Halifax Harbour
Water Quality Monitoring Program
Quarterly Report #13
(July 4 to September 12, 2007**)**

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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 water quality surveys that include over 30 sites distributed from the Bedford Basin to the Outer Halifax Harbour. Water samples taken at 1 m and 10 m depths are analyzed for a range of parameters. In addition, continuous profiles of basic hydrographic properties (salinity, temperature and density), dissolved oxygen and fluorescence are collected. From June 2004 to June 2006 the surveys were conducted weekly and from July 2006 onward, slightly modified surveys are conducted bi-weekly. The sample and profile data are presented in survey reports (weekly or bi-weekly, as appropriate) along with ancillary data including water level, wind, rainfall and other parameters. The reports are generated as inserts into a binder (JWEL and COA, 2004). Electronic copies of the reports and data files are also delivered to the client. A detailed description of the program is contained in the introduction section of the report binder.

The weekly/bi-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/bi-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. Project reports and data are available on the Halifax Regional Municipality (HRM) website:
http://www.halifax.ca/harboursol/waterqualitydata.html

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 are documented in the project report binder.

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1 Introduction

This quarterly report is a summary of Halifax Harbour Water Quality Monitoring Project (HHWQMP) data collected from 4 July to 12 September 2007 (surveys 133 to 138). The data for the period are discussed in terms of compliance/exceedance of applicable water quality guidelines (Halifax Harbour Task Force, 1990), and how they affect recommendations for program modification. An emphasis in this report is a continued assessment of the efficacy of the sampling program and of the potential introduction of systematic sampling bias in the data. This is a necessary step in the more detailed statistical analysis of the data that can occur subsequently. This report discusses just the thirteenth quarter. Every fourth quarterly report includes an annual summary of data and trends over the previous four quarters. In the interest of making each quarterly report useful as a stand alone document, there is a significant amount of repetition of background information among the quarterly reports.

2 Reporting

The basic report format for both survey and quarterly reports 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 reports continue to be made as experience dictates. There have been no changes this quarter.

In earlier quarterly reports (up to Quarterly Report 8), the data from the center of Bedford Basin (Station G2) was compared with data collected at a nearby site by the Bedford Basin Phytoplankton Monitoring Program (BBPMP), a project of the Department of Fisheries and Oceans at Bedford Institute of Oceanography. The BBPMP discontinued the summary time series contour plots that were used for comparison purposes. The data is still available in the form of individual profile plots and time series plots at selected depths. Selected points from the BBPMP Dissolved Oxygen (DO) profiles are now compared with the HHWQMP DO for purposes of ground truthing. The time series contour plots of the HHWQMP data in the centre of the Basin are instructive in the description of longer term variability in the harbour and are continued in the annual summary discussions in every fourth quarterly report.

From time to time, errors are discovered in the reports after they have been issued. An Errata/Changes section is included in the Introduction section of the report binder and is updated on a quarterly basis. In addition to errors the Errata/Changes section documents the changes in the sampling program and reporting.

3 Sampling Program

Survey sampling is done on a bi-weekly basis as of July 2006. Sampling is conducted from one of several vessels, operated by Connors Diving Services Ltd., based at the Armdale Yacht Club. The details of the sampling program are discussed in the introduction section of the project report binder and Quarterly Report 1. The locations of the 34 regular sampling sites are included in Figure 1. These sites are a combination of historically occupied sites (Jordan, 1972), some project specific sites and identified recreational (yacht club/beach) sites. Sampling involves the collection of continuous profile data and discrete water samples at 1 and 10 m water depth. The level of analysis varies from site to site as depicted in Figure 1: CTD only (CTD only stations); CTD and coliform bacteria (Coliform stations); or CTD, Bacteria, and additional contaminant analysis (Chemistry stations). In addition to the regular sites, Figure 1 includes a sample site in Dartmouth Cove (DC), established in response to public concern. At this site, a 1 m water sample and profile data are obtained. The water sample is analyzed for the full suite of parameters. This site is sampled once a month during the summer. The "supplemental sample" procedure that has been established allows water samples to be taken at additional sites, based on visual observations, at the discretion of the field team.

Sampling protocol/sample handling has been dictated by experience and specific lab directions. CTD casts are performed according to the manufacturer's recommendation and data analysis follows standard procedures. These protocols are documented in the project binder with weekly and quarterly reports.

3.1 Program Changes

There have been no program changes this quarter. A summary of the sampling and analysis schedules and relevant established criteria in place at the end of thirteenth quarter (12 Sep 07) are in Table 1. This table indicates that the carbonaceous biochemical oxygen demand ($CBOD_5$) and total oil and grease (TOG) analyses, discontinued from regular sampling due to lack detection, are now performed only for "supplemental samples".

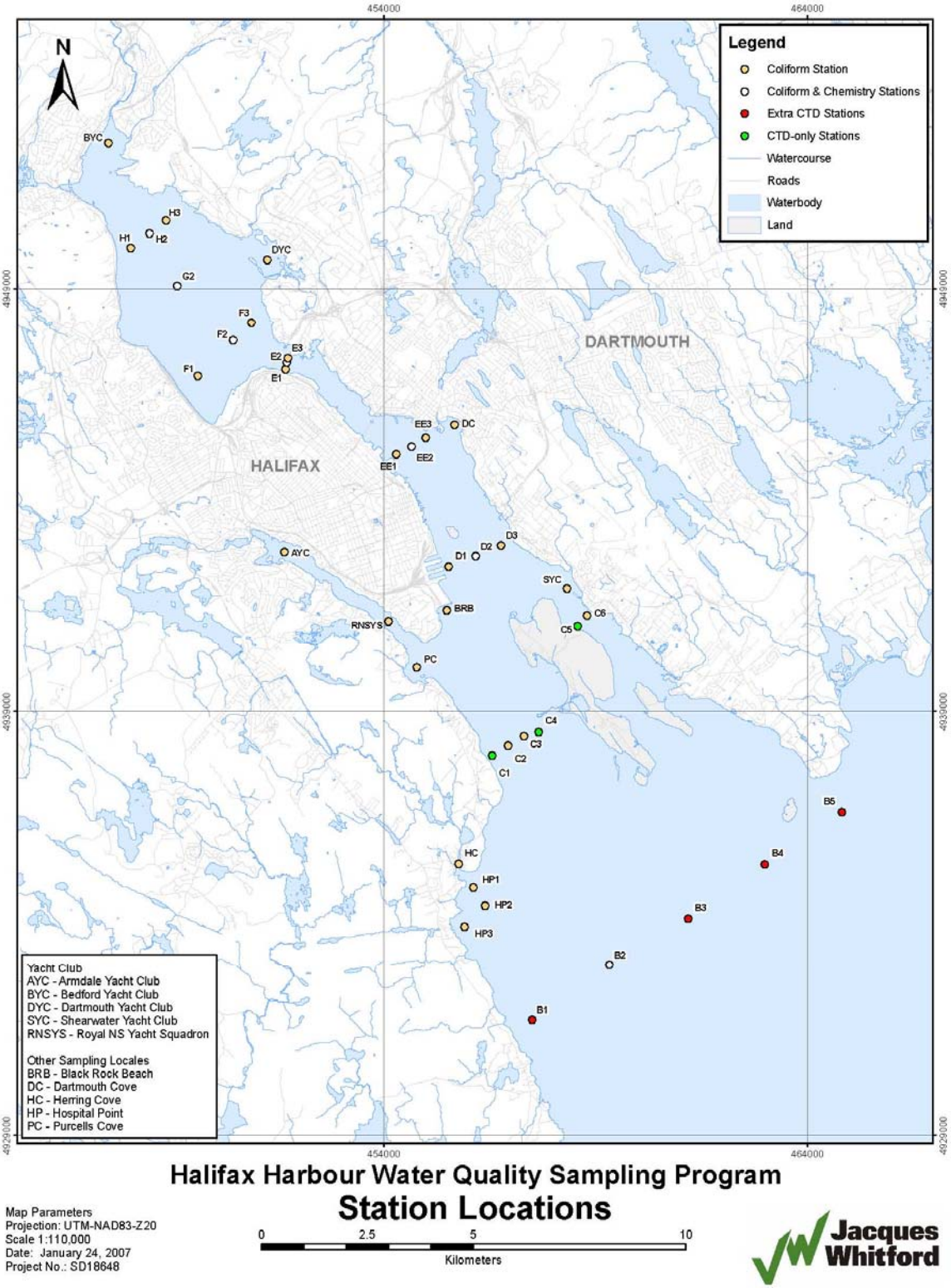


Figure 1. Halifax Inlet sample locations

Table 1. Summary of measured parameters as of 12 September 2007.

	RDL		Harbour Task Force Guideline	Water Use Category	Sampling Stations (refer to Fig. 1)	Sampling frequency
	value	units				
Profile Data					All	bi-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		
			8	SA		
Dissolved Oxygen	n/a	mg/L	7	SB		
			6	SC		
Secchi depth	n/a	m	n/a	n/a		
Bacteria Samples					Bacteria + Chemical	bi-weekly
Fecal Coliform	1	cfu/ 100mL	14	SA		
			200	SB		
			none	SC		
Chemical Samples						
CBOD	5	mg/L	none		Supplemental sites	unscheduled
Ammonia Nitrogen	0.05	mg/L	none		Chemical sites	bi-weekly
			<10%			
TSS	0.5	mg/L	background	all	Chemical sites	bi-weekly
Total Oil and Grease	5	mg/L	10	all	Supplemental sites	unscheduled
Metal scan						bi-weekly
Cadmium	0.1	ug/L	9.3	all	Chemical sites	
Copper	0.1	ug/L	2.9	all	Chemical sites	
Lead	0.1	ug/L	5.6	all	Chemical sites	
Manganese	1	ug/L	100.0	all	Chemical sites	
Nickel	0.5	ug/L	8.3	all	Chemical sites	
Zinc	1	ug/L	86.0	all	Chemical sites	
Mercury	0.01	ug/L	0.025	all	Chemical sites	
Cobalt	0.1	ug/L	none		Chemical sites	
Iron	1	ug/L	none		Chemical sites	

3.2 Supplemental Samples

Based on recommendations from Quarterly Report 2, a supplemental sample protocol has been instituted to take opportunistic samples of visible water quality features in the Harbour, or to document unusual discharge conditions (e.g. bypass etc). These samples are acquired on a discretionary and exploratory basis when an interesting feature, such as a visible front, plume, or patch of visibly deteriorated water quality is encountered. It is anticipated that these samples will have lower water quality than most normal samples. As such, the samples are processed for the full range of parameters specified at the beginning of the program, including parameters which have been eliminated from normal sampling due to lack of detection. During this quarter, in addition to the previously mentioned quasi-regular sample at DC (survey 135, 31 Jul 07), there was a supplemental sample of visibly deteriorated water at Harbourside in downtown Halifax.

