Halifax Harbour
Water Quality Monitoring Program
Quarterly Report #3

Prepared for:

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DISCLAIMER

PREFACE

The Halifax Harbour Water Quality Monitoring Project (HHWQMP) is an ongoing project, part of the Halifax Harbour Solutions Project (HRM and JWEL, 2002). It commenced in June 2004, before any of the proposed sewage treatment changes were put into effect, and is slated to continue for a year following the commission of the final plant (June 2009). The project is based on weekly sampling at over 30 sites located from the Bedford Basin to the Outer Halifax Harbour. Water samples taken at 1m and 10m depths are analyzed for a range of parameters. In addition, continuous profiles of basic hydrographic properties (salinity, temperature and density), dissolved oxygen and chlorophyll *a* are collected. The sample and profile data are presented in weekly reports along with ancillary data including water level, wind, rainfall and other parameters. The weekly reports are generated as inserts into a binder (JWEL and COA, 2004). The detailed datasets are also archived to CD and delivered on a weekly basis with the reports. A detailed description of the program is contained in the introduction section of the report binder.

The weekly data sets are reviewed on a quarterly basis (13 weeks). The main objective of the quarterly reports is to summarize and evaluate the weekly data sets in terms of water quality objectives and concerns. The quarterly report also provides an opportunity to review the effectiveness of various aspects of the program and recommend changes that will improve the program.

The HHWQMP program involves an extensive network of personnel including boat operators, field technicians, laboratory technicians and their associated equipment and procedures. The study team also includes managers, oceanographers and water quality experts. The routines, procedures, report and data archive formats are evolving as the project proceeds. These will be documented in the quarterly reports.

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1 Introduction

This quarterly report represents a summary of Halifax Harbour Water Quality Monitoring Project (HHWQMP) data collected from 21 December 2004 to 15 March 2005. The analysis presented here represents an evolving presentation of the data. The data for the period are discussed in terms of compliance/exceedance of applicable water quality guidelines, and how they affect recommendations for program modification. The emphasis in this report is a continued assessment of the efficacy of the sampling program and the potential for introduction of systematic sampling bias in the data. This is a necessary step in the more detailed statistical analysis of the data which can occur as the project proceeds. In addition, in this report, the data from the center of Bedford Basin (Station G2) is compared with data collected at the same site by the Bedford Basin Phytoplankton Monitoring Program conducted by scientists with the Department of Fisheries and Oceans at Bedford Institute of Oceanography.

2 Weekly Reporting

The basic weekly report format is discussed in detail in the introduction of the project report binder and in Quarterly Report #1 (QR1)(JWL and COA, 2004). Slight modifications and enhancements to the weekly reports continue to be made as experience dictates. These include the addition of a general "State of the Harbour" comment to the cover page (Week 31, 19 Jan), and a change in the density parameter plotted from σ_t (sigma-t which uses in situ temperature) to σ_θ (sigma-theta or potential density which uses potential temperature) (Week 39, 15 Mar). Sigma–theta represents the density of the water if it were at the surface (atmospheric pressure). This removes the effect of in situ pressure, thereby facilitating comparison of the inherent density of water at different depths. This is a minor change, only marginally affecting values in the deeper Basin. Several minor improvements to specifying contouring intervals and ranges were also made throughout the quarter.

From time to time errors have been found in the analysis routines. To date these have not affected the measured values presented. An Errata section will be added to the Introduction section of the report binder and will be updated on a quarterly basis. This will be used to document issues which could affect the interpretation of the data.

The internal structure of the MATLAB scripts continues to be revised to streamline the processing. Ultimately these scripts, which track the complete sequence of the data processing/display can be provided as part of the data documentation.

3 Sampling Program

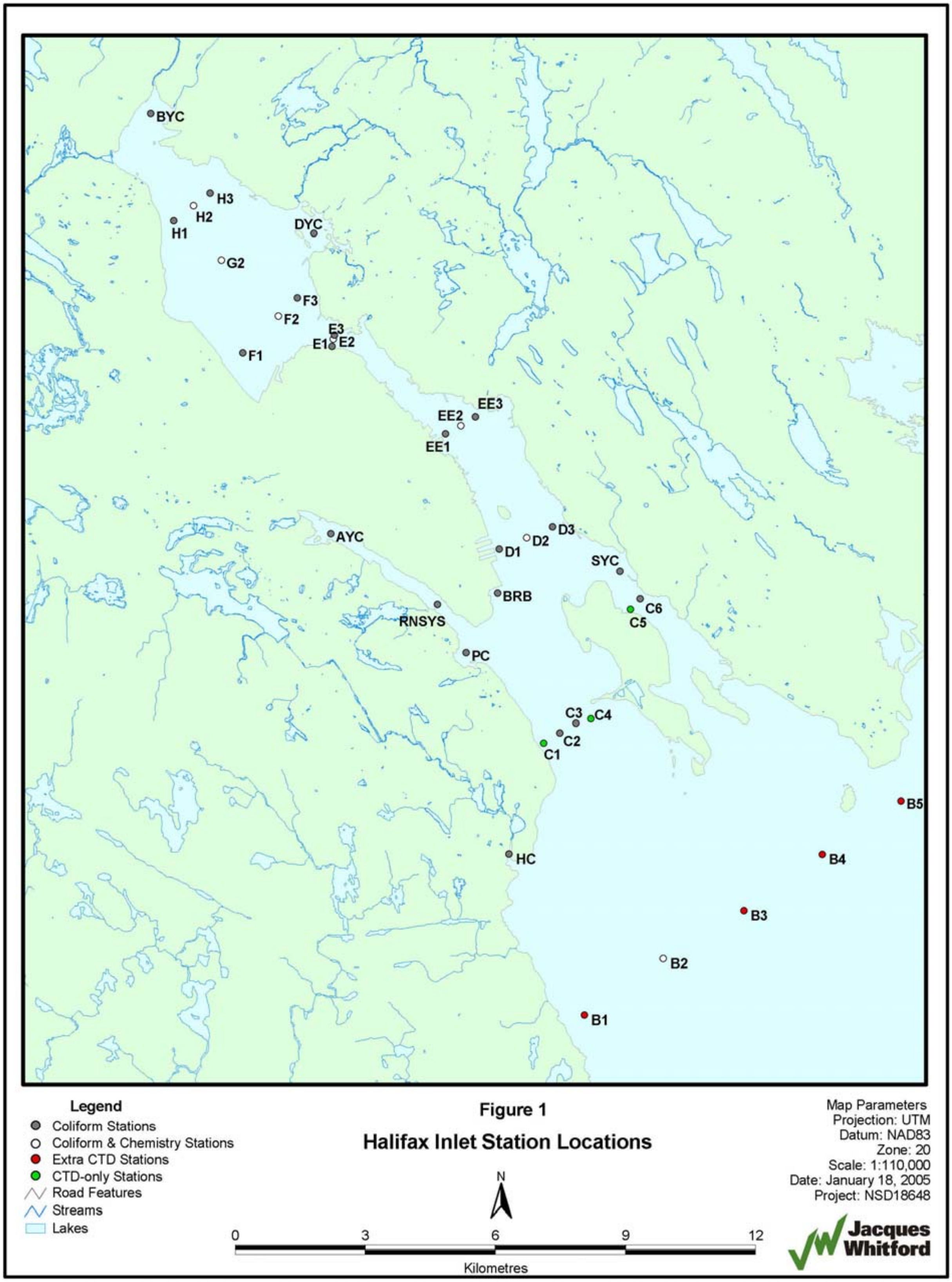
Survey sampling is conducted from one of two vessels based at the Armdale Yacht Club (AYC). The details of the sampling program are discussed in the introduction section of the project report binder and QR1. The locations of the 34 sampling sites are included for reference in Figure 1. Sampling involves the collection of continuous profile data and discrete water samples at 1 and 10m water depth. A summary of the sampling and analysis schedules and relevant established criteria are reiterated in Table 1. Based on recommendations in QR2 (JWL and COA, 2004), a "supplemental sample" procedure was implemented (Section 3.3), which samples sites at the discretion of the field team. Lab analysis on these supplementary samples is made possible using funds banked from missed samples during the regular program. During this quarter there were many instances of missed samples due to ice, particularly in bays and inlets, and at times over the entire Bedford Basin.

An issue which should be reviewed is the location of the sampling sites. Particularly, it should be noted that there is currently no sampling in the vicinity of the existing raw sewage outfall south of Herring Cove. This area is also the area where the outfall for the Hospital point sewage treatment plant will be located. In addition several recreational areas have come to light, including the area adjacent to the boardwalk in Eastern Passage, the beach at the Dingle, Wreck Cove (McNabs Island), and a beach area just south of the Bedford Yacht Club. These areas should be considered in terms of bacterial sampling.

Issues and changes in the sampling procedure occurring during the third quarter are summarized in the following sub-sections.

3.1 Sampling Order

Sampling order is varied to minimize biasing the collected data with respect to known diurnal variations in sewage load and sunlight. Sampling generally occurs on Tuesday, with Wednesday and Thursday as contingency days. A variable circuit was designed that results in ‘quasi’ random sampling, subject to certain operational constraints. This procedure is discussed in QR1. The efficacy of the sampling procedure, with respect to sample timing, updated to include this quarter, is discussed in subsections below. The sampling order for Quarter 3 is presented in Table 2.


BYC
H3
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AYC
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RNSYS
PC
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C2
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B5
HC
B4
B3
B2
B1
Legend
Coliform Stations
Coliform & Chemistry Stations
Extra CTD Stations
CTD-only Stations
Road Features
Streams
Lakes
Figure 1
Halifax Inlet Station Locations
N
0
3
6
9
12
Kilometres
Map Parameters
Projection: UTM
Datum: NAD83
Zone: 20
Scale: 1:110,000
Date: January 18, 2005
Project: NSD18648
Jacques Whitford

Table 1. Summary of measured parameters

	EQL value	EQL units	Harbour Task Force Guideline	Water Use Category	Sampling Stations (refer to Fig. 1)	Sampling frequency
Profile Data					All	weekly
Salinity	n/a	PSU	n/a	n/a		
Temperature	n/a	C°	n/a	n/a		
Chlorophyll *a*	n/a	ug/L	n/a	n/a		
Dissolved Oxygen	n/a	mg/L	8 7 6	SA SB SC		
Secchi depth	n/a	m	n/a	n/a		
Bacteria Samples					Bacteria + Chemical	weekly
Fecal Coliform	0	cfu/ 100ml	14 200	SA SB		
Chemical Samples					Chemical sites	bi-weekly
CBOD	5	mg/L	none			
Ammonia Nitrogen	0.05	mg/L	none			
TSS	0.5	mg/L	<10% background	all		
Total Oil and Grease	5	mg/L	10	all		
Metal scan					Chemical sites	bi-weekly
Cadmium	3	ug/L	9.3	all		
Chromium	20	ug/L	50.0	all		
Copper	20	ug/L	2.9	all		
Lead	5	ug/L	5.6	all		
Manganese	20	ug/L	100.0	all		
Nickel	20	ug/L	8.3	all		
Zinc	50	ug/L	86.0	all		
Aluminum	100	ug/L	none			
Antimony	20	ug/L	none			
Arsenic	20	ug/L	none			
Barium	50	ug/L	none			
Beryllium	20	ug/L	none			
Bismuth	20	ug/L	none			
Boron	500	ug/L	none			
Cobalt	10	ug/L	none			
Lithium	20	ug/L	none			
Iron	500	ug/L	none			
Molybdenum	20	ug/L	none			
Selenium	50	ug/L	none			
Strontium	50	ug/L	none			
Thallium	1	ug/L	none			
Tin	20	ug/L	none			
Titanium	20	ug/L	none			
Uranium	1	ug/L	none			
Vanadium	20	ug/L	none			

Table 2. Sample collection order (green sites are CTD only)

Date	21-Dec-04	28-Dec-04	9-Jan-05	12-Jan-05	19-Jan-05	26-Jan-05	31-Jan-05	8-Feb-05	15-Feb-05	22-Feb-05	2-Mar-05	10-Mar-05	15-Mar-05
Survey #	27	28	29	30	31	32	33	34	35	36	37	38	39
Code	b10		b9a	a13a	a12a	ah1	a14a	b6a	b3	ah1	b1	b5a	a15
1	D1	No	AYC	HC	AYC	C1	AYC	AYC	C2	HC	AYC	C3	SYC
2	D2	Sampling	RNSYS	B2	RNSYS	C2	PC	RNSYS	C1	B2	RNSYS	C4	C6
3	EE2		PC	C3	PC	C3	C4	PC	HC	C1	PC	C5	C5
4	EE1		EE1	C4	C1	C4	C3	B2	B2	C2	C2	C6	D3
5	E2		EE2	C5	C2	BRB	B2	HC	C3	C3	C1	SYC	D2
6	E1		D2	C6	BRB	D1	HC	C1	C4	C4	HC	D3	EE3
7	F2		D1	SYC	D1	D2	C1	C2	C5	C5	B2	EE3	EE2
8	F1		BRB	D3	EE1	EE2	C2	BRB	C6	C6	C3	E3	E3
9	G2		C2	D2	E1	EE1	BRB	D1	SYC	SYC	C4	F3	E2
10	H1		C1	EE3	F1	E2	D1	D2	D3	D3	C5	DYC	F2
11	H2		HC	EE2	G2	E1	EE1	EE2	EE3	D2	C6	H3	F3
12	BYC		B2	E3	H1	F1	E1	EE1	E3	EE3	SYC	BYC	DYC
13	H3		C3	E2	BYC	F2	F1	E2	F3	EE2	D3	H2	H3
14	DYC		C4	F2	H2	G2	G2	E1	DYC	E3	EE3	H1	H2
15	F3		C5	F3	H3	GH1	H1	F2	H3	E2	E3	G2	BYC
16	E3		C6	DYC	DYC	H2	BYC	F1	BYC	F3	F3	F1	H1
17	EE3		SYC	H3	F3	BYC	H2	G2	H2	F2	DYC	F2	G2
18	D3		D3	H2	F2	H3	H3	H1	H1	DYC	H3	E1	F1
19	SYC		EE3	BYC	E2	F3	DYC	H2	G2	H3	BYC	E2	E1
20	C6		E3	H1	E3	E3	F3	BYC	F1	H2	H2	EE1	EE1
21	C5		F3	G2	EE2	EE3	F2	H3	F2	BYC	H1	EE2	D1
22	C4		DYC	F1	EE3	D3	E2	DYC	E1	H1	G2	D2	BRB
23	C3		H3	E1	D2	SYC	E3	F3	E2	G2	F1	D1	AYC
24	B2		BYC	EE1	D3	C6	EE2	E3	EE1	F1	F2	BRB	RNSYS
25	HC		H2	D1	SYC	C5	EE3	EE3	EE2	E1	E1	C2	PC
26	C1		H1	BRB	C6	PC	D2	D3	D2	EE1	E2	C1	C2
27	C2		G2	C2	C5	RNSYS	D3	SYC	D1	D1	EE1	HC	C1
28	BRB		F1	C1	C4	AYC	SYC	C6	BRB	BRB	EE2	B2	HC
29	PC		F2	PC	C3	DYC	C6	C5	PC	PC	D2	PC	B2
30	RNSYS		E1	RNSYS	B2	B2	C5	C4	RNSYS	RNSYS	D1	RNSYS	C3
31	AYC		E2	AYC	HC	HC	RNSYS	C3	AYC	AYC	BRB	AYC	C4

3.2 Sampling Bias

There are two issues regarding potential bias in the dataset. The first is the relative bias between sites. That is, whether the statistics from one site can be compared with those from another site. The second is the absolute bias with respect to the environmental forcing, or how well the dataset represents typical conditions in the harbour. Our sampling has operational constraints which introduce a morning/early afternoon bias to the entire dataset. It is unlikely that this can be addressed, except to document it.

