. These included:

1. Individual incubation period during the monitoring program (2008 – 2010)
2. Pre-WUP$_{\text{Actual}}$: Pre-WUP operations based on recorded daily reservoir elevations (1994 – 2004)
3. WUP$_{\text{Actual}}$: WUP operations based on recorded daily reservoir elevations (2006 – 2016)

The ELZ output for each year was a depth profile of periphyton biomass densities (g/m^2) at 0.1 m intervals that was recorded on October 31, last day of the periphyton growing period. This output was then multiplied by the shoreline surface area (m^2) of each depth interval to obtain a biomass value in units of 10^3 kg. It is important to note that mortality, whether natural or by grazing, was not accounted for. Nor were potential density dependent effects taken into account (such as shading when periphyton mats thicken). Rather, the ELZ output was viewed as an indicator of periphyton growth potential. This output was calculated separately for each year of modelling and was summarised by integrating the growth potential data across all depths. Upper and lower boundary depths of this periphyton growth potential was also identified. These were defined as the upper and lower depths at which growth potential was greater than 0.1×10^3 kg respectively. These depth integrated biomass data, along with boundary elevations, were summarized across all years of simulation in terms of the median, minimum and maximum values. Statistical comparisons between model runs were done using the Mann-Whitney U test, model outputs were generally not normally distributed or homoscedastic.

3 Results

3.1 Periphyton Growth Rates

There was a total of 625 estimates of periphyton growth rates obtained throughout the study, including all plates, sites, sampling sessions and study years. This includes data from the control array in 2007, all the data collected in years 2008 through 2009, and the 41 plates that were found floating on the surface which indicated a dewatered state (i.e., assigned biomass value of 0 mg/m^2). The top most plate in the array (i.e., 2 m below El 53.3 m) was the most commonly found floating on the surface (26 of the 41 plates). On 15 of these 26 occasions with floating plates, a second floating plate was encountered, indicating that WSE was below El 49.3 m. In 2007, only data from the dynamic array was collected. The static array apparatus became entangled following deployment and reliable periphyton biomass samples could not be obtained. Thus the 2007 data were excluded from analysis except when the dynamic array data were analysed on their own.

Periphyton growth rates ranged from 0.000 to 0.058 d^{-1} and averaged 0.020 d^{-1} overall. The data were normally distributed with a variance of 6.16 x 10^{-5} and skewness of 1.113 (n = 468). These data excluded the plates found floating at the surface. There were however, two instances where growth rates were too small to accurately measure and were assigned a value of 0.000 d^{-1}. These were included in the dataset. Two-way ANOVA revealed significant between-year and between-site differences in periphyton growth ($F_{2,467}$ = 3.907, P = 0.021 and $F_{2,467}$ = 4.393, P = 0.013 respectively). However, there was no consistent pattern in these differences ($F_{4,467}$ = 6.940, P < 0.001), either across years or sites. Though statistically significant, these two variables were only able to explain 8.7% of the variance periphyton growth rates, the majority of which was due to the interaction between study year and site (5.4%). The study year and site variables explained 1.6 and 1.7% of the total variance respectively. A summary of study year and site means is provided in Table 2.

Table 2. Summary of study year and site mean periphyton growth rates (d^{-1}). The Static 1 site is located midway up the Upper Clowhom Lake, as is the Dynamic array site, while the Static 2 site is located midway up the Lower Clowhom Lake

Study Year	**Study Site**			
	Static 1	**Static 2**	**Dynamic**	**Mean**
2008	0.021	0.021	0.019	0.020
2009	0.025	0.017	0.020	0.020
2010	0.017	0.021	0.017	0.018
Mean	0.021	0.019	0.019	0.020

Among the plates that were sampled from the dynamic array (control group), mean growth rate was found to be 0.019 d^{-1} with values ranging from 0.002 to 0.049 d^{-1}. Two-way ANOVA on these data using plate depth and study year as factors found no significant difference between study year means when the 2007 data were included in the analysis ($F_{3,230}$ = 0.910, P = 0.437). There was however, a significant difference in mean growth rates across plate depths ($F_{10,230}$ = 2.192, P = 0.020). Multiple comparisons between plates means identified differences between the highest mean growth rate (0.021 d^{-1} at a plate depth of 6 m) and the three lowest mean growth rates at depths of 16 to 20 m as the main driver of the significant plate effect (Figure 2). The depth profile of periphyton growth rates however, was not consistent across study years, resulting in a significant interaction effect ($F_{30,230}$ = 1.618, P = 0.029). Overall, the plate depth and its interaction (difference in pattern) across study years was able to explain 27.1% of the total variance in periphyton growth rate (8.4 and 18.7% respectively).

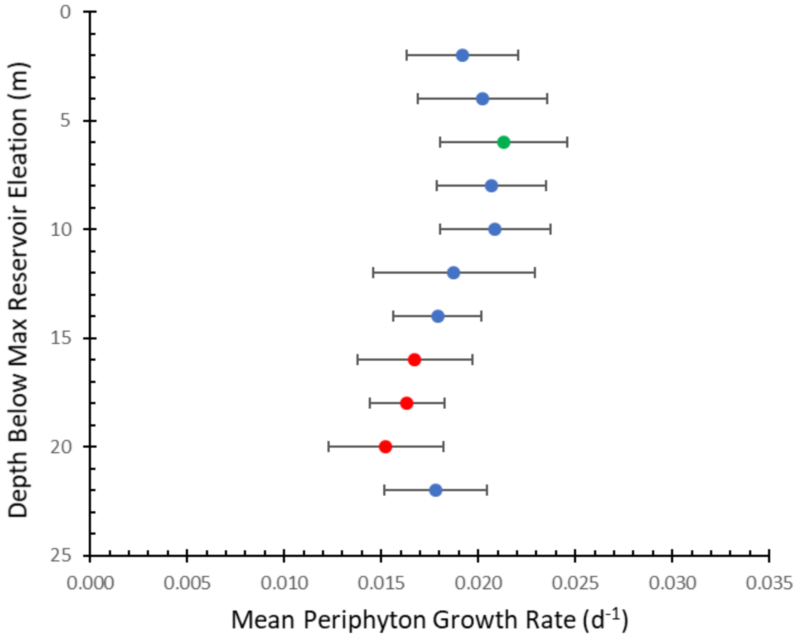


Figure 2. *Mean periphyton growth rates (± 95 % Confidence limits) as a function of plate depth (relative to maximum reservoir elevation of El 53.34 m) across all study years (2007 – 2010) at the dynamic array site. This represents the control response in the study. The green symbol represents the highest growth rate. The three symbols in red indicate the three lowest growth rates that were found to be significantly different from the peak value. The blue symbols indicate growth rates that were not significantly different from any other of the plate means.*

Two-way ANOVA of the periphyton growth rate data at the static array Site 1 revealed a depth profile similar to the dynamic array site, where the highest mean growth rate (found at a plate depth 10 m below maximum reservoir elevation) was significantly greater than the three lowest growth rates found at plate depths 18 to 22 m below maximum reservoir elevation (Figure 3; $F_{8,161}$ = 2.659, P = 0.009). The plate depth factor explained 10.2% of the variance in periphyton growth rates at the site (σ = 7.01 x 10^{-5}). Another 15.1% of this variance at the site was attributed to significant mean growth differences between study years (Table 1; $F_{2,161}$ = 15.743, P < 0.001). There was however, no significant interact term in the ANOVA ($F_{16,161}$ = 1.268, P = 0.226), indicating that the depth profile was relatively consistent between years, despite the differences in yearly means. The total variance in growth rates explained by the two significant factors in the ANOVA was 25.3%. It should be noted that the ANOVA excluded data from the two top-most plates, as these were frequently floating at the surface. As noted earlier, mean periphyton growth rate at this static (treatment) site was significantly greater than the dynamic (control) site (Table 2).

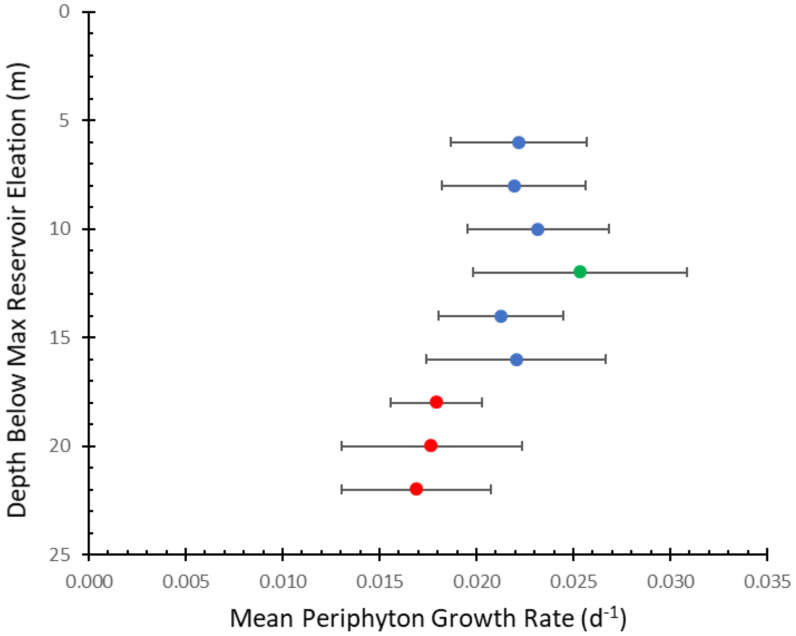


Figure 3. Mean periphyton growth rates (± 95 % Confidence limits) as a function of plate depth (relative to maximum reservoir elevation of El 53.34 m) across all study years (2008 – 2010) at the static array site 1 adjacent to the dynamic array in Upper Clowhom Lake. The green symbol represents the highest growth rate. The three symbols in red indicate the three lowest growth rates that were found to be significantly different from the peak value. The blue symbols indicate growth rates that were not significantly different from any other of the plate means.

When the two-way ANOVA was repeated with the static array data collected in Lower Clowhom Lake (Static 2), a different outcome was observed. A noted earlier, a significant difference in mean periphyton growth rates was observed between study years (Table 2; $F_{2,161} = 4.786$, $P = 0.010$). At the site, the study year effect explained 5.4% of the total variance in periphyton growth rates ($\sigma = 6.13 \times 10^{-5}$), which had a grand mean of 0.019 d^{-1}. Also different from the dynamic array site was the fact that there appeared to be no significant difference in periphyton growth rates across plate depths ($F_{8,161} = 1.211$, $P = 0.297$); nor was there a significant interact effect with study year ($F_{16,161} = 1.319$, $P = 0.194$). It should be noted again that the ANOVA excluded data from the two top-most plates, as these were frequently floating at the surface. A plot of mean periphyton growth rates as a function of plate depth is provided in Figure 4. Though ANOVA outcomes differed between the dynamic and static array at Site 2 in Lower Clowhom Lake, the site means were nearly identical (Table 2).

Depth-averaged periphyton growth rate for each sampling date (See Table 1) showed no apparent seasonal pattern when plotted over a calendar year (Figure 5), though there was subtle tendency for growth rates to be slightly higher in September than other times of the year. There was however, one outlier point on July 2, 2009 at the Static 1 Array, where growth was nearly double the overall average for the study (0.38 d^{-1} vs 0.20 d^{-1} respectively). This confounded the presence of any underlying trend. When ignoring the outlier, a seasonal trend became more apparent, but a 3rd order polynomial regression analysis found that it was insufficient to be statistically significant ($R^2_{Adj} = 0.081$, $P = 0.066$).

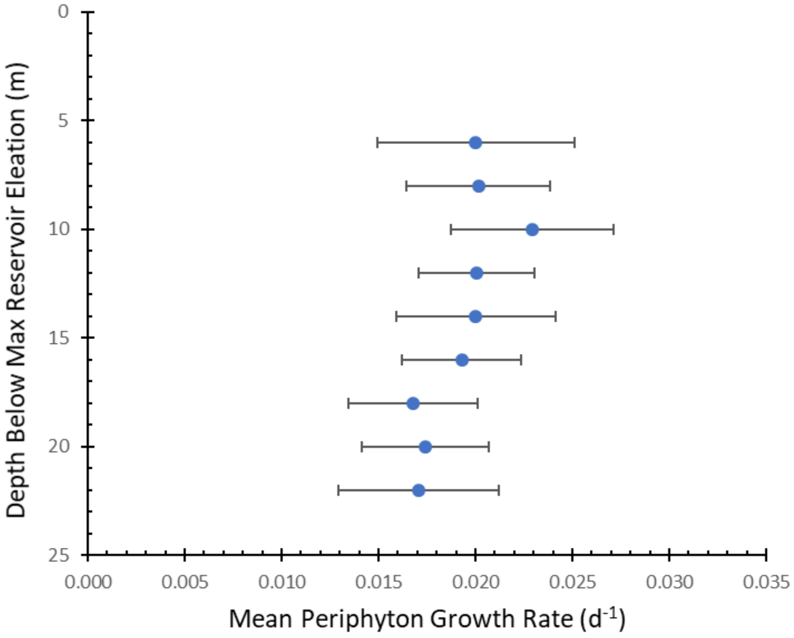
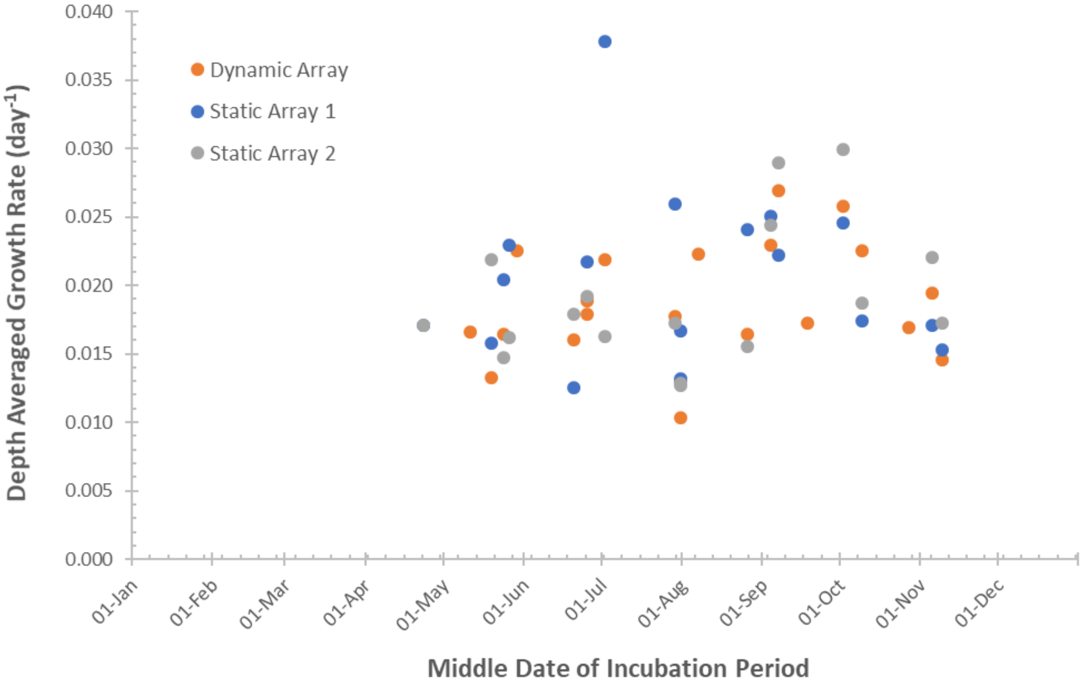


Figure 4. Mean periphyton growth rates (± 95 % Confidence limits) as a function of plate depth (relative to maximum reservoir elevation of El 53.34 m) across all study years (2008 – 2010) at the Upper Clowhom Lake Static array site (Static 2).



3.2 Depth Integrated Periphyton Biomass

Expected DIPB ratios for Static Array 1 ranged from 0.771 to 1.000 and had a median of 0.920. The range of DIPB_{Exp} ratios were nearly identical to that of Static Array 2 (0.770 to 1.000), but the median was slightly lower (0.889). There was however, no significant difference between the two when tested using the Mann-Whitney U test (U= 145.5, P = 0.177). Nor was there a significant difference between either of the two Static Array median DIPB_{Exp} ratios with that predicted by ELZ modelling (median ratio = 0.922, U = 124.0, P = 0.646 and U = 140.5, P = 0.253). The range of modelled DIPB ratios was also similar to the range observed at either static site (0.713 to 1.040).