3.3 Sampling Order

Sampling generally occurs on Tuesday, with Wednesday and Thursday as contingency days. Every survey the sampling order is varied to minimize biasing the collected data with respect to known diurnal variations in sewage load and sunlight. A variable circuit is used that results in 'quasi' random sampling, subject to certain operational constraints. This procedure is discussed in Quarterly Report 1. Wind, waves and visibility can limit operations in the Outer Harbour. Each week, a primary and an alternate sampling route are provided to the field team. If the primary route has the Outer Harbour sampled early in the day, the alternate route will have it sampled late in the program. The decision on which route to take is made between the field team and the boat operator considering the weather forecast for the day. The sampling order for each survey in the thirteenth quarter is presented in Table 2.

Also, Table 2 lists the missed stations and additional samples (described above) for each survey. During this quarter, the only missed station was B2. This was missed in each of two surveys 135 (31 Jul07) and 136 (14 Aug 07).

3.4 Data Return

In addition to the missed sites detailed above, there were other sporadic data losses generally associated with quality control issues that were discovered during data processing. These are discussed in the individual survey reports. All factors considered, the overall data return for the quarter is summarized in Table 3.

3.5 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 that introduce a morning/early afternoon bias to the entire dataset. It is impractical to address this fully, 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 thirteenth quarter.

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

Date	4 Jul 07	18 Jul 07	31 Jul 07	14 Aug 07	29 Aug 07	12 Sep 07
Survey	133	134	135	136	137	138
1	AYC	AYC	BRB	SYC	EE3	HC
2	RNSYS	RNSYS	D1	C6	EE2	HP1
3	PC	PC	D2	C5	D3	HP2
4	C4	HC	EE1	D3	D2	HP3
5	C3	HP3	EE2	D2	SYC	B2
6	B2	HP2	E1	EE3	C6	C1
7	HP3	HP1	E3	EE2	C5	C2
8	HP2	B2	E2	E3	C4	C3
9	HP1	C4	F1	E1	C3	C4
10	HC	C3	F2	E2	B2	BRB
11	C1	C2	G2	F3	HP3	D1
12	C2	C1	H1	F2	HP2	D2
13	BRB	C6	H2	DYC	HP1	EE1
14	D1	C5	BYC	H3	HC	EE2
15	EE1	SYC	H3	H2	C1	E3
16	F1	D3	DYC	BYC	C2	E1
17	G2	EE1	F3	H1	BRB	E2
18	H1	F3	EE3	G2	D1	F2
19	BYC	DYC	D3	F1	EE1	F1
20	H3	H3	SYC	EE1	F1	G2
21	H2	BYC	C6	D1	G2	H1
22	DYC	H1	C5	BRB	H1	H2
23	F3	H2	C4	C2	BYC	BYC
24	F2	G2	C3	C1	H3	H3
25	E1	F2	HP3	HC	H2	DYC
26	E3	F1	HP2	HP1	DYC	F3
27	E2	E1	HP1	HP2	F3	EE3
28	EE3	E3	HC	HP3	F2	D3
29	EE2	E2	C2	C3	E1	SYC
30	D3	EE3	C1	C4	E3	C6
31	D2	EE2	PC	PC	E2	C5
32	SYC	D1	RNSYS	RNSYS	PC	PC
33	C6	D2	AYC	AYC	RNSYS	RNSYS
34	C5	BRB			AYC	AYC
No data			B2	B2		
Supplemental			DC		HS	

Table 3. Quarter thirteen data return.

Chemical	Target	Achieved	Percent Return
7 sites			
NH3	84	80	
TSS	84	80	
Metal Suite	84	80	
Mercury	84	80	
Total	**336**	**320**	**95%**

Bacteria	Target	Achieved	
28 sites			
F Coliform	372	368	
Total	**372**	**368**	**99%**

Profiles	Target	Achieved	
31 sites			
C-T	204	201	
Dissolved Oxygen	204	201	
Chlorophyll	204	201	
Total	**612**	**603**	**99%**
All data records	**1320**	**1291**	**98%**

3.5.1 Time of Day

Sewage flows have significant regular diurnal variations that can affect the water quality in the Harbour on short timescales. In residential areas there are generally two flow peaks a day, the largest occurring in the morning, and the second in the evening. In systems with relatively short flow distances these generally occur around 0800 – 0900 and 2100. In commercial areas the flows are much more uniform during the day and low at night. 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 (fluorescence) and dissolved oxygen. The short term variation in sewage load is primarily an issue in the Inner Harbour, relatively close to the outfalls, however sunlight affects the entire Harbour. In Halifax there is also a significant diurnal tidal component affecting water levels. This is considered in the subsequent section.

Figure 2 shows the sampling time at each site since the start of the program in June 2004. The data from the thirteenth quarter are shown in red. In this figure the sample sites are generally sorted from north to south. There are a few patterns that emerge that have been documented previously. The stations at the north end of Bedford Basin have a smaller

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, a function of travel time from the Armdale Yacht club in the Northwest Arm. Even if a site is sampled first, it still takes time to travel there. Given that sampling begins at the same time every week, these effects are unavoidable.

The diagram indicates that overall there has been a morning bias in the Outer Harbour stations, a result of weather conditions this quarter. This creates an afternoon bias in the remainder of the data. This is strongest in the Basin. In the Inner Harbour sampling is relatively uniformly distributed. The Northwest Arm that has a built in early morning/late afternoon bias had four of six surveys in the afternoon.

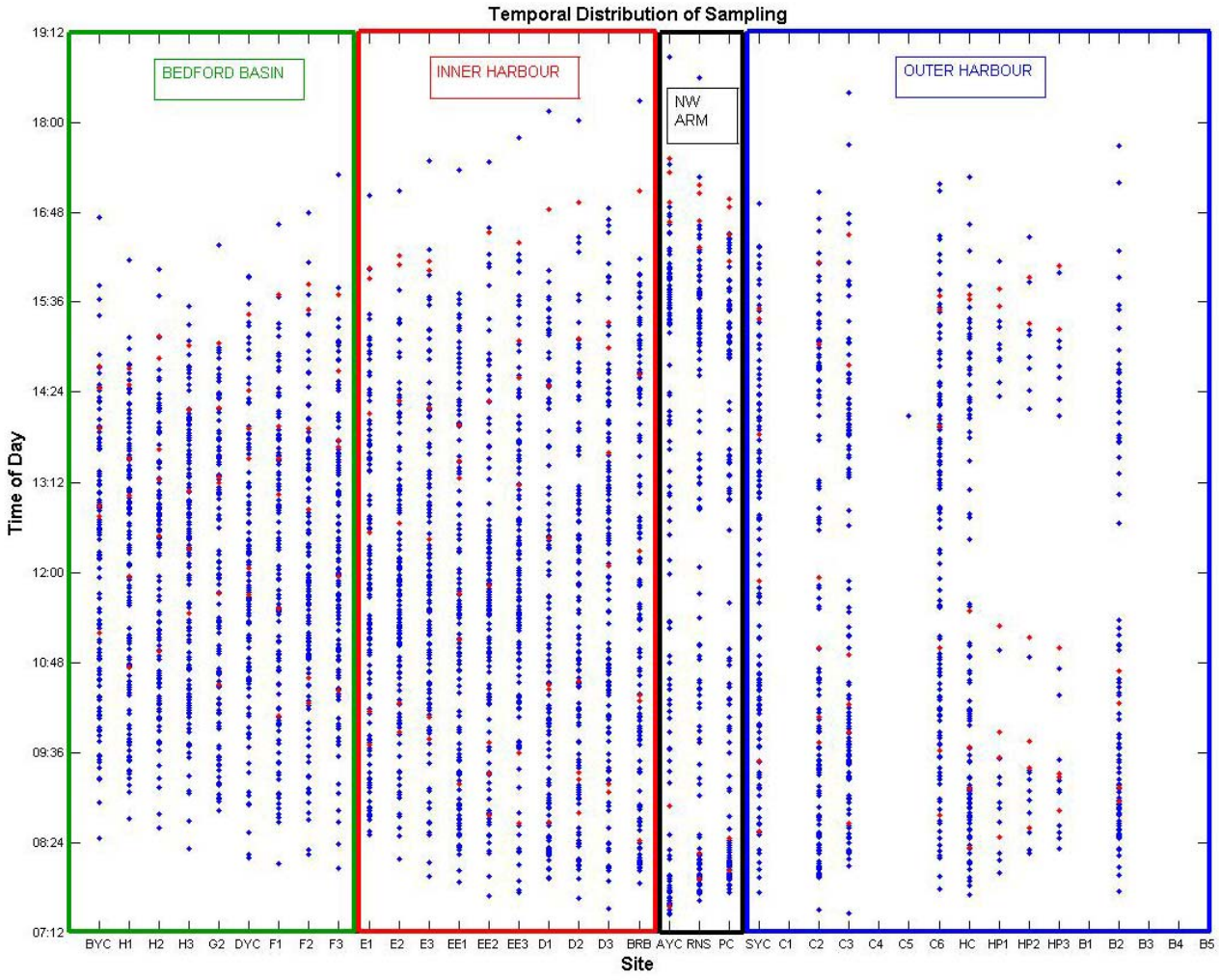


Figure 2. Temporal sampling distribution by site over entire program. Red markers denote points from 4 July to 12 September 2007.

3.5.2 Water Levels

The water level at the time of sampling can affect the results. The two most obvious considerations are whether a particular sample was taken upstream or downstream (based on flood/ebb direction) from the nearest outfall, and the variation in initial dilution, caused by variations in submergence depth, from shallow shoreline outfalls. These are both issues primarily in the Inner Harbour.

Water level variations in the Harbour are caused by the tides and meteorological forcing. The meteorologically-induced changes are mostly of longer period and, except in large storms, are much smaller in magnitude than the tides. Because of their longer duration their effect on Harbour flushing can be significant and their impact on water quality may warrant investigation in the future. Note that the tidal currents in the Harbour are, for the most part, not that strong and may be over ridden by local/regional meteorological effects (Hurlbut et al., 1990). This means, for example, that the surface current may not always be going out on a falling tide. However, the occurrence of surges is relatively random and the possibility of inducing a systematic sampling bias is small compared with that of the very regular higher frequency tides. The tides in Halifax Harbour are classified as semidiurnal, meaning that there are two high and two low tides in a day.

There is also a potential bias introduced by regular weekly/bi-weekly sampling. Sampling that occurs on the same day every second week 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 (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.