The following section is a first look at potential bias with respect to time of day, water level, and rainfall during the third quarter.

3.2.1 Time of Day

Sewage flows have significant regular diurnal variations, which can affect the water quality in the harbour. In addition to variations in sewage load, the most obvious diurnal variation is in sunlight. Sunlight is perhaps the major contributor to the die off of bacteria, and can have effects on other parameters, particularly chlorophyll *a* and dissolved oxygen. The variation in sewage load is primarily an issue in the Inner Harbour, relatively close to the outfalls, while sunlight affects the entire harbour.

Figure 2 represents the sampling time at each site since the start of the program in June 2004. The data from the third quarter are shown in red. The sites are generally sorted from north to south. There are a few patterns which emerge. The stations at the north end of Bedford Basin have less of a range of sampling times. This is because logistics dictates that the surveys never start or end in the Basin. In general, the range of sampling times increases with distance south. This is a function of travel time from the Northwest Arm. Even if a site is sampled first, time is still taken to travel there. Given that sampling begins at the same time every week (07:00), and the boat originates in the Northwest Arm, it would be expected that Armdale Yacht Club (AYC) would have the earliest and latest sample times. This is the case except for outliers at Herring Cove, B2 and C3, the result of a single survey which was delayed due to contingencies. Given the necessary operational constraints the sampling scheme has resulted in a reasonably uniform distribution in the Inner Harbour (Section D through Section E) where diurnal fluctuations would likely be greatest. The diagram indicates that Station E1 was never sampled as early as E2 and E3. There appears to be no systemic reason for this, but occurred due to sampling delays when E1 was sampled early. A similar situation affects Site F1.

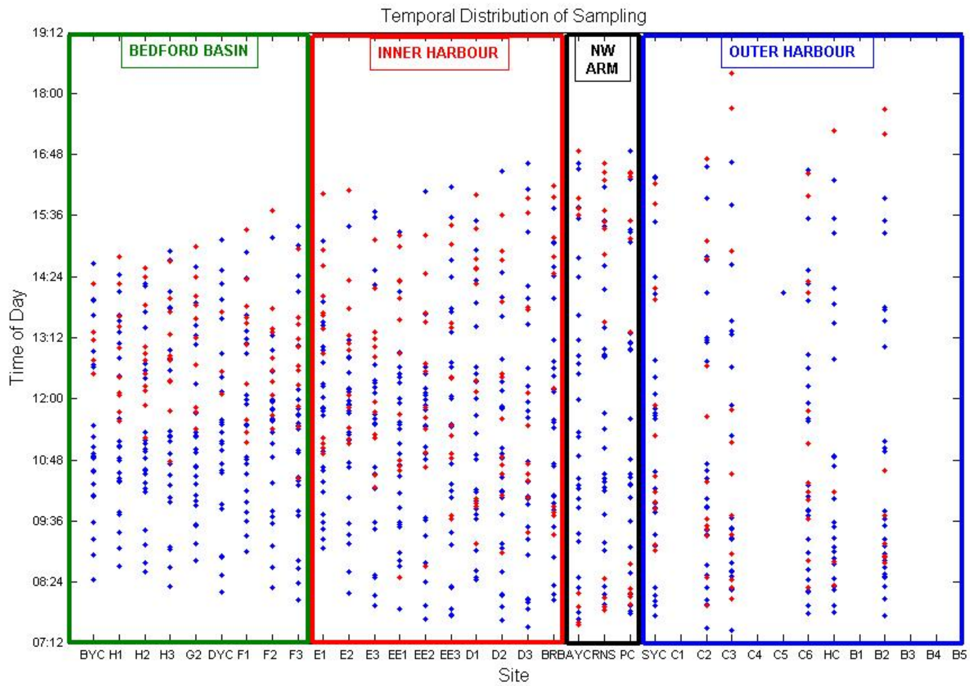


Figure 2. Temporal sampling distribution by site

3.2.2 Water Levels

The water level at the time of sampling can affect the results. The two most obvious effects are expected to be whether a particular sample was taken upstream or downstream (based on tide direction) from the nearest outfall, and the variation in initial dilution from shallow outfalls. These are both issues primarily in the Inner Harbour. In the many shallow outfalls that currently exist in the harbour, the change in water depth can be a significant part of the water depth at the outfall. This can have a major effect on initial dilution and can affect whether a discrete plume or “pool” of effluent can exist at a sample site.

There is a potential bias introduced by regular weekly sampling. Sampling which occurs on the same day every second week (the chemical sampling) could occur at the same point in the fortnightly tidal cycle (i.e. the same tidal range). An initial assessment of the tidal signal in Halifax Harbour indicates that the fortnightly cycle is sufficiently irregular enough (i.e. the tides are sufficiently "mixed") that this problem is unlikely, particularly given the variation in sampling day (Tuesday or Wednesday, sometimes Thursday). This issue will be monitored and may be revisited more rigorously at a later time.

A preliminary assessment of water level during sampling follows. The probability distribution of water level (above chart datum) as derived from the tide gauge at the Naval Dockyard in Halifax (CHS station 490) for the period June 2004 to March 2005 is shown in Figure 3**.** The red line is the baseline against which water levels during sampling will be compared. The overall water level distribution is slightly bi-modal, which is expected, given the primarily sinusoidal nature of the tides. The minimum height roughly corresponds to the mean tide level. However the distribution is actually relatively flat, between 0.6 m and 1.8 m. In an ideal situation each site would be sampled in a distribution similar to the overall distribution.

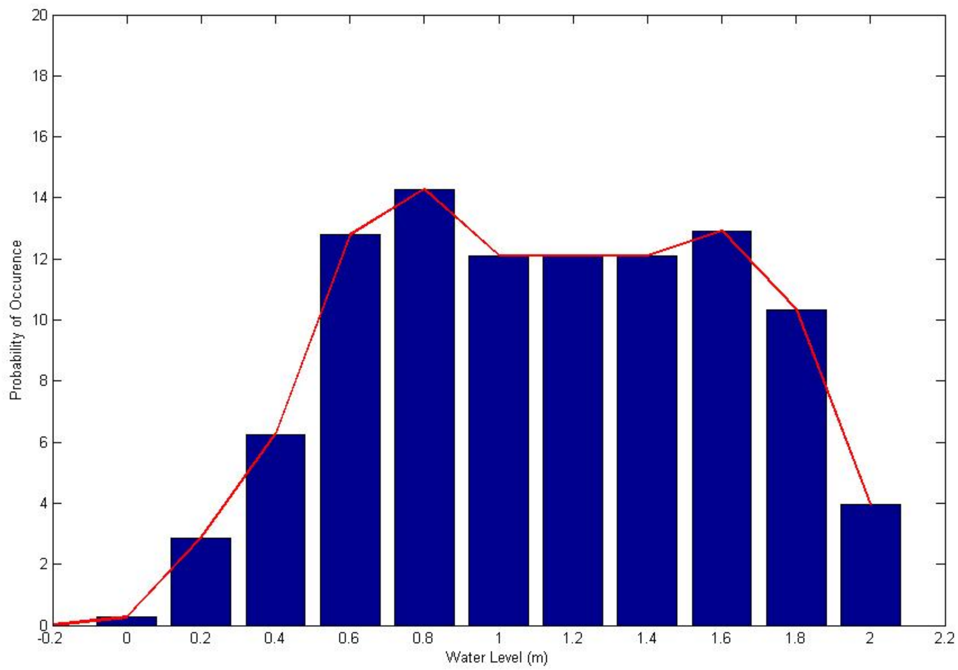


Figure 3. Probability distribution of water levels in Halifax, June 2004 to March 2005

Figure 4 shows the distribution of water levels at the time of sampling compared to the overall water level distribution. The sampling distributions show that a relatively full range of water levels has been sampled at each site. There are no great variations from the baseline distribution except perhaps a slight bias toward higher water levels in the vicinity of the Northwest Arm (Stations AYC, RNSYS, PC and BRB).

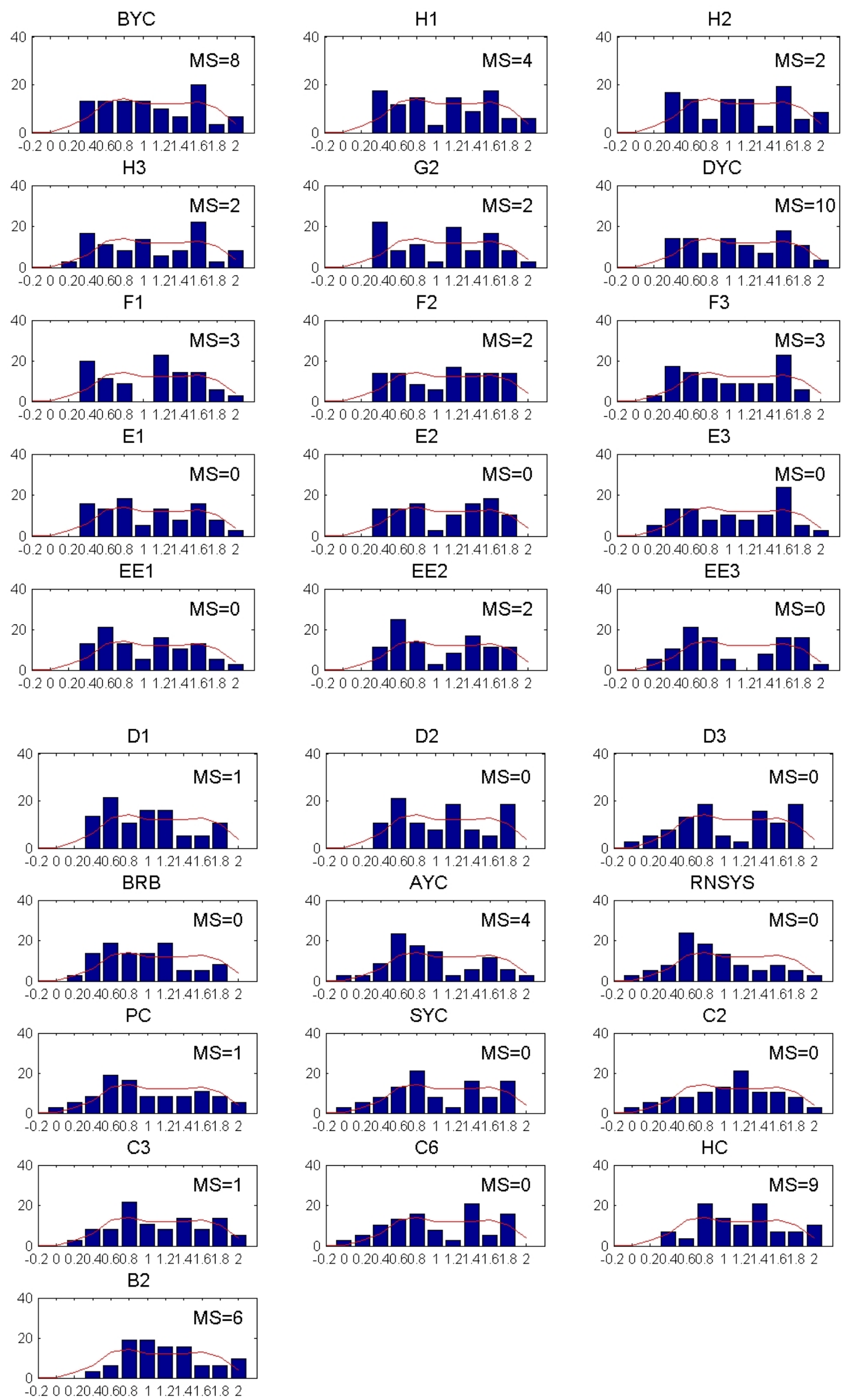


Figure 4. Water level distribution at each site during sampling June 2004 to March 2005.
Note: MS = Missed samples

3.2.3 Precipitation

Rainfall affects both the sewage loads and the dynamics of the harbour. Following a rain event, effluent flow increases in a combined sewage system; collected material in the sewage pipes can be flushed; and the harbour, in response to the increased fresh water input, can become more stratified, enhancing estuarine circulation. The combination of increased flow and stratification can have a great effect on the near field behaviour of the plumes from the outfalls. These effects lag the rainfall by some time and persist for some period after the rain stops. The duration of the impact, of course, depends on the magnitude of the rain event. For purposes of discussion we will, somewhat arbitrarily, select a three day precipitation window for our analysis. The red line in Figure 5 depicts the probability distribution of precipitation integrated over the current and previous two days for the entire program period (23 June to 15 March). The blue bars on this plot represent a similar analysis performed for sampling days only. The plot indicates that our sampling is relatively unbiased with respect to precipitation. Over the entire nine month period about 43 % of days had precipitation less than 5 mm in the 72 hour window. The sampling day distribution also includes 43% of these “dry days”. On the other end, we generally have a good match given the limited number of samples. If anything we are slightly over-representing moderately wet weather (7.5-12.5 mm).