The range of observed DIPB ratios at Static Array 1 was very different from either the expected or modelled DIPB ratios (Figure 6). The lowest observed ratio was 0.513 and the highest 2.159. The latter indicated >2-fold increase in possible growth rates at the Static Array 1 site, despite with variable reservoir elevations. Growth could also be half of what would be expected. This increase in the range of ratios relative to expected values was also observed at the Static Array 2 site, though it was not as broad (0.410 to 1.509). Despite the differences in range, the observed median DIPB ratio at the Static Array 1 Site was nearly identical with the expected median ratio (0.920 vs 0.918, U = 115, P = 0.933). This was also the case for the Static Array 2 site (0.929 vs 0.889, U = 137, P = 0.319). Overall, there was no significant difference across all median DIPB ratios, regardless of how it was calculated.

Figure 5. Seasonal distribution of depth-averaged periphyton growth rate data calculated for each incubation period

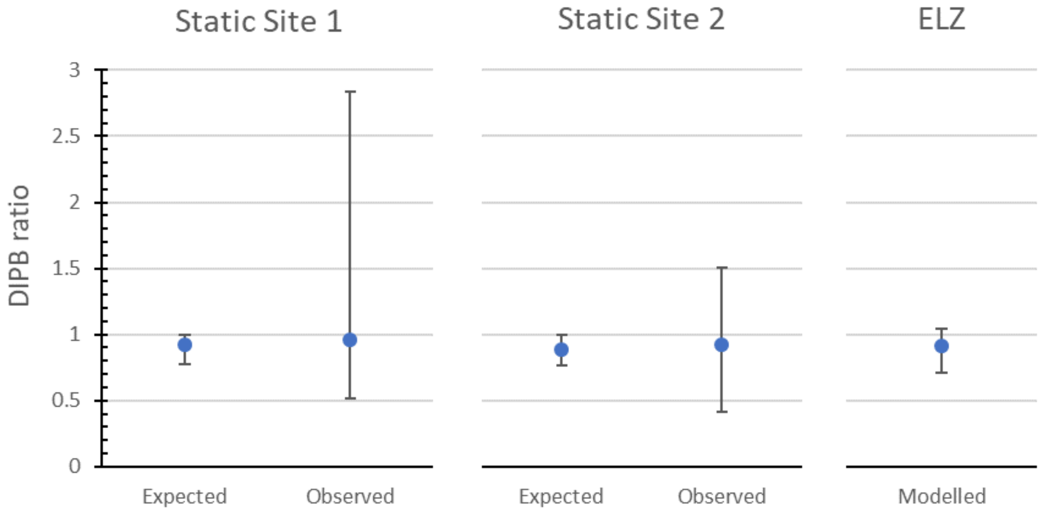
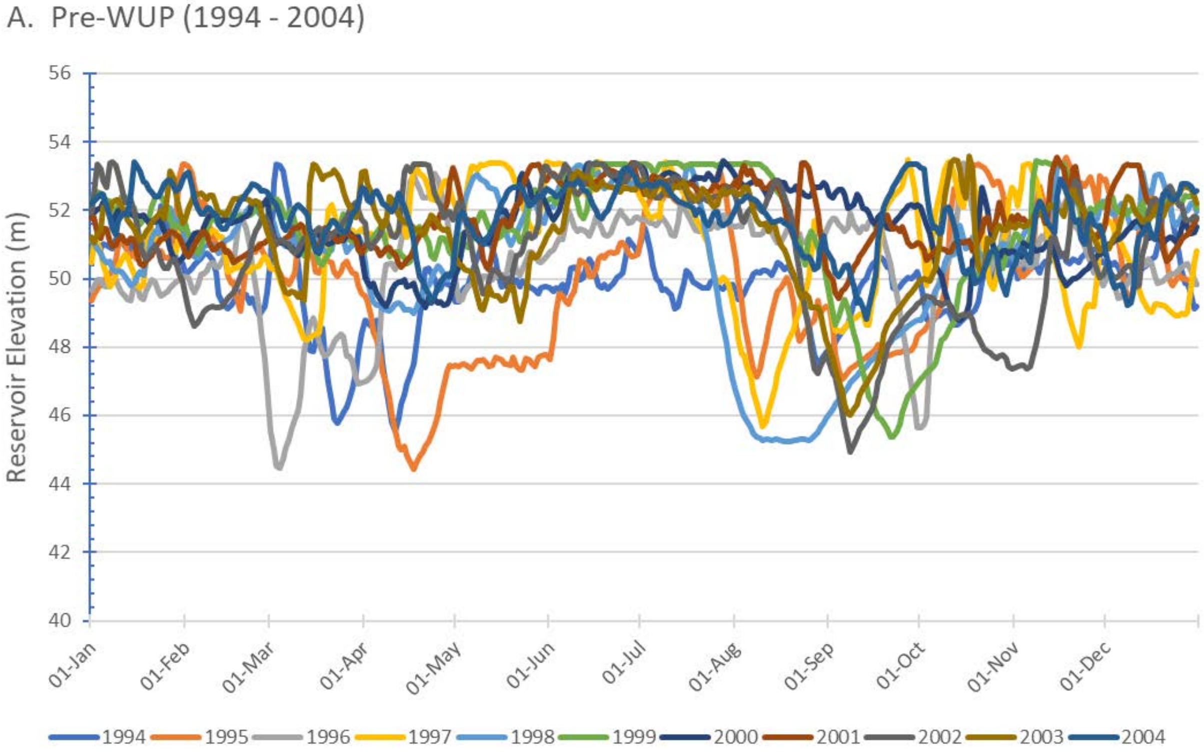


Figure 6. Median and range of expected, modelled and observed depth-integrated periphyton biomass (DIPB) Static: Dynamic ratios representing the proportional loss of periphyton biomass due to reservoir fluctuation.

3.3 ELZ Modelling

3.3.1 Reservoir elevations

Pre-WUP (1995 to 2005) and WUP (2006 to 2016) reservoir elevations are plotted as a function of time in figures 7A and B. There are clear distinctions between the two study periods that show the effects of WUP implementation. In the first period prior to WUP implementation, reservoir elevation regularly fluctuated between El 53.34 m and El 48 m with deep drafts down to El 45 m occurring



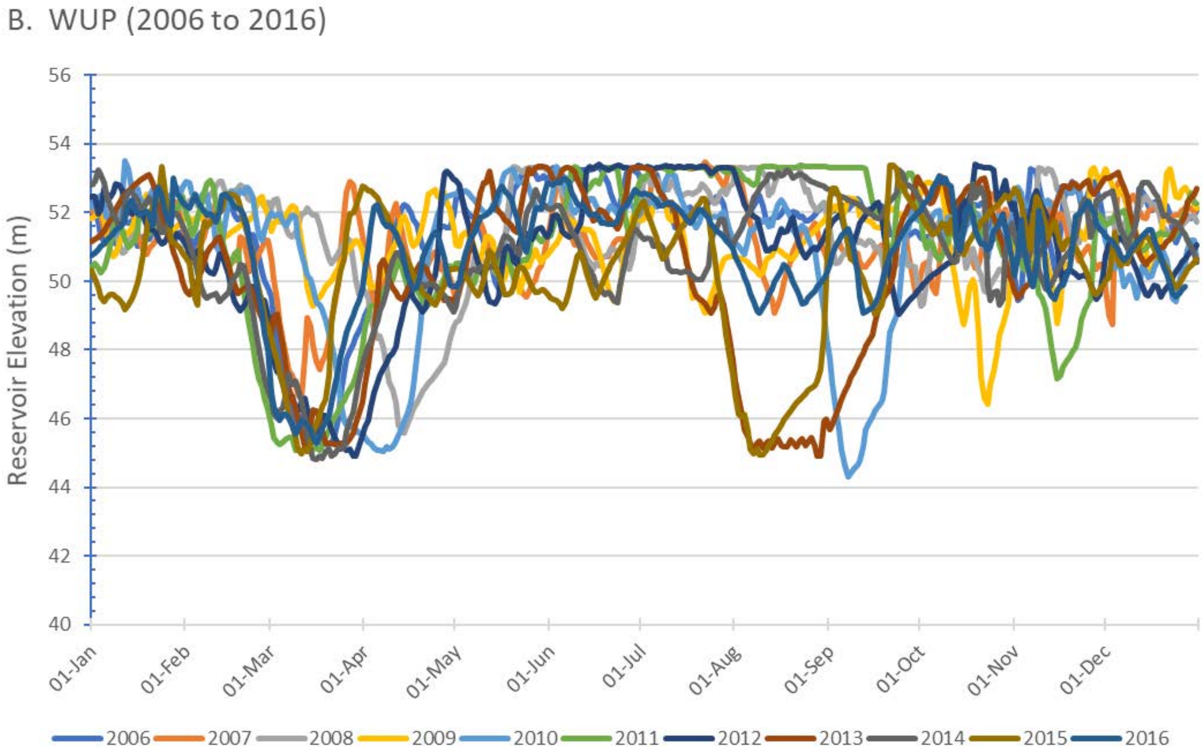


Figure 7. Clowhom Lake Reservoir elevation pre and post-WUP implementation.

in most years. Deep draw-downs occurred most frequently in the fall and in some years (3 out of 11 years), the spring as well.

Following WUP implementation, reservoir operations were constrained to a narrower range, with the lower limit being raised to El 49 m as recommended by the CC. Also, reservoir drawdowns associated with regular facility maintenance occurred in the spring, thus limiting the occurrence of maintenance drawdowns in fall (5 out of 11 years). It should be noted that a spring drawdown occurred in all years during the WUP phase of operations, and that fall maintenance drawdowns were in addition to the normal spring activity. This strong adherence to a scheduled maintenance protocol was not apparent in the reservoir operations prior to WUP implementation.

Though not immediately apparent in the elevation plots, another difference between the two study periods was an apparent increase in the amplitude of short term reservoir fluctuations (with a periodicity < 3 weeks) following WUP implementation. This was most apparent in the summer, where in most years prior to WUP implementation, short-term reservoir elevation fluctuations were relatively shallow and had short periodicities. This shallow cycling increased in amplitude following WUP implementation, despite a narrowing of the normal operating range. This was apparently in response to turbine reliability concerns which limited operations to either 'On' or 'Off' modes (BC Hydro 2013). Under this constraint, the reservoir would typically be drafted by operating the turbine unit at full capacity, then allowed to refill by taking the unit off line.

3.3.2 ELZ results

ELZ model outputs for the pre-WUP and WUP daily times series of reservoir elevations are summarized in Figure 8 and Table 3. Annual periphyton growth potentials ranged from 92 to 3410 x 10^3 kg during the pre-WUP phase of the study period and 46 to 1831 x 10^3 kg during the WUP phase. Medians were 297 and 419 10^3 kg respectively. Although the difference in medians would suggest better periphyton growing conditions during WUP operations, a Mann-Whitney U test showed that it was not statistically significant ($U_{2,10} = 65$, P = 0.797). The range data however do suggest that there was a better chance for high periphyton growth during the pre-WUP operations compared to the WUP condition as both the upper and lower bounds were higher.

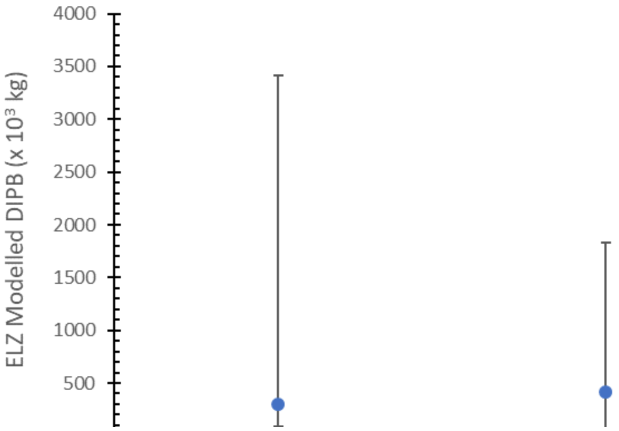


Table 3. Yearly periphyton growth potential, measured as depth integrated periphyton biomass during the Mar 1 to Oct 31 growing season, and its relationship to whether there was a spring and/or fall drawdown. The checks note those years where a drawdown occurred, but was close to or outside the growing season period.

Reservoir.

Pre-WUP				**WUP**			
Year	DIPB (x 10^3 kg)	Drawdown		Year	DIPB (x 10^3 kg)	Drawdown	
		Spring	Fall			Spring	Fall
1994	1226	✓		2006	612	✓	
1995	357	✓	✓	2007	1831	✓	✓*
1996	232	✓	✓	2008	192	✓	
1997	125		✓	2009	615	✓	✓*
1998	263		✓	2010	46	✓	✓
1999	97		✓	2011	420	✓	
2000	2171			2012	263	✓	
2001	3410			2013	222	✓	✓
2002	92		✓	2014	542	✓	
2003	297		✓	2015	224	✓	✓
2004	2675			2016	997	✓	

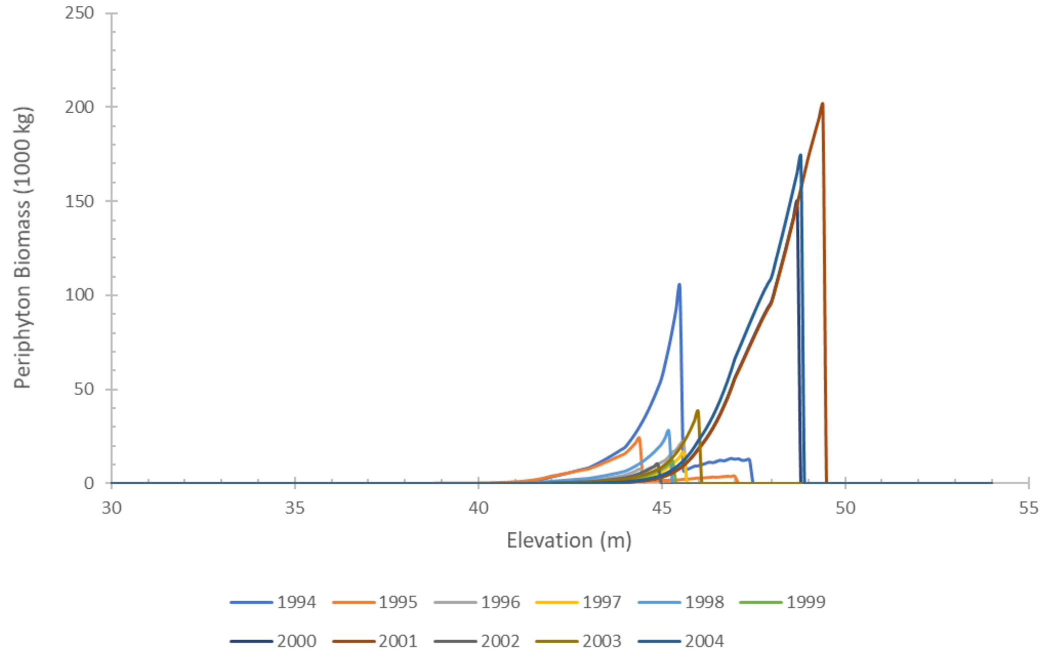
A closer assessment of the links between reservoir operation and periphyton growth potential found that during the pre-WUP phase, years with neither a spring or fall drawdown had the highest BIPB values (median DIPB = 2675 x 10^3 kg, n = 3; Table 3). In contrast, years with a fall drawdown, regardless of whether there was a spring drawdown or not, had the lowest potential for periphyton growth (median DIPB = 232 x 10^3 kg, n = 7; Table 3). For the one year with just a spring drawdown, growth potential was roughly midway between these to extremes (DIPB = 1226 x 10^3 kg). During WUP operations, there was a spring drawdown every year. In those years when there was also a fall drawdown (excluding the late Fall drawdowns in 2007 and 2009 which occurred near to or after the Oct

31 end of the growing season), median DIPB = 222 x 10^3 kg (n = 3; Table 3); similar to that pre-WUP. In the absence of a fall drawdown (including those of 2007 and 2009, the outcomes were mixed with growth potentials ranging from 192 to 1831 x 10^3 kg (n = 8; Table 3). The median DIPB in the latter case was 577 x 10^3 kg.