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 July to September 2007 is shown in Figure 3. The overall water level distribution is slightly bi-modal with a mean of about 1m. In this quarter the peak at lower water levels is higher than the peak at higher water levels and there is an unusual dip at 1.6 m. In an ideal situation each site would be sampled in a distribution similar to the overall baseline distribution.

Figure 4 shows the distribution of water levels at each site at the time of sampling (blue bars) compared to the overall water level distribution for the quarter, as represented by the red line recreated from Figure 3. This shows that for this quarter, for Bedford Basin (section E and north); there was a bias towards sampling lower water levels. South of this, in the Inner Harbour and Northwest Arm, the distribution relatively well sampled. In the Outer Harbour, particularly at the HP and B2 sites the sampling is quite heavily biased toward higher water levels. If more detailed analysis is performed, particularly in the Inner Harbour where water level/tidal phase is more important, the analysis may have to include the tidal phase explicitly.

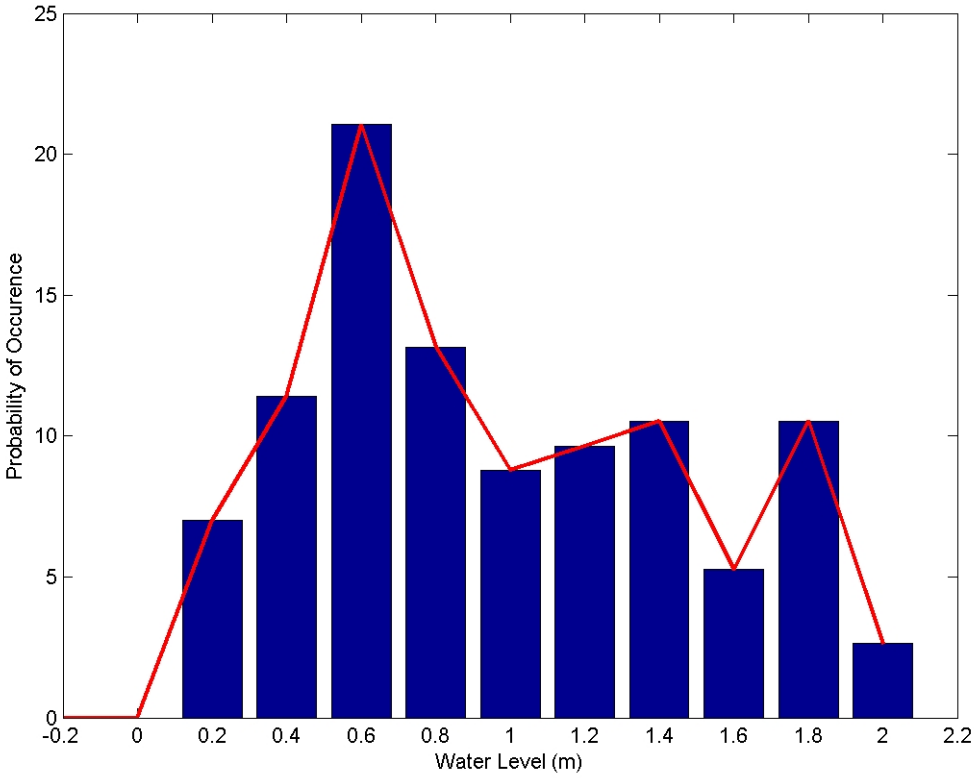


Figure 3. Probability distribution of water levels in Halifax, July to September 2007.

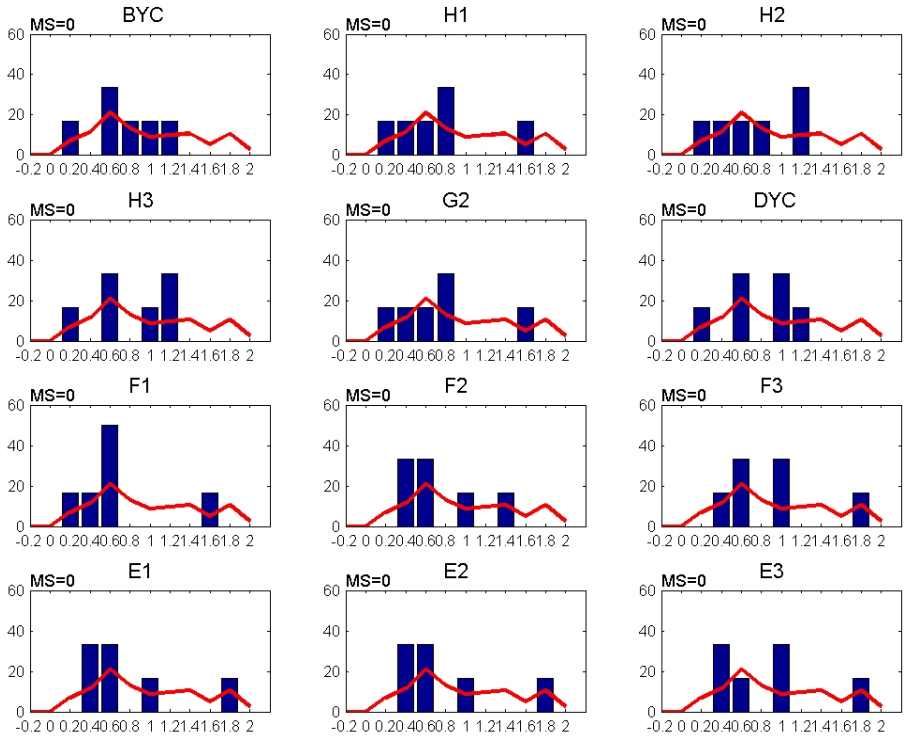


Figure 4a. Water level distribution at each site during sampling 4 July to 12 September 2007. Note: MS = Missed samples.

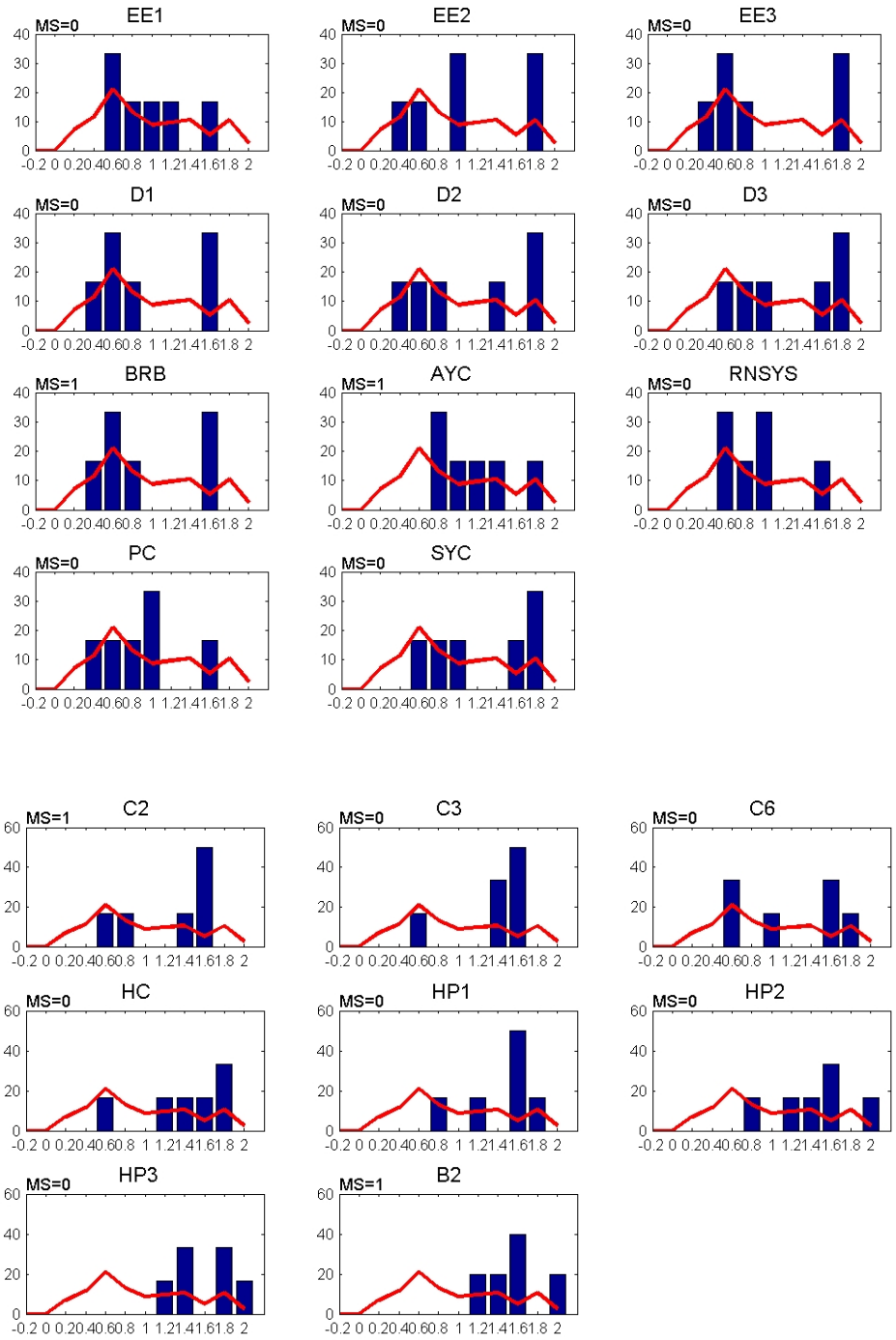


Figure 4b. Water level distribution at each site during sampling 4 July to 12 September 2007. Note: MS = Missed samples.

3.5.3 Precipitation

Rainfall affects both the sewage loads and the dynamics of the Harbour. In a combined sewer system, like in Halifax, increased flow due to a rainfall event can mobilize material that has collected in the sewer pipes in low flow conditions resulting in quite high loads. Additionally, in response to the increased fresh water input, the harbour can become more stratified, enhancing estuarine circulation. The combination of increased flow and stratification can have a significant effect on the near field behaviour of the plumes from the outfalls. These effects lag the rainfall and persist for a period of time after the rain stops. The duration of the impact, of course, depends on the magnitude of the rain event and the condition of the watershed. For purposes of discussion we have, somewhat arbitrarily, selected a three day (72 hour) 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 this quarter (4 July 2007 to 12 September 2007). The blue bars on this plot represent a similar analysis performed for sampling days only. The plot indicates that our sampling has been biased toward wet weather. Days with no precipitation for the previous 72 hours occurred ≈55% of the time but represent <35% of the sampling days. Most of the sampling occurred on days affected by moderate precipitation. However, there were at least two events with >45 mm precipitation that were not sampled.