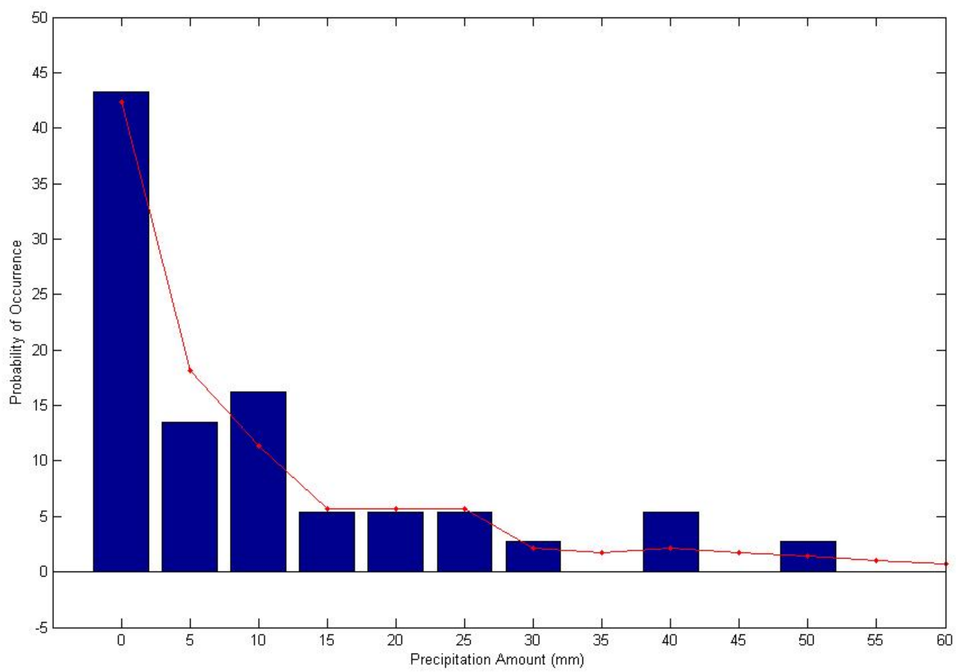


Figure 5. Probability distribution of cumulative 72 hour rainfall

3.3 Supplemental Samples

Based on recommendations from Quarterly Report #2, a supplemental sample protocol to opportunistically sample visible water quality features in the Harbour has been instituted. These samples are acquired on a discretionary exploratory basis when an interesting feature, such as a visible front or plume, is encountered. The samples are processed for the full range of parameters specified originally at the beginning of the program, including parameters which have been eliminated from normal sampling due to lack of detection. It is anticipated that these samples will have lower water quality than most normal samples. During this quarter one such sample was taken on week 39 (15 Mar 05). The laboratory results for this sample are reported in Section 4.10

3.4 Sampling Protocol

Sampling protocol has been dictated by experience and lab directions. CTD casts are performed according to the manufacturer's recommendation. These protocols will be documented and added to the project binder with weekly and quarterly reports.

4 Water Quality Results and Discussion

Results of the water quality sampling are discussed in the following sections with emphasis on compliance with water quality guidelines, and any need for modifications to the initial program.

4.1 Fecal Coliform

The Guidelines for Canadian Recreational Water Quality (GCRWQ) (Health and Welfare Canada 1992) evaluate the compliance with water quality criteria based on geometric mean. The geometric mean of n values is defined as:

$$GM = (x_1 \cdot x_2\ x_3\ \ldots\ x_n)^{1/n}$$

To compute geometric mean some adjustments to the data are required. Zeros are not valid in the calculation, so ones (1's) are substituted for all zero values. The result of this is that there will be no zero counts reported at any site. An appropriate interpretation of a reported mean value of one, then, is that it is equivalent to "less than or equal to" one. Out of range values are reported by the lab as >10,000 in the units reflective of the resolution of the analysis being performed (see Lab Resolution section below and in QR#1). For statistical purposes, these values are, relatively arbitrarily, replaced by 14,999. This is simply a number >10,000 which is easily identified.

Maps representing the geometric mean values over all samples for each of the three quarters to date are presented in Figures 6 through 8. In these figures, values in red exceed swimming guidelines (200 cfu/100 mL); values in blue exceed shellfishing guidelines (14 CFU/100 mL); and values in black indicate suitability for either activity. Separate maps are presented for the 1 and 10m samples. In the following discussion it is helpful to refer to the station map (Figure 1.)

Overall the coliform levels are lowest in the first quarter (summer), highest in the second quarter (autumn) and interestingly, intermediate in the third quarter (winter). These variations are likely due to variations in source strength (wet weather), circulation patterns (harbour flushing rate), and variations in sunlight and water temperature. Cooler water and reduced sunlight both increase bacterial survival times, resulting in higher concentrations.

In all cases the coliform values are highest in the Inner Harbour for both the 1m and 10m samples, but within this is some variability. In the summer (Quarter 1), the concentration distribution is similarly centered on section EE for both the 1 and 10m samples. This pattern repeats in autumn (Quarter 2), however the centre of the distribution seems to be displaced slightly down harbour in the near surface, and up harbour in the 10m samples. In the winter (Quarter 3), this trend is more pronounced, with the highest concentrations in the near surface samples being centered on section D, and the high concentration in the 10m samples centered up harbour closer to section EE. The displacement is consistent with typical estuarine circulation, with fresher water flowing out at the surface and a deeper return flow of more saline water.

There is similarity between quarters in the vertical distribution. The 1m values are higher than the 10m values in the southern part of Inner Harbour (south of section EE or D) and Outer Harbour, while the 10m values are higher than the 1m values in Bedford Basin. The transition point between these two regimes varies between quarters. In the first quarter, the transition is between the Narrows and the Basin; in the second quarter, sections E and F exhibit similar concentrations top and bottom. In Quarter 3, the transition is all the way down to section EE. These variations are possibly due to seasonal variations in harbour circulation patterns and density distribution, consistent with the variations in the horizontal distribution discussed above.

The water density data indicates that in the Basin, the coliform are associated with a deeper layer representative of the water in the Inner Harbour, while the 1 m sample generally occurs in a less dense layer likely resulting from freshwater runoff into the Basin. Therefore, the Inner Harbour is likely to be the source of bacteria over much of the Basin, rather than a local source, such as the Mill Cove sewage treatment plant (STP) or Sackville River. It is also possible that the effluent from the Mill Cove STP generally stays submerged below the pycnocline which tends to exist in the northern Basin and contributes somewhat to the coliform concentration in this lower layer. South of the Basin, the stratification associated with this estuarine circulation is much less consistent, being greatly affected by sporadic meteorological events (rain and snowmelt).

It is clear from visual evidence that the plumes from the major outfalls exhibit a large amount of variability. Another factor which may affect the horizontal distribution of bacteria concentration is that the density stratification associated with these events will affect the outfall dynamics and may control whether the untreated effluent ends up in a surface or bottom layer.

As discussed in QR #2, significant variations in FC levels from week to week appear to correlate with meteorological and oceanographic phenomena affecting bacteria source strength and flushing rate of the harbour. This is also discussed in the weekly reports.

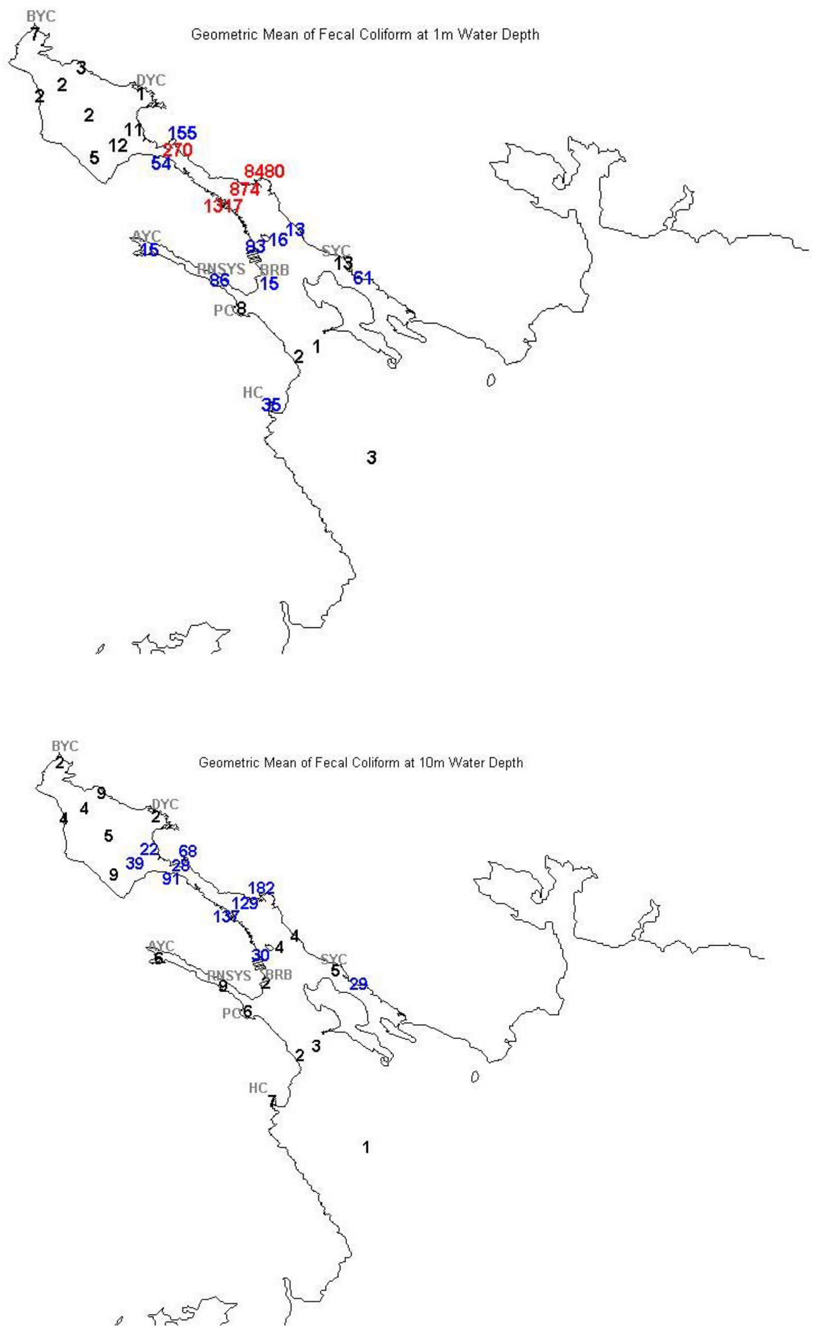
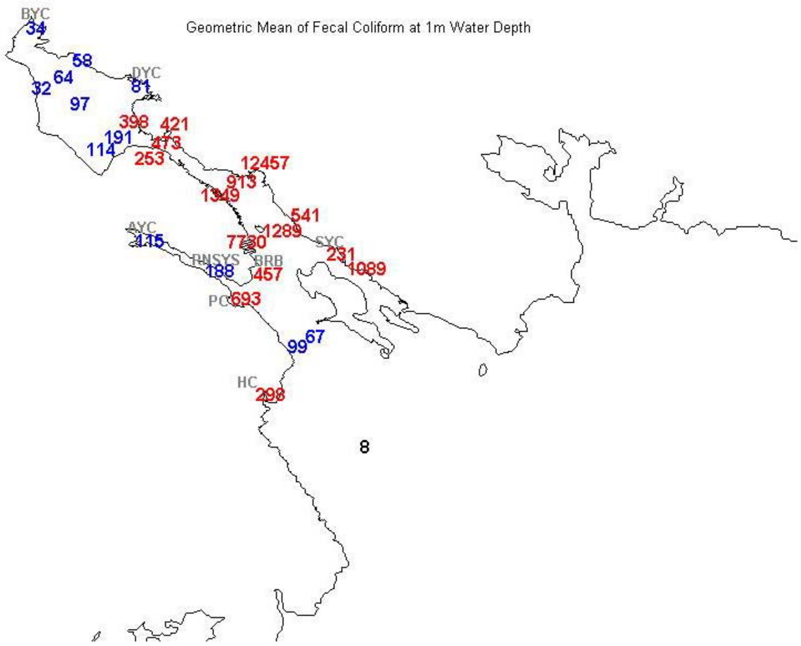


Figure 6. Fecal coliform geometric means (cfu/100mL), 23 June thru 14 Sept. 2004



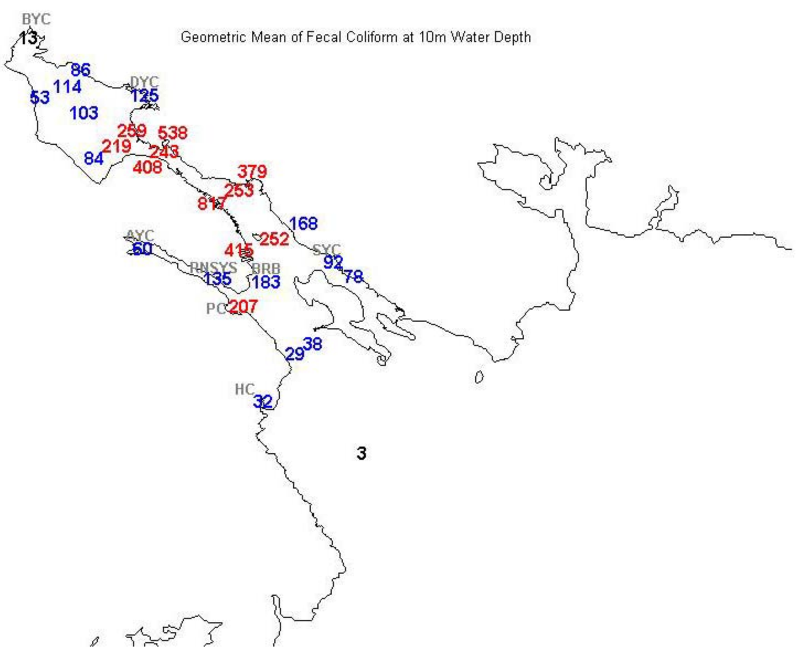
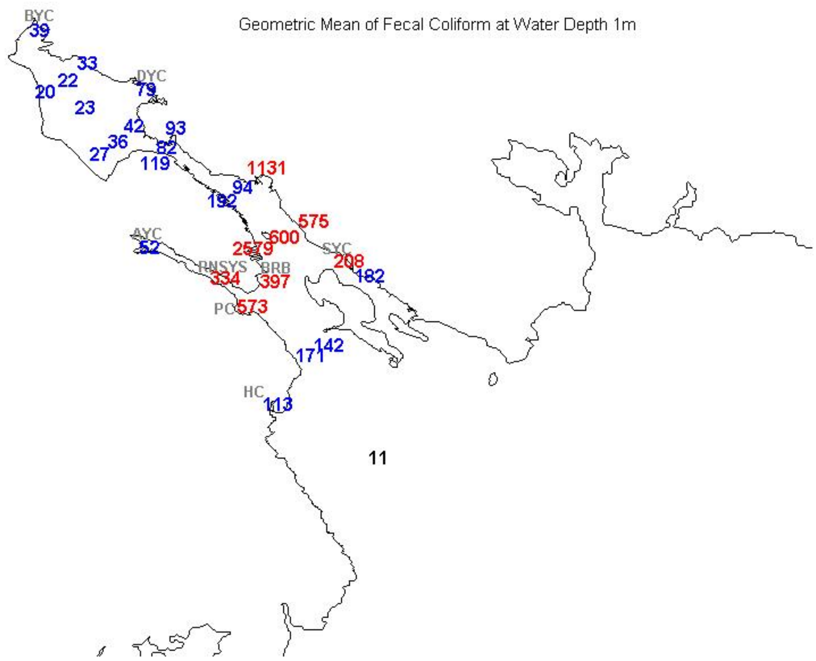