The depth profile of periphyton biomasses for each year of ELZ modelling revealed a potential cause for this variable outcome in WUP DIPB data when there was no fall drawdown (Figures 9a and b). Prior to WUP, short term fluctuations in reservoir elevation were small in amplitude and had short periodicities. This allowed for relatively smooth, highly peaked depth profiles to develop. This was the main reason why DIPB values were so high where reservoir elevations were relatively stable. In contrast, such smooth peaks rarely occurred during the WUP period, Rather, most appeared to have a 'saw-toothed' profile, indicative of frequent, deep (within WUP constraints), but short-term reservoir fluctuations. This was indeed observed in the reservoir elevation timeseries during the WUP phase of operations and was found to be a result of changes in how the facility is operated due to facility reliability concerns.

It is also interesting to note that the range of elevations with notable periphyton growth (i.e., modelled periphyton biomass > 0.1 x10^3 kg) did not differ significantly between study phases. Prior to WUP implementation, the median upper and lower boundaries of notable growth potential was El 49.0 and 41.15 m respectively. After WUP implementation, the median upper and lower boundaries were

El 45.8 and 41.2 m respectively. Though there was an apparent large difference in median upper boundaries El 45.8 m vs El 49.0 m) the difference was not statistically significant ((Mann-Whitney $U_{2,10}$ = 62, P = 0.192) due to the wide range of values within each study phase. The median lower boundaries



A. Pre-WUP, Mar 1 - Oct 31

B. WUP, Mar 1 - Oct 31

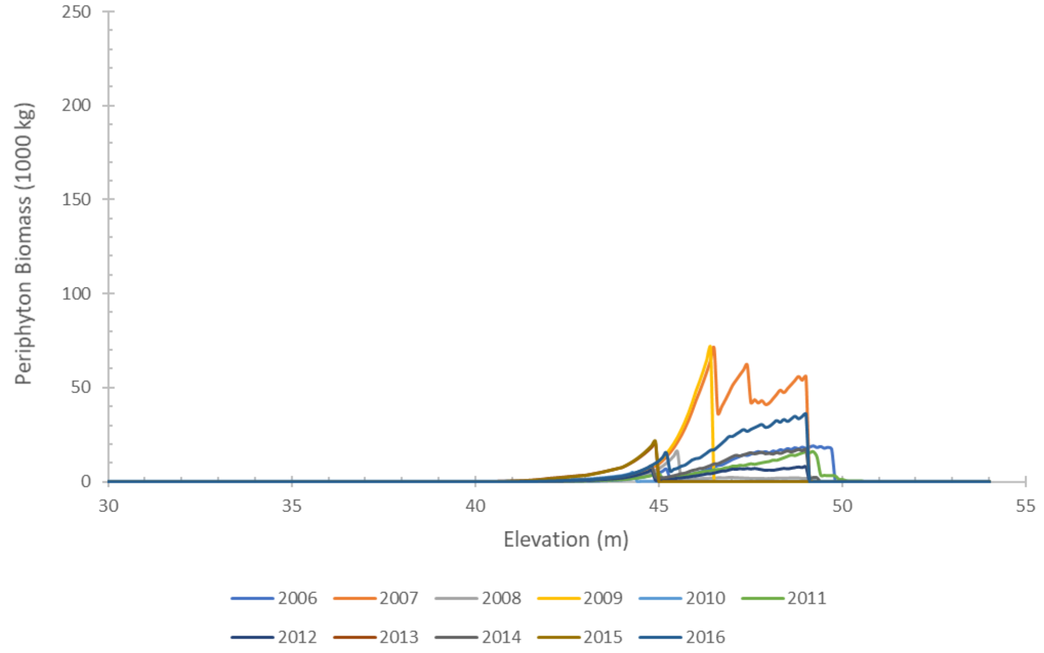


Figure 9. *Annual Periphyton growth potential (total biomass on Oct 31) as a function of reservoir elevation illustration the depth profile of that growth potential.*

were nearly identical.

4 Discussion

4.1 General study outcomes

4.1.1 Periphyton Grow Rates

The concept of an effective littoral zone, measured in terms of primary production in the form of epipelic periphyton growth, is predicated in the assumption that the availability of light (in the form of photosynthetically active radiation) plays a dominant role governing periphyton growth. As water levels drop in a reservoir, higher light intensities are brought to deeper areas of the reservoir shore, thus accelerating growth in those areas. This was clearly demonstrated in Stave Lake Reservoir where a similar but more intensive investigation of the ELZ concept was carried out (Bruce and Beer 2016). At very low light intensities, there was a base level of periphyton growth that appeared to be driven by heterotrophic organisms capable of mixotrophy (growth by either chemo or photosynthesis). As light intensity increased, photosynthesis appeared to play a greater role in growth among the mixotrophs, and autotrophic growth became increasingly more prevalent. The increase in growth however reached a saturation point where growth became largely independent of light intensity. At very high light intensities, photo-inhibition may occur, where excessive light intensities interfere with photosynthetic efficiency (Wetzel 2001). This however, was not observed in the field at Stave Lake Reservoir. Base level of periphyton growth was estimated to be 0.024 d^{-1} and increased with light intensity to a maximum of 0.104 d^{-1}. Once the maximum was reached, growth remained constant rather than decrease due to photo-inhibition.

In Clowhom Lake Reservoir, this pattern of growth with light was not observed. Though a statistically significant growth relationship was found with light intensity at depth, the range of variation was very small when compared to the range of values observed in Stave Lake Reservoir. In fact, periphyton growth rates rarely exceed the 0.024 base growth level observed in Stave Lake Reservoir. The lack of a strong light intensity response in the periphyton growth data was also noted in the time plots where growth rates showed little change over the course of the growing season. The reason for this in uncertain. Both the Stave Lake and Clowhom Lake reservoir share a similar orientation relative to the suns seasonal arc, though Stave Lake is a much larger reservoir with less shadowing from adjacent mountains. Epilimnetic water temperatures (average temperature of the top 8 m of water) are also similar, both peaking in late august/early September in the range of 18 to 22°C. Nitrate nitrogen concentrations in February when the Clowhom Lake samples were collected by Bruce (2003) were much lower than that of Stave Lake at the same time of year (mean = 99 vs 156 µg/L respectively; Bruce 2003, Bruce and Beer 2016). Nitrogen nitrate levels are typically at a seasonal high for this time of year, suggesting that nitrogen availability in Clowhom Lake is less than Stave Lake reservoirs. In contrast, total phosphorus levels in Clowhom Lake Reservoir were nearly double that of Stave Lake Reservoir (mean = 4.3 vs 2.2 µg/L respectively; Bruce 2003, Bruce and Beer 2016). Though nutrient concentrations were slightly different between reservoir systems, both are considered to be ultra-oligotrophic where primary production is severely limited by the lack of available nutrients. Whether the differences above are sufficient to explain the lack of a strong light response in periphyton growth is unclear. It is possible that growing conditions were much poorer in Clowhom Lake Reservoir and that sampling intervals were not long enough to establish measurable growth differences between sampling plates. Regression analysis did reveal a significant relationship between interval length and growth rate across all years of study

($R_{Adj}^2 = 0.160$, $P = 0.004$), but the direction of the regression was opposite that expected; i.e., higher growth rates were more commonly encountered when sampling intervals were shorter.

Another possible cause for the lack of a strong light response is the orientation of the sampling plates. In the Stave Lake study, all sampling plates were oriented along a horizontal plane, creating flat surfaces that did not rely on strong attachment mechanisms for colonies to grow. In the Clowhom Lake study, all plates were vertically oriented. Thus, for colonies to establish and growth to occur, the periphyton had to firmly attach themselves to the plate and not slough off when the periphyton matte became too thick. Sloughing could explain the negative regression between growth and sampling interval. At short time intervals, plate biomass increases steadily, but as sampling interval lengthens, the chances of sloughing increases, limiting the amount of biomass that can remain attached to the plate. Consequently, growth rates gradually become lower since biomass stops increasing with time due to sloughing. The vertical orientation of plates may also have affected the amount of light hitting it. When perpendicular to the sun's direction, light would have directly hit one surface but, not the other. Light would have had to penetrate the plate to reach the other side or receive light in the form of background scatter. If the plates were in line with the sun, neither surface would have received direct sunlight. The extent with which the plates maintained their orientation relative to the sun over time is unknown, but could have varied depending on prevailing winds and direction of underwater currents. This would have confounded light vs growth rate relationship as well. It would appear that the vertical orientation of the growth plates, and perhaps plate orientation relative to the path of sunlight, was likely a significant confounding factor affecting the monitoring study's results. These results must be used with caution and interpreted accordingly.

4.1.2 Depth Integrated Periphyton Biomass

A key prediction of the ELZ concept and how it applied to a reservoir setting, is that the downward shift in photic zone as a reservoir is drafted would allow for faster epilithic periphyton growth in deeper waters. This would in turn provide part compensation for the loss in periphyton biomass due to dewatering at higher elevations. The net loss of littoral primary production would therefore not be as great as if only the dewatered biomass was taken into consideration. This was the rationale for comparing DIPB values between the two static treatments sites and the dynamic control site. The expected DIPB ratios calculated from the dynamic site data alone (i.e., DIPB remaining where only dewatered loss are taken into account) indicated that for the Clowhom Lake Reservoir, a median 10% of the shoreline (over an elevation range of El 53.43 to El 33.34 m) would be impacted by WUP operations if only dewatering losses were accounted for. Observed ratios from the two treatment sites were slightly lower, suggesting that there was only a median 8% loss. This would intern suggest that there was some compensation by the shift in photic zone but, the difference however was not statistically significant. This was due mostly to the large variance in the Observed DIPB ratio data, where in some instances, treatment DIPB was more than twice that recorded at the control site.

The low variance in expected DIPB ratios was an artifact of the estimation procedure and only reflected that arising from between-sampling period differences in reservoir operations. The Observed DIPB ratios however, also included site-specific differences, as well as and the effects of patchy colonization of individual growth plates. The Stave Reservoir studies of Bruce and Beer (2014, 2015 and 2016) all noted that plate colonization is never uniform (at least not *in situ*). Rather, it is highly patchy in distribution as well as species composition. This patchiness in growth among plates was likely a key contributor to the variance in Observed DIPB ratios, and likely masked any compensatory effect, if present, of shifting photic zones.

The ELZ modelling results did not prove to be very informative, though a slightly lower proportional loss in DIPB was predicted compared to the Expected DIPB ratios (median 8.5 vs 10% loss respectively). It too was not statistically significant, suggesting that the compensatory effect could also be masked by between-sampling period differences in DIPB ratios.

Overall, the DIPB ratio data pointed to a possible compensatory benefit of shifting photic zones as would be predicted by the conceptual ELZ model. This improvement however, appeared negligible compared to the spatial and temporal variances that may occur in periphyton communities. As a means of validating the ELZ concept, the results of this study proved inconclusive. Future attempts to validate the ELZ model using this approach will require greater sampling effort to accommodate the highly patchy distribution of periphyton communities.

4.1.3 ELZ Modelling

ELZ modelling analysis revealed that there was no significant difference in littoral zone outcomes between pre-WUP and WUP operations, though the median outcome was higher during the WUP phase of the monitoring study. Analysis of yearly outcomes during the pre-WUP phase indicated a potential for significantly greater periphyton production in those years when reservoir drawdowns were limited to the spring season. Though this delayed the start of periphyton production in the upper elevations of the reservoir, it did yield significantly higher DIPB than in years when there was only a fall drawdown or both a spring and fall drawn down. The latter condition yielded the lowest DIPB values. In three of these study years, there was no drawdown which resulted in the highest DIPB values. These outcomes were in line with WUP expectations based on an earlier version of the ELZ modeling algorithm (used during the WUP process), which led to the recommendation that maintenance drawdowns be limited to the spring months.

Spring maintenance drawdowns were indeed carried out in all years of WUP operations, but in some years, these proved insufficient to complete all maintenance/repair work and a second, late summer/fall drawdown was also implemented. In those years, as in the pre-WUP phase, DIPB values were at their lowest, except when it occurred at the end or after the study's periphyton growing period. There were 5 such years. Unlike the pre-WUP phase, there were no years when deep drawdowns were entirely avoided. The latter limited the range of possible DIPB outcomes. Of the remaining six WUP years, there were no fall drawdowns, and DIPB values in the order of 1000 x 10^3 kg were expected. This however, did not always occur. Analysis of the periphyton depth profiles revealed a saw-toothed pattern where growth reaching an exponential peak was expected. This was indicative of frequent short-term, but modest amplitude (1 to 3 m) fluctuations in reservoir elevation that interfered with steady periphyton growth by repeatedly dewatering the littoral zone at different elevations. These short-term fluctuations were indeed observed in the reservoir elevation data and reflected a change in facility operations due to reduced turbine operating capabilities (BC Hydro 2013). The sole unit at the powerhouse facility is now primarily operated either in the "On" or "Off" modes with limited capability to regulate output. As a result, the reservoir was operated differently within the reservoir constraints than in the pre-WUP phase of the study. During the WUP, the reservoir would be allowed to fill, the unit brought online to generate power at maximum capability drafting the reservoir, and then turned off to allow the reservoir to refill again.

It would appear that the WUP operation did indeed have the potential to increase Clowhom Lake Reservoir periphyton production, but these gains were undermined by additional maintenance related drawdowns later in the growing season, and by the change in the way the reservoir was operated within the WUP constraints.

4.2 Impact hypotheses

This monitoring study was designed to address two impact hypotheses proposed by the CC during the WUP process. These impact hypotheses are addressed as follows:

H_01: Depth-integrated periphyton biomass of the littoral zone ($DIPB_{Lit}$), relative to that offshore ($DIPB_{Pel}$), does not vary annually as a function of (i.e. is correlated to) reservoir operations.

Because sampling intervals were not consistent both within and between study years, empirical DIPB comparisons were not valid. However, comparisons using growth rates can be made. Statistically significant differences in growth rates were found between study years, indicating that the ***Impact Hypothesis*** H_01 ***can be rejected****. Furthermore, yearly average growth in 2010 was found to be significantly lower than the two other study years (2008 and 2009). In 2010, there were two drawdown periods within the studies defined periphyton growing period, while in the other two years there was only a single spring drawdown (2008) or a spring drawdown and a second fall draw down that occurred at the end of the growing period. This was not consistent with the ELZ modelling results however, which showed that the higher growth rates in 2008 and 2009 did not necessarily translate into higher DIPB. This was likely due to the effects of short term reservoir fluctuations within the WUP reservoir constraints, as well as the potential confounding effects of periphyton sloughing due to the vertical orientation of sampling plates.*

H_02: Measured ratio of $DIPB_{Lit}$ to $DIPB_{Pel}$ is correlated with that predicted by the ELZ model.

Both modelled and empirical DIPB ratios showed that the losses in DIPB due to the dewatering of habitat may have been partially compensated by higher periphyton growth at depth due to a downward shift in the photic zone. However, the magnitude of this positive effect was small compared to the variance in DIPB ratios observed between study years, sampling periods, and study sites. This may also have been further complicated by a high degree of patchiness in the distribution and species composition of periphyton communities growing ion the plates (Bruce and Beer 20xx). The combined effect was that the difference was not statistically significant and in turn the ***Impact Hypothesis*** H_02 ***could not be rejected.*** *However, in terms of validating the ELZ metric, this outcome was inclusive, particularly in light of how the vertical orientation of sampling plates may have confounded the empirical results.*

4.3 Management questions

This study was designed to address several management questions, the results of which are as follows:

4.3.1 From COMMON3:

1. *How accurate is the ELZ model and corresponding performance measure (PM) in predicting changes in littoral zone productivity as a function of reservoir operations?*

This management question could not be addressed with the outcome of this study. The lack of a strong growth response with light intensity confounded the study results and appeared to be a consequence of the vertical orientation in growth plates used to cultivate the periphyton samples. It would appear that this vertical orientation allowed sloughing to occur, limiting the size of the periphyton colony over time. Also, the amount of light the plates received may not have been consistent over time, changing with prevailing winds and/or direction of underwater currents. The ELZ model used in this study however was a good predictor of periphyton biomass in the Stave Lake Reservoir (Bruce and Beer, 2016).