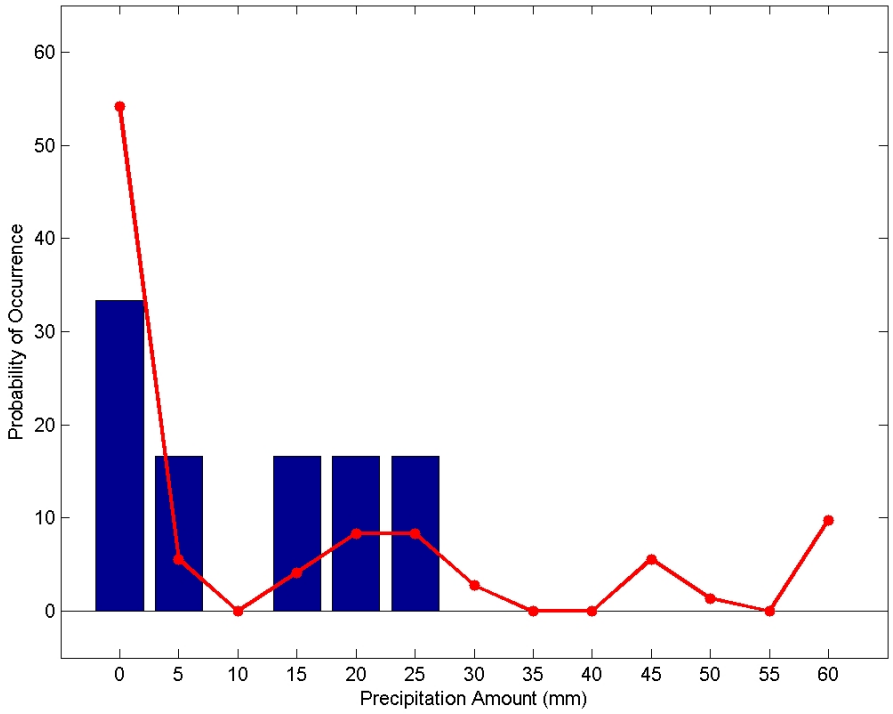


Figure 5. Probability distribution of cumulative 72 hour rainfall, 4 July to 12 September 2007.

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 program.

4.1 Fecal Coliform

4.1.1 Out-of-Range Values

The adaptive lab procedure, using different fecal coliform detection ranges for different sites, developed as a result of previous recommendations, has reduced the number of out-of-range values significantly. For this quarter there were four out-of-range values. Three were in survey 135 (31 July 07) for 1 m samples in section E. The last was the 1m sample at E-1 in survey 136 (14 Aug 07). Survey 135 was quite unusual with unusual FC distributions everywhere. This was due to unusual oceanographic conditions and likely the sewage diversion to Fairview Cove. These conditions persisted to a lesser extent into survey 136.

4.1.2 Quarterly Means

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

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

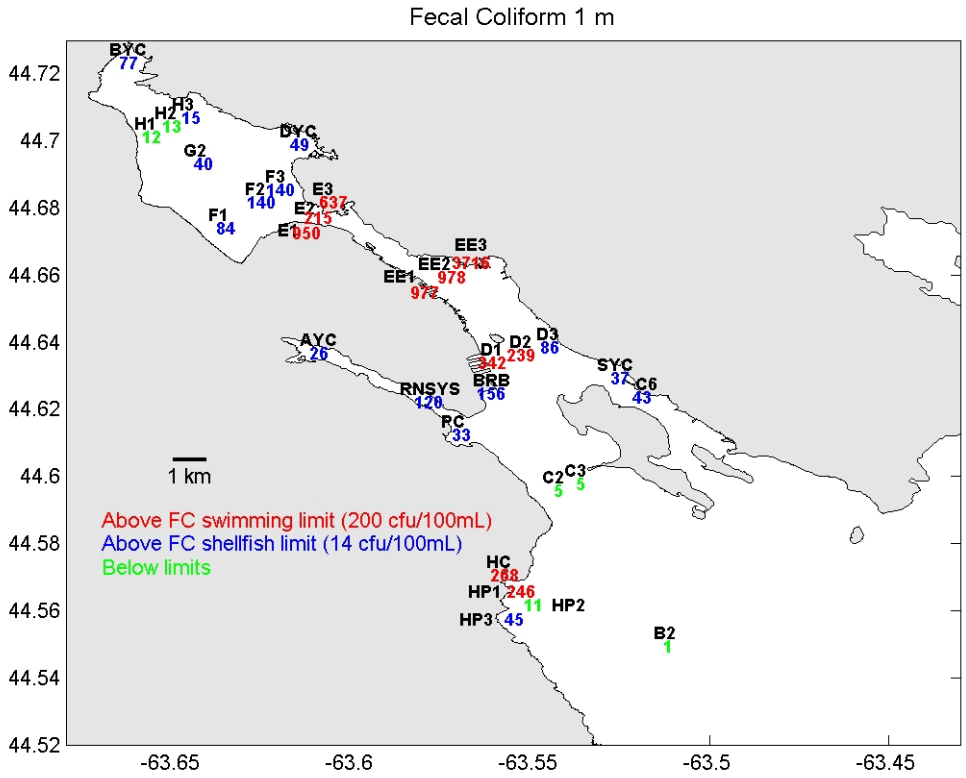
To compute geometric mean, some adjustments to the data are required. Zeros are not valid in the calculation, so ones (1's) are substituted for all zero values. The result of this is that there will be no zero counts reported at any site. An appropriate interpretation of a reported mean value of one, 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. For this analysis out of range values are replaced by 10,000.

Maps representing the geometric mean values over all samples for the thirteenth quarter are presented in Figure 6. In this figure, values in red exceed swimming guidelines (200 cfu/100 mL); values in blue exceed shellfishing guidelines (14 cfu/100 mL); and values in green indicate suitability for either activity. Separate maps are presented for the 1 and 10m samples.

For the 1 m samples, and to a lesser extent, the 10 m samples, the geometric mean coliform values are high in the Inner Harbour. The center of the spatial distribution at

10m is shifted northward, with respect to the center of the distribution at 1m perhaps suggesting a net inward bottom flow in the harbour during the quarter. However the 1m distribution seems shifted up-harbour relative to the Inner Harbour sources. South of the Narrows, the maximum values at any site are in the 1 m sample. Unusually, through the Narrows and much of the Basin the values at 1m are higher than or similar to the values at 10 m. This may be due to particularly stratified conditions that occurred at times during the quarter in combination with the additional source of bacteria into the Basin surface water by the sewage diversion to Fairview Cove.

The geometric mean values exceeding the swimming guidelines occur in much of the Inner Harbour at 1 m and 10 m. The only values in excess of these guidelines outside of the Inner Harbour were in the 1m samples at HC and HP1, due to the influence of the Tribune Head outfall. A more rigorous discussion of guideline exceedance follows.



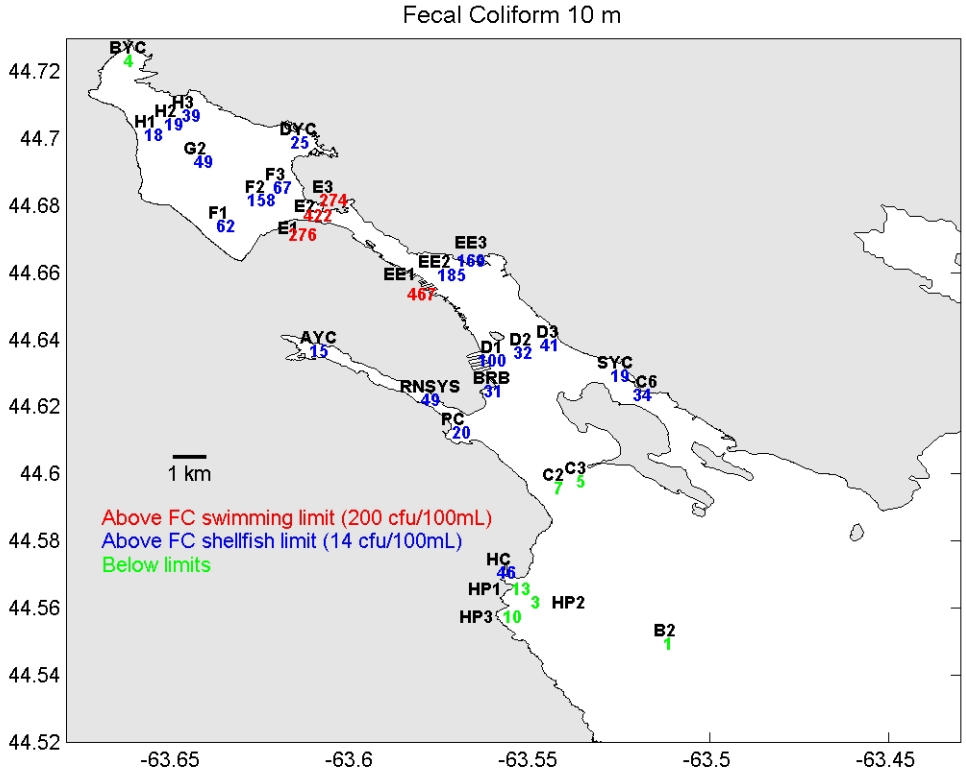


Figure 6. Fecal coliform geometric means (cfu/100mL) at 1m and 10m, 4 July to 12 September 2007.

4.1.3 Guideline Exceedance

As presented in Quarterly Report 1, the Harbour Task Force fecal coliform guidelines (Harbour Task Force, 1990) are interpreted using the methodology for swimming areas, presented in the Guidelines for Canadian Recreational Water Quality (Health and Welfare Canada, 1992). The recreational guidelines specify that in swimming areas, the geometric mean of at least five fecal coliform values taken within 30 days should not exceed 200 cfu/100mL, and any sample with values >400 cfu/100mL should trigger re-sampling. This strictly applies only to areas classified SB (recreational) by the Task Force (Table 1). The implications for areas classified SA and SC are discussed subsequently. The original weekly sampling regimen resulted in five samples within 30 days and allowed a fairly rigorous application of this analysis. The change to bi-weekly sampling in quarter nine means that the data do not meet the criteria of five samples within 30 days. The analysis is continued using a three sample floating average to meet the 30 day window but sacrifice the five sample criteria. We feel that the analysis, though no longer a rigorous application of the criteria, remains instructive.

Interpreting this procedure in our context results in a bi-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.

In the following discussion the terms "acceptable", "questionable" and "unacceptable" will refer to these primary contact levels and not the Harbour Task Force SA, SB and SC guidelines. These guidelines will be discussed subsequently.

