NUTRIENT AND DISSOLVED OXYGEN CONCENTRATIONS IN THE LETANG INLET, NEW BRUNSWICK, IN THE SUMMER OF 1994

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ABSTRACT

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The distributions of nutrients (silicate, phosphate, nitrate, nitrite, and ammonia) and dissolved oxygen, as well as associated hydrographic parameters, were measured during three surveys of the Letang Inlet, New Brunswick, in the summer of 1994. Samples were collected from Letang Harbour, Lime Kiln Bay, Blacks Harbour, and Bliss Harbour during surveys conducted in July, August, and September. On the August survey, samples were also collected from Back Bay and a detailed set of measurements were made in Bliss Harbour, close to the largest salmon farm in the Inlet.

RÉSUMÉ

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On a mesuré les distributions de nutriments (silicates, phosphates, nitrates, nitrites et ammoniac) et d'oxygène dissous, ainsi que divers paramètres hydrographiques connexes, au cours de trois relevés réalisés dans l'anse Letang, au Nouveau-Brunswick, en été 1994. Des échantillons ont été prélevés à Letang Harbour, dans la baie Lime Kiln, à Blacks Harbour et à Bliss Harbour durant les relevés réalisés en juillet, août et septembre. Dans le relevé d'août, on aussi recueilli des échantillons à Back Bay et pris des mesures détaillées à Bliss Harbour, à proximité de la plus grande pisciculture de saumon de l'anse.

INTRODUCTION

The Letang Inlet is a marine tidal inlet approximately 15 km in length located on the New Brunswick shore of the Bay of Fundy (Fig. 1). The Inlet consists of a number of smaller embayments: Letang Harbour, Blacks Harbour, Lime Kiln Bay, Bliss Harbour, and Back Bay. Water exchange in the Letang is dominated by the high tides of the Bay of Fundy: spring tides are >8 m. In contrast, the influence of freshwater inputs to the Letang is negligible: the drainage basin of the Letang is only 86 km^2. The mean depth of the inlet at low water (spring tide) is 8 m, so tidal exchange volumes can be greater than low water volumes, especially as extensive areas of the inlet dry at low tide.

Human activities that affect the Letang include salmon aquaculture (some 20 farm sites were producing approximately 5000 t of salmon per year in 1992), a fish-processing plant at Blacks Harbour and a cannery at Back Bay, which are seasonal operations, a municipal sewage treatment plant serving the town of Blacks Harbour (Population 1,200), and a pulp mill situated near Lake Utopia (Fig. 1).

Because all of these activities discharge wastes that can alter the ambient nutrient and dissolved oxygen levels, the Letang Inlet has been the subject of a number of field and modeling studies in recent years which have been evaluating such things as water quality in the Letang (Strain et al. 1995) and benthic impacts of salmon farms (Hargrave et al. 1993). This report presents the results of three surveys which measured nutrient and dissolved oxygen concentrations throughout the Letang Inlet in the summer of 1994.

METHODS

SAMPLING

Water samples were collected from the stations shown on Figures 2 to 5 using 5-L Niskin bottles deployed from a Cape Island fishing boat. Samples were collected from Letang Harbour, Lime Kiln Bay, Blacks Harbour, and Bliss Harbour during surveys on July 7, 1994, August 16-17, 1994, and September 20, 1994. During the August survey, samples were also collected from Back Bay and a detailed set of measurements were made in Bliss Harbour, close to the largest salmon farm in the Inlet (at the time of the survey, the farm operators were using a large compressor to increase oxygen levels in their cages). Depths were measured using a meter wheel. Station positions were determined using a hand-held global positioning system receiver (non-differential) and, in the case of the transects run close to the fish farm in Bliss Harbour on August 17, 1994, using an optical rangefinder to measure the distance of stations from the fish pens. One site in Letang Harbour (Stations 20, 26, 33, 35, and 51) and one in Bliss Harbour (Stations 22, 25, 36, 42, and 50) were occupied repeatedly on the August 16 and 17 surveys to obtain a series of measurements at different stages of the semi-diurnal tide.

The Niskin bottles were subsampled for dissolved oxygen, salinity, nutrients (silicate, phosphate, nitrate, nitrite, and ammonia), and biochemical oxygen demand. Nutrient samples

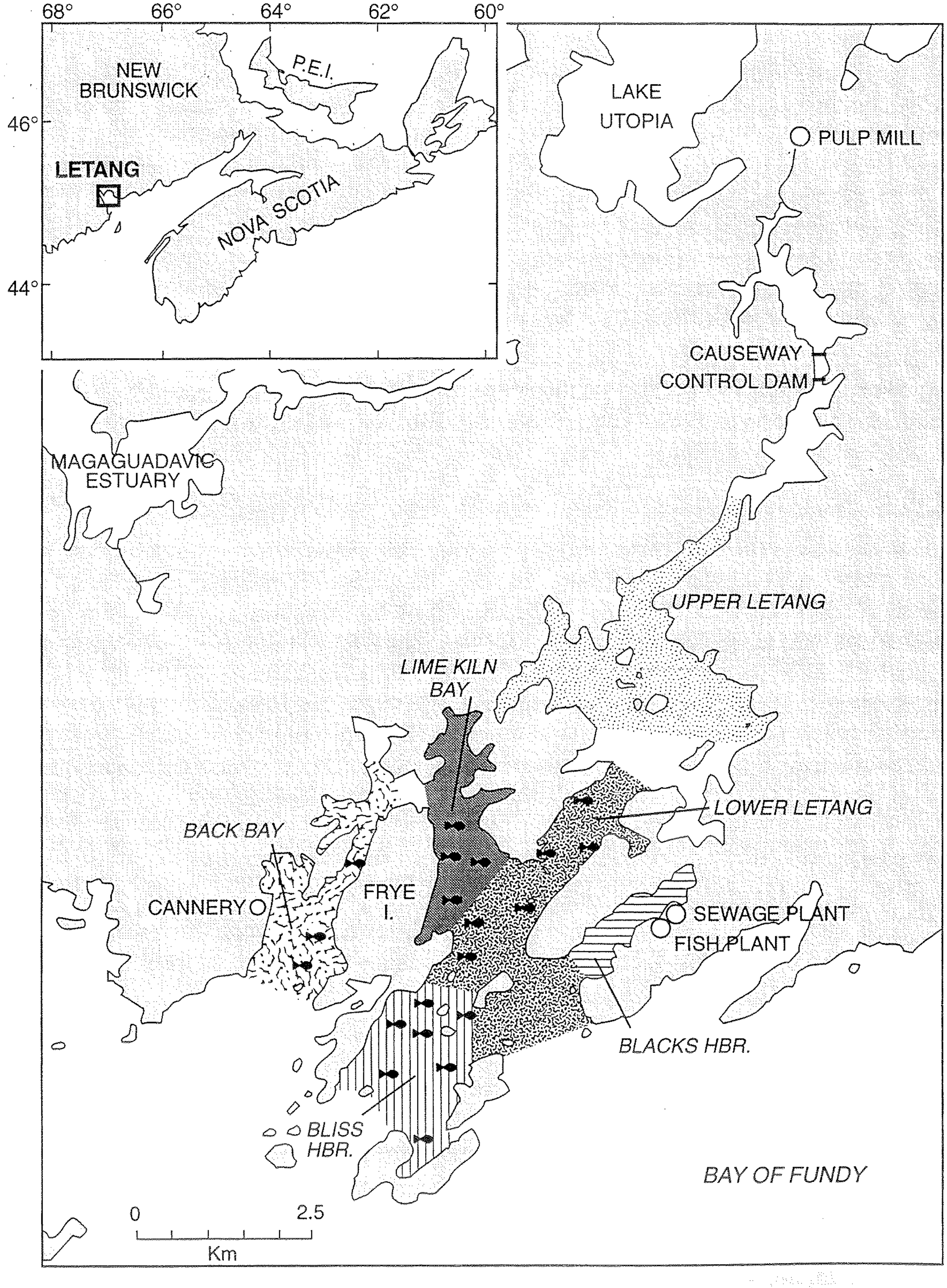

Figure 1. Study area.

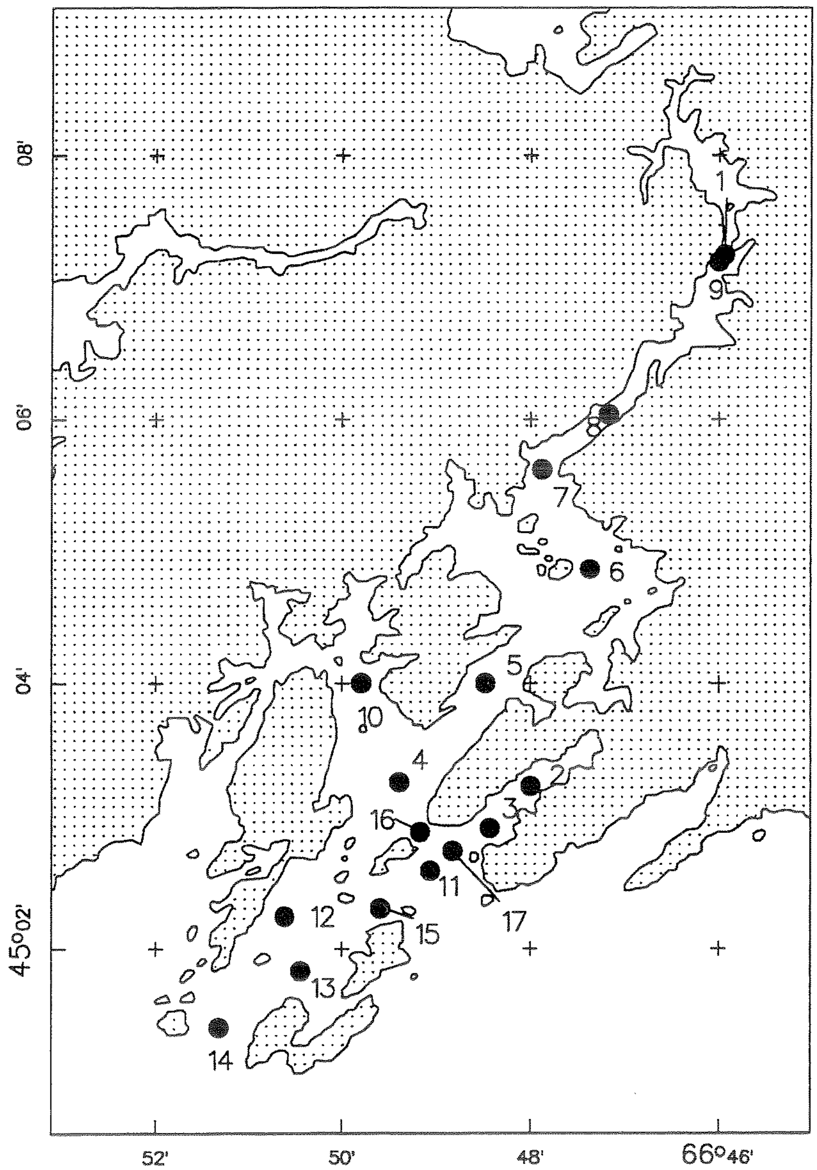

Figure 2. Stations sampled on July 7, 1994.