2. *Are there changes in model parameters or in the model algorithm that could improve predictive capability and reliability for future WUP processes, including those at other BC Hydro facilities?*

For the same reasons as above, this management question could not be addressed with the outcome of this study. The ELZ model used in this study was shown to be an effective predictor of periphyton biomass in the Stave Lake Reservoir. Its accuracy as it applies to Clowhom Lake Reservoir however remains unknown.

4.3.2 From COMMON2:

3. *If a change [in fish productivity metrics] is observed, is it correlated with changes in littoral area as measured by the ELZ performance measure?*

Catch per unit effort (CPUE) statistics were obtained from Bates and Coombs (2012) for each fish survey year of the fish productivity monitoring study (2006, 2008, and 2010). Total CPUE for all salmonids (rainbow trout, cutthroat trout and kokanee) was 0.70, 0.85, and 1.07 fish/h respectively for each survey year. Rainbow trout were the most numerous in all years (n = 48), followed by cutthroat trout (n = 16) and kokanee (n = 7). Fish effort was standardized for each year of survey, which involved the setting of 2 floating, 2 sinking and a single drift gillnet for three hours, totalling 27 hours each survey. In those same years, the ELZ Model predicted 612, 192 and 46 x 10^3 kg of potential periphyton growth for each study year. This would suggest the two variables were negatively correlated, which is opposite of what would be expected. The fish caught in each survey however ranged in age from 2 to 5 years, making it difficult to infer a causal relationship between the year of catch and ELZ calculated for that year. The CPUE in any given year was more likely the sum of effects over multiple years. Thus, the CPUE metric cannot be considered a useful indicator of fish productivity when trying to relate it to same-year ELZ periphyton biomass. Unfortunately, there were too few fish observations to carry out the cohort analysis necessary to assess the effects of multiyear fluctuations in ELZ on Clowhom Lake fish populations.

The only other metric related to fish productivity collected with sufficient rigor for analysis was the condition factor of rainbow and cutthroat trout (Bates and Coombs 2012). In both cases, ANOVA found no significant differences in condition factor between study years (2006, 2008, 2010; $F_{2,48} = 0.030$, $P = 0.969$; $F_{2,10} = 0.225$, $P = 0.768$ respectively). Condition factors averaged 1.08 (SD = 0.08) and 0.99 (SD = 0.12) respectively for rainbow and cutthroat trout, indicating that these fish were generally in good condition (i.e., their body weight was close to or better than ideal for their body length). Given the range of ELZ predictions for the same survey years, there was clearly no correlation between the two data sets, indicating that fish condition was not affected by differences in potential littoral productivity.

4.3.3 From COMMON1:

4. *If [wildlife species] diversity and use is low [in the wetland habitat] and the operational linkage high, what [additional or new] constraints would have to be put in place to ensure protection of that habitat, and possibly improve these values? Does the implementation of the WUP satisfy these criterions?*

Wildlife use of the wetland habitat immediately upstream of Upper Clowhom lake reservoir and its potential linkage to operations has yet to be fully explored. The monitoring studies associated with this aspect of WUP operations are still ongoing. However, one issue that has been raised is the risk to the wetland's amphibian population when reservoir elevations are drawn down in spring for maintenance work at the Clowhom Dam facility. These drawdowns can result in significant dewatering of the wetland habitat, particularly when upper Clowhom River flows are low, which can in turn potentially strand amphibian egg masses and larvae (Evelyn et al. 2016). It has been suggested that the maintenance drawdown be moved earlier in the year (start of February) or be postponed to the fall based on amphibian requirements.

Results of the present study show that maintenance drawdowns in the spring have less impact on periphyton production in the reservoir than ones done in late summer or the fall. Thus, moving the drawdown to the fall can lead to negative impacts on littoral periphyton production. This impact may be small though, as the benefits of spring maintenance drawdowns (compared to fall drawdowns) have been undermined by recent changes in turbine operations. These operations have led to a more prominent cycling of reservoir elevations that continuously dewaters potential littoral habitat. Also, the lack of a strong correlation between littoral periphyton and condition factor suggests that there may be minimal impact to fish populations. Indeed, the recent radio isotope surveys carried out in Lower Campbell Reservoir suggest that littoral primary production plays a minimal role in fish production and that inputs such a leaf litter and phytoplankton are far more important sources of basal nutrients (Perrin et al. 2016). Terrestrial insects were also found to be an important external nutrient source. Given that littoral periphyton may not be a significant contributor to the reservoir's food web, it is possible that changes to the maintenance drawdown period may have minimal impact the reservoir's fish ecology and can be a feasible solution to the wetland issue. It should be stressed however, that this only considers the role of littoral periphyton production and does not include other factors such as the possible effect on tributary access, use of shoreline spawning and rearing habitats and the connectivity between the water's edge and terrestrial habitats (other than the wetland habitat in spring). There may also be hydrological consequences of shifting the maintenance drawdown period.

An interactive operations model has been developed, based on the one used during the WUP, to examine the possible hydrological and environmental consequences of alternative operating regimes. The model includes calculation of the ELZ metric, along with other values that were deemed important by the CC during the WUP consultation process. Because answering the management question will involve the trade-off of multiple values, it cannot be addressed in the context of this study. The tools to do so however, have been developed and are ready to be used in a separate study setting.

5 Conclusions

Analysis of the periphyton biomass data collected at each array found growth rates that were well below that expected for similar studies carried out in Stave Lake Reservoir. Values were comparable to Stave Lake growth rates in near darkness and did not vary appreciably with PAR intensity, though statistically significant differences were found with the sampling depth. It was hypothesised that the vertical orientation of the sampling plates used to grow the periphyton may have allowed sloughing to occur, limiting the amount of periphyton that could adhere to its surface. This was considered to have confounded the periphyton biomass data and as a result, prevented a direct test of the ELZ model as it applies to the Clowhom Reservoir. In turn, Impact hypothesis H_02, which deals with ELZ model accuracy, could not be tested. Nor could the two management hypotheses directly associated with the littoral monitor be addressed.

The ELZ model empirically derived for the Stave Lake Reservoir was adapted to the Clowhom reservoir as an alternative to the conceptual model developed for the WUP process. It was used in this study to evaluate the effects of WUP operations of the reservoir ELZ for each year of study (1994 to 2016) and was incorporated into a larger reservoir-operations model suitable for trade off analysis with other reservoir values.

Analysis of depth integrated periphyton biomass (DIPB) data, showed that reservoir operations do have an effect on periphyton growth. The number of drawdowns per year, their timing, and the presence of short term fluctuations all had an influence on DIPB outcomes. WUP operations, because of the short-term fluctuations, did not achieve the expected benefits of limiting maintenance drawdowns to the spring. When compared to Stave Lake Reservoir, measured DIPB values in Clowhom Lake Reservoir were generally much smaller. It is thought that this may be due the vertical orientation of the growth plates used in this study, which may deter colonisation and/or promote sloughing when colonies become sufficiently large.

Modelled ELZ values were found to be uncorrelated with rainbow and cutthroat trout condition factors in those years surveyed (2006, 2008 and 2010). Condition was the only productivity related metric that could be compared with same year ELZ data.

Because the benefits of WUP operations on fish production appear to be limited, particularly with respect to littoral periphyton production, a shift in timing for the annual maintenance drawdown should be considered as a possible mitigation strategy to help reduce the stranding of amphibian eggs and larvae in the adjacent wetlands. Such consideration should not be done in isolation of other watershed values and the reservoir operations model developed in this study can be used to facilitate this trade-off analysis.

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7 Appendices

Appendix I: Periphyton biomass and growth rate data for Clowhom Lake Reservoir 2007 to 2010

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
1	2007	17-Apr	43	1	A	2						
2	2007	17-Apr	43	1	B	4	0.1252	0.1243	0.0009		90	0.015
3	2007	17-Apr	43	1	C	6						
4	2007	17-Apr	43	1	D	8						
5	2007	17-Apr	43	1	E	10						
6	2007	17-Apr	43	1	F	12	0.1295	0.1286	0.0009		90	0.015
7	2007	17-Apr	43	1	G	14	0.1284	0.1275	0.0009		90	0.015
8	2007	17-Apr	43	1	H	16	0.1251	0.1241	0.0010		100	0.016
9	2007	17-Apr	43	1	I	18						
10	2007	17-Apr	43	1	J	20	0.1275	0.1267	0.0008		80	0.014
11	2007	17-Apr	43	1	K	22	0.1780	0.1726	0.0054		540	0.043
12	2007	17-Apr	43	2	A	2				1		
13	2007	17-Apr	43	2	B	4	0.1246	0.1236	0.0010		100	0.016
14	2007	17-Apr	43	2	C	6	0.1278	0.1267	0.0011		110	0.017
15	2007	17-Apr	43	2	D	8	0.1312	0.1284	0.0028		280	0.031
16	2007	17-Apr	43	2	E	10	0.1293	0.1274	0.0019		190	0.025
17	2007	17-Apr	43	2	F	12	0.1293	0.1274	0.0019		190	0.025
18	2007	17-Apr	43	2	G	14	0.1268	0.1254	0.0014		140	0.020
19	2007	17-Apr	43	2	H	16	0.1316	0.1296	0.0020		200	0.026
20	2007	17-Apr	43	2	I	18	0.1268	0.1262	0.0006		60	0.011
21	2007	17-Apr	43	2	J	20	0.1233	0.1226	0.0007		70	0.012
22	2007	17-Apr	43	2	K	22	0.1249	0.1243	0.0006		60	0.011
23	2007	17-Apr	43	3	A	2						
24	2007	17-Apr	43	3	B	4						
25	2007	17-Apr	43	3	C	6						
26	2007	17-Apr	43	3	D	8						
27	2007	17-Apr	43	3	E	10						
28	2007	17-Apr	43	3	F	12						
29	2007	17-Apr	43	3	G	14						
30	2007	17-Apr	43	3	H	16						
31	2007	17-Apr	43	3	I	18						
32	2007	17-Apr	43	3	J	20						
33	2007	17-Apr	43	3	K	22						
34	2007	03-Jun	45	1	A	2						
35	2007	03-Jun	45	1	B	4						
36	2007	03-Jun	45	1	C	6						
37	2007	03-Jun	45	1	D	8						
38	2007	03-Jun	45	1	E	10						
39	2007	03-Jun	45	1	F	12						
40	2007	03-Jun	45	1	G	14						
41	2007	03-Jun	45	1	H	16						
42	2007	03-Jun	45	1	I	18						
43	2007	03-Jun	45	1	J	20						
44	2007	03-Jun	45	1	K	22						
45	2007	03-Jun	45	2	A	2						
46	2007	03-Jun	45	2	B	4						
47	2007	03-Jun	45	2	C	6						
48	2007	03-Jun	45	2	D	8						
49	2007	03-Jun	45	2	E	10						
50	2007	03-Jun	45	2	F	12						
51	2007	03-Jun	45	2	G	14						
52	2007	03-Jun	45	2	H	16						
53	2007	03-Jun	45	2	I	18						
54	2007	03-Jun	45	2	J	20						
55	2007	03-Jun	45	2	K	22						
56	2007	03-Jun	45	3	A	2	0.1260	0.1251	0.0009		90	0.014
57	2007	03-Jun	45	3	B	4	0.1249	0.1239	0.0010		100	0.015
58	2007	03-Jun	45	3	C	6	0.1282	0.1272	0.0010		100	0.015
59	2007	03-Jun	45	3	D	8	0.1287	0.1273	0.0014		140	0.019
60	2007	03-Jun	45	3	E	10	0.1251	0.1237	0.0014		140	0.019

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
61	2007	03-Jun	45	3	F	12	0.1253	0.1242	0.0011		110	0.016
62	2007	03-Jun	45	3	G	14	0.1238	0.1229	0.0009		90	0.014
63	2007	03-Jun	45	3	H	16	0.1212	0.1200	0.0012		120	0.018
64	2007	03-Jun	45	3	I	18	0.1290	0.1278	0.0012		120	0.018
65	2007	03-Jun	45	3	J	20	0.1285	0.1274	0.0011		110	0.016
66	2007	03-Jun	45	3	K	22	0.1260	0.1249	0.0011		110	0.016
67	2007	17-Jul	44	1	A	2	0.1360	0.1342	0.0018		180	0.023
68	2007	17-Jul	44	1	B	4						
69	2007	17-Jul	44	1	C	6						
70	2007	17-Jul	44	1	D	8						
71	2007	17-Jul	44	1	E	10						
72	2007	17-Jul	44	1	F	12						
73	2007	17-Jul	44	1	G	14						
74	2007	17-Jul	44	1	H	16						
75	2007	17-Jul	44	1	I	18						
76	2007	17-Jul	44	1	J	20						
77	2007	17-Jul	44	1	K	22						
78	2007	17-Jul	44	2	A	2				1		
79	2007	17-Jul	44	2	B	4				1		
80	2007	17-Jul	44	2	C	6	0.1280	0.1264	0.0016		160	0.022
81	2007	17-Jul	44	2	D	8	0.1255	0.1242	0.0013		130	0.019
82	2007	17-Jul	44	2	E	10	0.1286	0.1278	0.0008		80	0.013
83	2007	17-Jul	44	2	F	12	0.1218	0.1208	0.0010		100	0.016
84	2007	17-Jul	44	2	G	14	0.1252	0.1239	0.0013		130	0.019
85	2007	17-Jul	44	2	H	16	0.1216	0.1202	0.0014		140	0.020
86	2007	17-Jul	44	2	I	18						
87	2007	17-Jul	44	2	J	20	0.1252	0.1243	0.0009		90	0.015
88	2007	17-Jul	44	2	K	22						
89	2007	17-Jul	44	3	A	2	0.1271	0.1260	0.0011		110	0.017
90	2007	17-Jul	44	3	B	4	0.1267	0.1254	0.0013		130	0.019
91	2007	17-Jul	44	3	C	6	0.1325	0.1308	0.0017		170	0.023
92	2007	17-Jul	44	3	D	8	0.1286	0.1274	0.0012		120	0.018
93	2007	17-Jul	44	3	E	10	0.1252	0.1242	0.0010		100	0.016
94	2007	17-Jul	44	3	F	12	0.1316	0.1305	0.0011		110	0.017
95	2007	17-Jul	44	3	G	14	0.1270	0.1253	0.0017		170	0.023
96	2007	17-Jul	44	3	H	16	0.1248	0.1232	0.0016		160	0.022
97	2007	17-Jul	44	3	I	18	0.1163	0.1151	0.0012		120	0.018
98	2007	17-Jul	44	3	J	20	0.1295	0.1284	0.0011		110	0.017
99	2007	17-Jul	44	3	K	22	0.1261	0.1247	0.0014		140	0.020
100	2007	28-Aug	42	1	A	2	0.1247	0.1241	0.0006		60	0.011
101	2007	28-Aug	42	1	B	4						
102	2007	28-Aug	42	1	C	6						
103	2007	28-Aug	42	1	D	8						
104	2007	28-Aug	42	1	E	10						
105	2007	28-Aug	42	1	F	12						
106	2007	28-Aug	42	1	G	14						
107	2007	28-Aug	42	1	H	16						
108	2007	28-Aug	42	1	I	18						
109	2007	28-Aug	42	1	J	20						
110	2007	28-Aug	42	1	K	22						
111	2007	28-Aug	42	2	A	2				1		
112	2007	28-Aug	42	2	B	4	0.1294	0.1276	0.0018		180	0.025
113	2007	28-Aug	42	2	C	6	0.1284	0.1270	0.0014		140	0.021
114	2007	28-Aug	42	2	D	8	0.1276	0.1265	0.0011		110	0.018
115	2007	28-Aug	42	2	E	10	0.1285	0.1278	0.0007		70	0.013
116	2007	28-Aug	42	2	F	12	0.1323	0.1309	0.0014		140	0.021
117	2007	28-Aug	42	2	G	14	0.1221	0.1214	0.0007		70	0.013
118	2007	28-Aug	42	2	H	16	0.1253	0.1245	0.0008		80	0.014
119	2007	28-Aug	42	2	I	18	0.3586	0.3337	0.0249		2490	0.077
120	2007	28-Aug	42	2	J	20	0.1187	0.1181	0.0006		60	0.011