Figure 7. Fecal coliform geometric means (cfu/100mL) 22 Sept. thru 14 Dec. 2004



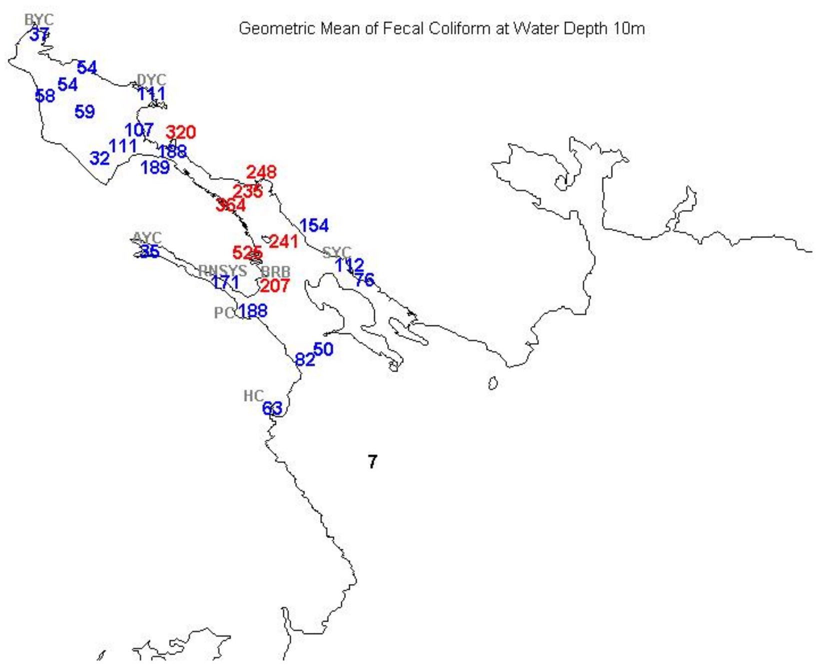


Figure 8. Fecal coliform geometric means, 21 Dec 2004 thru 15 March 2005

4.1.1 Guideline Exceedance

As presented in QR #1, the Harbour Task Force fecal coliform guidelines (Harbour Task Force, 1990) are interpreted using the methodology presented in the Guidelines for Canadian Recreational Water Quality (Health and Welfare Canada, 1992). This specifies that for fecal coliform in swimming areas the geometric mean of at least five samples taken within 30 days should not exceed 200 cfu/100mL, and any sample with values >400 cfu/100mL should trigger re-sampling. Our sampling regime generally meets the criteria of five samples within 30 days.

Interpreting this procedure in our context results in a weekly assessment, at three levels:

1. ACCEPTABLE, defined as a geometric mean <200 cfu/100mL
2. QUESTIONABLE, geometric mean <200 cfu/100mL but one or more samples >400 cfu/100mL
3. UNACCEPTABLE, geometric mean >200 cfu/100mL.

If there are missed samples within the 30 day period, the analysis uses a reduced number of samples, rather than extending the time beyond thirty days. Tables 3 and 4 show the results of the analysis for the 1m and 10 m samples respectively. The tables represent the floating 30 day geometric mean and, in parentheses, the number of samples (max 5) used in the average. In this quarter there are quite a few missed samples (fewer than five samples in the average) at some sites, primarily due to ice.

These Tables indicate a general decrease in bacteria concentrations over the quarter, though at some sites there are indications of an increase again near the end of the quarter. The 1 m samples from the first week of the quarter have a split of 0/12/16 among the categories of acceptable, questionable and unacceptable, while by the last week of the quarter, the split is 10/8/8 (plus 2 missing site stats). This trend is particularly interesting because in quarter two, the concentrations increased throughout the quarter to a maximum at the end. As in quarter two, sites which are relatively removed from the direct influence of outfalls and other sources of freshwater input, show a smooth trend. However, as opposed to quarter two, where a monotonic increase was observed, for this quarter it is a nearly monotonic decrease.

The main contributors to bacteria die off in salt water are water temperature and sunlight. The maximum concentrations, as represented by the floating geometric mean, are experienced at winter solstice, the time of least daylight. The surface water temperature at the start of the quarter was about 3-4°C, while the minimum surface water temperature is about 0°C on or about the end of February. The data suggest that sunlight may dominate the relationship within this temperature range.

Table 3. 30 day geometric mean (number of samples) of 1m fecal coliform concentrations (#/100 ml)

	Outer Harbour				Eastern Passage		Inner Harbour									
	B2	HC	C2	C3	C6	SYC	BRB	D1	D2	D3	EE1	EE2	EE3	E1	E2	E3
21-Dec-04	42 (5)	214 (5)	615 (5)	357 (5)	715 (5)	1424 (5)	1024 (5)	3904 (4)	2455 (5)	1679 (5)	295 (5)	112 (4)	1620 (5)	301 (5)	176 (4)	97 (5)
Christmas	57 (4)	367 (4)	651 (4)	313 (4)	1074 (4)	1713 (4)	1487 (4)	5369 (3)	2496 (4)	1627 (4)	220 (4)	57 (3)	929 (4)	312 (4)	176 (4)	254 (4)
5-Jan-05	38 (4)	303 (4)	487 (4)	287 (4)	816 (4)	1106 (4)	963 (4)	4718 (4)	1728 (4)	1162 (4)	140 (4)	47 (4)	1381 (4)	119 (4)	76 (4)	122 (4)
12-Jan-05	25 (4)	87 (4)	529 (4)	263 (4)	427 (4)	644 (4)	902 (4)	3736 (4)	1070 (4)	1309 (4)	145 (4)	57 (4)	788 (4)	174 (4)	77 (4)	139 (4)
19-Jan-05	17 (4)	56 (4)	316 (4)	143 (4)	196 (4)	302 (4)	962 (4)	5106 (4)	457 (4)	690 (4)	86 (4)	31 (4)	1076 (4)	76 (4)	99 (4)	85 (4)
26-Jan-05	9 (3)	39 (3)	210 (4)	97 (4)	141 (4)	208 (4)	541 (4)	6338 (4)	460 (4)	597 (4)	123 (4)	56 (4)	1985 (4)	36 (4)	55 (4)	55 (4)
31-Jan-05	6 (4)	39 (3)	206 (5)	123 (5)	86 (5)	166 (5)	533 (5)	7530 (5)	407 (5)	382 (5)	127 (5)	54 (5)	1795 (5)	39 (5)	37 (5)	50 (5)
8-Feb-05	3 (4)	14 (2)	98 (5)	64 (5)	37 (5)	58 (5)	388 (5)	7988 (5)	357 (5)	294 (5)	163 (5)	93 (5)	1053 (5)	35 (5)	25 (5)	48 (5)
15-Feb-05	4 (3)	47 (1)	81 (5)	53 (5)	21 (5)	21 (5)	224 (5)	5170 (5)	224 (5)	155 (5)	310 (5)	140 (5)	1041 (5)	58 (5)	52 (5)	91 (5)
22-Feb-05	3 (3)	0 0	78 (5)	73 (5)	38 (5)	22 (5)	162 (5)	2608 (5)	234 (5)	124 (5)	475 (5)	218 (5)	915 (5)	187 (5)	49 (5)	145 (5)
2-Mar-05	3 (3)	0 0	57 (5)	74 (5)	53 (5)	28 (5)	142 (5)	1715 (5)	250 (5)	167 (5)	236 (5)	137 (5)	535 (5)	270 (5)	71 (5)	183 (5)
10-Mar-05	3 (2)	0 0	46 (5)	64 (5)	114 (5)	39 (5)	112 (5)	581 (5)	241 (5)	239 (5)	228 (5)	137 (5)	431 (5)	256 (5)	135 (5)	251 (5)
15-Mar-05	2 (2)	0 0	58 (5)	94 (5)	155 (5)	81 (5)	131 (5)	573 (5)	230 (5)	327 (5)	175 (5)	109 (5)	735 (5)	223 (5)	191 (5)	206 (5)

	Bedford Basin									Northwest Arm		
	F1	F2	F3	DYC	G2	H1	H2	H3	BYC	PC	RNSYS	AYC
21-Dec-04	193 (4)	134 (4)	345 (4)	159 (4)	204 (4)	103 (4)	168 (4)	107 (4)	109 (4)	864 (5)	376 (5)	116 (5)
Christmas	278 (3)	154 (3)	244 (3)	188 (3)	298 (3)	304 (3)	330 (3)	235 (3)	187 (3)	650 (4)	200 (4)	269 (4)
5-Jan-05	86 (3)	45 (3)	57 (3)	41 (3)	124 (3)	64 (3)	83 (3)	72 (3)	45 (3)	353 (4)	189 (4)	231 (4)
12-Jan-05	61 (4)	43 (4)	43 (4)	40 (4)	130 (4)	64 (4)	82 (4)	82 (4)	43 (4)	320 (4)	96 (4)	58 (4)
19-Jan-05	26 (4)	22 (4)	19 (4)	26 (3)	47 (4)	25 (4)	36 (4)	34 (4)	29 (4)	390 (4)	97 (4)	42 (4)
26-Jan-05	13 (4)	13 (4)	11 (4)	20 (2)	21 (4)	11 (4)	19 (4)	18 (4)	15 (3)	587 (4)	46 (4)	18 (4)
31-Jan-05	11 (5)	9 (5)	14 (5)	20 (2)	17 (5)	10 (5)	18 (5)	19 (5)	15 (3)	849 (5)	55 (5)	13 (5)
8-Feb-05	8 (5)	10 (5)	13 (5)	39 (1)	10 (5)	7 (5)	12 (5)	18 (5)	17 (2)	1118 (5)	78 (5)	11 (5)
15-Feb-05	8 (5)	25 (5)	29 (5)	0	6 (5)	6 (5)	7 (5)	13 (5)	8 (1)	1595 (4)	255 (5)	29 (5)
22-Feb-05	8 (4)	34 (5)	32 (5)	0	5 (5)	8 (4)	6 (5)	27 (5)	0	772 (4)	484 (5)	28 (4)
2-Mar-05	11 (4)	42 (5)	37 (5)	0	5 (5)	8 (4)	5 (5)	23 (5)	0	674 (4)	1233 (5)	58 (3)
10-Mar-05	13 (3)	91 (4)	37 (4)	0	5 (4)	8 (3)	4 (4)	22 (4)	0	255 (4)	2863 (5)	222 (2)
15-Mar-05	16 (3)	66 (4)	33 (4)	0	6 (4)	16 (3)	7 (4)	27 (4)	11 (1)	148 (4)	1273 (5)	640 (1)

Note: Red indicates exceedance of swimming criteria (geometric mean >200). Yellow denotes "questionable" water quality, resampling is indicated (mean < 200, but one or more samples >400). Green indicates compliance with criteria.