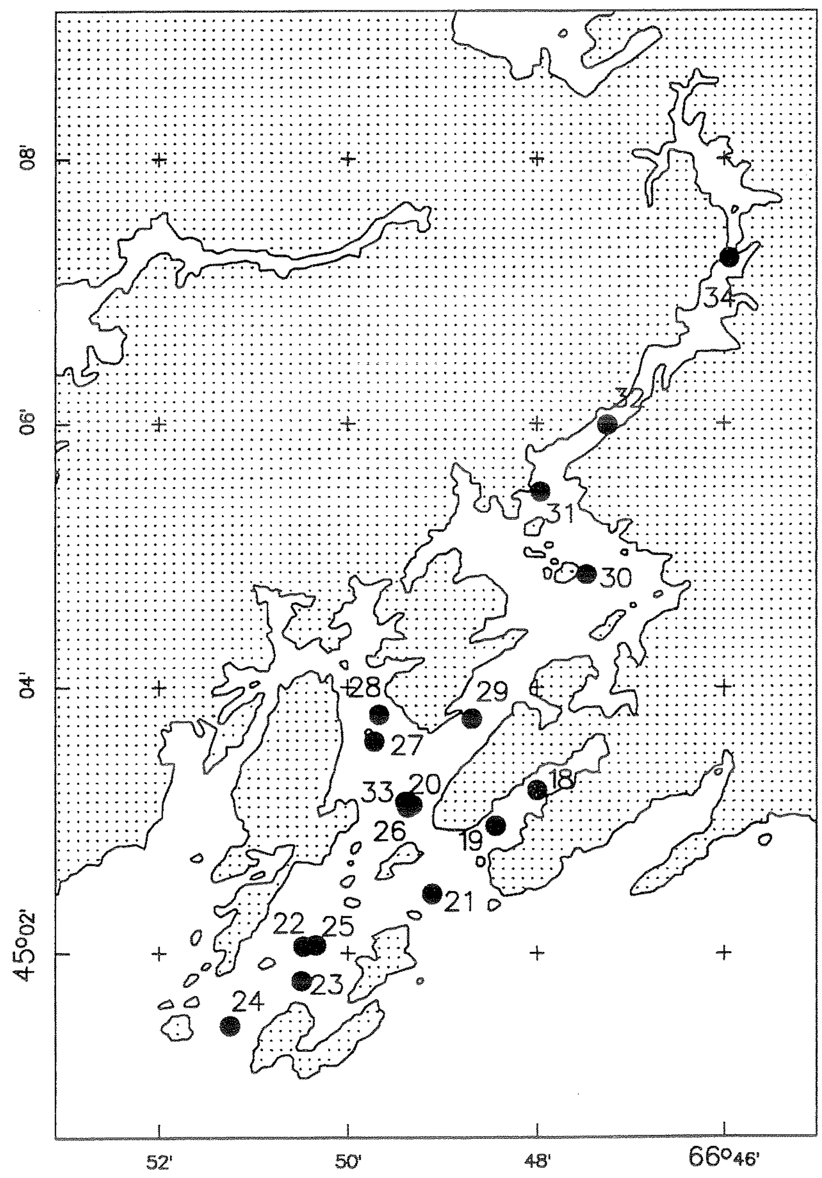

Figure 3. Stations sampled on August 16, 1994.

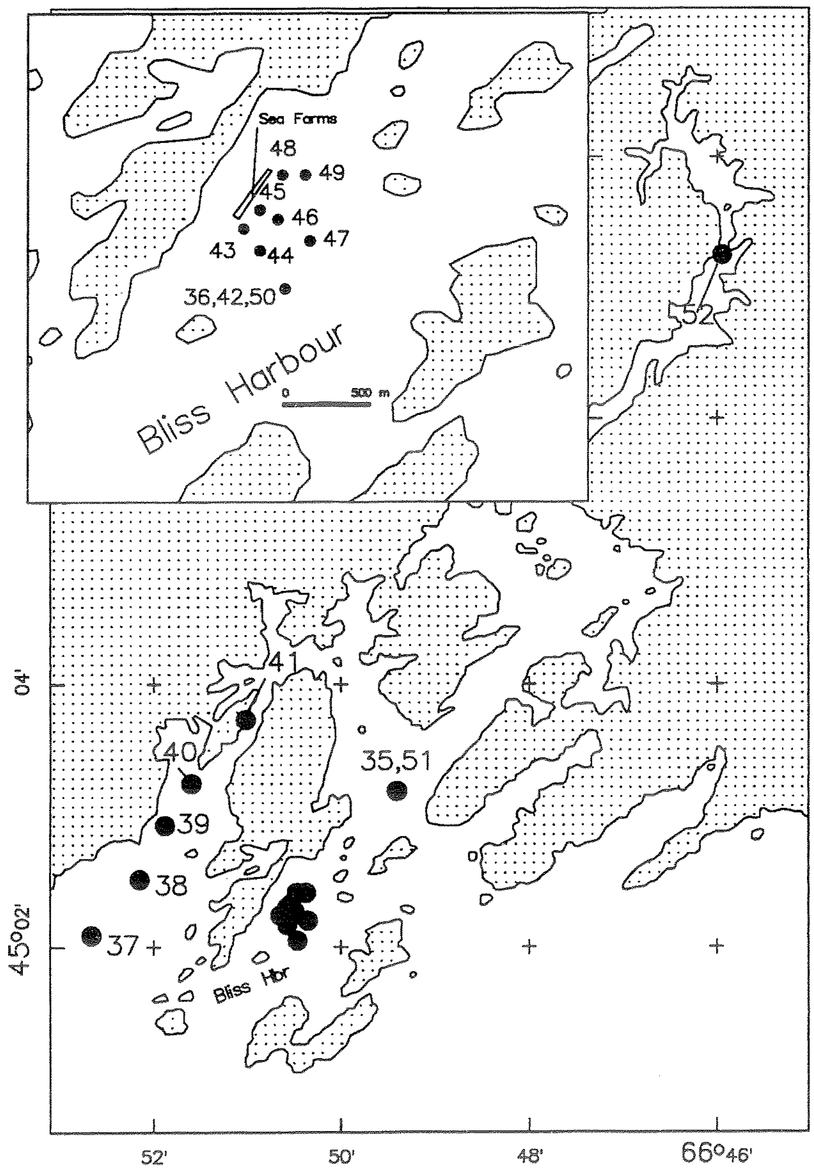

Figure 4. Stations sampled on August 17, 1994. Inset shows stations near the fish farm in Bliss Harbour.

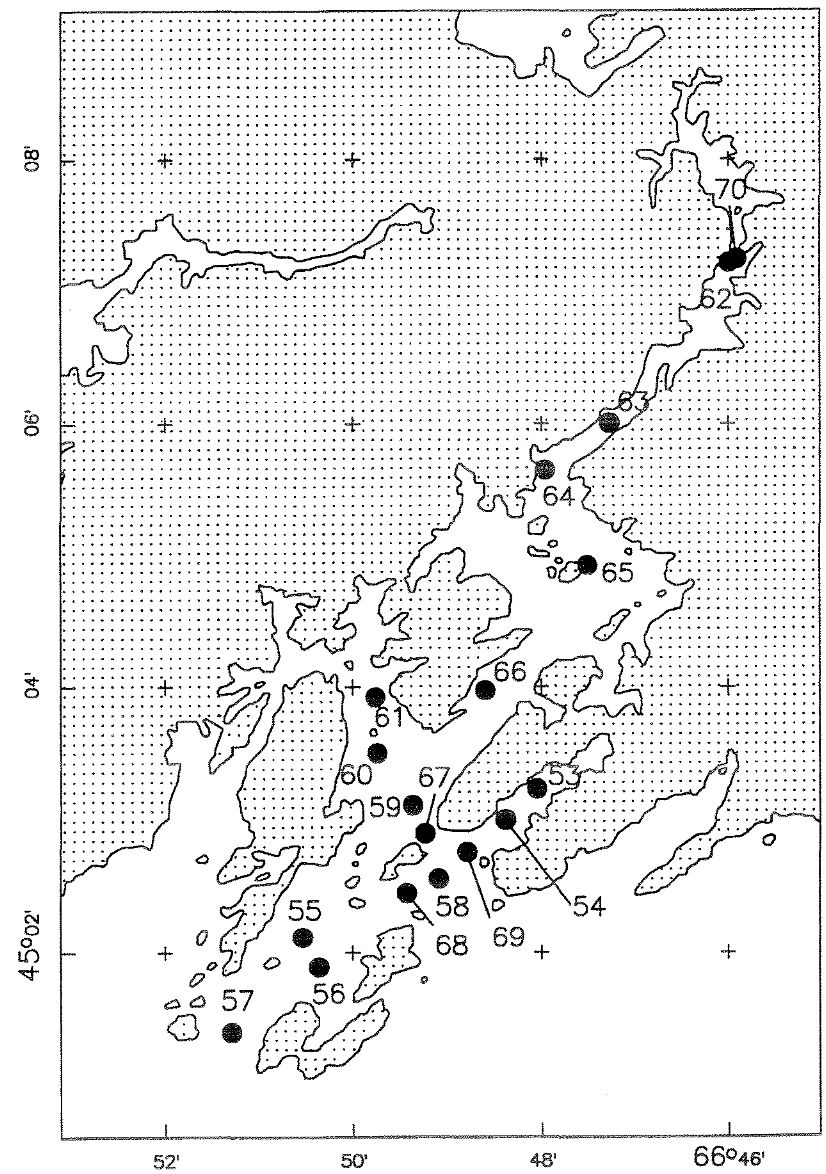

Figure 5. Stations sampled on September 20, 1994.

were collected in 30-mL high-density polyethylene bottles and frozen as soon as possible after collection.

In addition to the discrete samples, profiles of salinity, temperature, fluorescence, dissolved oxygen, and photosynthetically active radiation (PAR) were obtained with a Sea-Bird SBE-25 CTD. Only the CTD temperatures, PAR, and fluorescence that correspond to the depths of the discrete samples are reported here. More complete CTD data may be obtained from the authors. Precision and accuracy of the CTD temperatures are better than 0.01°C. PAR data are reported in μEinsteins m^{-2} sec^{-1}. The raw fluorescence data are nominally converted to the equivalent of μg chlorophyll $liter^{-1}$, but this conversion factor has not been calibrated with discrete chlorophyll analyses for this dataset.