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
121	2007	28-Aug	42	2	K	22	0.1203	0.1191	0.0012		120	0.019
122	2007	28-Aug	42	3	A	2	0.1219	0.1199	0.0020		200	0.026
123	2007	28-Aug	42	3	B	4	0.1254	0.1224	0.0030		300	0.033
124	2007	28-Aug	42	3	C	6	0.1288	0.1256	0.0032		320	0.034
125	2007	28-Aug	42	3	D	8	0.1285	0.1261	0.0024		240	0.029
126	2007	28-Aug	42	3	E	10	0.1292	0.1263	0.0029		290	0.032
127	2007	28-Aug	42	3	F	12	0.1225	0.1210	0.0015		150	0.022
128	2007	28-Aug	42	3	G	14	0.1167	0.1160	0.0007		70	0.013
129	2007	28-Aug	42	3	H	16	0.1186	0.1180	0.0006		60	0.011
130	2007	28-Aug	42	3	I	18	0.1305	0.1296	0.0009		90	0.015
131	2007	28-Aug	42	3	J	20	0.1276	0.1268	0.0008		80	0.014
132	2007	28-Aug	42	3	K	22	0.1313	0.1304	0.0009		90	0.015
133	2007	10-Oct	43	1	A	2	0.1255	0.1249	0.0006		60	0.011
134	2007	10-Oct	43	1	B	4	0.1285	0.1265	0.0020		200	0.026
135	2007	10-Oct	43	1	C	6						
136	2007	10-Oct	43	1	D	8						
137	2007	10-Oct	43	1	E	10	0.1254	0.1247	0.0007		70	0.012
138	2007	10-Oct	43	1	F	12	0.1288	0.1272	0.0016		160	0.022
139	2007	10-Oct	43	1	G	14	0.1274	0.1263	0.0011		110	0.017
140	2007	10-Oct	43	1	H	16	0.1339	0.1321	0.0018		180	0.024
141	2007	10-Oct	43	1	I	18	0.1270	0.1262	0.0008		80	0.014
142	2007	10-Oct	43	1	J	20	0.1306	0.1298	0.0008		80	0.014
143	2007	10-Oct	43	1	K	22	0.1321	0.1311	0.0010		100	0.016
144	2007	10-Oct	43	2	A	2	0.1275	0.1267	0.0008		80	0.014
145	2007	10-Oct	43	2	B	4	0.1221	0.1210	0.0011		110	0.017
146	2007	10-Oct	43	2	C	6	0.1283	0.1277	0.0006		60	0.011
147	2007	10-Oct	43	2	D	8	0.1268	0.1260	0.0008		80	0.014
148	2007	10-Oct	43	2	E	10	0.1272	0.1265	0.0007		70	0.012
149	2007	10-Oct	43	2	F	12	0.1235	0.1230	0.0005		50	0.009
150	2007	10-Oct	43	2	G	14	0.1273	0.1266	0.0007		70	0.012
151	2007	10-Oct	43	2	H	16	0.1248	0.1245	0.0003		30	0.006
152	2007	10-Oct	43	2	I	18	0.1256	0.1249	0.0007		70	0.012
153	2007	10-Oct	43	2	J	20	0.1331	0.1322	0.0009		90	0.015
154	2007	10-Oct	43	2	K	22	0.1316	0.1308	0.0008		80	0.014
155	2007	10-Oct	43	3	A	2	0.1293	0.1287	0.0006		60	0.011
156	2007	10-Oct	43	3	B	4	0.1297	0.1278	0.0019		190	0.025
157	2007	10-Oct	43	3	C	6	0.1262	0.1246	0.0016		160	0.022
158	2007	10-Oct	43	3	D	8	0.1278	0.1265	0.0013		130	0.019
159	2007	10-Oct	43	3	E	10	0.1310	0.1291	0.0019		190	0.025
160	2007	10-Oct	43	3	F	12	0.1351	0.1332	0.0019		190	0.025
161	2007	10-Oct	43	3	G	14	0.1277	0.1264	0.0013		130	0.019
162	2007	10-Oct	43	3	H	16	0.1284	0.1278	0.0006		60	0.011
163	2007	10-Oct	43	3	I	18	0.1308	0.1301	0.0007		70	0.012
164	2007	10-Oct	43	3	J	20	0.1286	0.1281	0.0005		50	0.009
165	2007	10-Oct	43	3	K	22	0.1268	0.1262	0.0006		60	0.011
166	2007	13-Nov	34	1	A	2	0.1298	0.1293	0.0005		50	0.012
167	2007	13-Nov	34	1	B	4	0.1294	0.1284	0.0010		100	0.020
168	2007	13-Nov	34	1	C	6						
169	2007	13-Nov	34	1	D	8	0.1535	0.1471	0.0064		640	0.059
170	2007	13-Nov	34	1	E	10	0.1345	0.1327	0.0018		180	0.030
171	2007	13-Nov	34	1	F	12						
172	2007	13-Nov	34	1	G	14	0.1303	0.1294	0.0009		90	0.019
173	2007	13-Nov	34	1	H	16	0.1367	0.1350	0.0017		170	0.029
174	2007	13-Nov	34	1	I	18	0.1311	0.1302	0.0009		90	0.019
175	2007	13-Nov	34	1	J	20	0.1283	0.1278	0.0005		50	0.012
176	2007	13-Nov	34	1	K	22						
177	2007	13-Nov	34	2	A	2	0.1276	0.1270	0.0006		60	0.014
178	2007	13-Nov	34	2	B	4	0.1269	0.1259	0.0010		100	0.020
179	2007	13-Nov	34	2	C	6	0.1262	0.1257	0.0005		50	0.012
180	2007	13-Nov	34	2	D	8	0.1266	0.1258	0.0008		80	0.017

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
181	2007	13-Nov	34	2	E	10	0.1265	0.1257	0.0008		80	0.017
182	2007	13-Nov	34	2	F	12	0.1259	0.1253	0.0006		60	0.014
183	2007	13-Nov	34	2	G	14	0.1263	0.1255	0.0008		80	0.017
184	2007	13-Nov	34	2	H	16	0.1313	0.1303	0.0010		100	0.020
185	2007	13-Nov	34	2	I	18	0.1274	0.1267	0.0007		70	0.016
186	2007	13-Nov	34	2	J	20	0.1265	0.1256	0.0009		90	0.019
187	2007	13-Nov	34	2	K	22	0.1261	0.1250	0.0011		110	0.022
188	2007	13-Nov	34	3	A	2	0.1288	0.1280	0.0008		80	0.017
189	2007	13-Nov	34	3	B	4	0.1294	0.1285	0.0009		90	0.019
190	2007	13-Nov	34	3	C	6	0.1303	0.1293	0.0010		100	0.020
191	2007	13-Nov	34	3	D	8	0.1297	0.1288	0.0009		90	0.019
192	2007	13-Nov	34	3	E	10	0.1250	0.1243	0.0007		70	0.016
193	2007	13-Nov	34	3	F	12	0.1290	0.1282	0.0008		80	0.017
194	2007	13-Nov	34	3	G	14	0.1263	0.1257	0.0006		60	0.014
195	2007	13-Nov	34	3	H	16	0.1291	0.1284	0.0007		70	0.016
196	2007	13-Nov	34	3	I	18	0.1311	0.1303	0.0008		80	0.017
197	2007	13-Nov	34	3	J	20	0.1360	0.1353	0.0007		70	0.016
198	2007	13-Nov	34	3	K	22	0.1269	0.1262	0.0007		70	0.016
199	2008	11-Jun	35	1	A	2	0.1274	0.1264	0.001	1		
200	2008	11-Jun	35	1	B	4	0.1291	0.1282	0.0009		90	0.018
201	2008	11-Jun	35	1	C	6	0.1229	0.1217	0.0012		120	0.023
202	2008	11-Jun	35	1	D	8	0.1243	0.1233	0.001		100	0.020
203	2008	11-Jun	35	1	E	10	0.1265	0.1255	0.001		100	0.020
204	2008	11-Jun	35	1	F	12	0.1293	0.1283	0.001		100	0.020
205	2008	11-Jun	35	1	G	14	0.129	0.1281	0.0009		90	0.018
206	2008	11-Jun	35	1	H	16	0.1235	0.1223	0.0012		120	0.023
207	2008	11-Jun	35	1	I	18	0.1256	0.1244	0.0012		120	0.023
208	2008	11-Jun	35	1	J	20	0.1281	0.1271	0.001		100	0.020
209	2008	11-Jun	35	1	K	22	0.1254	0.1245	0.0009		90	0.018
210	2008	11-Jun	35	2	A	2	0.1252	0.1245	0.0007	1		
211	2008	11-Jun	35	2	B	4	0.1242	0.1234	0.0008	1		
212	2008	11-Jun	35	2	C	6	0.125	0.1245	0.0005		50	0.012
213	2008	11-Jun	35	2	D	8	0.13	0.1291	0.0009		90	0.018
214	2008	11-Jun	35	2	E	10	0.1195	0.1188	0.0007		70	0.015
215	2008	11-Jun	35	2	F	12	0.1263	0.1255	0.0008		80	0.017
216	2008	11-Jun	35	2	G	14	0.1289	0.1283	0.0006		60	0.013
217	2008	11-Jun	35	2	H	16	0.1285	0.1279	0.0006		60	0.013
218	2008	11-Jun	35	2	I	18	0.1281	0.1276	0.0005		50	0.012
219	2008	11-Jun	35	2	J	20	0.1255	0.1248	0.0007		70	0.015
220	2008	11-Jun	35	2	K	22	0.1235	0.1227	0.0008		80	0.017
221	2008	11-Jun	35	3	A	2	0.1276	0.1263	0.0013		130	0.024
222	2008	11-Jun	35	3	B	4	0.1249	0.1242	0.0007		70	0.015
223	2008	11-Jun	35	3	C	6	0.127	0.1261	0.0009		90	0.018
224	2008	11-Jun	35	3	D	8	0.1215	0.1204	0.0011		110	0.021
225	2008	11-Jun	35	3	E	10	0.1222	0.1215	0.0007		70	0.015
226	2008	11-Jun	35	3	F	12	0.1235	0.1228	0.0007		70	0.015
227	2008	11-Jun	35	3	G	14	0.1234	0.1227	0.0007		70	0.015
228	2008	11-Jun	35	3	H	16	0.1277	0.1271	0.0006		60	0.013
229	2008	11-Jun	35	3	I	18	0.1252	0.1244	0.0008		80	0.017
230	2008	11-Jun	35	3	J	20	0.1228	0.1221	0.0007		70	0.015
231	2008	11-Jun	35	3	K	22	0.1239	0.1234	0.0005		50	0.012
232	2008	09-Jul	28	1	A	2	0.1293	0.1287	0.0006		60	0.017
233	2008	09-Jul	28	1	B	4	0.13	0.1291	0.0009		90	0.023
234	2008	09-Jul	28	1	C	6	0.1285	0.1275	0.001		100	0.025
235	2008	09-Jul	28	1	D	8	0.129	0.1279	0.0011		110	0.026
236	2008	09-Jul	28	1	E	10	0.1291	0.1281	0.001		100	0.025
237	2008	09-Jul	28	1	F	12	0.1295	0.1286	0.0009		90	0.023
238	2008	09-Jul	28	1	G	14	0.1293	0.1285	0.0008		80	0.021
239	2008	09-Jul	28	1	H	16	0.1289	0.1281	0.0008		80	0.021
240	2008	09-Jul	28	1	I	18	0.1288	0.1282	0.0006		60	0.017

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
241	2008	09-Jul	28	1	J	20	0.1286	0.1281	0.0005		50	0.014
242	2008	09-Jul	28	1	K	22	0.1297	0.1288	0.0009		90	0.023
243	2008	09-Jul	28	2	A	2	0.13	0.1294	0.0006	1		
244	2008	09-Jul	28	2	B	4	0.1281	0.1277	0.0004		40	0.012
245	2008	09-Jul	28	2	C	6	0.1302	0.1293	0.0009		90	0.023
246	2008	09-Jul	28	2	D	8	0.1337	0.1328	0.0009		90	0.023
247	2008	09-Jul	28	2	E	10	0.136	0.1353	0.0007		70	0.019
248	2008	09-Jul	28	2	F	12	0.138	0.1366	0.0014		140	0.031
249	2008	09-Jul	28	2	G	14	0.1301	0.1295	0.0006		60	0.017
250	2008	09-Jul	28	2	H	16	0.1296	0.1291	0.0005		50	0.014
251	2008	09-Jul	28	2	I	18	0.1284	0.1279	0.0005		50	0.014
252	2008	09-Jul	28	2	J	20	0.1313	0.1308	0.0005		50	0.014
253	2008	09-Jul	28	2	K	22	0.1305	0.1299	0.0006		60	0.017
254	2008	09-Jul	28	3	A	2	0.1295	0.1288	0.0007		70	0.019
255	2008	09-Jul	28	3	B	4	0.1286	0.1279	0.0007		70	0.019
256	2008	09-Jul	28	3	C	6	0.1283	0.1274	0.0009		90	0.023
257	2008	09-Jul	28	3	D	8	0.1287	0.1281	0.0006		60	0.017
258	2008	09-Jul	28	3	E	10	0.1297	0.1291	0.0006		60	0.017
259	2008	09-Jul	28	3	F	12	0.13	0.1294	0.0006		60	0.017
260	2008	09-Jul	28	3	G	14	0.129	0.1283	0.0007		70	0.019
261	2008	09-Jul	28	3	H	16	0.1302	0.1296	0.0006		60	0.017
262	2008	09-Jul	28	3	I	18	0.1292	0.1287	0.0005		50	0.014
263	2008	09-Jul	28	3	J	20	0.1268	0.1262	0.0006		60	0.017
264	2008	09-Jul	28	3	K	22	0.1282	0.1275	0.0007		70	0.019
265	2008	22-Aug	43	1	A	2	0.1303	0.1294	0.0009		90	0.015
266	2008	22-Aug	43	1	B	4	0.1288	0.1275	0.0013		130	0.019
267	2008	22-Aug	43	1	C	6	0.1292	0.1276	0.0016		160	0.022
268	2008	22-Aug	43	1	D	8	0.1354	0.1331	0.0023		230	0.028
269	2008	22-Aug	43	1	E	10	0.1348	0.1326	0.0022		220	0.027
270	2008	22-Aug	43	1	F	12	0.1331	0.1315	0.0016		160	0.022
271	2008	22-Aug	43	1	G	14	0.132	0.1312	0.0008		80	0.014
272	2008	22-Aug	43	1	H	16	0.129	0.1287	0.0003		30	0.006
273	2008	22-Aug	43	1	I	18	0.1276	0.1272	0.0004		40	0.008
274	2008	22-Aug	43	1	J	20	0.1299	0.1294	0.0005		50	0.009
275	2008	22-Aug	43	1	K	22	0.1292	0.1284	0.0008		80	0.014
276	2008	22-Aug	43	2	A	2	0.1307	0.1296	0.0011	1		
277	2008	22-Aug	43	2	B	4	0.1312	0.1293	0.0019		190	0.025
278	2008	22-Aug	43	2	C	6	0.1324	0.1318	0.0006		60	0.011
279	2008	22-Aug	43	2	D	8	0.1311	0.1301	0.001		100	0.016
280	2008	22-Aug	43	2	E	10	0.1353	0.1338	0.0015		150	0.021
281	2008	22-Aug	43	2	F	12	0.1318	0.1314	0.0004		40	0.008
282	2008	22-Aug	43	2	G	14	0.1355	0.1324	0.0031		310	0.033
283	2008	22-Aug	43	2	H	16	0.1303	0.1298	0.0005		50	0.009
284	2008	22-Aug	43	2	I	18	0.1306	0.1303	0.0003		30	0.006
285	2008	22-Aug	43	2	J	20	0.1329	0.1323	0.0006		60	0.011
286	2008	22-Aug	43	2	K	22	0.129	0.129	0		0	0.000
287	2008	22-Aug	43	3	A	2	0.1312	0.1305	0.0007		70	0.012
288	2008	22-Aug	43	3	B	4	0.1288	0.1282	0.0006		60	0.011
289	2008	22-Aug	43	3	C	6	0.1284	0.1278	0.0006		60	0.011
290	2008	22-Aug	43	3	D	8	0.1298	0.1291	0.0007		70	0.012
291	2008	22-Aug	43	3	E	10	0.129	0.1286	0.0004		40	0.008
292	2008	22-Aug	43	3	F	12	0.1303	0.1302	1E-04		10	0.002
293	2008	22-Aug	43	3	G	14	0.1275	0.127	0.0005		50	0.009
294	2008	22-Aug	43	3	H	16	0.1301	0.1295	0.0006		60	0.011
295	2008	22-Aug	43	3	I	18	0.1295	0.1288	0.0007		70	0.012
296	2008	22-Aug	43	3	J	20	0.1285	0.1277	0.0008		80	0.014
297	2008	22-Aug	43	3	K	22	0.1295	0.1289	0.0006		60	0.011
298	2008	18-Sep	27	1	A	2	0.1305	0.1292	0.0013	1		
299	2008	18-Sep	27	1	B	4	0.1296	0.1284	0.0012		120	0.029
300	2008	18-Sep	27	1	C	6	0.1313	0.1303	0.001		100	0.026