Table 4. 30 day geometric mean (number of samples) of 10m fecal coliform concentrations (#/100 ml)

	Outer Harbour				Eastern Passage		Inner Harbour									
	B2	HC	C2	C3	C6	SYC	BRB	D1	D2	D3	EE1	EE2	EE3	E1	E2	E3
21-Dec-04	12 (5)	77 (5)	92 (5)	78 (5)	168 (5)	198 (5)	329 (5)	572 (4)	582 (5)	363 (5)	214 (5)	215 (4)	263 (5)	344 (5)	128 (5)	327 (5)
Christmas	11 (4)	107 (4)	96 (4)	99 (4)	235 (4)	356 (4)	511 (4)	620 (3)	699 (4)	461 (4)	208 (4)	270 (3)	247 (4)	458 (4)	363 (4)	374 (4)
5-Jan-05	26 (4)	97 (4)	109 (4)	123 (4)	353 (4)	746 (4)	478 (4)	593 (4)	588 (4)	339 (4)	197 (4)	189 (4)	198 (4)	473 (4)	413 (4)	542 (4)
12-Jan-05	19 (4)	95 (4)	166 (4)	82 (4)	226 (4)	543 (4)	528 (4)	571 (4)	316 (4)	238 (4)	261 (4)	187 (4)	175 (4)	720 (4)	318 (4)	372 (4)
19-Jan-05	13 (4)	74 (4)	172 (4)	73 (4)	226 (4)	412 (4)	620 (4)	812 (4)	266 (4)	210 (4)	240 (4)	133 (4)	163 (4)	256 (4)	275 (4)	281 (4)
26-Jan-05	7 (3)	45 (3)	147 (4)	58 (4)	207 (4)	386 (4)	398 (4)	657 (4)	290 (4)	166 (4)	347 (4)	189 (4)	218 (4)	163 (4)	191 (4)	229 (4)
31-Jan-05	4 (4)	45 (3)	157 (5)	67 (5)	149 (5)	219 (5)	318 (5)	764 (5)	286 (5)	140 (5)	424 (5)	180 (5)	241 (5)	165 (5)	206 (5)	191 (5)
8-Feb-05	1 (4)	20 (2)	111 (5)	44 (5)	93 (5)	108 (5)	231 (5)	736 (5)	344 (5)	130 (5)	615 (5)	239 (5)	350 (5)	89 (5)	184 (5)	134 (5)
15-Feb-05	2 (3)	11 (1)	81 (5)	42 (5)	42 (5)	38 (5)	134 (5)	418 (5)	269 (5)	88 (5)	660 (5)	283 (5)	304 (5)	134 (5)	263 (5)	225 (5)
22-Feb-05	5 (3)	0	60 (5)	46 (5)	31 (5)	41 (5)	93 (5)	504 (5)	195 (5)	89 (5)	782 (5)	333 (5)	396 (5)	186 (5)	165 (5)	264 (5)
2-Mar-05	5 (3)	0	33 (5)	33 (5)	17 (5)	26 (5)	82 (5)	439 (5)	136 (5)	81 (5)	613 (5)	358 (5)	299 (5)	210 (5)	241 (5)	405 (5)
10-Mar-05	11 (2)	0	37 (5)	23 (5)	20 (5)	39 (5)	89 (5)	369 (5)	108 (5)	76 (5)	543 (5)	411 (5)	236 (5)	170 (5)	196 (5)	467 (5)
15-Mar-05	11 (2)	0	54 (5)	28 (5)	23 (5)	43 (5)	106 (5)	346 (5)	83 (5)	85 (5)	479 (5)	318 (5)	229 (5)	188 (5)	241 (5)	646 (5)

	Bedford Basin									Northwest Arm		
	F1	F2	F3	DYC	G2	H1	H2	H3	BYC	PC	RNSYS	AYC
21-Dec-04	211 (4)	471 (4)	197 (4)	159 (4)	186 (4)	197 (4)	294 (4)	212 (4)	58 (4)	164 (5)	211 (5)	39 (5)
Christmas	317 (3)	497 (3)	298 (3)	235 (3)	398 (3)	382 (3)	460 (3)	472 (3)	108 (3)	147 (4)	243 (4)	75 (4)
5-Jan-05	136 (3)	152 (3)	151 (3)	124 (3)	187 (3)	152 (3)	180 (3)	230 (3)	37 (3)	163 (4)	179 (4)	67 (4)
12-Jan-05	123 (4)	141 (4)	110 (4)	106 (4)	201 (4)	132 (4)	155 (4)	203 (4)	37 (4)	211 (4)	171 (4)	67 (4)
19-Jan-05	42 (4)	70 (4)	66 (4)	70 (3)	94 (4)	71 (4)	58 (4)	92 (4)	37 (4)	255 (4)	129 (4)	56 (4)
26-Jan-05	23 (4)	44 (4)	38 (4)	54 (2)	49 (4)	49 (4)	31 (4)	40 (4)	26 (3)	239 (4)	66 (4)	47 (4)
31-Jan-05	14 (5)	37 (5)	42 (5)	54 (2)	33 (5)	44 (5)	30 (5)	38 (5)	26 (3)	350 (5)	60 (5)	44 (5)
8-Feb-05	12 (5)	67 (5)	64 (5)	66 (1)	29 (5)	44 (5)	32 (5)	41 (5)	36 (2)	296 (5)	58 (5)	24 (5)
15-Feb-05	10 (5)	112 (5)	113 (5)	0	18 (5)	30 (5)	25 (5)	31 (5)	37 (1)	327 (4)	131 (5)	28 (5)
22-Feb-05	12 (4)	72 (5)	91 (5)	0	29 (5)	26 (4)	22 (5)	22 (5)	0	176 (4)	154 (5)	25 (4)
2-Mar-05	9 (4)	70 (5)	128 (5)	0	32 (5)	22 (4)	23 (5)	26 (5)	0	246 (4)	291 (5)	21 (3)
10-Mar-05	15 (3)	97 (4)	155 (4)	0	48 (4)	21 (3)	23 (4)	24 (4)	0	105 (4)	552 (5)	16 (2)
15-Mar-05	15 (3)	84 (4)	149 (4)	0	56 (4)	24 (3)	25 (4)	23 (4)	19 (1)	105 (4)	453 (5)	88 (1)

Note: Red indicates exceedance of swimming criteria (geometric mean >200). Yellow denotes "questionable" water quality, resampling is indicated (mean < 200, but one or more samples >400). Green indicates compliance with criteria.

4.1.2 Out of Range Values

The adapted lab procedure for detecting fecal coliform, developed as a result of previous recommendations, has reduced the number of out-of-range values significantly. The only site with out-of-range values is the 1m sample at station D1. Reviewing the data at this site shows that in the previous quarter, it was >10,000 six times while in the first quarter it was never >10,000, but registered 0 in the /cfu/ml range 5 times (representing a value between zero and 100 cfu/100ml. This is a site where the values are highly variable due to proximity to the large outfall and combined sewer overflow at Pier A. The lab resolution at this site should be increased to the CFU/10ml range. This will reduce the out-of-range values while still providing resolution in the 1-10 cfu/100 ml level

4.2 Ammonia Nitrogen

The laboratory "estimated quantification level" (EQL) for ammonia nitrogen is 0.05 mg/L. The values obtained for this period are shown in Table 5. Overall, 46 percent of all samples obtained had detectible values of ammonia. This compares with 68 percent in the second quarter, and 42 percent for the first quarter.

The values for this quarter are similar in magnitude to those observed in the first two quarters, and vary over a relatively small range. There appears to be little systematic variation with depth, with the mean over all 1 and 10 m samples being equal. If anything, there is a slight tendency for the maximum values to occur in the 10 m samples, though the values are not significantly higher than the maximum values in the 1 m samples. For the purpose of computing statistics, the EQL value was used for values below detection. The average and maximum values over all surveys are plotted over a centerline section of the Harbour in Figure 9.

Again, as in previous quarters, there appears to be some systematic temporal variability in the data. In this case, the values seem to increase through the quarter. This is seen best in the tabulated values, at the start of the quarter (21 Dec), there was only one sample with a detectible level of ammonia, while at the end of the quarter (15 Mar), the situation had reversed and only one sample was below EQL.

Table 5. Ammonia Nitrogen summary (mg/L)

1 M	B2	D2	EE2	E2	F2	G2	H2	mean	max
04-Dec-21	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
05-Jan-05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
05-Jan-19	0.05	0.05	0.05	0.05	0.05	0.06	0.08	0.06	0.08
05-Jan-31	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
05-Feb-15		0.06	0.10	0.09	0.09	0.06	0.07	0.08	0.10
05-Mar-02		0.06	0.08	0.09	0.06	0.08	0.11	0.08	0.11
05-Mar-15	0.06	0.07	0.05	0.07	0.08	0.08	0.08	0.07	0.08
mean	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.06	
max	0.06	0.07	0.10	0.09	0.09	0.08	0.11		0.11

10 M	B2	D2	EE2	E2	F2	G2	H2	mean	max
04-Dec-21	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
05-Jan-05	0.05	0.07	0.05	0.05	0.11	0.05	0.05	0.06	0.11
05-Jan-19	0.05	0.15	0.05	0.05	0.05	0.05	0.05	0.06	0.15
05-Jan-31	0.05	0.05	0.05	0.05	0.05	0.09	0.05	0.06	0.09
05-Feb-15		0.07	0.05	0.06	0.06	0.05	0.06	0.06	0.07
05-Mar-02		0.09	0.05	0.10	0.10	0.06	0.05	0.08	0.10
05-Mar-15	0.07	0.05	0.10	0.06	0.08	0.07	0.17	0.09	0.17
mean	0.05	0.08	0.06	0.06	0.07	0.06	0.07	0.06	
max	0.07	0.15	0.10	0.10	0.11	0.09	0.17		0.17

Note: green highlights indicate values below detection limits (0.05 mg/L)

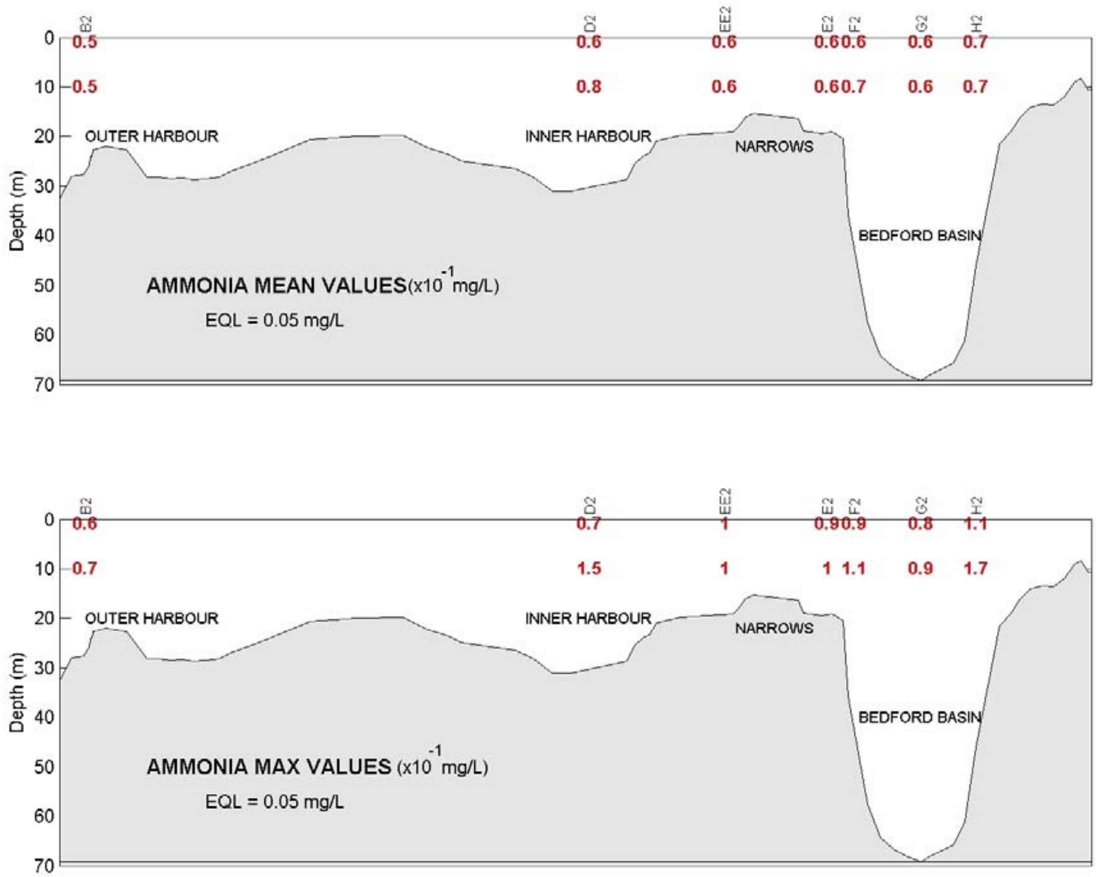


Figure 9. Mean and maximum value of ammonia nitrogen over all third quarter samples

4.3 Carbonaceous Biochemical Oxygen Demand

No detectible values were observed in the regular samples for this quarter. Further to a recommendation in QR #2, $CBOD_5$ analysis ceased on 25 May 05, after the reporting period for this report. $CBOD_5$ analysis will continue for supplemental samples. The one supplemental sample of this quarter, taken in a visible plume off the Duffus St. outfall, had detectible levels of $CBOD_5$ (see Section 4.10 for discussion of this sample).

4.4 Total Suspended Solids

A summary of the TSS values for this quarter is shown in Table 6. For the purpose of generating statistics, samples showing undetectable levels of TSS were given the value of the detection limit (i.e. 2 mg/L). For this quarter there is only one sample below the detection limit. Overall, the TSS values in the third quarter were higher than in the first two quarters. The mean value over all surveys is approximately 6 mg/L. This compares with approximately 2.6 mg/L in the first quarter and approximately 4.5 mg/L in the second quarter. The week-to-week variability evident in earlier data is not as clear in this quarter.

Table 6. Summary of TSS Data (mg/L)

1 M	B2	D2	EE2	E2	F2	G2	H2	mean	max
04-Dec-21	5.60	4.00	3.30	3.30	3.60	3.60	5.80	4.17	5.80
05-Jan-05	7.60	4.40	8.40	6.00	5.80	3.60	2.00	5.40	8.40
05-Jan-19	4.00	2.90	7.30	6.20	7.40	13.80	5.80	6.77	13.80
05-Jan-31	4.20	12.00	7.10	4.20	15.00	2.40	5.60	7.21	15.00
05-Feb-15		5.80	7.60	5.10	6.00	5.80	6.70	6.17	7.60
05-Mar-02		4.00	3.80	3.80	5.10	6.70	3.60	4.50	6.70
05-Mar-15	3.40	2.20	16.00	11.00	8.00	6.30	3.20	7.16	16.00
mean	4.96	5.04	7.64	5.66	7.27	6.03	4.67	5.91	
max	7.60	12.00	16.00	11.00	15.00	13.80	6.70		16.00

10 M	B2	D2	EE2	E2	F2	G2	H2	mean	max
04-Dec-21	2.90	5.10	3.80	4.90	2.70	2.20	2.40	3.43	5.10
05-Jan-05	7.30	4.00	4.70	6.90	8.70	6.00	6.40	6.29	8.70
05-Jan-19	3.80	11.80	5.30	6.40	6.90	2.90	2.90	5.71	11.80
05-Jan-31	8.40	8.90	11.00	5.80	4.00	7.30	4.00	7.06	11.00
05-Feb-15		6.00	5.30	2.20	7.30	6.20	7.10	5.68	7.30
05-Mar-02		4.20	2.70	6.70	3.30	5.60	7.80	5.05	7.80
05-Mar-15	2.60	7.60	12.00	8.00	6.80	16.00	5.30	8.33	16.00
mean	5.00	6.80	6.40	5.84	5.67	6.60	5.13	5.94	
max	8.40	11.80	12.00	8.00	8.70	16.00	7.80		16.00

Note: Green highlights indicate values below detection limit. (EQL = 1 mg/L except = 2mg/L for samples with lab duplicates).