DISSOLVED OXYGEN

Dissolved oxygen concentrations were measured by Winkler titrations, using equipment and techniques described by Levy et al. (1977). Precision and accuracy of these measurements are better than 1%.

BIOCHEMICAL OXYGEN DEMAND

To get a rough estimate of the biochemical oxygen demand (BOD), subsamples from a few samples from each survey were taken in 300-mL BOD bottles, which were stored in the dark in an insulated container for 5 d after collection. No attempt was made at rigorous temperature control or measurement during storage, but ambient temperatures were probably close to 20°C. Initial concentrations of dissolved O_2 were measured on separate subsamples using Winkler titrations (see above). Final concentrations were measured with an Orion® Model 840 dissolved oxygen meter.

SALINITY

Salinities of discrete samples were measured with a Guildline AutoSal® Model 8400 salinometer, standardized with IAPSO standard seawater from Ocean Scientific International. Precision and accuracy of these measurements are better than 0.01 psu.

NUTRIENTS

All nutrient analyses were performed using colorimetric techniques on a Technicon AutoAnalyzer II (AA II) segmented flow analyzer. Calibrations are done using a series of standards at six different concentrations analyzed at the beginning and end of each AA II run. All standards, and most samples, are analyzed in duplicate. Duplicate check standards, followed by duplicate blanks, are interspersed through the run (usually at intervals of 16 samples). Typical runs consist of 150 samples, standards, and blanks run at 30 samples/h using equal-length sample and wash cycles. For silicate, phosphate, nitrate, and nitrite, standards are prepared in NaCl solution (33 g/L); the latter is also used for wash water. For ammonia, freshwater standards and wash water are used. Detection limits and analytical precisions are determined for each nutrient for each run: detection limits are equal to three times the standard deviation of the blanks; the precision estimates are equal to the standard deviation of the check standards. The precision of the mean value for most samples (most samples are analyzed in duplicate) will be this precision divided by $\sqrt{2}$. These measures of analytical performance depend on the nature and source of the samples and the concentration range of the calibration standards as well as on the performance of the analytical equipment.

Because no certified reference materials are available for nutrients in seawater, it is not possible to determine analytical accuracy in a rigorous way. However, CSK standards (from the Sagami Research Center, Japan) are available. As these standards are prepared either in NaCl solution or in freshwater, they are not ideal reference materials. However, our experience has been that they are reasonably stable and useful for silicate, nitrate, and nitrite (nitrite CSK standards are not run frequently). CSKs are also available for phosphate, but erratic results and short shelf life make their use problematic. As an alternative approach to evaluating accuracy, our laboratory participates in the regular seawater nutrient intercalibration exercises organized by the International Council for the Exploration of the Sea. We have produced results consistent with the final "accepted" values for silicate, phosphate, and nitrate (e.g. Kirkwood et al. 1991, in which we were Laboratory No. 72). To date, we have not participated in the nitrite and ammonia portions of these intercalibrations because nitrite is an analysis we do only in special circumstances, and the ammonia method we use is only suitable for the high concentrations found near shore (see below).

More details on the methods for the individual nutrients follow.

<u>Silicate</u>

The analysis of reactive silicate is based on the formation of silicomolybdic acid and its subsequent reduction to a blue heteropoly acid. The basic chemistry is described in Grasshoff 1976 (and references therein). These samples were analyzed using the implementation of the method developed by Technicon (Technicon Industrial Method 186-72 W, 1973; see reagent table and flow diagram below). The main difference between this method and earlier ones is its use of ascorbic acid as a reducing agent. The rms differences between expected and nominal concentrations of silicate for CSK standards are 5.7, 3.6, and 2.5% at concentrations of 5, 25 and 50 μM, respectively. For the Letang samples, the detection limit varied from 0.23-0.43 μM (standards from 0-50 μM) and the precision from 1.0-1.7% (one population standard deviation).

Table 1. Reagents used in silicate analysis.

Reagent	Flow rate (mL/min.)	Component	Concentration
Ammonium molybdate reagent	0.42	$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$	10 g/L
		H_2SO_4	0.1 N
Oxalic acid	0.32	$H_2C_2O_4$	50 g/L
Ascorbic acid reagent	0.42	Ascorbic acid	17.6 g/L
		Acetone	50 mL/L
		Levor V	0.5 mL/L
Sample	0.32		

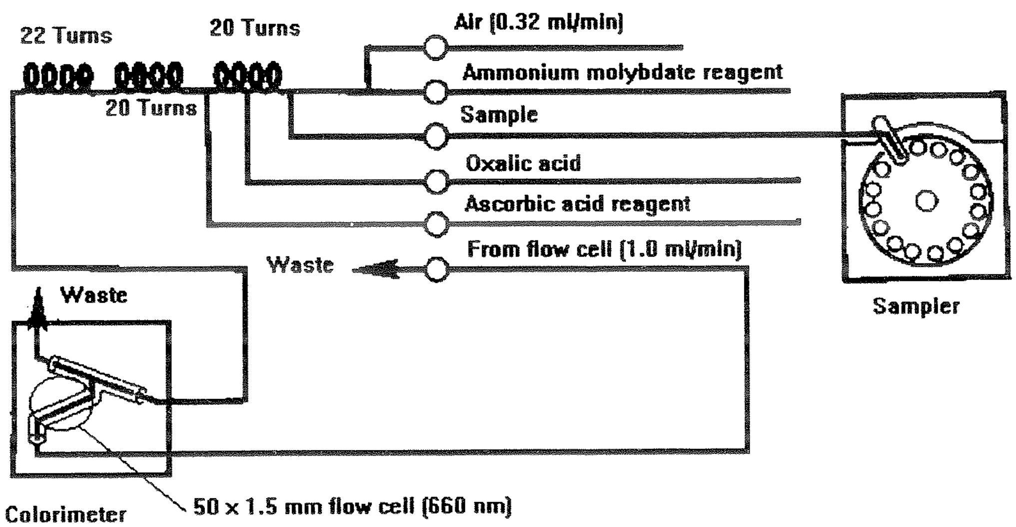

Figure 6. Flow diagram for silicate analysis.

Phosphate

The analysis of dissolved inorganic phosphate is based on the formation of a phosphomolybdenum blue complex, following a method originally described by Murphy and Riley

(1962). We use a slightly modified version of the implementation for autoanalyzers described in Technicon Industrial Method 155-71W, 1973. Our modification is one that is widely used (see Kirkwood et al. 1991). The mixed reagent is separated into two components to improve reagent stability, but the chemistry of the final mixture of sample and reagents in the spectrometer cell has not been altered. For the Letang samples, the detection limit varied from 0.030-0.084 µM (standards from 0-2 µM) and the precision from 2.5-8.0% (one population standard deviation). That this performance is worse than for typical offshore samples is probably a reflection of the high organic loads and turbidity in the waters of the Letang Inlet.

Table 2. Reagents used in phosphate analysis.

Reagent	Flow rate (mL/min.)	Component	Concentration
Mixed reagent	0.23	H_2SO_4	2.45 N
		$(NH_4)_6Mo_7O_{24}\cdot 4H_2O$	6 g/L
		$K(SbO)C_4H_4O_6\cdot \frac{1}{2}H_2O$ (antimony potassium tartrate)	0.15 g/L
Ascorbic acid	0.32	Ascorbic acid	3.9 g/L
		Levor V	2 mL/L
Sample	0.42		

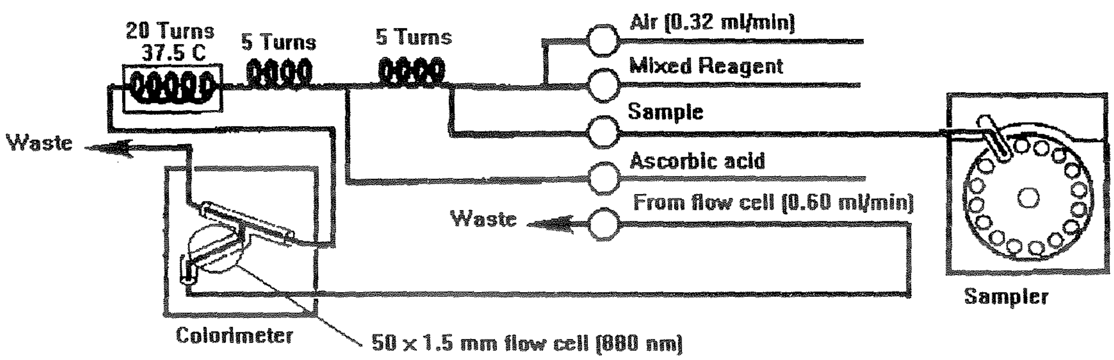

Figure 7. Flow diagram for phosphate analysis.

Nitrate

The analysis of nitrate is based on the measurement of a diazo dye formed by the reaction between sulfanilamide and nitrite, which in turn has been produced by the reduction of nitrate to nitrite on a copperized cadmium column. Because the analysis is based on the reduction of nitrate to nitrite, the method actually determines the sum of the nitrate and nitrite concentrations. In most seawater, the concentration of nitrite is small compared to that of nitrate. The basic chemistry is described by Grasshoff (1976). We use the implementation of the method described in Technicon Industrial Method 158-71W, 1972. The rms differences between expected and nominal concentrations of nitrate for CSK standards are 3.1, 1.7, and 1.8% at concentrations of 5, 10, and 30 μM, respectively. For the Letang samples, the detection limit was 0.28 μM (standards from 0-30 μM) and the precision varied from 0.9-2.2% (one population standard deviation).

Table 3. Reagents used in nitrate analysis.