Tables 4 and 5 show the results of the analysis for the 1 m and 10 m samples respectively. The tables represent the floating 30 day geometric mean and, in parentheses, the number of samples (max 3) used in the average. The values are colour coded to represent acceptable (green), questionable (yellow) and unacceptable (red) levels.

1 m Samples

As seen in the Table 4 below, for this quarter, there is a trend to increasing number of sites with unacceptable near surface water (1 m) as the quarter progresses. At section EE in Inner Harbour would be deemed "unacceptable" for primary body contact all of the time. Later in the quarter this extends to pretty much the whole Inner Harbour, (Sections D, EE and E). Also later in the quarter there were high values in the Basin, RNSYS, and HP1 and HC, all up harbour from major sewage sources. The last three surveys of the quarter were a bit unusual in the amount of apparent up harbour transport in the surface water.

10 m Samples

Referring to Table 5, the 10m floating mean values for this quarter show "unacceptable" water quality at 10m only sporadically and, but for one occurrence in the Basin, only in the Inner Harbour. These occur in sections EE and E, with one in section F. This is consistent with the pattern seen in the quarterly mean values.

Task Force Guidelines

Most of the sites that are regularly deemed unacceptable for swimming are in the Inner Harbour that is classified SC by the Halifax Harbour Task Force. There are no Task Force limits on bacteria in this area. The greatest number of Task Force guideline exceedances, occur in the class SB areas just outside the Inner Harbour that is in the southern Basin, Black Rock Beach and the Northwest Arm, particularly the RNSYS site. In this quarter these tend to occur to the north in the Basin, with only a single "unacceptable" value at BRB to the south. RNSYS, affected by chain rock outfall is "unacceptable" half of the time. The Outer Harbour is the only region classified SA. This has a lower requirement (14 cfu/100 mL) than the swimming criteria. The sites within the Task Force "Outer Harbour" boundaries are B2, HC and the HP section. HC (Herring Cove) never meets the SA guideline. The HP sites sometimes meet the SA guideline, but

these sites are periodically affected by the plume from the Tribune Head outfall. This quarter, site B2 meets the SA criteria all of the time.

Table 4. 30 day geometric mean (number of samples) of 1 m fecal coliform concentrations (cfu/100 ml).

	Outer Harbour							Northwest Arm			Eastern Pass.		Inner Harbour		
	B2	HP1	HP2	HP3	HC	C2	C3	PC	RNSYS	AYC	C6	SYC	BRB	D1	D2
Survey133	1 (3)	271 (3)	5 (3)	18 (3)	165 (3)	4 (3)	11 (3)	12 (3)	18 (3)	6 (3)	59 (3)	30 (3)	347 (3)	90 (3)	69 (3)
Survey134	1 (3)	65 (3)	4 (3)	9 (3)	89 (3)	7 (3)	17 (3)	117 (3)	47 (3)	10 (3)	23 (3)	23 (3)	63 (3)	113 (3)	65 (3)
Survey135	1 (2)	224 (3)	18 (3)	21 (3)	199 (3)	2 (3)	11 (3)	120 (3)	186 (3)	95 (3)	35 (3)	24 (3)	146 (3)	61 (3)	156 (3)
Survey136	1 (1)	254 (3)	18 (3)	85 (3)	428 (3)	4 (3)	5 (3)	174 (3)	1243 (3)	163 (3)	173 (3)	88 (3)	123 (3)	450 (3)	732 (3)
Survey137	1 (1)	341 (3)	17 (3)	350 (3)	645 (3)	6 (3)	3 (3)	33 (3)	416 (3)	32 (3)	76 (3)	40 (3)	199 (3)	1071 (3)	978 (3)
Survey138	1 (2)	258 (3)	7 (3)	116 (3)	278 (3)	9 (3)	2 (3)	26 (3)	219 (3)	21 (3)	11 (3)	21 (3)	72 (3)	1051 (3)	878 (3)

	Inner Harbour							Bedford Basin								
	D3	EE1	EE2	EE3	E1	E2	E3	F1	F2	F3	DYC	G2	H1	H2	H3	BYC
Survey133	27 (3)	756 (3)	551 (3)	2454 (3)	175 (3)	97 (3)	242 (3)	32 (3)	19 (3)	14 (3)	7 (3)	3 (3)	5 (3)	4 (3)	4 (3)	6 (3)
Survey134	53 (3)	543 (3)	487 (3)	722 (3)	35 (3)	15 (3)	56 (3)	13 (3)	9 (3)	14 (3)	11 (3)	3 (3)	4 (3)	2 (3)	2 (3)	6 (3)
Survey135	62 (3)	1242 (3)	577 (3)	1263 (3)	694 (3)	162 (3)	314 (3)	28 (3)	59 (3)	67 (3)	52 (3)	12 (3)	6 (3)	7 (3)	9 (3)	43 (3)
Survey136	142 (3)	2289 (3)	1474 (3)	2644 (3)	2407 (3)	356 (3)	1928 (3)	90 (3)	572 (3)	602 (3)	196 (3)	102 (3)	10 (3)	14 (3)	21 (3)	573 (3)
Survey137	280 (3)	2214 (3)	1866 (3)	6306 (3)	9654 (3)	976 (3)	2847 (3)	197 (3)	1195 (3)	816 (3)	215 (3)	386 (3)	13 (3)	38 (3)	50 (3)	990 (3)
Survey138	125 (3)	784 (3)	1574 (3)	14303 (3)	5092 (3)	279 (3)	1292 (3)	290 (3)	858 (3)	1073 (3)	142 (3)	475 (3)	24 (3)	29 (3)	37 (3)	558 (3)

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 5. 30 day geometric mean (number of samples) of 10 m fecal coliform concentrations (cfu/100 mL).

	Outer Harbour							Northwest Arm			Eastern Pass		Inner Harbour		
	B2	HP1	HP2	HP3	HC	C2	C3	PC	RNSYS	AYC	C6	SYC	BRB	D1	D2
Survey133	1 (3)	18 (3)	3 (3)	6 (3)	69 (3)	2 (3)	6 (3)	28 (3)	38 (3)	22 (3)	48 (3)	41 (3)	33 (3)	58 (3)	70 (3)
Survey134	1 (3)	45 (3)	9 (3)	20 (3)	39 (3)	5 (3)	6 (3)	36 (3)	37 (3)	18 (3)	34 (3)	23 (3)	31 (3)	99 (3)	58 (3)
Survey135	1 (2)	39 (3)	6 (3)	15 (3)	50 (3)	4 (3)	2 (3)	24 (3)	41 (3)	17 (3)	10 (3)	9 (3)	23 (3)	59 (3)	40 (3)
Survey136	1 (1)	26 (3)	6 (3)	42 (3)	63 (3)	11 (3)	4 (3)	31 (3)	64 (3)	12 (3)	29 (3)	14 (3)	39 (3)	149 (3)	41 (3)
Survey137	1 (1)	11 (3)	2 (3)	11 (3)	41 (3)	7 (3)	5 (3)	14 (3)	88 (3)	6 (3)	41 (3)	16 (3)	26 (3)	87 (3)	17 (3)
Survey138	1 (2)	5 (3)	2 (3)	5 (3)	20 (3)	16 (3)	5 (3)	10 (3)	87 (3)	10 (3)	46 (3)	16 (3)	27 (3)	163 (3)	15 (3)

	Inner Harbour							Bedford Basin								
	D3	EE1	EE2	EE3	E1	E2	E3	F1	F2	F3	DYC	G2	H1	H2	H3	BYC
Survey133	81 (3)	878 (3)	161 (3)	90 (3)	317 (3)	884 (3)	691 (3)	77 (3)	315 (3)	98 (3)	14 (3)	63 (3)	12 (3)	25 (3)	40 (3)	4 (3)
Survey134	50 (3)	397 (3)	164 (3)	56 (3)	118 (3)	179 (3)	222 (3)	47 (3)	189 (3)	35 (3)	9 (3)	26 (3)	24 (3)	9 (3)	17 (3)	3 (3)
Survey135	23 (3)	120 (3)	155 (3)	311 (3)	119 (3)	152 (3)	157 (3)	37 (3)	89 (3)	16 (3)	11 (3)	19 (3)	10 (3)	4 (3)	9 (3)	2 (3)
Survey136	38 (3)	195 (3)	261 (3)	309 (3)	519 (3)	431 (3)	164 (3)	37 (3)	137 (3)	31 (3)	14 (3)	24 (3)	10 (3)	4 (3)	19 (3)	7 (3)
Survey137	28 (3)	307 (3)	178 (3)	287 (3)	300 (3)	364 (3)	158 (3)	20 (3)	68 (3)	35 (3)	22 (3)	28 (3)	5 (3)	5 (3)	18 (3)	7 (3)
Survey138	35 (3)	634 (3)	215 (3)	262 (3)	258 (3)	464 (3)	181 (3)	85 (3)	141 (3)	148 (3)	67 (3)	62 (3)	36 (3)	56 (3)	66 (3)	5 (3)

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

4.2 Ammonia Nitrogen

Ammonia nitrogen is an important component in the nutrient balance in an estuary, and in high concentrations has potential for toxic effects; however, there is currently no marine water quality guideline for ammonia (CCME, 1999). The values obtained for this period are shown in Table 6. In addition, the quarterly mean and max values are plotted by station in Figure 7. The laboratory "reportable detection limit" (RDL) for ammonia nitrogen is 0.05 mg/L. For the purpose of computing statistics, the RDL/2, or 0.025 mg/L was used for values below detection. Missed samples are excluded from the calculations.

Ammonia nitrogen has consistently been present at levels that are around the detection limit of 0.05 mg/L. In this quarter, at 1 m, 48 % of samples had detectable levels of ammonia and at 10 m, 62 % of samples had detectable levels. In the 1m samples the

observations were variable around the detection limit. There was no clear site to site or survey to survey variation, except survey 134 (18 Jul 07) stands out for having no detectable levels. In the 10 m samples there were two surveys that seemed to have higher levels (survey 135 (31 Jul 07) and 137(29 Aug 07). In these samples the ammonia levels are lower in the Outer Harbour.

Table 6. Ammonia nitrogen summary (mg/L).
Note: green highlights indicate values below detection limits (0.05 mg/L). For statistics 0.025 mg/L was used for values below detection.