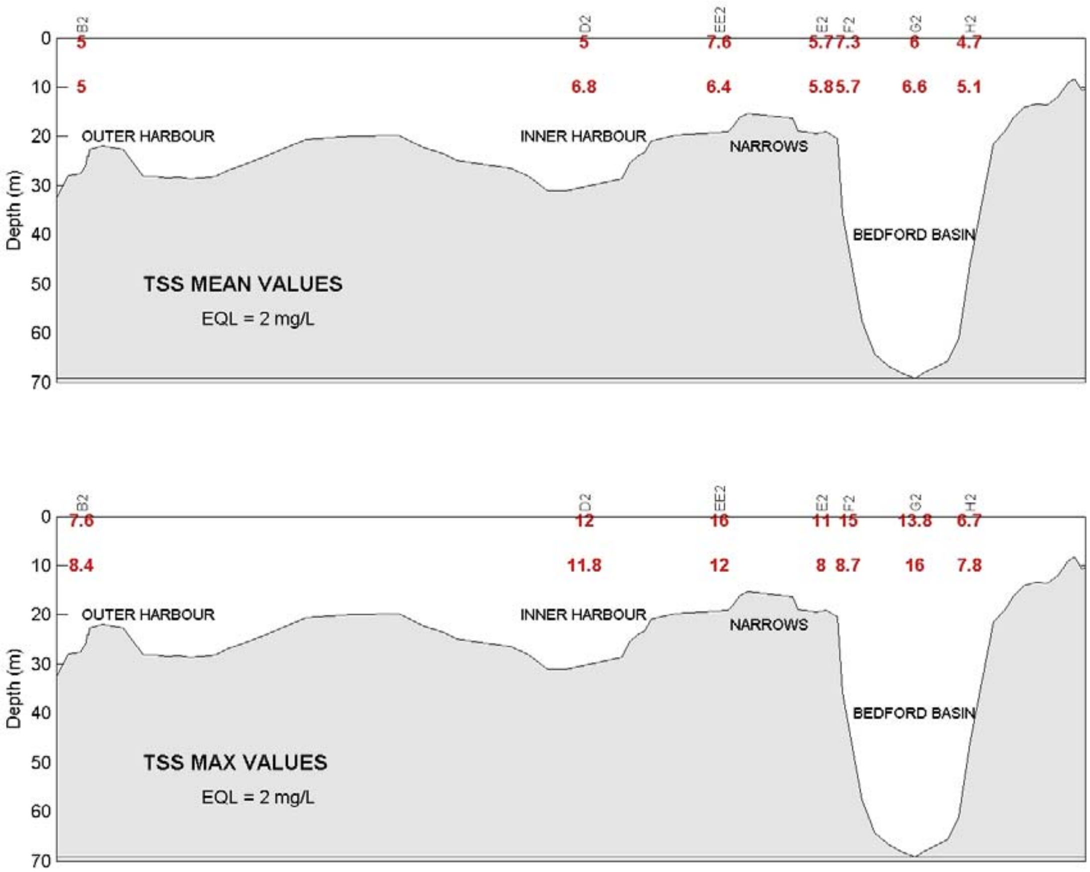


Figure 10. Mean and maximum values of TSS

4.5 Total Oils and Grease

There have been no detectible levels of total oil and grease in any of the samples in this quarter.

4.6 Metals

In the third quarter there have been eleven measurements (not counting the second sample of a lab duplicate) of metals of interest in excess of EQL's, out of a possible total of 735 measurements ((seven sites x two depths + plus one QA/QC) x seven surveys x seven metals – not discounting missed samples). This equates to about 1.5% detection, or, conversely, greater than 98% non-detectible values. The third quarter values are summarized in Table 7. Values in red indicate exceedance of guidelines.

Table 7. Summary of metal values >EQL for 22 Sep thru 14 Dec 2004

Lead EQL= 5 µg/L Guideline = 5.6 µg/L

Survey Date	Value (µg/L)	Site	Depth (m)
9-Jan-05	14	G2	10

Manganese EQL= 20 µg/L Guideline=100 µg/L

Survey Date	Value (µg/L)	Site	Depth (m)
2-Mar-05	21	EE2	1
	21	H2 (DUP)	10
15-Mar-05	24	H2	10
	26	F2	1

Zinc EQL = 50 µg/L Guideline = 86 µg/L

Survey Date	Value(µg/L)	Site	Depth (m)
15-Feb-05	58	D2	10
	90	D2 (DUP)	10
2-Mar-05	55	D2	1

Copper EQL = 20 µg/L Guideline = 2.9 µg/L

Survey Date	Value(µg/L)	Site	Depth (m)
21-Dec-04	25	G2 (DUP)	
9-Jan-05	21	EE2 (DUP)	10
15-Feb-05	21	D2	10
	23	D2 (DUP)	10
15-Mar-05	120	G2	1

The guideline exceedances occur in one sample of lead, one of zinc (in a lab duplicate sample), and five samples of copper (three in lab duplicates). The detection limit for copper is approximately 7 times the guideline value, so any copper detected is above the guideline. There is no obvious pattern, but it is interesting to note that the D2-10m sample on 15 Feb exceeded both the zinc and copper guidelines. Given the large number of non-detectible metal samples, the detectible levels would likely have to be considered outliers and discounted in any analysis.

The resolution of metals concentrations in the harbour has been recognized as an issue. The only existing high resolution metals data in the harbour waters was collected in 1989 (Dalziel et al.). This data is limited in spatial/ temporal extent and is now dated. Background data is critical to any future assessment of impacts of planned sewage treatment options. Options for modifying the program were discussed and recommendations made in QR #2. The implications of these recommendations are currently under consideration.

4.7 Temperature and Salinity

The Bedford Basin Plankton Monitoring Program (BBPMP) is a long standing program conducted by the Department of Fisheries and Oceans at the Bedford Institute of Oceanography. As part of the program, oceanographic profiles from the centre of Bedford Basin (near station G2) are collected on a weekly basis. The data consist of (among other parameters) temperature, salinity, temperature, chlorophyll *a*, and dissolved oxygen, which duplicates HHWQMP observations, and provides an opportunity to crosscheck observations of these parameters. Although not sharing the exact same coordinates, both sample sites are located near the deepest part of the Basin. Both programs are sampled weekly; the HHWQMP being each Tuesday, with contingency on Wednesday or sometimes Thursday; and the BBPMP usually sampling on Wednesday.

The HHWQMP and BBPMP temperature and salinity data for the third quarter are presented in Figures 11 and 12. The temperature data for each of the two programs show a very close correspondence. The main difference is that the HHWQMP data show a period of water temperatures greater than 5°C for the first few weeks of the period. This is not evident in the BBPMP data. There are two reasons for this. The HHWQMP plot actually starts a week earlier than the BBPMP data, and there was a week of missed data at G2 in the first week in January. The 5°C contour is an artifact of the MATLAB contouring routine filling in the missed data. There are, in fact, no temperatures greater than 5°C in the January data.

The salinity data also shows high degree of correspondence. Some of the fine detail varies, but these can generally be reconciled by missed data. Most notably the upward "spike" in the BBPMP salinity contours in January was mostly missed due to missed data in the middle of January. There appears to be no missed temperature or salinity data in the BBPMP dataset during this period.

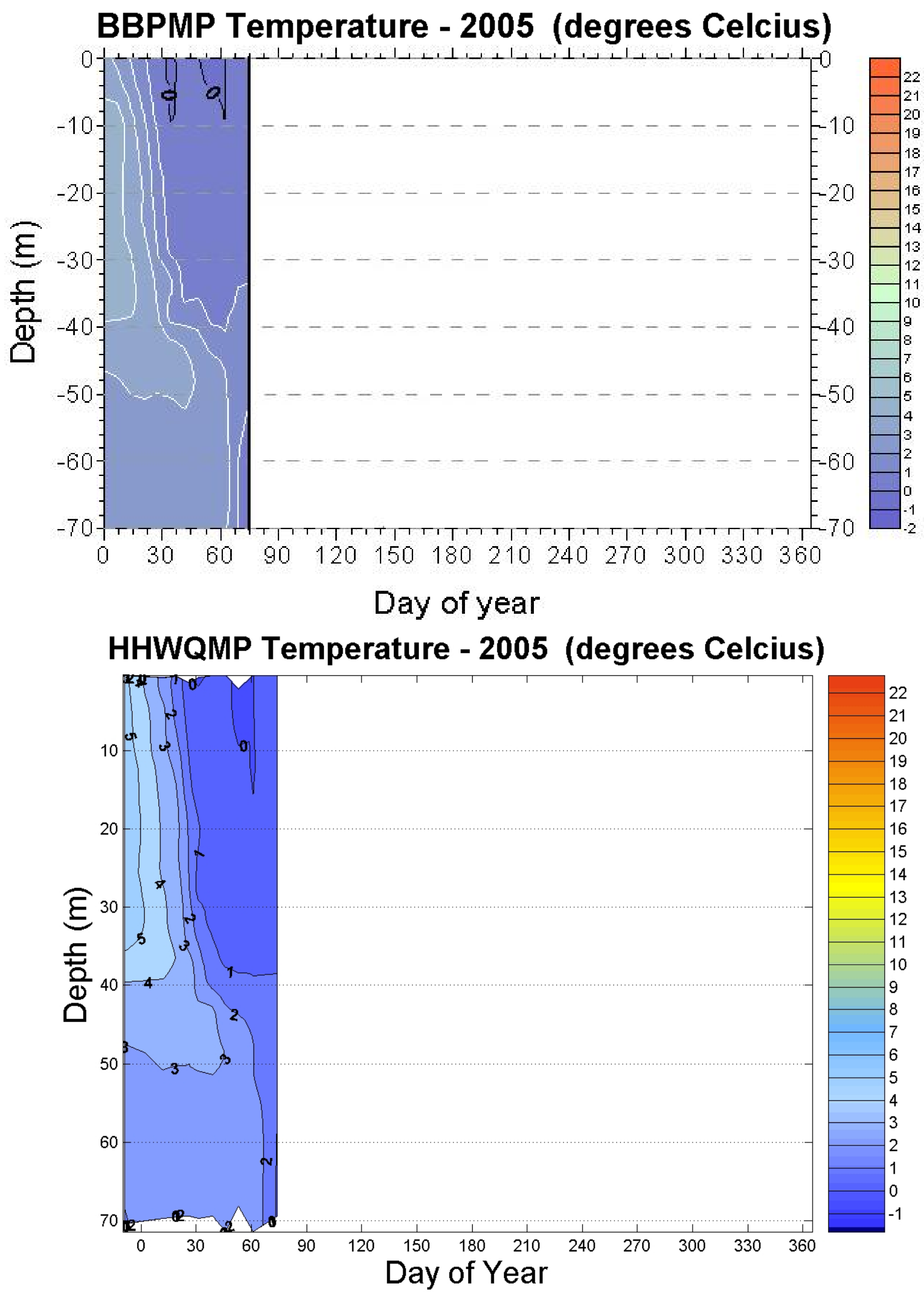


Figure 11. Comparison of BBPMP temperature data and HHWQMP data from Station G2 (1 Jan to 15 Mar 2005).

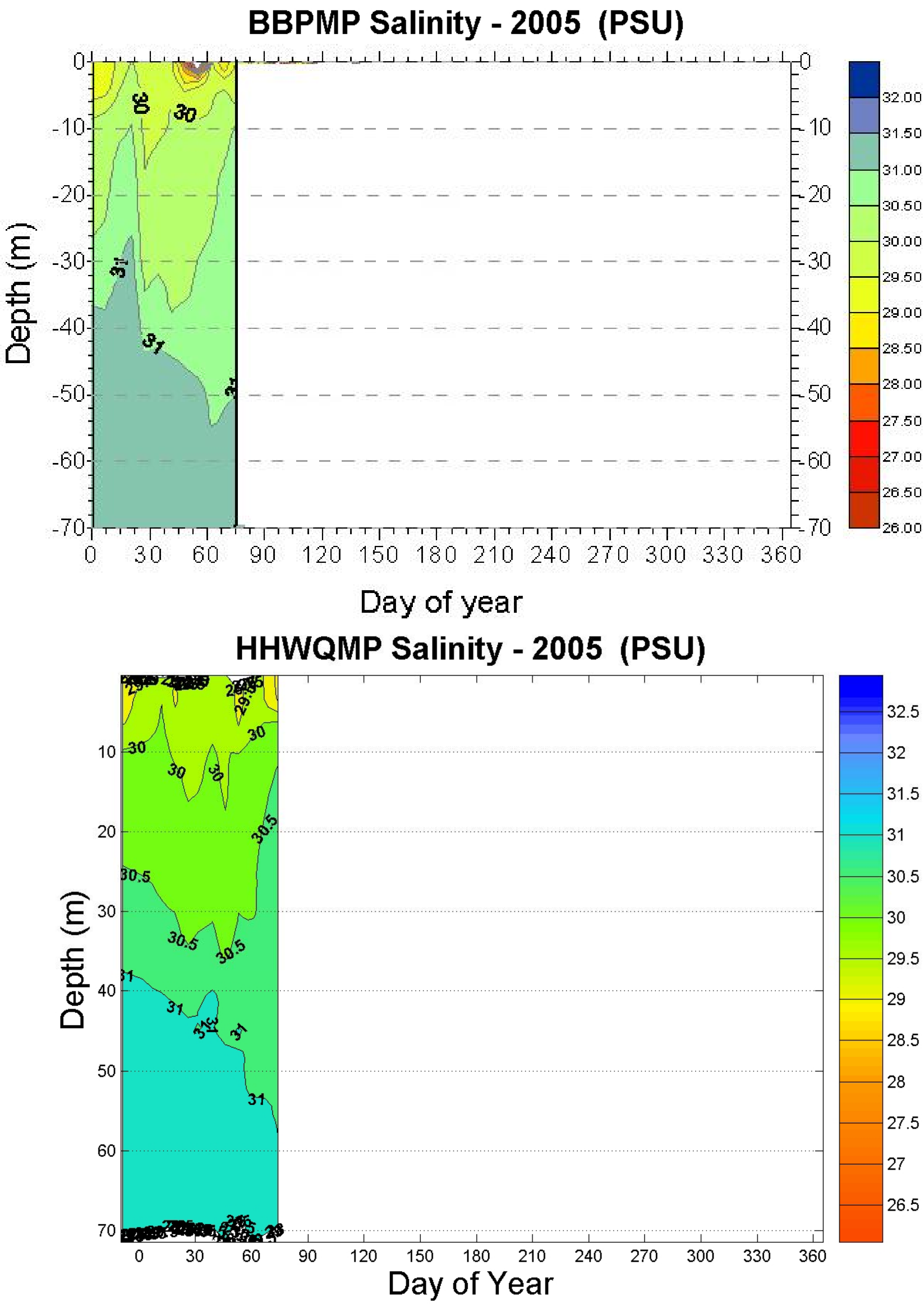


Figure 12. Comparison of BBPMP salinity data and HHWQMP data from Station G2 (1 Jan to 15 Mar 2005).