Reagent	Flow rate (mL/min.)	Component	Concentration
Ammonium chloride reagent	1.2	NH_4Cl	10 g/L
		NaOH	0.6 g/L
Colour reagent	0.32	Sulphanilamide	10 g/L
		H_3PO_4 (conc.)	100 mL/L
		N-1-Napthylene-diamine dihydrochloride	0.5 g/L
		Brij-35	0.5 mL/L
Copperizing reagent	N/A	$CuSO_4$•$5H_20$	20 g/L
Sample	0.32		

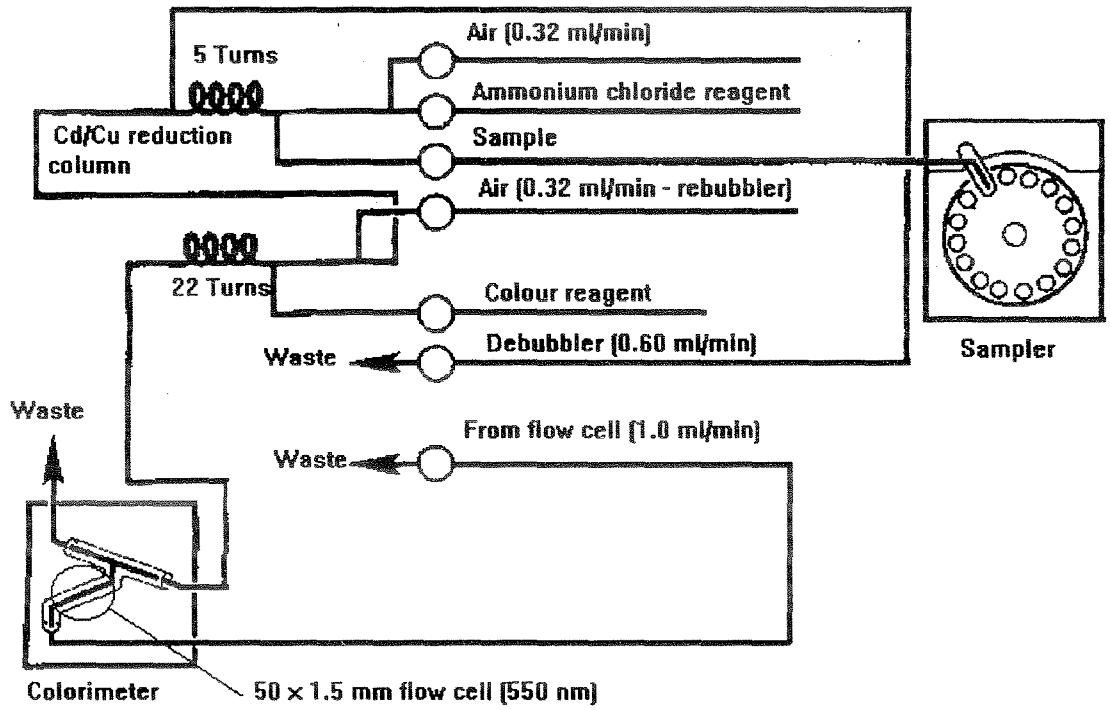

Figure 8. Flow diagram for nitrate analysis.

Nitrite

The analysis of nitrite is essentially the same as that for nitrate, but without the cadmium column reduction step. We use the implementation of the method described in Technicon Industrial Method 161-71W, 1973. The rms differences between expected and nominal concentrations for a recent set of nitrite CSK standards were 2.2, 1.3, and 5.4% at concentrations of 0.5, 1.0, and 2.0 μM, respectively. For the Letang samples, the detection limit varied from 0.033-0.081 μM (standards from 0-2 μM) and the precision from 1.6-2.8% (one population standard deviation).

Table 3. Reagents used in nitrite analysis.

Reagent	Flow rate (mL/min.)	Component	Concentration
Colour reagent	0.6	Sulphanilamide	10 g/L
		H_3PO_4 (conc.)	100 mL/L
		N-1-Napthylene-diamine dihydrochloride	0.5 g/L
		Brij-35	0.5 mL/L
Sample	0.6		

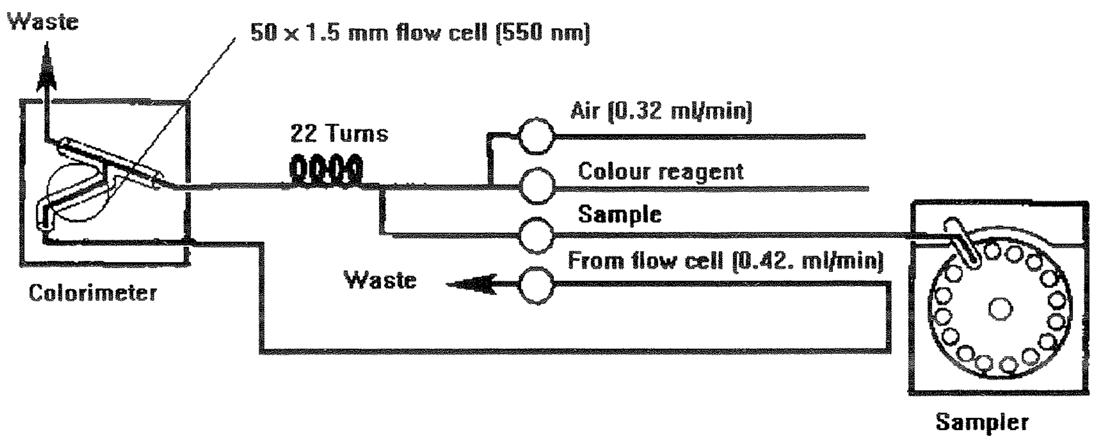

Figure 9. Flow diagram for nitrite analysis.

Ammonia

Methods for the analysis of ammonia in seawater are less established than those for the other nutrients. Whether pelagic concentrations can be measured by any autoanalyzer method is a subject of dispute, as is the feasibility of measuring ammonia on stored samples. We use the technique described below only for the measurement of the high concentrations found in coastal embayments. The ammonia technique is based on the reaction between ammonia, a chlorine donor, and phenol. Our method, which is still under development, uses a chemistry intermediate between that specified by Grasshoff and Johannsen (1972) and that specified by Mostert (1988).

The former used lower concentrations of phenol and higher concentrations of trisodium citrate than the latter. In addition, we have added EDTA to the buffer as suggested by Grasshoff (1983). We use an absorption wavelength of 630 nm, as did Mostert (1983; 1988) rather than the 610 nm used by Grasshoff. To increase the speed of the colour reaction, the system includes a heater at 70°C. A glass coil cooled with tapwater circulating through a copper coil downstream of the heater prevents bubbles from forming in the flow cell.

Although a detection limit can be calculated in the usual way, it has little meaning for this ammonia procedure because of problems associated with running saline samples against freshwater standards (freshwater standards are used because of poor reproducibility and linearity with standards made in NaCl solution). For the same reasons, the worst precision obtained from the check standards (9.3%) may be an underestimate. On one occasion we were able to use "ammonia-free" seawater (collected from 800 or 4000 m depth over the continental slope along the edge of the Scotian Shelf) to try to determine whether changes in analytical performance between fresh and saline matrices for the standards were due to refractive index effects or ammonia contamination in the NaCl used to prepare the artificial seawater. This one experiment suggested that contamination was likely the source of the problem and that concentrations below 1.5 µM cannot be reliably measured with freshwater standards. This tentative conclusion contradicts that of Mostert (1988), who believed that the refractive index correction was dominant.

Table 4. Reagents used in ammonia analysis.

Reagent	Flow rate (mL/min.)	Component	Concentration
Complexing buffer	0.6	Trisodium citrate	120 g/L
		NaOH	1.5 g/L
		EDTA (Na_2 salt)	10 g/L
		Brij-35	1 mL/L
Phenol reagent	0.16	Phenol	3.5 g/L
		$Na_2Fe(CN)_5NO{\cdot}2H_2O$	0.4 g/L
Hypochlorite reagent	0.16	Dichloro-S-triazine,2,4,6 trione salt	2.0 g/L
		NaOH	6.67 g/L
Sample	0.8		

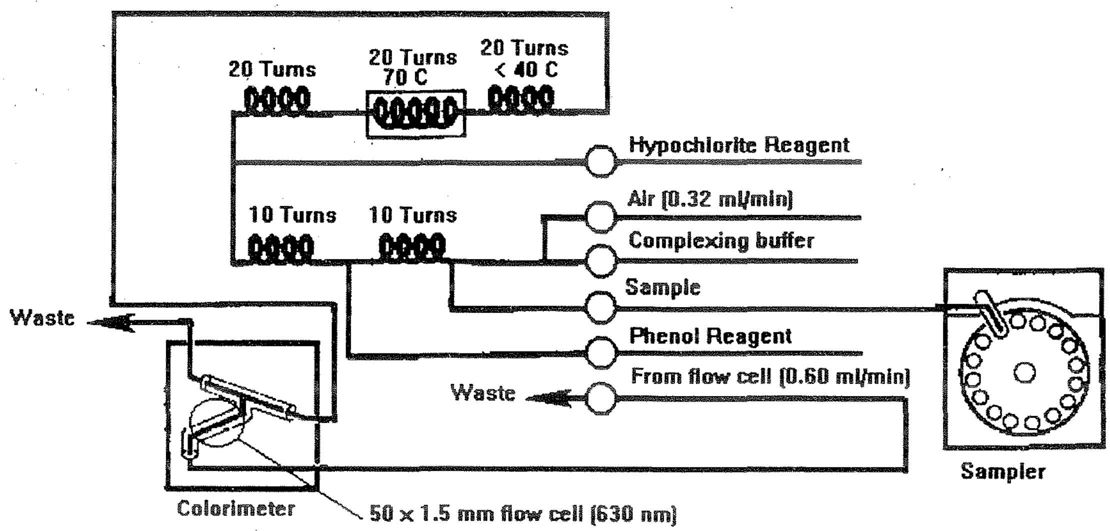

Figure 10. Flow diagram for ammonia analysis.

RESULTS

Appendix A lists the positions, times, and water depths for the stations shown on Figures 2 to 5. The July 7 survey was 3 d after a neap tide, the August 16 survey coincided with a neap tide, and the September 20 survey was 1 d after a spring tide. Low tides occurred at 08:24 and 20:39 h on July 7; 16:59 h on August 16; 05:44 and 18:09 h on August 17; and 09:44 and 22:06 h on September 20. High tides occurred at 14:28 h on July 7; 10:43 and 23:13 h on August 16; 11:53 h on August 17; and 15:48 h on September 20 (all times UT).

Appendix B lists the stations, sample depths, salinities, temperatures, nutrients, dissolved O_2, O_2 saturation, BOD, PAR, and fluorescence for all samples collected on the surveys.

DISCUSSION

Appendix C summarizes the data shown in Appendix B, giving minima, maxima, means, standard deviations, and number of samples for each survey for different groups of sites (these are shown in Fig. 1 and listed in Appendix A). The grouping of data is based on the embayments within the Inlet, but three of the groupings may require further information. Stations labelled "Sea Farm cages" were all within Bliss Harbour, but are treated separately because of their proximity to salmon cages. The "Control Dam" stations were either sampled on foot, directly from the dam (Stations 1, 34, 52, and 70) or from the water, getting as close to the dam as the high tide would permit (Stations 9 and 62). Stations labelled "Open Bay" were those that were closest to the open Bay of Fundy and which should have shown the least influence of discharges within the Letang Inlet.