1m	B2	D2	EE2	E2	F2	G2	H2	mean	max
133 (4 Jul 07)	ND	0.06	ND	0.06	ND	ND	ND	0.04	0.06
134 (18 Jul 07)	ND	ND	ND	ND	ND	ND	ND	ND	ND
135 (31 Jul 07)	missed	ND	0.06	0.09	0.08	ND	ND	0.05	0.09
136 (14 Aug 07)	missed	ND	0.06	0.05	0.09	0.10	0.10	0.07	0.10
137 (29 Aug 07)	0.06	0.09	0.05	0.08	0.06	0.07	ND	0.06	0.09
138 (12 Sep 07)	0.06	ND	0.07	ND	ND	ND	0.06	0.03	0.07
mean	0.04	0.04	0.05	0.05	0.05	0.04	0.04	0.04	
max	0.06	0.09	0.07	0.09	0.09	0.10	0.10		0.10

10m	B2	D2	EE2	E2	F2	G2	H2	mean	max
133 (4 Jul 07)	ND	ND	0.06	ND	ND	0.05	0.08	0.04	0.08
134 (18 Jul 07)	ND	ND	ND	0.07	ND	0.06	0.07	0.04	0.07
135 (31 Jul 07)	missed	0.08	0.06	0.07	0.11	0.10	0.15	0.10	0.15
136 (14 Aug 07)	missed	ND	ND	0.10	ND	0.12	ND	0.05	0.12
137 (29 Aug 07)	0.06	0.07	0.05	0.08	0.08	0.10	0.11	0.08	0.11
138 (12 Sep 07)	ND	ND	ND	0.06	0.09	0.09	0.06	0.04	0.09
mean	0.03	0.04	0.04	0.07	0.06	0.09	0.08	0.06	
max	0.06	0.08	0.06	0.10	0.11	0.12	0.15		0.15

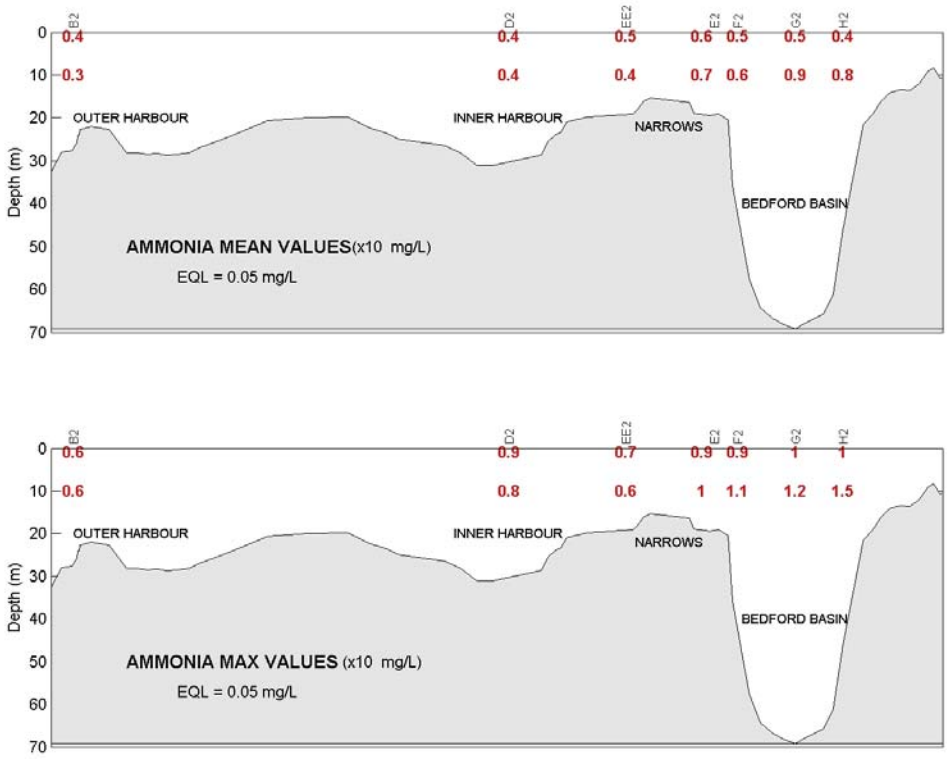


Figure 7. Mean and maximum values of ammonia nitrogen (X10 mg/L) over all thirteenth quarter samples.

4.3 Carbonaceous Biochemical Oxygen Demand

Further to a recommendation in Quarterly Report 2, $CBOD_5$ analysis for regular samples ceased on 25 May 2005, due to lack of detectable values. $CBOD_5$ analysis continues for supplemental samples, where there have been detectable values. Due to an oversight the supplemental sample this quarter was not analyzed for $CBOD_5$ so there were no $CBOD_5$ results this quarter.

4.4 Total Suspended Solids

A summary of the TSS values for this quarter is shown in Table 7. There were no samples that were below the RDL of 0.5 mg/L. The quarterly mean and max values are plotted by station in Figure 8. This quarter's site average values were in the range of 0.9 to 4.9 mg/L. The maximum values, by site, ranged from 2-9 mg/L. The values are moderate and the only clear pattern is the tendency for lower levels in the Outer Harbour. Overall, as with ammonia, there does not appear to be a strong correlation between TSS concentrations and meteorological events/oceanographic conditions. There are occasional higher values that seem to be associated with more extreme events (e.g.

storms, plankton blooms etc). These events are generally identifiable visually and are usually documented in field notes. In this quarter there were a relatively large number of visual observations of reduced water quality, however this does not seem to be reflected in the TSS data.

Table 7. TSS summary (mg/L).

1m	B2	D2	EE2	E2	F2	G2	H2	mean	max
133 (4 Jul 07)	0.5	2.3	7.7	2.7	4.4	3.0	5.0	3.7	7.7
134 (18 Jul 07)	2.1	2.7	3.8	4.9	3.1	2.3	8.4	3.9	8.4
135 (31 Jul 07)	missed	3.0	3.8	6.4	3.6	2.0	4.8	3.9	6.4
136 (14 Aug 07)	missed	2.2	2.0	3.0	3.0	1.0	0.9	2.0	3.0
137 (29 Aug 07)	0.6	2.5	3.0	3.1	3.2	2.8	3.5	2.7	3.5
138 (12 Sep 07)	0.5	1.5	4.6	5.8	4.7	3.1	6.7	3.8	6.7
mean	0.9	2.4	4.2	4.3	3.7	2.4	4.9	3.2	
max	2.1	3.0	7.7	6.4	4.7	3.1	8.4		8.4

10m	B2	D2	EE2	E2	F2	G2	H2	mean	max
133 (4 Jul 07)	0.9	2.0	2.1	2.3	4.3	7.0	2.3	3.0	7.0
134 (18 Jul 07)	2.0	2.5	5.0	2.6	3.3	5.0	3.1	3.4	5.0
135 (31 Jul 07)	missed	1.0	4.6	1.7	6.3	5.6	2.0	3.5	6.3
136 (14 Aug 07)	missed	2.6	4.0	2.0	3.8	3.0	3.0	3.1	4.0
137 (29 Aug 07)	1.2	2.8	5.7	1.9	1.8	1.6	5.9	3.0	5.9
138 (12 Sep 07)	1.0	1.8	2.0	2.7	2.3	5.8	7.1	3.2	7.1
mean	1.3	2.1	3.9	2.2	3.6	4.7	3.9	3.1	
max	2.0	2.8	5.7	2.7	6.3	7.0	7.1		7.1

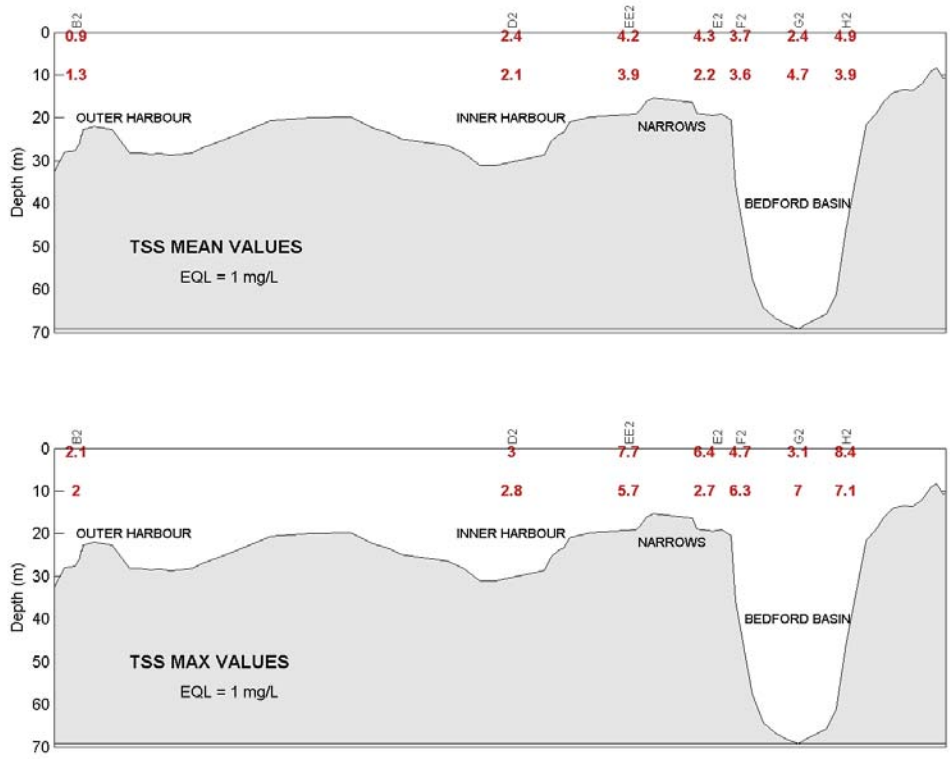


Figure 8. Mean and maximum values of total suspended solids (mg/L) over all thirteenth quarter samples.

4.5 Total Oils and Grease

Based on recommendations in Quarterly Report 5 regular sampling for total oil and grease was discontinued in, survey 73 (23 Nov 06). The analysis is retained for supplemental samples. By oversight, the supplemental sample taken this quarter was not analyzed for total oil and grease.

4.6 Metals

The results of the metals analysis are summarized in Figure 9. For this plot the non-detectable values are considered zero. Through the whole quarter there was a single guideline exceedance. In survey 138 (12 Sep 07) a mercury concentration of 0.05 µg/L was observed. This is twice the guideline of 0.025 µg/L. Mercury is seldom detectable at the 0.01 µg/L detection limit. Aside from this sample, the plot shows that of the metals for which guidelines exist copper, manganese and zinc regularly had detectable levels. Lead and nickel were occasionally detected, while cadmium was not detected. Iron is regularly detected, but has no guideline. Note that cobalt is also measured but has no guideline and is not regularly detectable, so it is not reported. The metal regularly closest to the exceedance level is copper with a mean value of about 30% of the guideline this

quarter. There was a single copper concentration of 2.8 µg/L measured, which is just under the 2.9 µg/L guideline.