4.8 Chlorophyll *a*

The reported values of Chlorophyll *a* are un-calibrated, generated using the default values provided with the Seabird instrument software. As such, though the units are mg/m^3, they are really more of a measure of fluorescence than of a true measure of the mass concentration of phytoplankton. The conversion to biomass is highly dependant on many factors, including species and condition of plankton present, and is approximate even when fully calibrated. The fluorescence values can be considered on a relative basis. This comparison is probably more valid within a survey, where conditions are more likely to be consistent over the harbour, than between surveys which occur under different conditions. The more separated in time, the more uncertain the comparison. Nonetheless, due to the large variability in natural plankton concentrations, the data provides useful information on the relative spatial and temporal variability of phytoplankton activity.

Throughout this quarter, the chlorophyll *a* levels were uniformly low at values of 1 mg/m^3 for the first 9 weeks. At week 10 (22 Feb 05), values started to increase with values greater than 1.5 mg/m^3 being observed. In the following weeks, the values increased slowly, particularly in Bedford Basin. At the end of the quarter (15 Mar 05), there is a maximum in all profiles throughout the harbour at a depth of 7-10m. The highest values are in the Basin at approximately 5 mg/m^3.

A comparison of HHWQMP fluorescence data with that of the BBPMP is presented in Figure 13. Note that BBPMP data is raw fluorescence and is not converted to chlorophyll concentration. Also, the BBPMP is presented on a variable scale, while the HHWQMP data is presented on a linear scale. These two factors indicate that the units and figure colours are not directly comparable. The general trends in the two data sets, however, are almost identical. Both data sets indicate a period of low activity, followed by the beginning of the spring bloom at the end of the quarter. The BBPMP collects water samples at discrete depths and performs detailed laboratory estimates of biomass at these points. The raw fluorescence data is used to infer the vertical distribution between samples. It is possible that a similar procedure could be used to enhance the utility of the spatial data collected by the HHWQMP. This may simply involve republishing tabulated data from the BBPMP to aid in interpretation of the HHWQMP. Discussions are underway with the BBPMP (see DO discussion below). Data presentation, format, units etc. will be coordinated with that program to maximize the utility of the HHWQMP data.

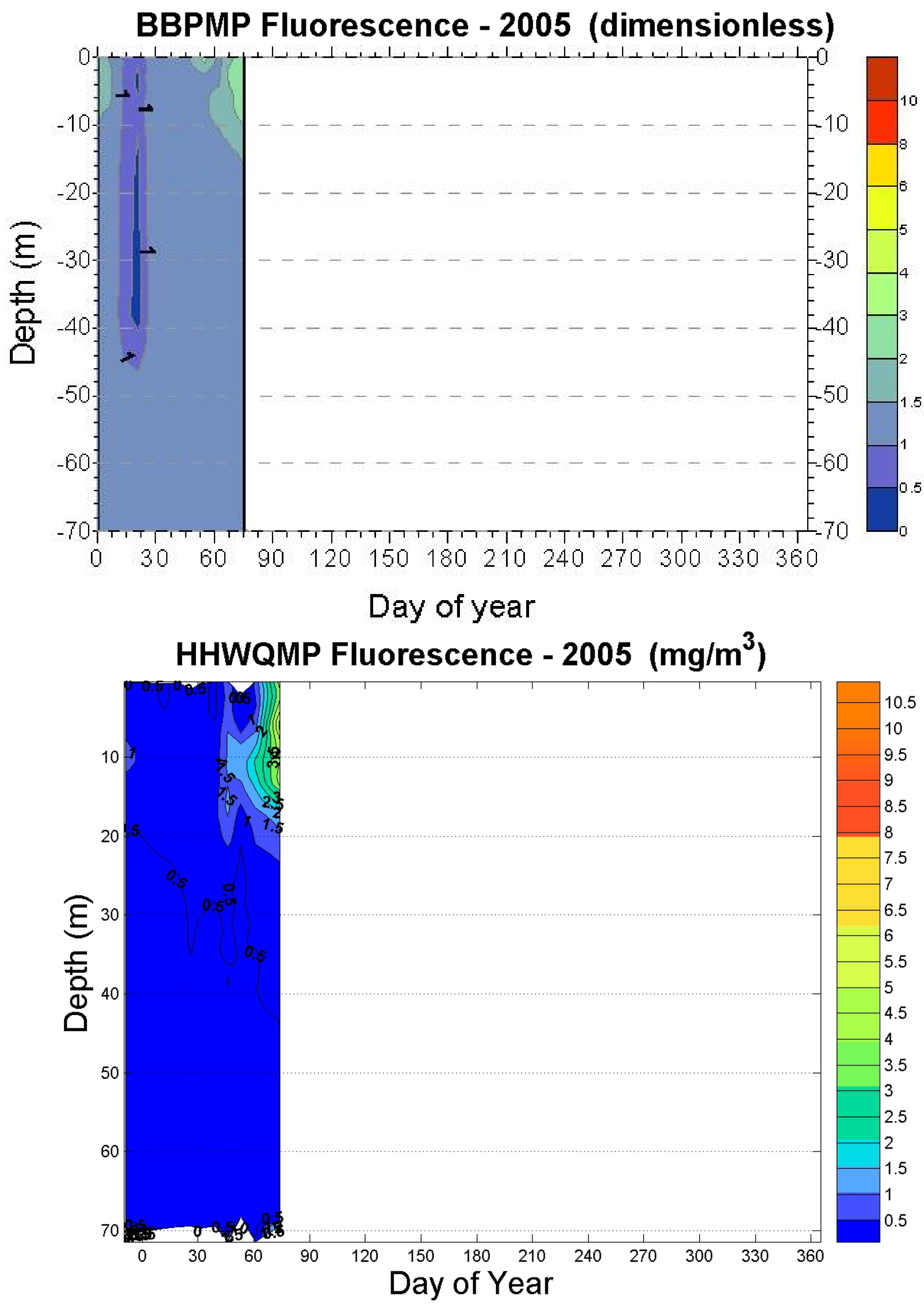


Figure 13. Comparison of BBPMP and HHWQMP fluorescence data from Station G2 (1 Jan to 15 Mar 2005).

4.9 Dissolved Oxygen

The dissolved oxygen data for this period are all above the applicable use-specific (SA, SB and SC) guidelines. The sole exception is the bottom waters of Bedford Basin which dropped to a low of less than 1 mg/L at the end of January. In the latter part of the quarter, there were times when very dense water occurred at the sill in the Narrows. It is likely that a relatively limited intrusion of this water into the intermediate and deep water of the basin occurred. This is corroborated by a slight increase in the DO to about 2 mg/L at the beginning of February.

Figure 14 represents a comparison of HHWQMP oxygen data with the BBPMP oxygen data. Note that the units for the HHWQMP plot are mL/L, rather than the mg/L which is used in the weekly reports, to correspond to the published BBPMP data. The conversion factor from mg/L to mL/L is approximately 0.7. It can be seen in the figures that the data collected by both programs show great similarity in the deeper section of the site, particularly when missed data is taken into account.

There were 5 weeks of missed or questionable DO data in the HHWQMP. This was an unusually high number of missed profiles associated with two instrument failures (battery failure and sensor failure), a missed sampling week (Christmas), and two instrument flow problems resulting in data loss at just G2. The data loss may have been exacerbated by evolving procedures for cold weather operations. The BBPMP had a single week of missed DO data (19 January). Missed data may explain the difference in shape of the low oxygen period at the very bottom of the plots. The missed data may have resulted in a false 1 mL/L contour in the beginning of the quarter in the HHWQMP data and may have resulted in missing the onset of this low oxygen condition in the BBPMP.

The data for the upper part of the water column shows considerable differences. On average, the BBPMP data shows an upper water column DO of 5-6 mL/L, while the HHWQMP data indicates levels of 6-7 mL/L, and a short period with values greater than 7 mL/L. This is a potentially significant discrepancy. A level of 5 mL/L converts to about 7.1 mg/L which is very close to the 7.0 mg/L class SB guideline applicable to the Basin. Discussions are ongoing with Dr. William Li of the BBPMP to determine the source of the discrepancy, and to obtain access to the program’s numerical data (rather than the publicly available graphical summaries) for more detailed comparison. Dissolved oxygen sensors are the most "finicky" sensors of those being used in this project. This is potentially a very important dataset, as DO is a key water quality parameter indicative of the health of the marine ecosystem. With bacterial issues being drastically improved with the current treatment plans, dissolved oxygen and nutrient dynamics will assume a larger role in future water quality management decisions. It is therefore important that the data be appropriately quality controlled. This continues to be investigated.

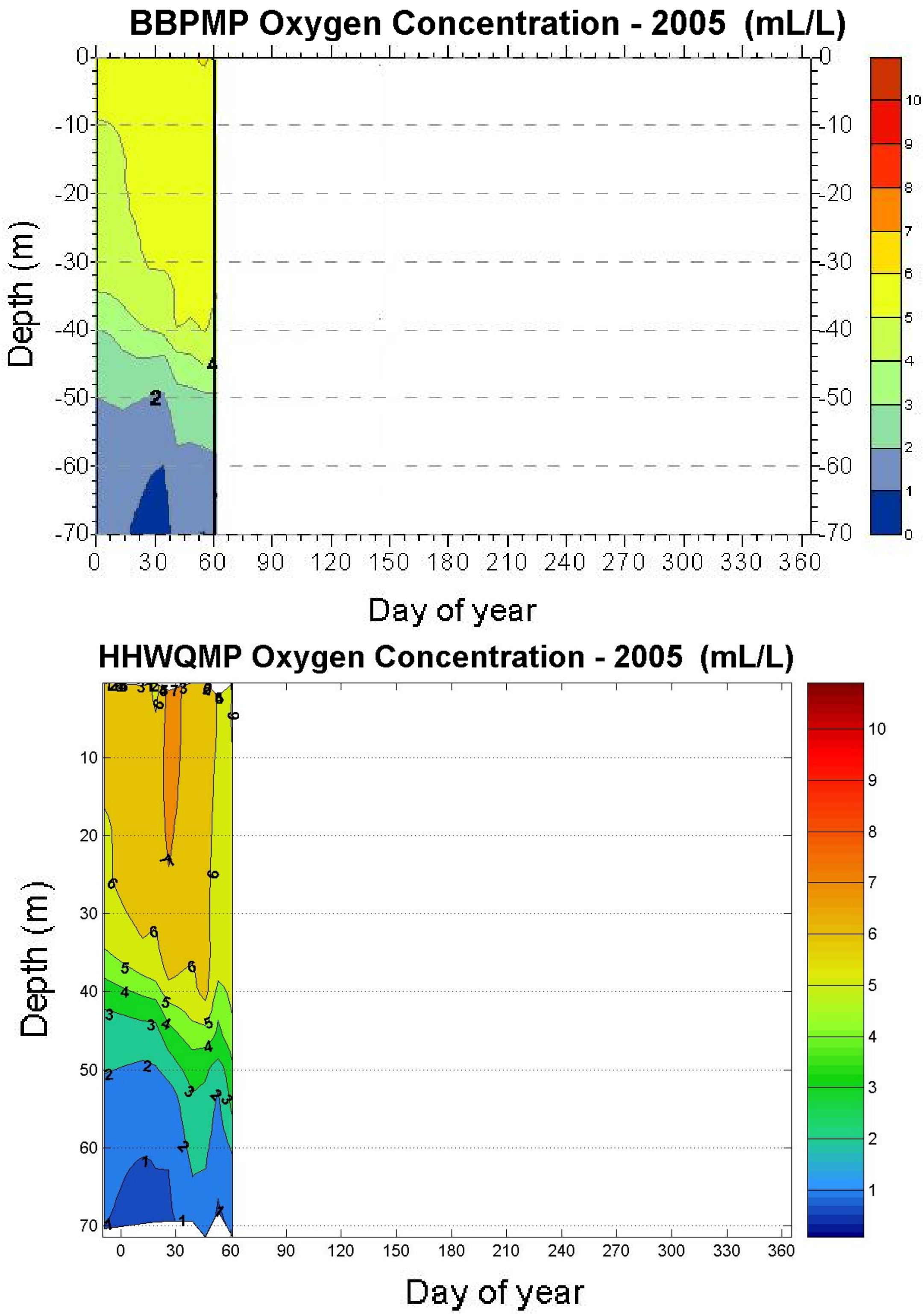


Figure 14. Comparison of BBPMP and HHWQMP dissolved oxygen data from Station G2 (1 Jan to 15 Mar 2005).

4.10 Supplemental Samples

A single supplemental sample was acquired on week 39 (15 Mar 05). This sampled a visible surface plume associated with the Duffus Street outfall near the Narrows. The plume is one of the largest and most persistent water quality features in the harbour, often being visible from boats, and even from many locations on land including both harbour bridges. The front observed on 15 Mar 05 extended from the cove containing the Duffus Street outfall (bounded by Pier 9 on the north and the Novadock dry dock to the south) to well out into the harbour. Inside the front, small surface waves were significantly damped and the water was visibly murky. There was significant detritus, including what appeared to be a large amount of very fine pieces of tissue paper. Figure 15 is a photo of the front approaching from the north (looking southward). Figure 16 is a photo from within the plume looking northward. Evident in this photo is a secondary front within the plume, across which was a substantial additional reduction in visual water quality. A surface sample was taken from inside the secondary front at a location of 44.6703N 63.5977W (NAD83). This site is plotted in Figure 17.