Although, as would be expected for a region of such intense tidal mixing, concentrations tended to be uniform through much of the Inlet, there are some features that do stand out. Silicate concentrations at the control dam were clearly much higher than anywhere else in the Letang in all three surveys, reaching values in excess of 50 μM. Mean values were approximately 15 times those found in more open parts of the Letang. These high input values apparently affected the silicate concentrations in the upper Letang during the July and August surveys, which were near the neap end of the tidal cycle, but not during the spring tides of the September survey. The pulp mill at the head of the Letang takes its process water from the Magaguadavic River (which is a separate watershed from the Letang), but discharges its waste into the Letang (see Strain et al. 1995). Although silicate concentrations in nearby rivers are highly variable, they reach values as high as 39 μM (unpublished data). The observed concentrations at the dam may therefore be consistent with freshwater inputs in the region.

Phosphate values at the control dam were also substantially elevated on all of the surveys, reaching values as high as 29 μM, with means ten to twenty times those elsewhere in the Inlet. Unlike the silicate case, these phosphate levels are very much higher than those found in nearby rivers (which were usually <0.4 μM, with a maximum of 1.3 μM, unpublished data). Approximately 20 t P a^{-1} (Strain et al. 1995) is added to the anaerobic digestor of the pulp mill. Combining this estimate with the total water discharge would predict a phosphate concentration of approximately 50 μM, strongly suggesting that these levels were due to the use of phosphorus at the mill. The phosphate inputs were sufficiently high to affect the levels in the upper Letang. High phosphate values were also found in Blacks Harbour on all three surveys, but mean values there were only about twice those in the other embayments of the Inlet. These Blacks Harbour values are caused by wastes from the fish processing plant.

Both nitrate and nitrite values were also elevated at the dam, with means five to ten times greater than elsewhere. Maximum values were 48 and 5.3 μM for nitrate and nitrite, respectively. Levels for nitrate in nearby rivers ranged from 0 to 15 μM (unpublished data). The high levels observed at the dam are probably at least partly due to the river water input.

Elevated ammonia levels were found both at the control dam and in Blacks Harbour on all surveys, with means of five to ten times greater than found in other embayments of the Inlet. Extreme values reached 50 μM at the dam and 41 μM in Blacks Harbour. The levels at the dam are greater than those in nearby rivers that have a maximum value of 6 μM. Approximately 240 t N a^{-1} were being added to the pulp mill digestor at this time. A calculation similar to that performed for phosphate predicts concentrations in excess of 1 mM NH_3. This nitrogen must be lost through either very efficient burial of nitrogen in the settling lagoon or very efficient conversion of the nitrogen to organic forms. Inputs through the dam also produce higher levels in the upper Letang than in the lower Letang. The high levels in Blacks Harbour result from fish processing there. Concentrations were also higher near the Sea Farm salmon cages than in the rest of Bliss Harbour.

Oxygen levels, as measured by O_2 saturation, were lower at the control dam and in Blacks Harbour than elsewhere during all the surveys. Oxygen levels were also lower at the Sea Farm cages than in the rest of Bliss Harbour, but saturation values did not get particularly low at the cages (94% - note that Sea Farms were blowing air into the water near the cages at the time of this survey). The 5-d BOD values were widely scattered: they varied from 20 to 117 μM, with the highest value at the dam in September.

There are also some seasonal trends that can be seen in these statistics. Silicate levels changed from approximately 2.5 μM in July to 6.5 μM in August and back to 3 μM in September. Phosphate levels went from ~0.6 to 0.8 to 1.0 over the same period. Nitrate changed from 2 to 4.5 from July to August, but then changed little in September. O_2 saturation dropped from July to August. These changes are likely a combination of seasonal and spring/neap tidal cycles.

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APPENDIX A. LOCATIONS AND TIMES (UNIVERSAL TIME) OF SITES SAMPLED IN THE LETANG INLET.

Station	Time (UT)	Latitude (N)	Longitude (W)	Depth (m)	Area
July 7, 1994:					
1	08:30	45° 7.25'	66° 45.94'	1	Control Dam
2	10:35	45° 3.22'	66° 48.00'	9	Blacks Harbour
3	10:55	45° 2.90'	66° 48.43'	13	Blacks Harbour
4	11:10	45° 3.25'	66° 49.40'	22	Lower Letang
5	11:33	45° 4.00'	66° 48.48'	19	Lower Letang
6	11:59	45° 4.87'	66° 47.37'	18	Upper Letang
7	12:19	45° 5.63'	66° 47.88'	12	Upper Letang
8	12:50	45° 6.04'	66° 47.17'	11	Upper Letang
9	13:25	45° 7.20'	66° 46.00'	5	Control Dam
10	14:30	45° 4.00'	66° 49.80'	11	Lime Kiln Bay
11	15:29	45° 2.58'	66° 49.07'	29	Lower Letang
12	15:50	45° 2.24'	66° 50.62'	16	Bliss Harbour
13	16:05	45° 1.83'	66° 50.45'	29	Bliss Harbour
14	16:22	45° 1.40'	66° 51.32'	23	Open Bay
15	16:48	45° 2.30'	66° 49.60'	25	Lower Letang
16	17:12	45° 2.87'	66° 49.18'	29	Lower Letang
17	17:28	45° 2.73'	66° 48.83'	25	Lower Letang
August 16, 1994:					
18	11:46	45° 3.22'	66° 48.00'	12	Blacks Harbour
19	12:07	45° 2.95'	66° 48.44'	17	Blacks Harbour
20	12:36	45° 3.11'	66° 49.32'	26	Lower Letang
21	12:50	45° 2.44'	66° 49.11'	28	Lower Letang
22	13:16	45° 2.05'	66° 50.47'	15	Bliss Harbour
23	13:35	45° 1.79'	66° 50.49'	27	Bliss Harbour
24	13:59	45° 1.45'	66° 51.25'	19	Open Bay
25	14:16	45° 2.06'	66° 50.34'	16	Bliss Harbour
26	14:48	45° 3.09'	66° 49.37'	26	Lower Letang
27	15:00	45° 3.59'	66° 49.72'	14	Lime Kiln Bay
28	15:17	45° 3.79'	66° 49.67'	6	Lime Kiln Bay
29	16:03	45° 3.76'	66° 48.69'	18	Lower Letang
30	16:33	45° 4.85'	66° 47.47'	15	Upper Letang
31	16:48	45° 5.49'	66° 47.96'	11	Upper Letang
32	17:10	45° 5.99'	66° 47.25'	7	Upper Letang
33	17:50	45° 3.13'	66° 49.39'	23	Lower Letang
34	19:10	45° 7.25'	66° 45.94'	1	Control Dam

Station	Time (UT)	Latitude (N)	Longitude (W)	Depth (m)	Area
August 17, 1994:					
35	11:34	45° 3.18'	66° 49.41'	26	Lower Letang
36	12:05	45° 2.05'	66° 50.47'	16	Bliss Harbour
37	12:54	45° 2.09'	66° 52.66'	30	Open Bay
38	13:05	45° 2.51'	66° 52.15'	23	Open Bay
39	13:25	45° 2.92'	66° 51.88'	18	Back Bay
40	13:39	45° 3.24'	66° 51.60'	20	Back Bay
41	14:03	45° 3.73'	66° 51.02'	20	Back Bay
42	14:52	45° 2.05'	66° 50.47'	17	Bliss Harbour
43	15:27	45° 2.24'	66° 50.65'	14	Sea Farm cages
44	15:43	45° 2.17'	66° 50.58'	16	Sea Farm cages
45	16:05	45° 2.30'	66° 50.58'	13	Sea Farm cages
46	16:20	45° 2.27'	66° 50.50'	12	Sea Farm cages
47	16:51	45° 2.20'	66° 50.36'	12	Sea Farm cages
48	17:08	45° 2.41'	66° 50.48'	12	Sea Farm cages
49	17:30	45° 2.41'	66° 50.38'	12	Sea Farm cages
50	17:43	45° 2.05'	66° 50.47'	12	Bliss Harbour
51	18:12	45° 3.18'	66° 49.41'	21	Lower Letang
52	19:32	45° 7.25'	66° 45.94'	1	Control Dam
September 20, 1994:					
53	11:28	45° 3.23'	66° 48.05'	8	Blacks Harbour
54	12:00	45° 3.00'	66° 48.38'	13	Blacks Harbour
55	12:30	45° 2.12'	66° 50.53'	14	Bliss Harbour
56	12:57	45° 1.89'	66° 50.36'	28	Bliss Harbour
57	13:08	45° 1.40'	66° 51.29'	21	Open Bay
58	13:49	45° 2.56'	66° 49.08'	28	Lower Letang
59	14:03	45° 3.11'	66° 49.36'	29	Lower Letang
60	14:18	45° 3.50'	66° 49.74'	19	Lime Kiln Bay
61	14:35	45° 3.92'	66° 49.76'	13	Lime Kiln Bay
62	15:30	45° 7.22'	66° 45.99'	6	Control Dam
63	15:50	45° 6.01'	66° 47.27'	12	Upper Letang
64	16:04	45° 5.65'	66° 47.96'	12	Upper Letang
65	16:20	45° 4.92'	66° 47.50'	20	Upper Letang
66	16:38	45° 3.97'	66° 48.59'	18	Lower Letang
67	16:58	45° 2.90'	66° 49.23'	29	Lower Letang
68	17:16	45° 2.45'	66° 49.42'	28	Lower Letang
69	17:31	45° 2.76'	66° 48.78'	26	Lower Letang
70	18:32	45° 7.25'	66° 45.90'	1	Control Dam

APPENDIX B. NUTRIENT AND DISSOLVED O_2 DATA FOR THE LETANG INLET.