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
301	2008	18-Sep	27	1	D	8	0.1298	0.1288	0.001		100	0.026
302	2008	18-Sep	27	1	E	10	0.1306	0.1292	0.0014		140	0.032
303	2008	18-Sep	27	1	F	12	0.1327	0.1312	0.0015		150	0.034
304	2008	18-Sep	27	1	G	14	0.1284	0.127	0.0014		140	0.032
305	2008	18-Sep	27	1	H	16	0.1287	0.1277	0.001		100	0.026
306	2008	18-Sep	27	1	I	18	0.1296	0.1288	0.0008		80	0.022
307	2008	18-Sep	27	1	J	20	0.1293	0.1289	0.0004		40	0.012
308	2008	18-Sep	27	1	K	22	0.1293	0.1288	0.0005		50	0.015
309	2008	18-Sep	27	2	A	2	0.1304	0.1295	0.0009	1		
310	2008	18-Sep	27	2	B	4	0.1308	0.1295	0.0013		130	0.031
311	2008	18-Sep	27	2	C	6	0.1296	0.1284	0.0012		120	0.029
312	2008	18-Sep	27	2	D	8	0.1322	0.1308	0.0014		140	0.032
313	2008	18-Sep	27	2	E	10	0.1404	0.1381	0.0023		230	0.044
314	2008	18-Sep	27	2	F	12	0.1319	0.1309	0.001		100	0.026
315	2008	18-Sep	27	2	G	14	0.1316	0.1304	0.0012		120	0.029
316	2008	18-Sep	27	2	H	16	0.1313	0.1305	0.0008		80	0.022
317	2008	18-Sep	27	2	I	18	0.1295	0.1292	0.0003		30	0.010
318	2008	18-Sep	27	2	J	20	0.1301	0.1298	0.0003		30	0.010
319	2008	18-Sep	27	2	K	22	0.1293	0.1287	0.0006		60	0.017
320	2008	18-Sep	27	3	A	2	0.1287	0.1278	0.0009		90	0.024
321	2008	18-Sep	27	3	B	4	0.1304	0.1302	0.0002		20	0.007
322	2008	18-Sep	27	3	C	6	0.1313	0.1296	0.0017		170	0.037
323	2008	18-Sep	27	3	D	8	0.1315	0.1306	0.0009		90	0.024
324	2008	18-Sep	27	3	E	10	0.1287	0.1279	0.0008		80	0.022
325	2008	18-Sep	27	3	F	12	0.1287	0.1281	0.0006		60	0.017
326	2008	18-Sep	27	3	G	14	0.1276	0.1269	0.0007		70	0.020
327	2008	18-Sep	27	3	H	16	0.1288	0.128	0.0008		80	0.022
328	2008	18-Sep	27	3	I	18	0.1289	0.1279	0.001		100	0.026
329	2008	18-Sep	27	3	J	20	0.1303	0.1291	0.0012		120	0.029
330	2008	18-Sep	27	3	K	22	0.1306	0.1296	0.001		100	0.026
331	2008	16-Oct	28	1	A	2	0.1263	0.1258	0.0005	1		
332	2008	16-Oct	28	1	B	4	0.1309	0.13	0.0009	1		
333	2008	16-Oct	28	1	C	6	0.1292	0.1284	0.0008		80	0.021
334	2008	16-Oct	28	1	D	8	0.1318	0.131	0.0008		80	0.021
335	2008	16-Oct	28	1	E	10	0.1299	0.1289	0.001		100	0.025
336	2008	16-Oct	28	1	F	12	0.13	0.1291	0.0009		90	0.023
337	2008	16-Oct	28	1	G	14	0.1296	0.1287	0.0009		90	0.023
338	2008	16-Oct	28	1	H	16	0.1284	0.1274	0.001		100	0.025
339	2008	16-Oct	28	1	I	18	0.1322	0.1314	0.0008		80	0.021
340	2008	16-Oct	28	1	J	20	0.1309	0.1302	0.0007		70	0.019
341	2008	16-Oct	28	1	K	22	0.1312	0.1288	0.0024		240	0.044
342	2008	16-Oct	28	2	A	2	0.131	0.1293	0.0017	1		
343	2008	16-Oct	28	2	B	4	0.1314	0.1303	0.0011	1		
344	2008	16-Oct	28	2	C	6	0.1295	0.1279	0.0016		160	0.034
345	2008	16-Oct	28	2	D	8	0.1318	0.1302	0.0016		160	0.034
346	2008	16-Oct	28	2	E	10	0.1319	0.1304	0.0015		150	0.033
347	2008	16-Oct	28	2	F	12	0.1333	0.1317	0.0016		160	0.034
348	2008	16-Oct	28	2	G	14	0.1321	0.1306	0.0015		150	0.033
349	2008	16-Oct	28	2	H	16	0.1314	0.1302	0.0012		120	0.028
350	2008	16-Oct	28	2	I	18	0.128	0.1268	0.0012		120	0.028
351	2008	16-Oct	28	2	J	20	0.1298	0.1287	0.0011		110	0.026
352	2008	16-Oct	28	2	K	22	0.1293	0.1286	0.0007		70	0.019
353	2008	16-Oct	28	3	A	2	0.1311	0.1298	0.0013		130	0.030
354	2008	16-Oct	28	3	B	4	0.1307	0.1293	0.0014		140	0.031
355	2008	16-Oct	28	3	C	6	0.1322	0.1309	0.0013		130	0.030
356	2008	16-Oct	28	3	D	8	0.1281	0.1273	0.0008		80	0.021
357	2008	16-Oct	28	3	E	10	0.1303	0.1294	0.0009		90	0.023
358	2008	16-Oct	28	3	F	12	0.1285	0.1278	0.0007		70	0.019
359	2008	16-Oct	28	3	G	14	0.1296	0.1286	0.001		100	0.025
360	2008	16-Oct	28	3	H	16	0.1308	0.1294	0.0014		140	0.031

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
361	2008	16-Oct	28	3	I	18	0.1297	0.1288	0.0009		90	0.023
362	2008	16-Oct	28	3	J	20	0.1307	0.1295	0.0012		120	0.028
363	2008	16-Oct	28	3	K	22	0.1283	0.1274	0.0009		90	0.023
364	2008	26-Nov	41	1	A	2	0.132	0.1302	0.0018		180	0.025
365	2008	26-Nov	41	1	B	4	0.1288	0.1277	0.0011		110	0.018
366	2008	26-Nov	41	1	C	6	0.1321	0.1306	0.0015		150	0.022
367	2008	26-Nov	41	1	D	8	0.1288	0.1276	0.0012		120	0.019
368	2008	26-Nov	41	1	E	10	0.1277	0.1267	0.001		100	0.017
369	2008	26-Nov	41	1	F	12	0.1286	0.1274	0.0012		120	0.019
370	2008	26-Nov	41	1	G	14	0.1313	0.1304	0.0009		90	0.016
371	2008	26-Nov	41	1	H	16	0.1293	0.1287	0.0006		60	0.011
372	2008	26-Nov	41	1	I	18	0.1304	0.1292	0.0012		120	0.019
373	2008	26-Nov	41	1	J	20	0.1298	0.1291	0.0007		70	0.013
374	2008	26-Nov	41	1	K	22	0.1314	0.1304	0.001		100	0.017
375	2008	26-Nov	41	2	A	2	0.1324	0.1309	0.0015		150	0.022
376	2008	26-Nov	41	2	B	4	0.1305	0.129	0.0015		150	0.022
377	2008	26-Nov	41	2	C	6	0.1322	0.1261	0.0061		610	0.048
378	2008	26-Nov	41	2	D	8	0.1313	0.1294	0.0019		190	0.026
379	2008	26-Nov	41	2	E	10	0.13	0.129	0.001		100	0.017
380	2008	26-Nov	41	2	F	12	0.1293	0.1282	0.0011		110	0.018
381	2008	26-Nov	41	2	G	14	0.1333	0.1319	0.0014		140	0.021
382	2008	26-Nov	41	2	H	16	0.13	0.1288	0.0012		120	0.019
383	2008	26-Nov	41	2	I	18	0.1306	0.1295	0.0011		110	0.018
384	2008	26-Nov	41	2	J	20	0.1295	0.1284	0.0011		110	0.018
385	2008	26-Nov	41	2	K	22	0.1295	0.1288	0.0007		70	0.013
386	2008	26-Nov	41	3	A	2	0.1297	0.1288	0.0009		90	0.016
387	2008	26-Nov	41	3	B	4	0.1303	0.1293	0.001		100	0.017
388	2008	26-Nov	41	3	C	6	0.1295	0.1284	0.0011		110	0.018
389	2008	26-Nov	41	3	D	8	0.1365	0.1348	0.0017		170	0.024
390	2008	26-Nov	41	3	E	10	0.1383	0.1366	0.0017		170	0.024
391	2008	26-Nov	41	3	F	12	0.143	0.1408	0.0022		220	0.028
392	2008	26-Nov	41	3	G	14	0.1376	0.1363	0.0013		130	0.020
393	2008	26-Nov	41	3	H	16	0.1368	0.1358	0.001		100	0.017
394	2008	26-Nov	41	3	I	18	0.1319	0.131	0.0009		90	0.016
395	2008	26-Nov	41	3	J	20	0.1342	0.1334	0.0008		80	0.014
396	2008	26-Nov	41	3	K	22	0.1331	0.1319	0.0012		120	0.019
397	2009	08-May	29	1	A	2	0.1309	0.1302	0.0007	1		
398	2009	08-May	29	1	B	4	0.1298	0.1287	0.0011	1		
399	2009	08-May	29	1	C	6	0.1300	0.1293	0.0007		70	0.018
400	2009	08-May	29	1	D	8	0.1283	0.1282	0.0001		10	0.003
401	2009	08-May	29	1	E	10	0.1306	0.1301	0.0005		50	0.014
402	2009	08-May	29	1	F	12	0.1286	0.1275	0.0011		110	0.026
403	2009	08-May	29	1	G	14	0.1291	0.1283	0.0008		80	0.020
404	2009	08-May	29	1	H	16	0.1285	0.1277	0.0008		80	0.020
405	2009	08-May	29	1	I	18	0.1316	0.1308	0.0008		80	0.020
406	2009	08-May	29	1	J	20	0.1283	0.1275	0.0008		80	0.020
407	2009	08-May	29	1	K	22	0.1306	0.1302	0.0004		40	0.012
408	2009	08-May	29	2	A	2	0.1327	0.1304	0.0023	1		
409	2009	08-May	29	2	B	4	0.1314	0.1308	0.0006	1		
410	2009	08-May	29	2	C	6	0.1307	0.1306	0.0001		10	0.003
411	2009	08-May	29	2	D	8	0.1288	0.1287	0.0001		10	0.003
412	2009	08-May	29	2	E	10	0.1311	0.1303	0.0008		80	0.020
413	2009	08-May	29	2	F	12	0.1303	0.1296	0.0007		70	0.018
414	2009	08-May	29	2	G	14	0.1306	0.1294	0.0012		120	0.027
415	2009	08-May	29	2	H	16	0.1316	0.1308	0.0008		80	0.020
416	2009	08-May	29	2	I	18	0.1309	0.1305	0.0004		40	0.012
417	2009	08-May	29	2	J	20	0.1294	0.1282	0.0012		120	0.027
418	2009	08-May	29	2	K	22	0.1308	0.1299	0.0009		90	0.022
419	2009	08-May	29	3	A	2						
420	2009	08-May	29	3	B	4						

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
421	2009	08-May	29	3	C	6						
422	2009	08-May	29	3	D	8						
423	2009	08-May	29	3	E	10						
424	2009	08-May	29	3	F	12						
425	2009	08-May	29	3	G	14						
426	2009	08-May	29	3	H	16						
427	2009	08-May	29	3	I	18						
428	2009	08-May	29	3	J	20						
429	2009	08-May	29	3	K	22						
430	2009	12-Jun	34	1	A	2	0.1307	0.1296	0.0011	1		
431	2009	12-Jun	34	1	B	4	0.1307	0.1301	0.0006		60	0.014
432	2009	12-Jun	34	1	C	6	0.1320	0.1306	0.0014		140	0.026
433	2009	12-Jun	34	1	D	8	0.1310	0.1296	0.0014		140	0.026
434	2009	12-Jun	34	1	E	10	0.1306	0.1290	0.0016		160	0.028
435	2009	12-Jun	34	1	F	12	0.1315	0.1300	0.0015		150	0.027
436	2009	12-Jun	34	1	G	14	0.1319	0.1308	0.0011		110	0.022
437	2009	12-Jun	34	1	H	16	0.1324	0.1312	0.0012		120	0.023
438	2009	12-Jun	34	1	I	18	0.1277	0.1270	0.0007		70	0.016
439	2009	12-Jun	34	1	J	20	0.1298	0.1289	0.0009		90	0.019
440	2009	12-Jun	34	1	K	22	0.1293	0.1283	0.0010		100	0.020
441	2009	12-Jun	34	2	A	2	0.1281	0.1274	0.0007	1		
442	2009	12-Jun	34	2	B	4	0.1314	0.1304	0.0010	1		
443	2009	12-Jun	34	2	C	6	0.1281	0.1280	0.0001		10	0.003
444	2009	12-Jun	34	2	D	8	0.1291	0.1285	0.0006		60	0.014
445	2009	12-Jun	34	2	E	10	0.1281	0.1272	0.0009		90	0.019
446	2009	12-Jun	34	2	F	12	0.1298	0.1290	0.0008		80	0.017
447	2009	12-Jun	34	2	G	14	0.1292	0.1283	0.0009		90	0.019
448	2009	12-Jun	34	2	H	16	0.1292	0.1285	0.0007		70	0.016
449	2009	12-Jun	34	2	I	18	0.1297	0.1288	0.0009		90	0.019
450	2009	12-Jun	34	2	J	20	0.1297	0.1288	0.0009		90	0.019
451	2009	12-Jun	34	2	K	22	0.1287	0.1277	0.0010		100	0.020
452	2009	18-Jun	40	3	A	2	0.1338	0.1317	0.0021		210	0.028
453	2009	18-Jun	40	3	B	4	0.1319	0.1304	0.0015		150	0.023
454	2009	18-Jun	40	3	C	6	0.1317	0.1303	0.0014		140	0.022
455	2009	18-Jun	40	3	D	8	0.1317	0.1298	0.0019		190	0.027
456	2009	18-Jun	40	3	E	10	0.1359	0.1342	0.0017		170	0.025
457	2009	18-Jun	40	3	F	12	0.1322	0.1308	0.0014		140	0.022
458	2009	18-Jun	40	3	G	14	0.1309	0.1296	0.0013		130	0.021
459	2009	18-Jun	40	3	H	16	0.1302	0.1292	0.0010		100	0.017
460	2009	18-Jun	40	3	I	18	0.1305	0.1296	0.0009		90	0.016
461	2009	18-Jun	40	3	J	20	0.1313	0.1304	0.0009		90	0.016
462	2009	18-Jun	40	3	K	22	0.1348	0.1323	0.0025		250	0.031
463	2009	15-Jul	32	1	A	2	0.1326	0.1318	0.0008	1		
464	2009	15-Jul	32	1	B	4	0.1340	0.1332	0.0008		80	0.018
465	2009	15-Jul	32	1	C	6	0.1370	0.1334	0.0036		360	0.048
466	2009	15-Jul	32	1	D	8	0.1342	0.1319	0.0023		230	0.037
467	2009	15-Jul	32	1	E	10	0.1367	0.1338	0.0029		290	0.043
468	2009	15-Jul	32	1	F	12	0.1438	0.1387	0.0051		510	0.057
469	2009	15-Jul	32	1	G	14	0.1348	0.1336	0.0012		120	0.025
470	2009	15-Jul	32	1	H	16	0.1366	0.1334	0.0032		320	0.045
471	2009	15-Jul	32	1	I	18	0.1330	0.1320	0.0010		100	0.022
472	2009	15-Jul	32	1	J	20	0.1352	0.1309	0.0043		430	0.052
473	2009	15-Jul	32	1	K	22	0.1322	0.1317	0.0005		50	0.013
474	2009	15-Jul	32	2	A	2	0.1319	0.1312	0.0007	1		
475	2009	15-Jul	32	2	B	4	0.1334	0.1319	0.0015		150	0.029
476	2009	15-Jul	32	2	C	6	0.1321	0.1314	0.0007		70	0.017
477	2009	15-Jul	32	2	D	8	0.1325	0.1316	0.0009		90	0.020
478	2009	15-Jul	32	2	E	10	0.1340	0.1331	0.0009		90	0.020
479	2009	15-Jul	32	2	F	12	0.1329	0.1323	0.0006		60	0.015
480	2009	15-Jul	32	2	G	14	0.1326	0.1322	0.0004		40	0.011