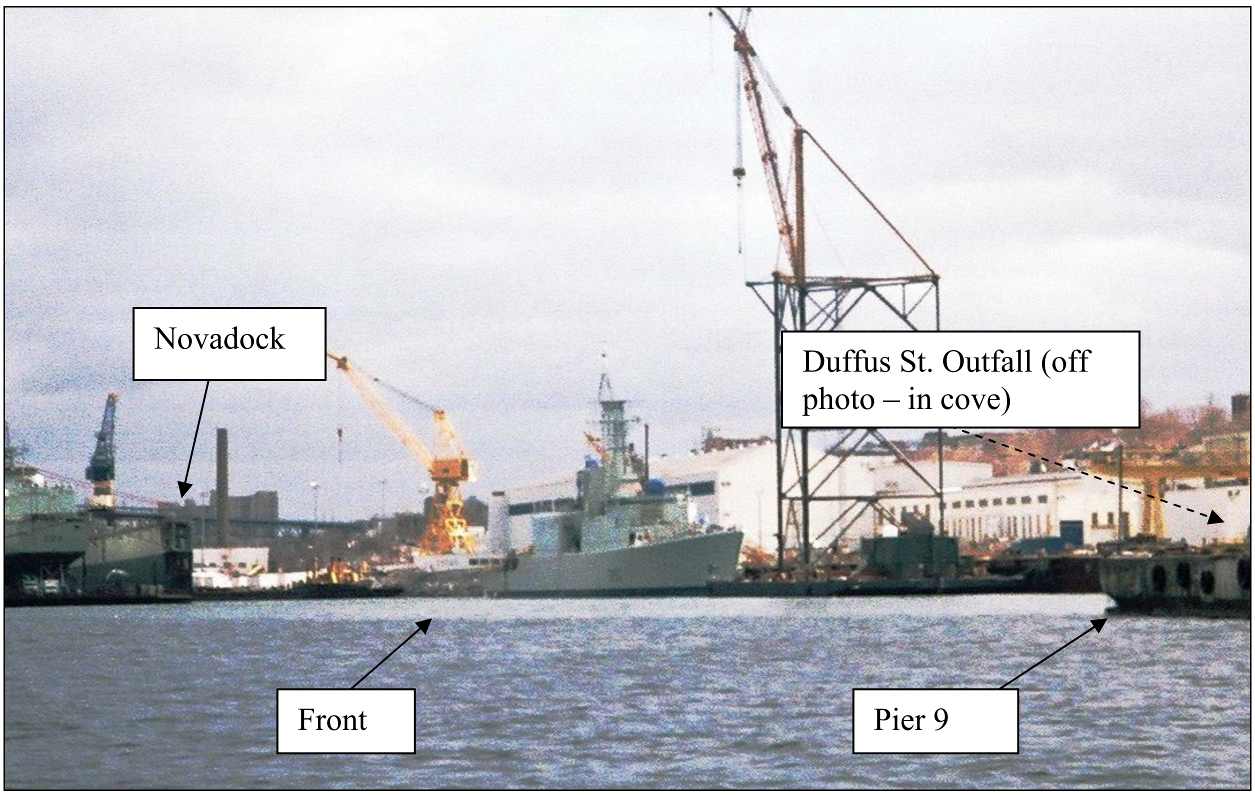


Figure 15. Photo showing front and surface "slick" associated with Duffus St. outfall, looking South

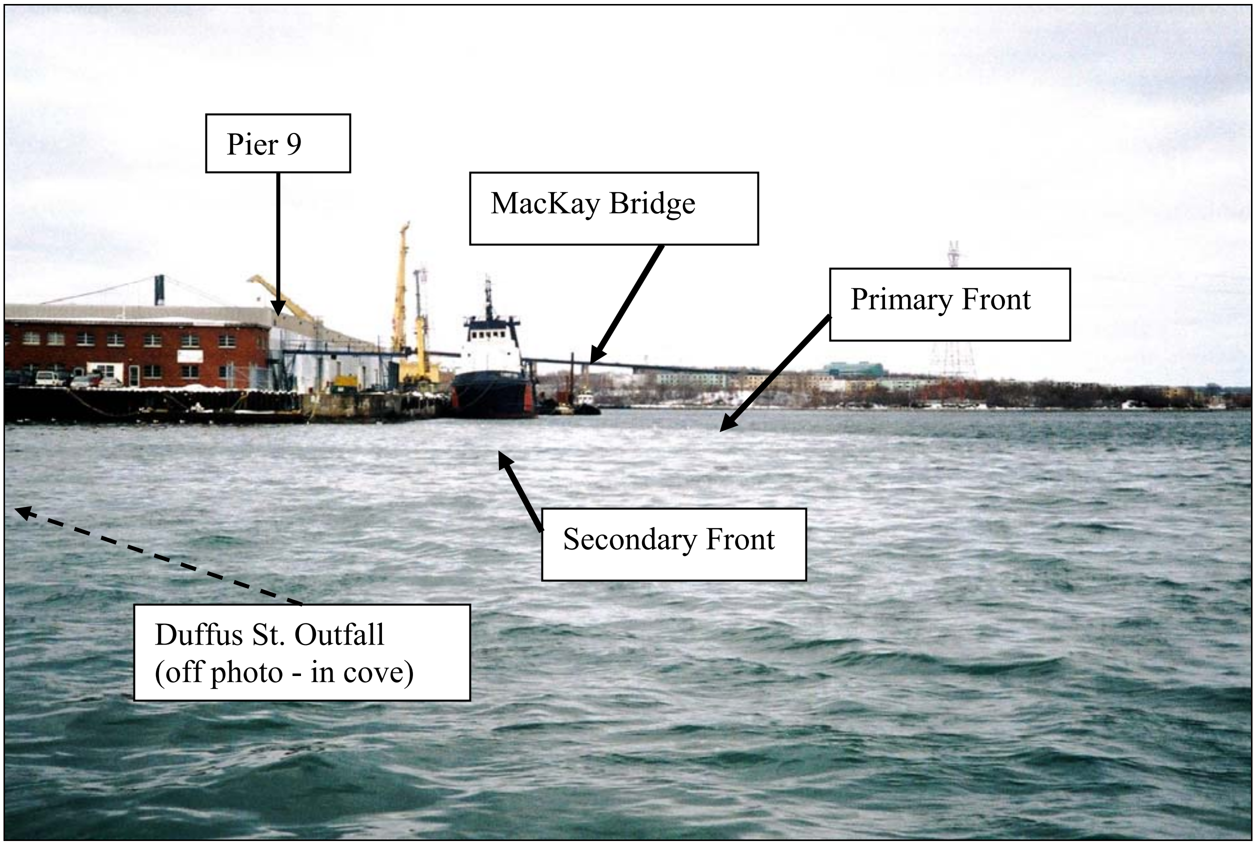


Figure 16. Photo showing fronts associated with Duffus St outfall taken from within surface plume (slick), looking north.

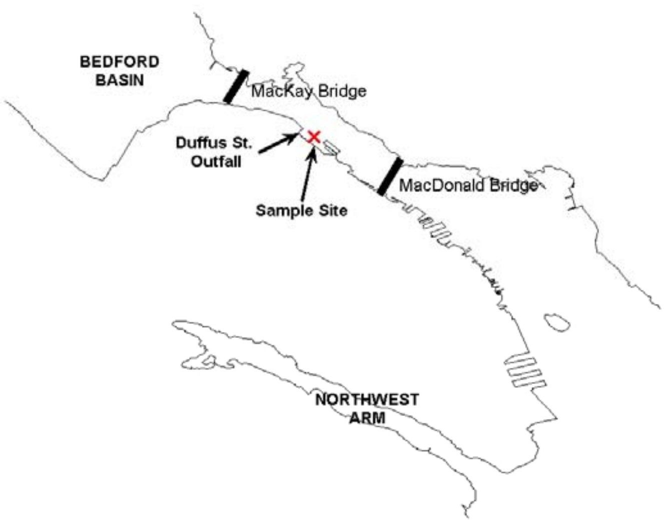


Figure 17. Location of Duffus St. outfall sample site on 15 March 05.

The significant results of the analysis of that sample are presented in Table 8. As expected, the fecal coliform values are very high, approximately three times higher than the next higher value at station EE3, a station often affected by the plume from the outfall off the World Peace Pavilion in Dartmouth. Aside from this, the value is more than an order of magnitude greater than any other value. Similarly, the ammonia level is the highest level observed to date by over a factor of two. The $CBOD_5$ value is only slightly above the EQL of 5 mg/L but is one of only three detectible values since the start of the program. If we assume a concentration of $CBOD_5$ in raw effluent to be 80-100 mg/L, then this value would imply an effluent to seawater dilution of 14 – 18:1. This number seems consistent with the other parameter values. Interestingly, though the visual water quality was clearly compromised at the sample site, the TSS value is high but is not the highest observed on this date. This implies that the nature but not the quantity of suspended material is different at this site. There were no detectible levels of metals of interest in these samples nor were there detectible levels of Total Oil and Grease.

Table 8. Detectible parameters of 15 March 05 supplemental sample

Detectible Parameter	**Units**	**Value**
Fecal Coliform	CFU/100mL	64,000
Ammonia (N)	mg/L	0.55
$CBOD_5$	mg/L	5.7
TSS	mg/L	14

5 Summary and Action Items

For each item, a brief statement of summary is provided along with any changes that occurred during the quarter, and action items that remain to be discussed with the Harbour Solution Project Team. These items reflect issues arising in this quarter as well as issues remaining from previous quarterly reports. Issues from previous reports are identified as "ongoing", and are listed with the number of the quarterly report in which they first occurred.

5.1 Reporting

Weekly Reports

Summary Statement – The weekly report analysis/presentation has been refined and is essentially in final form. There may be periodic changes required to accommodate any changes in data collection.

Changes – Corrections of minor errors in analysis routines.

Action

1. Continued review of reports for suitability.
2. Inclusion of Errata sheet in weekly report binder
3. Discussions regarding circulation of reports.

Quarterly Reports

Summary Statement – Quarterly report format and content continues to evolve.

Changes

1. Inclusion of section reporting on supplemental (discretionary) sampling
2. Inclusion of sections comparing HHWQMP data with weekly data collected at station G2 by the Bedford Basin Phytoplankton Monitoring Program at BIO.

Action

1. Continued development and streamlining of format, particularly standardization of water quality data analysis/display.
2. Discussion of content with respect to requirements of the project.
3. Outstanding item (QR1): Documentation of sampling and analysis methods along with QA/QC procedures for inclusion in the project binder.

5.2 Sampling Program

Summary Statement – Sampling continues as per end of second quarter.

Changes – “Supplemental Sampling" protocol implemented this quarter.

Action
1. Continued analysis of sampling scheme with respect to sample bias versus boat travel time with adjustment of scheduling to improve efficiency as dictated.
2. Consider modification of analysis suite to include/improve/remove some parameters (see below).
3. Consider additional/or substituted sampling sites to address Herring Cove and/or recreational area issues.

5.3 Water Quality Parameters

<u>Fecal Coliform</u>

Summary Statement – Overall, the third quarter levels are lower than reported in the second quarter, with a systematic decrease throughout the quarter. High values are prevalent in the Inner Harbour but can occur at any site during appropriate conditions. A variable analysis resolution scheme, implemented as a result of previous recommendations reduced the out of range values to only two this quarter. These values both occurred in the 1m samples at station D1. Based on analysis of high and low values to date at this site it appears that reduced resolution at this station would result in negligible data loss at the low end.

Changes – none.

Action
1. Include the 1m sample at station D1 (D1-1m) in the reduced resolution (CFU/10 ml) group.
2. Ongoing (QR1): Consider substitution of alternate and or additional tracers.

<u>Ammonia Nitrogen</u>

Summary Statement – Ammonia nitrogen has detectible values in 46% of samples.

Changes – None.

Action
Ongoing (QR1): Consider monitoring more nitrogen species.

$CBOD_5$

Summary Statement – No samples had detectible $CBOD_5$ levels at the EQL of 5 mg/L. The recommendation to drop $CBOD_5$ from regular sampling was implemented on 25 May 05, past the reporting period of this report. $CBOD_5$ analysis will be retained for supplemental samples.

Changes – None

Action - None

Total Suspended Solids

Summary Statement – Measured values are higher than for first two quarters. There was only one sample below EQL (1 mg/L for normal samples and 2 mg/L for split samples for lab duplicates).

Changes – None.

Action

Ongoing (QR2): consider using larger samples to reduce EQL to 0.5 mg/L (currently 1 mg/L).

Total Oils and Grease

Summary Statement – None detected.

Changes – Based on discussions of the recommendations from the first quarterly report, the Total Oil and Grease sampling procedure has been modified. Since 10 May, this analysis has been performed only in a surface grab sample at the chemistry sampling sites, rather than at the 1 and 10m sample depths. The original procedure was in place for all samples in this quarter.

Action

Consider dropping Total Oil and Grease from the analysis suite but for supplemental samples.

Metals

Summary Statement – There were 6 exceedances of metals guideline over the period (one lead, one zinc, and four copper). The metals concentrations in the harbour are under-resolved by our present technique (98% zeros). The only existing high resolution metals data in the harbour waters was collected in 1989 (Dalziel et al.). This data is limited in spatial/ temporal extent and is now dated. Background data is critical to any future assessment of impacts of planned sewage treatment options.

Changes – None.

Action – Consider recommended modification to metals analysis discussed in QR#2, (Section 4.6). In summary, this would involve some trade off of higher resolution lab analysis and reduced temporal and/or spatial resolution to accommodate budgetary considerations.

Chlorophyll *a*

Summary Statement – Uncalibrated fluorescence provides a relative measure of chlorophyll and hence phytoplankton activity throughout the harbour, but the absolute quantification of phytoplankton mass requires lab analysis of water samples.

Changes – None.

Action – Continue dialogue with BIO (BBPMP) to investigate procedures to enhance the utility of the HHWQMP data.

Dissolved Oxygen

Summary Statement – For this period oxygen levels are generally high in surface waters, but low in the deep water of Bedford Basin. There is some discrepancy with data collected from other sources. This is a potentially a very important dataset as DO is a key water quality parameter indicative of the health of the marine ecosystem. With bacterial issues being drastically improved with the current treatment plans, dissolved oxygen and nutrient dynamics will assume a larger role in future water quality management decisions. It is therefore important that the data be appropriately quality controlled.

Changes – .none

Action –

1. Continue dialogue with BIO (BBPMP).
2. Consider collecting samples for Winkler titration (QR#1)

References

Dalziel, J.A., P.A. Yeats and D.H. Loring, 1989. Dissolvedand particulate trace metal distributions in Halifax Harbour, In: H.B. Nicholls (ed.), Investigations of Marine Environmental Quality in Halifax Harbour, Can. Tech. Rep. Fish. Aquat. Sci. 1693:

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