Station	z (m)	Salinity (psu)	Temp (°C)	Si (μM)	PO_4 (μM)	NO_3+NO_2 (μM)	NO_2 (μM)	NH_3 (μM)	O_2 (μM)	O_2 Satn (%)	BOD (μM)	PAR ($\mu E \bullet m^{-2} \bullet s^{-1}$)	Fluorescence
July 7, 1994:													
1	0	14.43		37.39	12.35	27.77	2.40	20.0				0.0	
2	3	31.32	11.1	2.76	1.82	1.83	0.19	17.4	236	84		7.5	3.72
2	6	31.38	10.4	2.45	1.21	1.68	0.13	11.9	257	90		2.1	2.45
3	3	31.22	10.8	2.47	1.18	2.22	0.13	11.3	278	98		7.7	3.25
3	10	31.42	10.4	2.49	0.65	2.31	0.11	4.0	303	106	72	0.8	2.03
4	3	31.21	11.1	1.83	0.48	1.11	0.05	3.3	324	115		28.3	5.08
4	17	31.29	10.5	2.10	0.53	1.57	0.08	2.6	316	111		0.3	2.74
5	1	31.20	12.0	3.27	0.70	1.93	0.11	3.8	297	107		93.5	3.33
5	3	31.27	12.0	3.05	0.63	1.87	0.11	3.6	295	107	52	33.9	3.37
5	16	31.39	10.9	2.67	0.57	2.16	0.10	3.3	303	107	57	0.2	2.61
6	3	31.17	12.3	3.65	0.73	2.05	0.12	3.9	294	107		21.1	2.16
6	15	31.34	11.3	2.93	0.60	1.98	0.10	4.0	301	107		0.1	2.39
7	3	30.82	13.6	4.65	0.90	2.66	0.17	3.5	292	109		16.4	2.61
7	9	31.28	12.0	3.32	0.61	2.03	0.12	3.9	294	106		0.8	1.85
8	1	30.60	14.1	5.87	1.09	3.22	0.19	5.2	278	105		57.6	3.05
8	3	30.86	13.7	4.78	0.90	2.67	0.16	4.0	284	106	49	5.6	2.43
8	8	31.22	12.1	3.83	0.73	2.16	0.12	4.8	292	106	58	0.2	1.85
9	1	29.82	14.5	8.45	1.68	4.68	0.27	4.8	257	97		31.5	2.30
9	3	30.18	14.4	7.24	1.40	4.03	0.22	5.0	263	99		1.3	2.05
10	1	31.33	12.0	2.97	0.61	1.81	0.09	3.9	298	108		134.1	4.29
10	3	31.31	11.2	2.56	0.60	1.50	0.07	4.3	308	110	74	62.0	5.76
10	8	31.31	11.2	2.55	0.52	1.54	0.06	3.3	312	111	59	5.8	3.77
11	3	31.36	10.7	2.54	0.55	2.06	0.06	3.1	306	108		47.1	3.18

Station	z (m)	Salinity (psu)	Temp (°C)	Si (μM)	PO_4 (μM)	NO_3+NO_2 (μM)	NO_2 (μM)	NH_3 (μM)	O_2 (μM)	O_2 Satn (%)	BOD (μM)	PAR ($\mu E \bullet m^{-2} \bullet s^{-1}$)	Fluorescence
11	15	31.51	9.8	2.53	0.54	2.75	0.07	2.9	309	107		1.2	1.67
11	26	31.71	9.2	3.68	0.62	3.83	0.11	2.8	301	103		0.1	1.19
12	1	31.32	11.4	2.28	0.51	1.22	0.05	4.8	306	109		97.4	4.84
12	3	31.32	11.4	2.39	0.54	1.31	0.06	3.6	306	109	70	39.4	4.61
12	13	31.39	10.8	2.51	0.54	1.76	0.08	2.8	309	109	51	1.4	3.14
13	3	31.37	11.1	2.16	0.49	1.12	0.05	6.1	308	109		64.6	3.60
13	15	31.50	10.2	3.05	0.55	2.09	0.09	3.2	306	107		1.5	2.36
13	26	31.65	9.6	3.66	0.58	2.71	0.09	3.7	299	103		0.0	1.63
14	3	31.39	11.3	2.07	0.50	0.93	0.06	2.8	314	112		124.1	4.89
14	21	31.75	9.4	3.71	0.62	3.61	0.13	2.5	300	103		0.7	1.47
15	3	31.28	11.1	1.85	0.42	0.83	0.04	3.0	327	116		81.7	6.58
15	22	31.68	9.3	3.57	0.62	3.62	0.13	2.8	306	105		0.2	1.31
16	3	31.32	11.3	2.57	0.59	1.70	0.09	5.6	307	110		110.6	3.44
16	15	31.36	10.7	2.69	0.53	1.94	0.10	2.9	309	109		1.8	2.55
16	26	31.43	10.6	2.99	0.56	2.32	0.10	3.1	308	108		0.1	2.82
17	3	31.32	11.2	2.55	0.55	1.62	0.10	2.6	315	112		77.7	4.22
17	22	31.64	9.3	3.09	0.58	3.30	0.12	3.7	305	104		0.1	1.16
August 16, 1994:													
18	3	32.01	12.8	7.44	2.37	4.61	0.42	20.2				51.1	4.03
18	3	31.94	12.8	8.44	2.11	4.71	0.49	25.0	167	62		51.1	4.03
18	9	32.16	12.5	7.28	1.03	4.57	0.36	10.4	235	86		10.2	1.11
19	3	32.09	13.0	6.62	1.10	4.26	0.36	8.8				63.0	1.94
19	3	32.10	13.0	6.75	0.95	4.40	0.36	7.9	248	92	49	63.0	1.94
19	14	32.21	12.3	6.65	0.73	5.05	0.33	3.3	264	97	46	6.1	0.95
20	3	32.12	12.6	6.57	0.87	4.33	0.34	4.9				367.0	1.16
20	3	32.15	12.6	6.65	0.79	4.58	0.35	4.6	260	96		367.0	1.16

Station	z (m)	Salinity (psu)	Temp (°C)	Si (μM)	PO_4 (μM)	NO_3+NO_2 (μM)	NO_2 (μM)	NH_3 (μM)	O_2 (μM)	O_2 Satn (%)	BOD (μM)	PAR ($\mu E \bullet m^{-2} \bullet s^{-1}$)	Fluorescence
20	22	32.14	12.5	6.77	0.76	4.67	0.35	4.8	260	96		0.6	1.09
21	3	32.17	12.5	6.31	0.82	4.56	0.33	3.7				127.2	1.07
21	3	32.19	12.5	6.55	0.74	5.07	0.35	3.9	266	98		127.2	1.07
21	15	32.25	12.3	6.45	0.70	5.18	0.34	3.1	266	98		8.2	0.94
21	25	32.22	12.1	6.25	0.70	5.16	0.34	2.6	267	97		0.7	0.78
22	1	32.19	12.6	6.56	0.74	4.78	0.36	4.4	264	97		137.7	0.82
22	3	32.18	12.6	6.20	0.79	4.60	0.32	4.0				135.6	1.00
22	3	32.19	12.6	6.55	0.74	4.84	0.36	4.4	263	97	39	135.6	1.00
22	12	32.22	12.3	6.52	0.71	5.19	0.35	2.9	267	98	40	28.2	1.01
23	3	32.17	12.6	6.16	0.78	4.51	0.34	4.2				109.0	1.16
23	3	32.18	12.6	6.30	0.71	4.72	0.36	4.6	267	98		109.0	1.16
23	15	32.20	12.4	6.32	0.69	4.86	0.34	3.4	271	100		14.0	1.25
23	24	32.22	12.3	6.41	0.68	5.02	0.34	3.2	266	98		1.5	0.92
24	3	32.18	12.4	6.14	0.77	4.63	0.33	3.2				115.0	0.98
24	3	32.19	12.4	6.41	0.69	4.82	0.36	3.8	267	98		115.0	0.98
24	16	32.25	12.1	6.24	0.68	5.28	0.32	2.2	268	98		15.4	0.86
25	1	32.17	12.7	6.52	0.77	4.51	0.36	5.5				979.5	0.86
25	3	32.18	12.6	6.19	0.80	4.50	0.33	4.3				522.1	0.86
25	3	32.17	12.6	6.51	0.77	4.39	0.36	5.6	262	97		522.1	0.86
25	13	32.23	12.3	6.32	0.67	4.98	0.33	2.8	265	97		29.0	0.95
26	3	32.08	13.1	6.55	0.88	4.22	0.34	4.9				159.9	1.27
26	3	32.07	13.1	6.57	0.76	4.16	0.36	5.1	260	97		159.9	1.27
26	23	32.16	12.5	9.13	0.72	4.73	0.35	4.6	261	96		0.7	1.02
27	3	32.15	12.9	6.56	0.97	4.26	0.33	4.5				256.4	1.18
27	3	32.16	12.9	6.56	0.78	4.39	0.35	5.0	260	96		256.4	1.18
27	11	32.17	12.5	6.18	0.70	4.73	0.35	3.8	263	97		29.5	1.31
28	1	32.11		6.55	1.15	4.30	0.28	4.4	255			0.0	

Station	z (m)	Salinity (psu)	Temp (°C)	Si (μM)	PO_4 (μM)	NO_3+NO_2 (μM)	NO_2 (μM)	NH_3 (μM)	O_2 (μM)	O_2 Satn (%)	BOD (μM)	PAR ($\mu E \bullet m^{-2} \bullet s^{-1}$)	Fluorescence
28	3	32.15	12.8	6.48	0.87	4.30	0.33	4.1				198.1	1.13
28	3	32.14	12.8	6.36	1.14	4.75	0.29	4.6	253	94	46	198.1	1.13
29	1	31.93		6.81	1.20	4.31	0.33	3.5	260			0.0	
29	3	31.94	13.8	6.72	0.95	3.70	0.34	4.4				64.4	1.94
29	3	31.95	13.8	6.87	1.19	4.28	0.33	3.3	262	99	50	64.4	1.94
29	15	32.04	13.2	6.53	0.79	4.10	0.35	5.2	264	99	50	2.3	1.25
30	3	31.82	14.2	7.27	1.07	3.71	0.36	4.9				58.2	1.78
30	3	31.68	14.2	7.77	1.03	3.95	0.40	5.2	254	97		58.2	1.78
30	12	32.00	13.5	6.83	0.88	3.91	0.36	5.3	263	99		1.5	1.22
31	3	31.42	15.1	8.69	1.40	4.18	0.44	5.5				3.5	1.92
31	3	31.28	15.1	9.08	1.39	4.48	0.48	6.2	244	94		3.5	1.92
31	8	31.63	14.4	7.88	1.15	3.99	0.41	6.1	248	95		0.2	1.49
32	1	31.04	16.0	10.06	1.59	4.72	0.54	6.7	244	96		37.6	2.61
32	3	31.04	15.7	10.18	1.79	4.59	0.53	5.9				3.9	2.17
32	3	31.04	15.7	10.15	1.62	4.73	0.55	6.9	243	95	34	3.9	2.17
32	5	31.08	15.6	9.87	1.59	4.68	0.54	6.4	242	94	39	0.6	2.12
33	3	32.06	13.3	5.85	0.88	3.77	0.32	4.4				130.9	1.44
33	3	32.03	13.3	6.55	0.87	3.95	0.37	5.3	263	98		130.9	1.44
33	20	32.16	12.7	6.48	0.82	4.58	0.35	4.4	260	96		0.9	1.03
34	0	21.78		43.00	10.80	19.91	2.31	28.7				0.0	
34	0	22.44		33.22	9.40	16.02	2.29	25.0	95		20	0.0	
August 17, 1994:													
35	3	32.19	12.6	6.48	0.90	4.78	0.41	3.6	265	98		164.1	1.38
35	21	32.20	12.4	6.17	0.81	5.11	0.34	2.8	269	99		0.8	1.26
36	1	32.24	12.4	6.42	0.79	5.15	0.35	3.0	266	98		121.3	0.97
36	3	32.23	12.4	6.42	0.77	5.26	0.34	2.9	268	98		87.1	1.16