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
481	2009	15-Jul	32	2	H	16	0.1335	0.1327	0.0008		80	0.018
482	2009	15-Jul	32	2	I	18	0.1334	0.1328	0.0006		60	0.015
483	2009	15-Jul	32	2	J	20	0.1313	0.1307	0.0006		60	0.015
484	2009	15-Jul	32	2	K	22	0.1314	0.1307	0.0007		70	0.017
485	2009	15-Jul	26	3	A	2	0.1323	0.1316	0.0007		70	0.020
486	2009	15-Jul	26	3	B	4	0.1344	0.1333	0.0011		110	0.029
487	2009	15-Jul	26	3	C	6	0.1323	0.1315	0.0008		80	0.023
488	2009	15-Jul	26	3	D	8	0.1317	0.1311	0.0006		60	0.018
489	2009	15-Jul	26	3	E	10	0.1317	0.1310	0.0007		70	0.020
490	2009	15-Jul	26	3	F	12	0.1325	0.1319	0.0006		60	0.018
491	2009	15-Jul	26	3	G	14	0.1323	0.1314	0.0009		90	0.025
492	2009	15-Jul	26	3	H	16	0.1328	0.1318	0.0010		100	0.027
493	2009	15-Jul	26	3	I	18	0.1326	0.1318	0.0008		80	0.023
494	2009	15-Jul	26	3	J	20	0.1319	0.1312	0.0007		70	0.020
495	2009	15-Jul	26	3	K	22	0.1319	0.1313	0.0006		60	0.018
496	2009	13-Aug	29	1	A	2	0.1288	0.1282	0.0006	1		
497	2009	13-Aug	29	1	B	4	0.1285	0.1278	0.0007		70	0.018
498	2009	13-Aug	29	1	C	6	0.1296	0.1287	0.0009		90	0.022
499	2009	13-Aug	29	1	D	8	0.1286	0.1269	0.0017		170	0.034
500	2009	13-Aug	29	1	E	10	0.1281	0.1272	0.0009		90	0.022
501	2009	13-Aug	29	1	F	12	0.1332	0.1307	0.0025		250	0.043
502	2009	13-Aug	29	1	G	14	0.1300	0.1285	0.0015		150	0.032
503	2009	13-Aug	29	1	H	16	0.1285	0.1276	0.0009		90	0.022
504	2009	13-Aug	29	1	I	18	0.1290	0.1279	0.0011		110	0.026
505	2009	13-Aug	29	1	J	20	0.1275	0.1270	0.0005		50	0.014
506	2009	13-Aug	29	1	K	22	0.1293	0.1286	0.0007		70	0.018
507	2009	13-Aug	29	2	A	2	0.1307	0.1287	0.0020	1		
508	2009	13-Aug	29	2	B	4	0.1289	0.1285	0.0004	1		
509	2009	13-Aug	29	2	C	6	0.1291	0.1283	0.0008		80	0.020
510	2009	13-Aug	29	2	D	8	0.1295	0.1283	0.0012		120	0.027
511	2009	13-Aug	29	2	E	10	0.1298	0.1286	0.0012		120	0.027
512	2009	13-Aug	29	2	F	12	0.1302	0.1293	0.0009		90	0.022
513	2009	13-Aug	29	2	G	14	0.1299	0.1289	0.0010		100	0.024
514	2009	13-Aug	29	2	H	16	0.1284	0.1277	0.0007		70	0.018
515	2009	13-Aug	29	2	I	18	0.1282	0.1280	0.0002		20	0.006
516	2009	13-Aug	29	2	J	20	0.1279	0.1277	0.0002		20	0.006
517	2009	13-Aug	29	2	K	22	0.1279	0.1278	0.0001		10	0.003
518	2009	13-Aug	29	3	A	2	0.1282	0.1276	0.0006		60	0.016
519	2009	13-Aug	29	3	B	4	0.1281	0.1275	0.0006		60	0.016
520	2009	13-Aug	29	3	C	6	0.1288	0.1279	0.0009		90	0.022
521	2009	13-Aug	29	3	D	8	0.1281	0.1272	0.0009		90	0.022
522	2009	13-Aug	29	3	E	10	0.1279	0.1271	0.0008		80	0.020
523	2009	13-Aug	29	3	F	12	0.1287	0.1280	0.0007		70	0.018
524	2009	13-Aug	29	3	G	14	0.1293	0.1285	0.0008		80	0.020
525	2009	13-Aug	29	3	H	16	0.1297	0.1290	0.0007		70	0.018
526	2009	13-Aug	29	3	I	18	0.1277	0.1270	0.0007		70	0.018
527	2009	13-Aug	29	3	J	20	0.1273	0.1271	0.0002		20	0.006
528	2009	13-Aug	29	3	K	22	0.1282	0.1276	0.0006		60	0.016
529	2009	Sep-09	26	1	A	2	0.1274	0.1265	0.0009	1		
530	2009	Sep-09	26	1	B	4	0.1292	0.1286	0.0006	1		
531	2009	Sep-09	26	1	C	6	0.1285	0.1279	0.0006		60	0.018
532	2009	Sep-09	26	1	D	8	0.1280	0.1274	0.0006		60	0.018
533	2009	Sep-09	26	1	E	10	0.1289	0.1279	0.0010		100	0.027
534	2009	Sep-09	26	1	F	12	0.1302	0.1285	0.0017		170	0.038
535	2009	Sep-09	26	1	G	14	0.1303	0.1290	0.0013		130	0.032
536	2009	Sep-09	26	1	H	16	0.1304	0.1284	0.0020		200	0.042
537	2009	Sep-09	26	1	I	18	0.1276	0.1271	0.0005		50	0.016
538	2009	Sep-09	26	1	J	20	0.1270	0.1266	0.0004		40	0.013
539	2009	Sep-09	26	1	K	22	0.1263	0.1259	0.0004		40	0.013
540	2009	Sep-09	26	2	A	2	0.1278	0.1272	0.0006	1		

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
541	2009	Sep-09	26	2	B	4	0.1286	0.1280	0.0006	1		
542	2009	Sep-09	26	2	C	6	0.1294	0.1288	0.0006		60	0.018
543	2009	Sep-09	26	2	D	8	0.1290	0.1284	0.0006		60	0.018
544	2009	Sep-09	26	2	E	10	0.1276	0.1268	0.0008		80	0.023
545	2009	Sep-09	26	2	F	12	0.1285	0.1278	0.0007		70	0.020
546	2009	Sep-09	26	2	G	14	0.1271	0.1266	0.0005		50	0.016
547	2009	Sep-09	26	2	H	16	0.1290	0.1287	0.0003		30	0.010
548	2009	Sep-09	26	2	I	18	0.1290	0.1287	0.0003		30	0.010
549	2009	Sep-09	26	2	J	20	0.1293	0.1291	0.0002		20	0.007
550	2009	Sep-09	26	2	K	22	0.1272	0.1266	0.0006		60	0.018
551	2009	Sep-09	26	3	A	2	0.1296	0.1292	0.0004		40	0.013
552	2009	Sep-09	26	3	B	4	0.1289	0.1285	0.0004		40	0.013
553	2009	Sep-09	26	3	C	6	0.1293	0.1289	0.0004		40	0.013
554	2009	Sep-09	26	3	D	8	0.1289	0.1284	0.0005		50	0.016
555	2009	Sep-09	26	3	E	10	0.1275	0.1267	0.0008		80	0.023
556	2009	Sep-09	26	3	F	12	0.1271	0.1266	0.0005		50	0.016
557	2009	Sep-09	26	3	G	14	0.1280	0.1273	0.0007		70	0.020
558	2009	Sep-09	26	3	H	16	0.1274	0.1267	0.0007		70	0.020
559	2009	Sep-09	26	3	I	18	0.1270	0.1266	0.0004		40	0.013
560	2009	Sep-09	26	3	J	20	0.1259	0.1256	0.0003		30	0.010
561	2009	Sep-09	26	3	K	22	0.1291	0.1282	0.0009		90	0.025
562	2009	Oct-09	39	1	A	2				1		
563	2009	Oct-09	39	1	B	4				1		
564	2009	Oct-09	39	1	C	6	0.1323	0.1313	0.0010		100	0.018
565	2009	Oct-09	39	1	D	8	0.1313	0.1301	0.0012		120	0.020
566	2009	Oct-09	39	1	E	10	0.1335	0.1320	0.0015		150	0.023
567	2009	Oct-09	39	1	F	12	0.1326	0.1310	0.0016		160	0.025
568	2009	Oct-09	39	1	G	14	0.1337	0.1322	0.0015		150	0.023
569	2009	Oct-09	39	1	H	16	0.1340	0.1322	0.0018		180	0.026
570	2009	Oct-09	39	1	I	18	0.1324	0.1315	0.0009		90	0.016
571	2009	Oct-09	39	1	J	20	0.1327	0.1312	0.0015		150	0.023
572	2009	Oct-09	39	1	K	22	0.1330	0.1317	0.0013		130	0.021
573	2009	Oct-09	39	2	A	2				1		
574	2009	Oct-09	39	2	B	4				1		
575	2009	Oct-09	39	2	C	6	0.1313	0.1300	0.0013		130	0.021
576	2009	Oct-09	39	2	D	8	0.1312	0.1298	0.0014		140	0.022
577	2009	Oct-09	39	2	E	10	0.1321	0.1309	0.0012		120	0.020
578	2009	Oct-09	39	2	F	12	0.1319	0.1311	0.0008		80	0.015
579	2009	Oct-09	39	2	G	14	0.1310	0.1300	0.0010		100	0.018
580	2009	Oct-09	39	2	H	16	0.1312	0.1303	0.0009		90	0.016
581	2009	Oct-09	39	2	I	18	0.1324	0.1311	0.0013		130	0.021
582	2009	Oct-09	39	2	J	20	0.1317	0.1310	0.0007		70	0.014
583	2009	Oct-09	39	2	K	22	0.1323	0.1315	0.0008		80	0.015
584	2009	Oct-09	39	3	A	2						
585	2009	Oct-09	39	3	B	4						
586	2009	Oct-09	39	3	C	6						
587	2009	Oct-09	39	3	D	8						
588	2009	Oct-09	39	3	E	10						
589	2009	Oct-09	39	3	F	12						
590	2009	Oct-09	39	3	G	14						
591	2009	Oct-09	39	3	H	16						
592	2009	Oct-09	39	3	I	18						
593	2009	Oct-09	39	3	J	20						
594	2009	Oct-09	39	3	K	22						
595	2010	03-Jun	29	1	A	2	0.1296	0.1289	0.0007		70	0.018
596	2010	03-Jun	29	1	B	4	0.1272	0.1265	0.0007		70	0.018
597	2010	03-Jun	29	1	C	6	0.1266	0.1258	0.0008		80	0.020
598	2010	03-Jun	29	1	D	8	0.1267	0.1262	0.0005		50	0.014
599	2010	03-Jun	29	1	E	10	0.1272	0.1264	0.0008		80	0.020
600	2010	03-Jun	29	1	F	12	0.1273	0.1269	0.0004		40	0.012