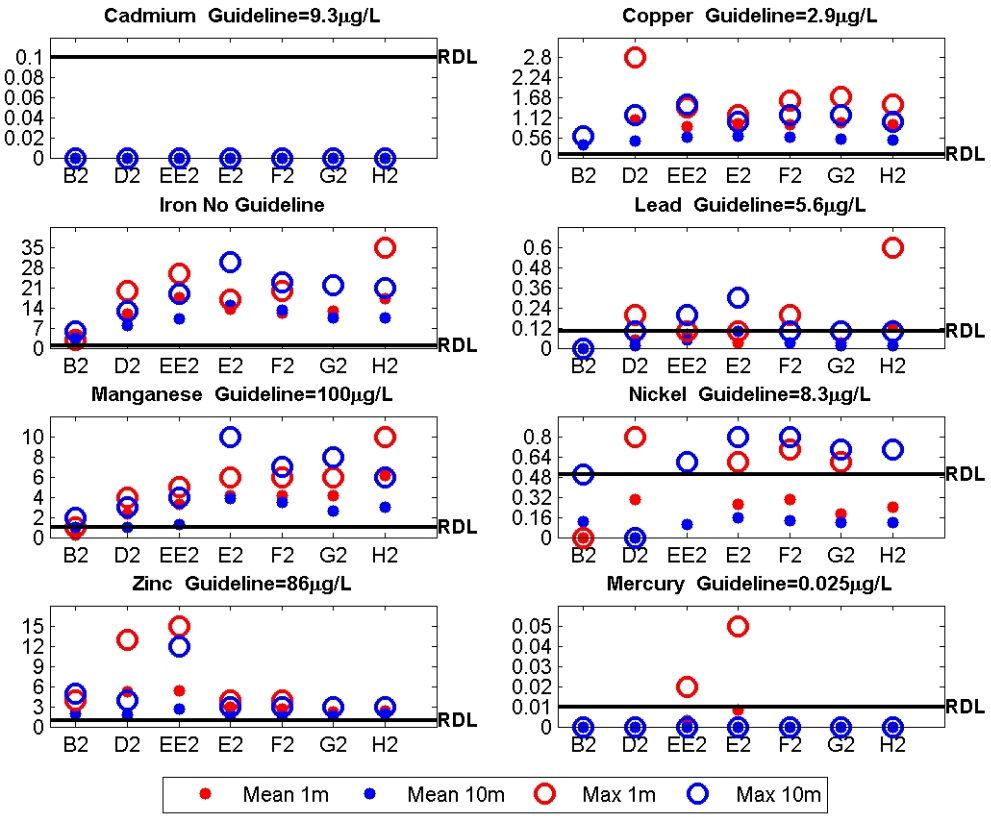


Figure 9. Mean and maximum values of metals (µg/L) over all thirteenth quarter samples.

4.7 Profile Data

The CTD used in this program measures continuous profiles of temperature, salinity, fluorescence and dissolved oxygen with depth. In early quarterly reports (up to Quarterly Report 8) the profile data was compared to the BBPMP data from the centre of Bedford Basin. This provided a check on the ranges and quality of the data collected for this survey. BBPMP has discontinued the time series contour plots so this comparison is no longer feasible. However, the contour plots of profile time series are useful in visualizing the longer term variation in the state of the harbour. These plots will be continued in the annual summary section of every fourth quarterly report (8, 12, 16 and 20).

4.7.1 Salinity and Temperature

The temperature, salinity and density (derived from temperature and salinity) profile data provides valuable information on the physical state of the harbour that is very useful in interpreting the water quality data in the weekly surveys. The data is discussed in that context in the survey reports. As time series, the data is useful in characterizing changes in the state of the harbour on meteorological (storms etc) and seasonal timescales. The most interesting point is probably the centre of Bedford Basin as this reflects not only the near surface (upper 20 m) response to wind and rain, but also shows the effects of the periodic intrusion of dense shelf bottom water into the Basin (forced by local and shelf-wide meteorological events). This longer term variation is discussed in the annual summaries.

4.7.2 Fluorescence

The HHWQMP 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 with water samples. However, the un-calibrated fluorescence values can be useful when 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 and space, 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.

The phytoplankton in Halifax Harbour generally exhibit more or less typical estuarine behaviour in the winter. That is, low productivity (<5 mg/m^3) during the winter followed by the strongest bloom of the year (40-80 mg/m^3) as sunlight returns in the spring (typically March). After the spring bloom, when light is plentiful, the behaviour seems to be affected by anthropogenic nutrient input. There are sporadic phytoplankton blooms throughout the summer and into the fall. These blooms can be close to the spring bloom in magnitude (30-40 mg/m^3) and occur until the drop in light levels in late fall and winter. There is a less distinct fall bloom that does not appear to be significantly different in intensity, based on fluorescence, than the blooms occurring throughout the summer. Phytoplankton blooms tend to start in the Basin and migrate outward to the rest of the harbour. The profile maximum values generally decrease in magnitude and occur lower in the water column further out of the harbour. The data in the Basin generally represents the maximum concentrations observed and is representative of the timing of phytoplankton activity in the remainder of the harbour. During this quarter there were relatively continuous high fluorescence levels with maximum values in the Basin varying from about 20 to 60 mg/m^3. The highest values of 60 mg/m^3or more occurred on consecutive surveys (136 – 137) in the last half of August.

4.7.3 Dissolved Oxygen

Comparison between dissolved oxygen determinations by different methods/instruments has proven uncertain. Part of this uncertainty is due to the vagaries of the instruments themselves. Additionally, small variations in processing procedures, particularly with "alignment" procedures, that assign depths to the DO measurements obtained with the CTD, can add uncertainty. The CTD sensors are quite stable, but tend to lose sensitivity with time. Due to the nature of the CTD itself, they cannot be user calibrated. The BBPMP routinely collects water samples for ground truthing their CTD DO measurements. The samples are analyzed with a well calibrated bench top DO meter. This data can be used to adjust the profile data. The BBPMP publishes the weekly profile data on their website. For purposes of comparison the DO values at 1 and 10 m are estimated from the plots, and are compared with corresponding values from the HHWQMP profiles in Table 8, below. Note that the BBPMP station is approximately 125 m east of the HHWQMP site G2 and that BBPMP samples are generally collected on the day following the HHWQMP samples, so direct correspondence is not to be expected.

Table 8. Comparison of HHWQMP and BBPMP dissolved oxygen data.

Survey	HHWQMP (mg/L)		BBPMP (mg/L)		Ratio (BBPMP/HHWQMP)	
Number	1m	10m	1m	10m	1m	10m
133 (4 Jul 07)	8.3	6.70	9.3	8.3	1.12	1.24
134 (18 Jul 07)	7.1	6.30	9.0	8.3	1.27	1.32
135 (31 Jul 07)	9.3	8.10	7.9	8.4	0.84	1.04
136 (14 Aug 07)	9.7	8.20	8.6	9.1	0.88	1.11
137 (29 Aug 07)	11.9	8.40	10.4	9.1	0.88	1.09
138(12 Sep 07)	9.6	8.20	9.6	8.0	1.00	0.98

For the first two surveys the normal project CTD was used. The trend of decreasing sensitivity seen in the previous quarter continues and the BBPMP data is about 25 - 30% higher than the HHWQMP. For surveys 135 through 137, a replacement CTD, just factory calibrated was used. In survey 138, the project CTD, just returned from factory service/calibration was returned to the project. The data from the first two surveys should be scaled up. The remainder of the data is quite comparable given the uncertainties, including the differences in time and location.

The Harbour Task Force Class SA, SB and SC water use classifications have guidelines for dissolved oxygen of 8.0, 7.0 and 6.0 mg/L respectively. Class SA pertains to the Outer Harbour and Class SC pertains to the Narrows and Inner Harbour. The remainder of the Harbour is classified as SB. To date, oxygen levels as measured in the program, are generally relatively high in surface waters, and chronically low in the deep water of Bedford Basin. This is consistent with the existing understanding that Bedford Basin is a fjord, in which at least periodic depressed oxygen in bottom water is typical. For this quarter, based on the HHWQMP data, adjusted appropriately in the first two surveys, the only guideline exceedance throughout the quarter is the persistent exceedance at the bottom of the Bedford Basin.

4.8 Supplemental Samples

Harbourside Market

A supplemental sample (44°39.021'N, 63°34.311'W) was taken at the wharf in front of the Harbourside Market in downtown Halifax (Figure 10). This was in a relatively large patch of visually very poor water quality. The water was extremely cloudy with a high concentration of relatively large particulates (Figure 11). The sample was taken as near the surface as possible.

Figure 10. Approaching Harbourside Market.

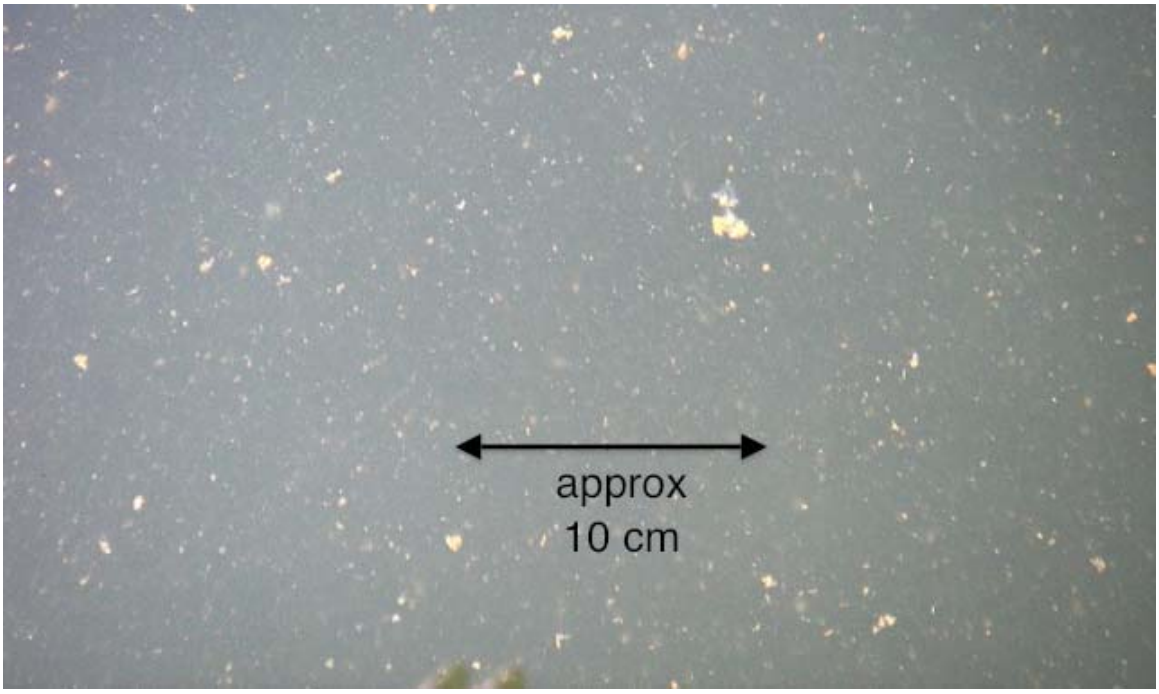


Figure 11. Turbid water/detritus in front of Harbourside.