Station	z (m)	Salinity (psu)	Temp (°C)	Si (μM)	PO_4 (μM)	NO_3+NO_2 (μM)	NO_2 (μM)	NH_3 (μM)	O_2 (μM)	O_2 Satn (%)	BOD (μM)	PAR ($\mu E \bullet m^{-2} \bullet s^{-1}$)	Fluorescence
36	13	32.23	12.3	6.44	0.78	5.29	0.35	2.6	267	98		8.6	1.05
37	3	32.24	12.3	5.88	0.72	5.29	0.32	1.7	275	101		445.1	0.76
37	15	32.28	12.0	6.12	0.73	5.56	0.32	1.7	268	98		18.3	0.87
37	25	32.31	12.0	6.28	0.73	5.65	0.30	1.7	267	97		1.8	0.87
38	3	32.23	12.4	7.18	0.71	5.05	0.31	1.9	271	100		426.8	0.94
38	20	32.30	12.3	6.20	0.77	5.03	0.30	2.8	270	99		5.2	1.06
39	3	32.24	12.7	6.56	0.87	4.37	0.31	6.4	255	94		485.5	1.30
39	15	32.26	12.4	6.48	0.79	4.96	0.31	3.3	266	98		12.6	1.23
40	1	32.21	13.7	7.02	1.15	4.23	0.33	7.7	251	95		1441.0	3.38
40	3	32.22	13.0	6.76	0.95	4.25	0.33	6.4	255	95		481.3	1.13
40	17	32.27	12.3	6.56	0.83	5.05	0.32	3.5	262	96		3.6	1.07
41	3	32.20	13.4	7.11	1.00	4.07	0.36	7.4	250	94		481.2	1.36
41	17	32.26	12.5	6.85	0.89	4.91	0.35	4.4	259	95		1.6	1.07
42	1	32.20		6.40	0.80	4.57	0.34	4.2	267			0.0	
42	3	32.19	12.8	6.33	0.80	4.56	0.34	3.8	270	100		721.8	1.11
42	14	32.22	12.3	6.22	0.77	4.81	0.33	2.8	272	100		28.0	1.07
43	3	32.19	12.8	6.46	0.91	4.56	0.35	6.6	253	94		253.7	1.26
43	11	32.22	12.4	6.32	0.80	4.71	0.34	4.0	264	97		46.1	1.68
44	3	32.19	12.8	6.46	0.88	4.50	0.35	5.5	259	96		572.3	0.95
44	13	32.22	12.4	6.35	0.81	4.75	0.33	3.7	264	97		28.7	1.32
45	3	32.19	12.8	6.59	0.96	4.60	0.35	8.8	241	89		214.7	1.07
45	10	32.22	12.5	6.36	0.90	4.84	0.35	7.2	249	92		42.7	1.37
46	3	32.18	12.8	6.47	0.90	4.65	0.34	5.8	254	94		477.4	1.30
46	9	32.21	12.5	6.52	0.86	4.82	0.35	5.7	254	93		67.3	1.54
47	3	32.18	13.0	6.54	0.89	4.70	0.35	5.6	254	94		405.0	1.03
47	9	32.21	12.7	6.52	0.95	4.76	0.36	8.1	246	91		63.4	1.76
48	3	32.19	13.1	6.73	0.90	4.82	0.36	5.8	256	95		420.7	1.01

Station	z (m)	Salinity (psu)	Temp (°C)	Si (μM)	PO_4 (μM)	NO_3+NO_2 (μM)	NO_2 (μM)	NH_3 (μM)	O_2 (μM)	O_2 Satn (%)	BOD (μM)	PAR ($\mu E \cdot m^{-2} \cdot s^{-1}$)	Fluorescence
48	9	32.21	12.6	6.81	0.97	4.87	0.36	8.6	243	90		60.7	1.50
49	3	32.18	13.1	6.73	0.90	4.73	0.35	5.4	258	96		503.5	1.32
49	9	32.19	12.6	6.82	0.92	4.86	0.33	6.2	253	93		49.3	1.51
50	3	32.20	13.0	6.46	0.87	4.93	0.31	4.1	267	99		443.0	1.14
50	9	32.21	12.6	6.63	0.83	4.98	0.33	4.7	263	97		79.9	1.67
51	3	32.07	13.4	6.90	0.92	4.42	0.34	5.2	259	97		91.7	1.70
51	18	32.15	12.9	6.79	0.88	4.69	0.34	4.9	259	96		1.4	1.33
52	0	4.99		53.73	21.81	45.51	5.29	38.5	50			0.0	
September 20, 1994:													
53	1	32.54	13.0	2.93	3.07	4.10	0.39	40.8	109	41		403.8	5.14
53	3	32.56	13.1	3.33	2.85	3.81	0.37	37.7	120	45		63.5	7.26
53	5	32.60	13.0	3.55	1.96	3.67	0.31	24.1	189	70		16.2	5.44
54	1	32.59	13.0	2.73	2.21	3.67	0.33	23.2	188	70		512.9	3.42
54	3	32.59	13.0	2.79	2.12	3.64	0.32	21.9	193	72	72	149.3	5.29
54	10	32.63	12.9	3.21	1.30	3.85	0.29	4.8	242	90	25	6.4	2.84
55	1	32.66	12.6	3.52	0.96	4.43	0.27	3.7	256	95		720.7	1.40
55	3	32.66	12.6	3.48	1.03	4.57	0.28	3.2	256	95	27	311.1	1.61
55	11	32.67	12.6	3.63	1.10	4.75	0.27	3.3	256	95	28	16.0	1.40
56	3	32.63	12.6	3.26	0.99	4.82	0.28	3.2	271	100		358.1	1.78
56	15	32.63	12.6	3.27	0.96	4.80	0.26	2.6	264	98		8.1	1.95
56	25	32.66	12.6	3.60	1.03	4.91	0.27	2.6	280	104		0.4	1.85
57	3	32.65	12.7	3.18	0.95	4.08	0.26	2.6	263	97		408.6	1.54
57	18	32.65	12.7	3.31	0.97	4.43	0.26	2.8	257	95		3.5	2.10
58	3	32.62	12.9	3.08	0.97	3.91	0.27	3.0	263	98		72.8	2.70
58	15	32.63	12.8	3.16	0.90	3.91	0.25	2.4	276	102		8.2	2.44
58	25	32.68	12.6	3.84	0.99	4.55	0.25	3.0	254	94		0.7	1.78

Station	z (m)	Salinity (psu)	Temp (°C)	Si (μM)	PO_4 (μM)	NO_3+NO_2 (μM)	NO_2 (μM)	NH_3 (μM)	O_2 (μM)	O_2 Satn (%)	BOD (μM)	PAR ($\mu E \bullet m^{-2} \bullet s^{-1}$)	Fluorescence
59	3	32.63	12.8	3.16	1.05	4.21	0.26	3.4	257	95		509.3	1.77
59	15	32.62	12.8	3.21	1.06	4.17	0.27	3.9	261	97		7.8	2.66
59	26	32.62	12.8	3.25	1.05	4.18	0.27	3.6				0.3	1.82
60	3	32.63	12.8	3.21	1.07	4.30	0.27	3.7	257	95		300.9	2.14
60	16	32.62	12.8	3.24	1.07	4.27	0.27	3.6				3.1	2.42
61	1	32.60	13.0	3.26	1.11	4.01	0.26	4.3	253	94		768.5	1.50
61	3	32.60	13.0	3.17	1.16	3.84	0.27	4.8	249	93	26	367.2	2.22
61	10	32.61	12.9	3.28	1.17	4.00	0.28	4.7	254	95	37	20.9	2.41
62	1	29.59	13.6	9.07	5.63	12.52	1.04	12.1	217	80		18.0	3.98
62	3	31.73	13.5	6.89	1.85	5.67	0.37	4.8	238	89		1.4	1.89
63	1	32.36	13.3	4.52	1.47	4.45	0.32	4.5	245	92		564.8	1.58
63	3	32.42	13.3	4.33	1.40	4.32	0.30	4.6	246	92	26	138.9	1.64
63	9	32.51	13.2	3.66	1.31	4.08	0.26	4.7				2.7	1.68
64	1	32.50	13.5	3.58	1.32	4.12	0.29	4.7	253	95		1013.0	1.91
64	3	32.50	13.4	3.59	1.31	4.12	0.30	4.3	253	95		276.9	2.15
64	9	32.54	13.2	3.35	1.27	4.00	0.28	4.5	259	97		8.4	2.91
65	3	32.59	13.1	3.43	1.22	4.03	0.28	4.3	253	95		327.0	2.85
65	17	32.61	12.9	3.23	1.13	4.07	0.30	4.6	253	94		1.6	2.11
66	1	32.62	13.1	3.19	1.11	4.36	0.34	3.7	256	96		741.2	1.42
66	3	32.62	13.0	3.25	1.11	4.27	0.29	4.1	257	96	31	375.6	2.12
66	15	32.63	12.8	3.37	1.10	4.34	0.29	3.3	257	95	34	6.2	2.31
67	3	32.63	12.9	3.21	1.11	4.32	0.29	3.6	256	95		175.4	2.05
67	15	32.63	12.9	3.31	1.13	4.27	0.28	3.8	259	96		5.0	2.33
67	26	32.63	12.8	3.34	1.09	4.38	0.32	3.7	258	96		0.2	3.11
68	3	32.64	12.9	3.25	1.02	4.49	0.26	2.5	263	98		396.6	1.83
68	25	32.64	12.6	3.49	1.03	4.92	0.28	2.7	256	95		0.5	1.83
69	3	32.63	13.1	3.10	1.04	3.97	0.26	2.9	280	105		324.2	3.19

Station	z (m)	Salinity (psu)	Temp (°C)	Si (μM)	PO_4 (μM)	NO_3+NO_2 (μM)	NO_2 (μM)	NH_3 (μM)	O_2 (μM)	O_2 Satn (%)	BOD (μM)	PAR ($\mu E \bullet m^{-2} \bullet s^{-1}$)	Fluorescence
69	23	32.51	12.8	3.37	1.02	4.34	0.26	3.0	260	96		1.3	2.60
70	0	0.95		48.05	28.87	47.89	7.32	49.5	126		117	0.0	