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
601	2010	03-Jun	29	1	G	14	0.1285	0.1280	0.0005		50	0.014
602	2010	03-Jun	29	1	H	16	0.1271	0.1265	0.0006		60	0.016
603	2010	03-Jun	29	1	I	18	0.1283	0.1275	0.0008		80	0.020
604	2010	03-Jun	29	1	J	20	0.1283	0.1277	0.0006		60	0.016
605	2010	03-Jun	29	1	K	22	0.1259	0.1256	0.0003		30	0.009
606	2010	03-Jun	29	2	A	2	0.1279	0.1272	0.0007		70	0.018
607	2010	03-Jun	29	2	B	4	0.1275	0.1266	0.0009		90	0.022
608	2010	03-Jun	29	2	C	6	0.1270	0.1260	0.0010		100	0.024
609	2010	03-Jun	29	2	D	8	0.1275	0.1269	0.0006		60	0.016
610	2010	03-Jun	29	2	E	10	0.1277	0.1268	0.0009		90	0.022
611	2010	03-Jun	29	2	F	12	0.1291	0.1281	0.0010		100	0.024
612	2010	03-Jun	29	2	G	14	0.1287	0.1277	0.0010		100	0.024
613	2010	03-Jun	29	2	H	16	0.1307	0.1297	0.0010		100	0.024
614	2010	03-Jun	29	2	I	18	0.1295	0.1287	0.0008		80	0.020
615	2010	03-Jun	29	2	J	20	0.1267	0.1258	0.0009		90	0.022
616	2010	03-Jun	29	2	K	22	0.1273	0.1265	0.0008		80	0.020
617	2010	03-Jun	29	3	A	2	0.1280	0.1275	0.0005		50	0.014
618	2010	03-Jun	29	3	B	4	0.1275	0.1268	0.0007		70	0.018
619	2010	03-Jun	29	3	C	6	0.1267	0.1262	0.0005		50	0.014
620	2010	03-Jun	29	3	D	8	0.1271	0.1265	0.0006		60	0.016
621	2010	03-Jun	29	3	E	10	0.1278	0.1273	0.0005		50	0.014
622	2010	03-Jun	29	3	F	12	0.1271	0.1266	0.0005		50	0.014
623	2010	03-Jun	29	3	G	14	0.1271	0.1269	0.0002		20	0.006
624	2010	03-Jun	29	3	H	16	0.1278	0.1276	0.0002		20	0.006
625	2010	03-Jun	29	3	I	18	0.1273	0.1266	0.0007		70	0.018
626	2010	03-Jun	29	3	J	20	0.1269	0.1267	0.0002		20	0.006
627	2010	03-Jun	29	3	K	22	0.1276	0.1269	0.0007		70	0.018
628	2010	07-Jul	34	1	A	2	0.1273	0.1267	0.0006		60	0.014
629	2010	07-Jul	34	1	B	4	0.1276	0.1270	0.0006		60	0.014
630	2010	07-Jul	34	1	C	6	0.1287	0.1278	0.0009		90	0.019
631	2010	07-Jul	34	1	D	8	0.1289	0.1280	0.0009		90	0.019
632	2010	07-Jul	34	1	E	10	0.1303	0.1294	0.0009		90	0.019
633	2010	07-Jul	34	1	F	12	0.1293	0.1287	0.0006		60	0.014
634	2010	07-Jul	34	1	G	14	0.1281	0.1275	0.0006		60	0.014
635	2010	07-Jul	34	1	H	16	0.1287	0.1281	0.0006		60	0.014
636	2010	07-Jul	34	1	I	18	0.1291	0.1285	0.0006		60	0.014
637	2010	07-Jul	34	1	J	20	0.1290	0.1284	0.0006		60	0.014
638	2010	07-Jul	34	1	K	22	0.1283	0.1278	0.0005		50	0.012
639	2010	07-Jul	34	2	A	2	0.1279	0.1273	0.0006		60	0.014
640	2010	07-Jul	34	2	B	4	0.1345	0.1318	0.0027		270	0.038
641	2010	07-Jul	34	2	C	6	0.1299	0.1291	0.0008		80	0.017
642	2010	07-Jul	34	2	D	8	0.1310	0.1298	0.0012		120	0.023
643	2010	07-Jul	34	2	E	10	0.1285	0.1275	0.0010		100	0.020
644	2010	07-Jul	34	2	F	12	0.1285	0.1274	0.0011		110	0.022
645	2010	07-Jul	34	2	G	14	0.1295	0.1282	0.0013		130	0.024
646	2010	07-Jul	34	2	H	16	0.1295	0.1280	0.0015		150	0.027
647	2010	07-Jul	34	2	I	18	0.1285	0.1273	0.0012		120	0.023
648	2010	07-Jul	34	2	J	20	0.1292	0.1283	0.0009		90	0.019
649	2010	07-Jul	34	2	K	22	0.1294	0.1284	0.0010		100	0.020
650	2010	07-Jul	34	3	A	2	0.1286	0.1278	0.0008		80	0.017
651	2010	07-Jul	34	3	B	4	0.1291	0.1280	0.0011		110	0.022
652	2010	07-Jul	34	3	C	6	0.1284	0.1274	0.0010		100	0.020
653	2010	07-Jul	34	3	D	8	0.1298	0.1288	0.0010		100	0.020
654	2010	07-Jul	34	3	E	10	0.1297	0.1289	0.0008		80	0.017
655	2010	07-Jul	34	3	F	12	0.1291	0.1285	0.0006		60	0.014
656	2010	07-Jul	34	3	G	14	0.1282	0.1276	0.0006		60	0.014
657	2010	07-Jul	34	3	H	16	0.1292	0.1287	0.0005		50	0.012
658	2010	07-Jul	34	3	I	18	0.1290	0.1285	0.0005		50	0.012
659	2010	07-Jul	34	3	J	20	0.1288	0.1281	0.0007		70	0.016
660	2010	07-Jul	34	3	K	22	0.1282	0.1277	0.0005		50	0.012

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
661	2010	24-Aug	48	1	A	2	0.1320	0.1311	0.0009	1		
662	2010	24-Aug	48	1	B	4	0.1338	0.1324	0.0014		140	0.018
663	2010	24-Aug	48	1	C	6	0.1347	0.1332	0.0015		150	0.019
664	2010	24-Aug	48	1	D	8	0.1352	0.1337	0.0015		150	0.019
665	2010	24-Aug	48	1	E	10	0.1362	0.1345	0.0017		170	0.021
666	2010	24-Aug	48	1	F	12	0.1342	0.1331	0.0011		110	0.015
667	2010	24-Aug	48	1	G	14	0.1332	0.1323	0.0009		90	0.013
668	2010	24-Aug	48	1	H	16	0.1324	0.1309	0.0015		150	0.019
669	2010	24-Aug	48	1	I	18	0.1328	0.1320	0.0008		80	0.012
670	2010	24-Aug	48	1	J	20	0.1332	0.1325	0.0007		70	0.011
671	2010	24-Aug	48	1	K	22	0.1343	0.1333	0.0010		100	0.014
672	2010	24-Aug	48	2	A	2	0.1335	0.1328	0.0007		70	0.011
673	2010	24-Aug	48	2	B	4	0.1325	0.1317	0.0008		80	0.012
674	2010	24-Aug	48	2	C	6	0.1354	0.1336	0.0018		180	0.021
675	2010	24-Aug	48	2	D	8	0.1343	0.1331	0.0012		120	0.016
676	2010	24-Aug	48	2	E	10	0.1339	0.1330	0.0009		90	0.013
677	2010	24-Aug	48	2	F	12	0.1333	0.1319	0.0014		140	0.018
678	2010	24-Aug	48	2	G	14	0.1334	0.1327	0.0007		70	0.011
679	2010	24-Aug	48	2	H	16	0.1330	0.1322	0.0008		80	0.012
680	2010	24-Aug	48	2	I	18	0.1332	0.1321	0.0011		110	0.015
681	2010	24-Aug	48	2	J	20	0.1336	0.1325	0.0011		110	0.015
682	2010	24-Aug	48	2	K	22	0.1343	0.1332	0.0011		110	0.015
683	2010	24-Aug	48	3	A	2	0.1351	0.1337	0.0014		140	0.018
684	2010	24-Aug	48	3	B	4	0.1327	0.1313	0.0014		140	0.018
685	2010	24-Aug	48	3	C	6	0.1353	0.1337	0.0016		160	0.020
686	2010	24-Aug	48	3	D	8	0.1340	0.1327	0.0013		130	0.017
687	2010	24-Aug	48	3	E	10	0.1336	0.1324	0.0012		120	0.016
688	2010	24-Aug	48	3	F	12	0.1342	0.1336	0.0006		60	0.010
689	2010	24-Aug	48	3	G	14	0.1330	0.1322	0.0008		80	0.012
690	2010	24-Aug	48	3	H	16	0.1324	0.1323	0.0001		10	0.002
691	2010	24-Aug	48	3	I	18	0.1317	0.1312	0.0005		50	0.008
692	2010	24-Aug	48	3	J	20	0.1319	0.1316	0.0003		30	0.005
693	2010	24-Aug	48	3	K	22	0.1330	0.1319	0.0011		110	0.015
694	2010	22-Sep	29	1	A	2	0.1327	0.1321	0.0006	1		
695	2010	22-Sep	29	1	B	4	0.1327	0.1321	0.0006	1		
696	2010	22-Sep	29	1	C	6	0.1335	0.1326	0.0009		90	0.022
697	2010	22-Sep	29	1	D	8	0.1346	0.1335	0.0011		110	0.026
698	2010	22-Sep	29	1	E	10	0.1349	0.1338	0.0011		110	0.026
699	2010	22-Sep	29	1	F	12	0.1345	0.1335	0.0010		100	0.024
700	2010	22-Sep	29	1	G	14	0.1364	0.1351	0.0013		130	0.029
701	2010	22-Sep	29	1	H	16	0.1350	0.1340	0.0010		100	0.024
702	2010	22-Sep	29	1	I	18	0.1345	0.1337	0.0008		80	0.020
703	2010	22-Sep	29	1	J	20	0.1341	0.1334	0.0007		70	0.018
704	2010	22-Sep	29	1	K	22	0.1325	0.1321	0.0004		40	0.012
705	2010	22-Sep	29	2	A	2	0.1332	0.1329	0.0003	1		
706	2010	22-Sep	29	2	B	4	0.1352	0.1344	0.0008	1		
707	2010	22-Sep	29	2	C	6	0.1326	0.1318	0.0008		80	0.020
708	2010	22-Sep	29	2	D	8	0.1359	0.1348	0.0011		110	0.026
709	2010	22-Sep	29	2	E	10	0.1399	0.1375	0.0024		240	0.042
710	2010	22-Sep	29	2	F	12	0.1327	0.1319	0.0008		80	0.020
711	2010	22-Sep	29	2	G	14	0.1327	0.1317	0.0010		100	0.024
712	2010	22-Sep	29	2	H	16	0.1343	0.1328	0.0015		150	0.032
713	2010	22-Sep	29	2	I	18	0.1348	0.1335	0.0013		130	0.029
714	2010	22-Sep	29	2	J	20	0.1342	0.1331	0.0011		110	0.026
715	2010	22-Sep	29	2	K	22	0.1393	0.1369	0.0024		240	0.042
716	2010	22-Sep	29	3	A	2	0.1334	0.1317	0.0017		170	0.034
717	2010	22-Sep	29	3	B	4	0.1352	0.1333	0.0019		190	0.037
718	2010	22-Sep	29	3	C	6	0.1377	0.1361	0.0016		160	0.033
719	2010	22-Sep	29	3	D	8	0.1374	0.1351	0.0023		230	0.041
720	2010	22-Sep	29	3	E	10	0.1374	0.1358	0.0016		160	0.033

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
721	2010	22-Sep	29	3	F	12	0.1357	0.1345	0.0012		120	0.027
722	2010	22-Sep	29	3	G	14	0.1343	0.1334	0.0009		90	0.022
723	2010	22-Sep	29	3	H	16	0.1326	0.1319	0.0007		70	0.018
724	2010	22-Sep	29	3	I	18	0.1330	0.1322	0.0008		80	0.020
725	2010	22-Sep	29	3	J	20	0.1336	0.1330	0.0006		60	0.016
726	2010	22-Sep	29	3	K	22	0.1327	0.1322	0.0005		50	0.014
727	2010	27-Oct	35	1	A	2	0.1331	0.1320	0.0011		110	0.021
728	2010	27-Oct	35	1	B	4	0.1329	0.1316	0.0013		130	0.024
729	2010	27-Oct	35	1	C	6	0.1326	0.1320	0.0006		60	0.013
730	2010	27-Oct	35	1	D	8	0.1339	0.1331	0.0008		80	0.017
731	2010	27-Oct	35	1	E	10	0.1308	0.1305	0.0003		30	0.007
732	2010	27-Oct	35	1	F	12	0.1345	0.1336	0.0009		90	0.018
733	2010	27-Oct	35	1	G	14	0.1365	0.1355	0.0010		100	0.020
734	2010	27-Oct	35	1	H	16	0.1351	0.1342	0.0009		90	0.018
735	2010	27-Oct	35	1	I	18	0.1338	0.1326	0.0012		120	0.023
736	2010	27-Oct	35	1	J	20	0.1342	0.1332	0.0010		100	0.020
737	2010	27-Oct	35	1	K	22	0.1343	0.1333	0.0010		100	0.020
738	2010	27-Oct	35	2	A	2	0.1344	0.1325	0.0019	1		
739	2010	27-Oct	35	2	B	4	0.1346	0.1334	0.0012		120	0.023
740	2010	27-Oct	35	2	C	6	0.1326	0.1315	0.0011		110	0.021
741	2010	27-Oct	35	2	D	8	0.1322	0.1314	0.0008		80	0.017
742	2010	27-Oct	35	2	E	10	0.1320	0.1312	0.0008		80	0.017
743	2010	27-Oct	35	2	F	12	0.1318	0.1311	0.0007		70	0.015
744	2010	27-Oct	35	2	G	14	0.1333	0.1325	0.0008		80	0.017
745	2010	27-Oct	35	2	H	16	0.1338	0.1327	0.0011		110	0.021
746	2010	27-Oct	35	2	I	18	0.1326	0.1316	0.0010		100	0.020
747	2010	27-Oct	35	2	J	20	0.1385	0.1369	0.0016		160	0.027
748	2010	27-Oct	35	2	K	22	0.1328	0.1322	0.0006		60	0.013
749	2010	27-Oct	35	3	A	2	0.1319	0.1313	0.0006		60	0.013
750	2010	27-Oct	35	3	B	4	0.1315	0.1306	0.0009		90	0.018
751	2010	27-Oct	35	3	C	6	0.1344	0.1333	0.0011		110	0.021
752	2010	27-Oct	35	3	D	8	0.1337	0.1330	0.0007		70	0.015
753	2010	27-Oct	35	3	E	10	0.1392	0.1373	0.0019		190	0.030
754	2010	27-Oct	35	3	F	12	0.1374	0.1328	0.0046		460	0.049
755	2010	27-Oct	35	3	G	14	0.1363	0.1352	0.0011		110	0.021
756	2010	27-Oct	35	3	H	16	0.1337	0.1328	0.0009		90	0.018
757	2010	27-Oct	35	3	I	18	0.1350	0.1345	0.0005		50	0.012
758	2010	27-Oct	35	3	J	20	0.1354	0.1339	0.0015		150	0.026
759	2010	27-Oct	35	3	K	22	0.1302	0.1290	0.0012		120	0.023
760	2010	23-Nov	27	1	A	2	0.1277	0.1270	0.0007	1		
761	2010	23-Nov	27	1	B	4	0.1298	0.1291	0.0007	1		
762	2010	23-Nov	27	1	C	6	0.1278	0.1272	0.0006		60	0.017
763	2010	23-Nov	27	1	D	8	0.1289	0.1281	0.0008		80	0.022
764	2010	23-Nov	27	1	E	10	0.1298	0.1290	0.0008		80	0.022
765	2010	23-Nov	27	1	F	12	0.1289	0.1283	0.0006		60	0.017
766	2010	23-Nov	27	1	G	14	0.1290	0.1285	0.0005		50	0.015
767	2010	23-Nov	27	1	H	16	0.1280	0.1275	0.0005		50	0.015
768	2010	23-Nov	27	1	I	18	0.1278	0.1275	0.0003		30	0.010
769	2010	23-Nov	27	1	J	20	0.1279	0.1276	0.0003		30	0.010
770	2010	23-Nov	27	1	K	22	0.1288	0.1285	0.0003		30	0.010
771	2010	23-Nov	27	2	A	2	0.1300	0.1294	0.0006	1		
772	2010	23-Nov	27	2	B	4	0.1278	0.1274	0.0004	1		
773	2010	23-Nov	27	2	C	6	0.1267	0.1261	0.0006		60	0.017
774	2010	23-Nov	27	2	D	8	0.1275	0.1272	0.0003		30	0.010
775	2010	23-Nov	27	2	E	10	0.1256	0.1249	0.0007		70	0.020
776	2010	23-Nov	27	2	F	12	0.1277	0.1270	0.0007		70	0.020
777	2010	23-Nov	27	2	G	14	0.1283	0.1283	0.0000		0	0.000
778	2010	23-Nov	27	2	H	16	0.1284	0.1274	0.0010		100	0.026
779	2010	23-Nov	27	2	I	18	0.1278	0.1269	0.0009		90	0.024
780	2010	23-Nov	27	2	J	20	0.1283	0.1275	0.0008		80	0.022

Record	Year	Date	Days	Site	Plate	Depth	OW	MW	AFDW	Surface	Biomass (mg/m2)	Growth
781	2010	23-Nov	27	2	K	22	0.1301	0.1295	0.0006		60	0.017
782	2010	23-Nov	27	3	A	2	0.1308	0.1301	0.0007		70	0.020
783	2010	23-Nov	27	3	B	4	0.1291	0.1285	0.0006		60	0.017
784	2010	23-Nov	27	3	C	6	0.1298	0.1295	0.0003		30	0.010
785	2010	23-Nov	27	3	D	8	0.1317	0.1311	0.0006		60	0.017
786	2010	23-Nov	27	3	E	10	0.1301	0.1294	0.0007		70	0.020
787	2010	23-Nov	27	3	F	12	0.1310	0.1307	0.0003		30	0.010
788	2010	23-Nov	27	3	G	14	0.1298	0.1292	0.0006		60	0.017
789	2010	23-Nov	27	3	H	16	0.1327	0.1321	0.0006		60	0.017
790	2010	23-Nov	27	3	I	18	0.1283	0.1279	0.0004		40	0.012
791	2010	23-Nov	27	3	J	20	0.1300	0.1296	0.0004		40	0.012
792	2010	23-Nov	27	3	K	22	0.1298	0.1296	0.0002		20	0.007