The results of the lab analysis are presented in Table 9. Surprisingly, the concentrations measured in this sample were unremarkable, except that copper (2.2 ug/L) and lead (0.2 ug/L) concentrations were the highest measured in the survey. Neither of these represents guideline exceedances, but the copper concentration is close to the guideline value of 2.9 ug/L.

Table 9. Supplemental sample lab results.

	UNITS	1m	RDL
BACTERIA			
Fecal Coliform	cfu/100mL	360	1
INORGANICS			
Carbonaceous BOD	mg/L	NA	5
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.05
Total Suspended Solids	mg/L	4.6	0.5
OIL & GREASE			
Total Oil & Grease	mg/L	NA	5
METALS WITH GUIDELINES			
Cadmium (Cd)	ug/L	ND	0.1
Copper (Cu)	ug/L	2.2	0.1
Lead (Pb)	ug/L	0.2	0.1
Manganese (Mn)	ug/L	3.0	1
Mercury (Hg)	ug/L	ND	0.01
Nickel (Ni)	ug/L	0.6	0.5
Zinc (Zn)	ug/L	6.0	1
METALS WITH NO GUIDELINES			
Cobalt (Co)	ug/L	0.0	0.1
Iron (Fe)	ug/L	19.0	1

Dartmouth Cove

A regular summer monthly sample was taken at the DC site (Figure 1) in survey 135 (31 Jul 07). This was a single sample at 1m analyzed for all parameters except $CBOD_5$ and total oil and grease. The results of the analysis (Table 10) were relatively unremarkable. The FC, ammonia and TSS are relatively high, about the same as the maximum values in the regular survey sites. Similarly, the metals concentrations were within the range of other observations this survey. There were no guideline exceedances.

Table 10. Dartmouth Cove sample lab results (31 Jul 07).

	UNITS	1m	RDL
BACTERIA			
Fecal Coliform	CFU/ 100mL	>10,000	1
INORGANICS			
Carbonaceous BOD	mg/L	NA	5
Nitrogen (Ammonia Nitrogen)	mg/L	0.11	0.05
Total Suspended Solids	mg/L	5.0	0.5
OIL & GREASE			
Total Oil & Grease	mg/L	NA	5
METALS WITH GUIDELINES			
Cadmium (Cd)	ug/L	ND	0.1
Copper (Cu)	ug/L	1.5	0.1
Lead (Pb)	ug/L	0.1	0.1
Manganese (Mn)	ug/L	11.0	1
Mercury (Hg)	ug/L	ND	0.01
Nickel (Ni)	ug/L	0.5	0.5
Zinc (Zn)	ug/L	4.0	1
METALS WITH NO GUIDELINES			
Cobalt (Co)	ug/L	ND	0.1
Iron (Fe)	ug/L	38.0	1

5 Summary

For each item, a brief statement of summary is provided along with any changes that occurred during the quarter and any new or ongoing issues.

5.1 Reporting

Survey Reports

The 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
- None

Quarterly Reports

The Quarterly report discussion is limited to the data of that quarter. Every fourth Quarterly report includes a section reviewing the data over the last year. Each quarterly report contains a discussion of any supplemental samples taken in the quarter.

Changes
- None

5.2 Sampling Program

The sampling route selection continues as per the end of the ninth quarter. As of that time the routes were modified to always either start or end in the Northwest Arm, where the survey boat is based. This was done based on travel time considerations and does introduce an early morning/late afternoon bias into the NW Arm data. The morning sampling may coincide with the peak diurnal sewage flows and may result in a bias in water quality samples near the chain rock outfall (e.g. RNSYS, PC). This is also a function of the plume trajectory at the time of sampling. This should be considered in a detailed analysis of RNSYS and PC water quality data. The sampling sites remain as at the end of quarter 10. The last change has been the addition of the HP sites. The sample analysis remains the same as at the end of quarter nine. The last modification was the addition of the high resolution metals analysis.

Changes
- None

5.3 Water Quality Parameters

Fecal Coliform

In general, the geometric mean coliform values are well above primary contact guidelines in the Inner Harbour. Outside of the Inner Harbour high values are more sporadic. The occurrence of high values outside the Inner Harbour are primarily dependant on oceanographic conditions that may transport water from the Inner Harbour either up or down harbour, and secondarily dependant on loading events (e.g. storms) that may increase loads thereby raising levels everywhere. Both of these often act together. This quarter, the spatial distribution of fecal coliform seemed shifted down-harbour, in the 1m and up-harbour in the 10m samples. The maximum mean values are quite high, but their distribution is quite contained. There are only six sites (four at 1m and two at 10m) having geometric means greater than 200 cfu/100 mL and all of these are in the Inner Harbour.

With respect to compliance with Task Force guidelines the most numerous exceedances are in the class SB rated areas adjacent to the Inner Harbour. This quarter class SB exceedances were very limited and all, but for one, are to the South at BRB. There are also class SB exceedances at RNSYS due to the periodic influence of the chain rock outfall. The class SA guideline in the Outer Harbour is generally not met at HC and the HP sites, likely due to the periodic influence of the Tribune Head outfall. The class SA guideline is met at B2 throughout the quarter.

The existing variable sample resolution scheme has resulted in a few out-of-range values in this quarter. These were all in what appeared to be unusual conditions, including the sewage diversion. Normally these sites periodically experience low values and a decrease in resolution, and commensurate increase in resolution of high values, at these sites could result in a loss of resolution at on the lower detection limit. The lab resolution has been left unchanged.

Changes

- None

Outstanding item: The current Canadian Environmental Quality Guidelines (ceqg-rcqe.ccme.ca) recommend enterococci over fecal coliform as a tracer of human waste contamination in salt water. There are several practical reasons for continuing to monitor fecal coliform including historical continuity, and consistency with WWTP monitoring procedures. The trend toward enterococci will likely continue and it would be advantageous to future endeavours if the monitoring program could bridge to the use of this tracer. Enterococci are considered to be more specific than fecal coliform in identifying contamination by human waste. In Halifax the overwhelming source of bacterial contamination is sewage. The concentration of fecal coliform in the Harbour would likely correlate very strongly with the more human specific enterococci. Limited sampling of both parameters could allow investigation of this correlation.

Ammonia Nitrogen

Ammonia nitrogen has consistently been present at levels that are around the detection limit of 0.05 mg/L. Overall, in this quarter 55% of samples had detectable levels of ammonia. The values are generally relatively uniform throughout the harbour except they tend to be somewhat lower in the Outer Harbour at B2. This quarter there is no clear temporal variability. There does not seem to be a simple correlation between ammonia concentrations and meteorological/oceanographic conditions, as is evident in the coliform data.

Ammonia nitrogen is an attractive tracer as it is routinely monitored in sewage treatment facilities and, therefore, has quantifiable source strength in sewage. Recognizing nitrogen as the key nutrient in marine systems, and the potential importance that nutrients have in the Harbour oxygen dynamics, additional species of nitrogen should continue to be considered for monitoring.

Changes
- None

$CBOD_5$

Based on recommendations in Quarterly Report 2, $CBOD_5$ was dropped from regular analysis in survey 49 (25 May 2005). Until that time there were an insignificant number of regular samples with detectable $CBOD_5$ at the 5 mg/L level. $CBOD_5$ has been retained as a tracer for the supplemental sampling program. There was no $CBOD_5$ monitoring this quarter.

Changes
- None

Total Suspended Solids

The TSS values in the harbour are generally moderate with no obvious strong correlation in space or time with oceanographic or sewage loading conditions. This quarter the survey means ranged from 2.0 to 3.9 mg/L. There are at times higher values that seem to be associated with more extreme events (e.g. storms, plankton blooms etc). These events are generally identifiable visually and are usually documented in field notes. In this quarter there were a relatively large number of visual observations of reduced water quality, however this does not seem to be reflected in the TSS data. The only clear spatial pattern is that the TSS is generally lower in the outer Harbour at B2.

Changes:
- None

Total Oils and Grease

Based on recommendations in Quarterly Report 5, total oils and grease was dropped from regular analysis in survey 75 (23 Nov 05), due to lack of detection. It is retained in supplemental sample analysis. This quarter the TOG analysis for the supplemental samples in Harbourside and Dartmouth Cove was inadvertently omitted.

Changes
- None

Metals

In general the metals with guidelines are present at levels well below the guidelines. The metal that is consistently closest to exceeding the guideline is copper. In this quarter the mean copper values are less than 20% of the 2.9 µg/L guideline. However in this quarter there was a single guideline exceedance. In survey 138 (12 Sep 07) the E2-1m sample had a mercury concentration of 0.05 µg/L, twice the applicable guideline. Mercury is very seldom detectable at the 0.01 µg/L RDL.

Changes:
- None

Fluorescence

Un-calibrated fluorescence provides a relative measure of chlorophyll and hence phytoplankton activity throughout the Harbour. The HHWQMP data allows for the gross identification of phytoplankton activity and is particularly useful in the interpretation of the DO data. The fluorescence data could also be useful to add a spatial interpretation to the detailed phytoplankton analysis at the BBPMP site. During this quarter there was relatively consistent high phytoplankton activity with maximum levels of 20-60 mg/m^3. The highest levels observed during the quarter (maximum levels of > 60 mg/m^3), were in surveys 137-138 at the end of August.

Changes
- None

Dissolved Oxygen

To date, oxygen levels as measured in the program, are generally relatively high in surface waters, and chronically low in the deep water of Bedford Basin. This is consistent with the existing understanding that Bedford Basin is a fjord, in which at least periodic depressed oxygen in bottom water is typical. This quarter several different instruments were used, due to servicing/calibration of the project CTD. Inter-comparison presents a fairly consistent picture of Dissolved Oxygen in the harbour. This suggests that the only guideline exceedance this quarter is the persistent class SB guideline (7.0 mg/L)

exceedance in the Basin Bottom water. There are continuing issues of DO sensor calibration/ground truth (Section 4.7.3).

Changes

- None

6 References

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