APPENDIX C. SUMMARY STATISTICS

Month	Area	Min.	Max.	Mean	σ	n
Silicate:						
July	Blacks Harbour	2.45	2.76	2.54	0.13	4
July	Bliss Harbour	2.16	3.66	2.68	0.52	6
July	Control Dam	7.24	37	17.7	13.9	3
July	Lime Kiln Bay	2.55	2.97	2.69	0.20	3
July	Lower Letang	1.83	3.68	2.73	0.54	15
July	Open Bay	2.07	3.71	2.89	0.82	2
July	Upper Letang	2.93	5.87	4.15	0.94	7
August	Back Bay	6.48	7.11	6.76	0.23	7
August	Blacks Harbour	6.62	8.44	7.2	0.64	6
August	Bliss Harbour	6.16	6.63	6.39	0.13	20
August	Control Dam	33	54	43	8.4	3
August	Lime Kiln Bay	6.18	6.56	6.45	0.14	6
August	Lower Letang	5.85	9.13	6.66	0.6	21
August	Open Bay	5.88	7.18	6.31	0.36	8
August	Sea Farm cages	6.32	6.82	6.55	0.16	14
August	Upper Letang	6.83	10.18	8.78	1.21	10
September	Blacks Harbour	2.73	3.55	3.09	0.3	6
September	Bliss Harbour	3.26	3.63	3.46	0.15	6
September	Control Dam	6.89	48	21.3	18.9	3
September	Lime Kiln Bay	3.17	3.28	3.23	0.04	5
September	Lower Letang	3.08	3.84	3.29	0.18	16
September	Open Bay	3.18	3.31	3.25	0.07	2
September	Upper Letang	3.23	4.52	3.71	0.43	8
Phosphate:						
July	Blacks Harbour	0.65	1.82	1.21	0.42	4
July	Bliss Harbour	0.49	0.58	0.53	0.03	6
July	Control Dam	1.40	12.4	5.14	5.09	3
July	Lime Kiln Bay	0.52	0.61	0.57	0.04	3
July	Lower Letang	0.42	0.70	0.56	0.06	15
July	Open Bay	0.50	0.62	0.56	0.06	2
July	Upper Letang	0.60	1.09	0.79	0.17	7
August	Back Bay	0.79	1.15	0.92	0.11	7
August	Blacks Harbour	0.73	2.37	1.38	0.62	6
August	Bliss Harbour	0.67	0.87	0.76	0.05	20
August	Control Dam	9.40	22	14.0	5.55	3
August	Lime Kiln Bay	0.70	1.15	0.93	0.17	6

Month	Area	Min.	Max.	Mean	σ	n
August	Lower Letang	0.70	1.20	0.85	0.13	21
August	Open Bay	0.68	0.77	0.72	0.03	8
August	Sea Farm cages	0.80	0.97	0.90	0.05	14
August	Upper Letang	0.88	1.79	1.35	0.29	10
September	Blacks Harbour	1.30	3.07	2.25	0.58	6
September	Bliss Harbour	0.96	1.10	1.01	0.05	6
September	Control Dam	1.85	29	12.1	12.0	3
September	Lime Kiln Bay	1.07	1.17	1.12	0.04	5
September	Lower Letang	0.90	1.13	1.05	0.06	16
September	Open Bay	0.95	0.97	0.96	0.01	2
September	Upper Letang	1.13	1.47	1.30	0.10	8
Nitrate:						
July	Blacks Harbour	1.68	2.31	2.01	0.26	4
July	Bliss Harbour	1.12	2.71	1.70	0.56	6
July	Control Dam	4.03	27.8	12.2	11.0	3
July	Lime Kiln Bay	1.50	1.81	1.62	0.14	3
July	Lower Letang	0.83	3.83	2.17	0.84	15
July	Open Bay	0.93	3.61	2.27	1.34	2
July	Upper Letang	1.98	3.22	2.40	0.43	7
August	Back Bay	4.07	5.05	4.55	0.38	7
August	Blacks Harbour	4.26	5.05	4.60	0.25	6
August	Bliss Harbour	4.39	5.29	4.82	0.27	20
August	Control Dam	16.0	45.5	27.2	13.1	3
August	Lime Kiln Bay	4.26	4.75	4.46	0.21	6
August	Lower Letang	3.70	5.18	4.49	0.42	21
August	Open Bay	4.63	5.65	5.16	0.33	8
August	Sea Farm cages	4.50	4.87	4.73	0.11	14
August	Upper Letang	3.71	4.73	4.29	0.37	10
September	Blacks Harbour	3.64	4.10	3.79	0.16	6
September	Bliss Harbour	4.43	4.91	4.71	0.16	6
September	Control Dam	5.67	47.9	22.0	18.5	3
September	Lime Kiln Bay	3.84	4.30	4.08	0.18	5
September	Lower Letang	3.91	4.92	4.29	0.24	16
September	Open Bay	4.08	4.43	4.26	0.18	2
September	Upper Letang	4.00	4.45	4.15	0.15	8
Nitrite:						
July	Blacks Harbour	0.11	0.19	0.14	0.03	4
July	Bliss Harbour	0.05	0.09	0.07	0.02	6
July	Control Dam	0.22	2.40	0.97	1.01	3

Month	Area	Min.	Max.	Mean	σ	n
July	Lime Kiln Bay	0.06	0.09	0.07	0.01	3
July	Lower Letang	0.04	0.13	0.09	0.03	15
July	Open Bay	0.06	0.13	0.10	0.03	2
July	Upper Letang	0.10	0.19	0.14	0.03	7
August	Back Bay	0.31	0.36	0.33	0.02	7
August	Blacks Harbour	0.33	0.49	0.39	0.05	6
August	Bliss Harbour	0.31	0.36	0.34	0.01	20
August	Control Dam	2.29	5.29	3.30	1.41	3
August	Lime Kiln Bay	0.28	0.35	0.32	0.03	6
August	Lower Letang	0.32	0.41	0.35	0.02	21
August	Open Bay	0.30	0.36	0.32	0.02	8
August	Sea Farm cages	0.33	0.36	0.35	0.01	14
August	Upper Letang	0.36	0.55	0.46	0.07	10
September	Blacks Harbour	0.29	0.39	0.34	0.04	6
September	Bliss Harbour	0.26	0.28	0.27	0.01	6
September	Control Dam	0.37	7.32	2.91	3.13	3
September	Lime Kiln Bay	0.26	0.28	0.27	0.01	5
September	Lower Letang	0.25	0.34	0.28	0.02	16
September	Open Bay	0.26	0.26	0.26	0.00	2
September	Upper Letang	0.26	0.32	0.29	0.02	8
Ammonia:						
July	Blacks Harbour	4.05	17.4	11.14	4.74	4
July	Bliss Harbour	2.76	6.08	4.03	1.11	6
July	Control Dam	4.8	20	9.9	7.1	3
July	Lime Kiln Bay	3.28	4.3	3.81	0.42	3
July	Lower Letang	2.6	5.62	3.28	0.72	15
July	Open Bay	2.48	2.84	2.66	0.18	2
July	Upper Letang	3.48	5.23	4.19	0.56	7
August	Back Bay	3.32	7.70	5.59	1.69	7
August	Blacks Harbour	3.33	25	12.6	7.51	6
August	Bliss Harbour	2.64	5.58	3.88	0.86	20
August	Control Dam	25	38	31	5.7	3
August	Lime Kiln Bay	3.76	4.97	4.38	0.38	6
August	Lower Letang	2.59	5.34	4.25	0.82	21
August	Open Bay	1.71	3.81	2.39	0.75	8
August	Sea Farm cages	3.69	8.76	6.20	1.47	14
August	Upper Letang	4.89	6.93	5.90	0.65	10
September	Blacks Harbour	4.84	41	25	11.8	6
September	Bliss Harbour	2.56	3.66	3.08	0.39	6
September	Control Dam	4.84	50	22	19.6	3

Month	Area	Min.	Max.	Mean	σ	n
September	Lime Kiln Bay	3.63	4.82	4.24	0.51	5
September	Lower Letang	2.41	4.06	3.28	0.49	16
September	Open Bay	2.64	2.81	2.73	0.09	2
September	Upper Letang	4.25	4.69	4.53	0.15	8
O_2 Saturation:						
July	Blacks Harbour	83.8	106	94.4	8.4	4
July	Bliss Harbour	102.9	109.4	107.8	2.4	6
July	Control Dam	97.1	99.4	98.2	1.2	2
July	Lime Kiln Bay	107.9	111	109.5	1.3	3
July	Lower Letang	102.7	116.1	108.5	3.6	15
July	Open Bay	102.9	112	107.4	4.6	2
July	Upper Letang	104.7	109	106.6	1.2	7
August	Back Bay	93.7	97.7	95.2	1.2	7
August	Blacks Harbour	61.7	96.7	84.2	13.5	4
August	Bliss Harbour	96.6	100	98.1	1.0	15
August	Lime Kiln Bay	93.6	96.7	95.6	1.4	3
August	Lower Letang	95.6	98.9	97.2	1.1	15
August	Open Bay	97.3	100.8	98.6	1.2	7
August	Sea Farm cages	89.2	96.9	93.7	2.4	14
August	Upper Letang	94.2	98.7	95.5	1.5	7
September	Blacks Harbour	40.6	90	64.6	17.0	6
September	Bliss Harbour	94.6	103.5	97.5	3.4	6
September	Control Dam	80.4	89.1	84.8	4.4	2
September	Lime Kiln Bay	92.8	95.4	94.2	0.9	4
September	Lower Letang	93.9	104.6	96.9	2.8	15
September	Open Bay	95.2	97.4	96.3	1.1	2
September	Upper Letang	91.7	96.9	94.2	1.7	7
BOD (5 d):						
July	Blacks Harbour	72	72	72		1
July	Bliss Harbour	51	70	60.5	9.5	2
July	Lime Kiln Bay	59	74	66.5	7.5	2
July	Lower Letang	52	57	54.5	2.5	2
July	Upper Letang	49	58	53.5	4.5	2
August	Blacks Harbour	46	49	47.5	1.5	2
August	Bliss Harbour	39	40	39.5	0.5	2
August	Control Dam	20	20	20		1
August	Lime Kiln Bay	46	46	46		1
August	Lower Letang	50	50	50	0.0	2
August	Upper Letang	34	39	36.5	2.5	2

Month	Area	Min.	Max.	Mean	σ	n
September	Blacks Harbour	25	72	48.5	23.5	2
September	Bliss Harbour	27	28	27.5	0.5	2
September	Control Dam	117	117	117		1
September	Lime Kiln Bay	26	37	31.5	5.5	2
September	Lower Letang	31	34	32.5	1.5	2
September	Upper Letang	26	26	26		1