PHASE 2 OF THE HOPE BAY PROJECT
DRAFT ENVIRONMENTAL IMPACT STATEMENT

Appendix V5-7B

Doris North Gold Mine Project: 2011 Aquatics Effects Monitoring Program (AEMP) Marine Expansion Baseline Report

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DORIS NORTH GOLD MINE PROJECT
2011 Aquatic Effects Monitoring Program (AEMP)
Marine Expansion Baseline Report

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December 2011

DORIS NORTH GOLD MINE PROJECT

2011 AQUATIC EFFECTS MONITORING PROGRAM (AEMP) MARINE EXPANSION BASELINE REPORT

December 2011
Project #1009-007-05

Citation:

Rescan. 2011. *Doris North Gold Mine Project: 2011 Aquatic Effects Monitoring Program (AEMP) Marine Expansion Baseline Report*. Prepared for Hope Bay Mining Limited by Rescan Environmental Services Ltd.

Prepared for:

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Hope Bay Mining Limited

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Executive Summary

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Executive Summary

The 2011 Aquatic Effects Monitoring Program (AEMP) Marine Expansion Baseline work was conducted by Rescan Environmental Services Ltd. (Rescan) on behalf of Hope Bay Mining Ltd. (HBML) for the Doris North Project. The Doris North Property is located approximately 125 km southwest of Cambridge Bay, Nunavut, on the south shore of Melville Sound. The nearest communities are Omingmaktok (Bay Chimo; 75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

This report presents the results from the 2011 AEMP Marine Expansion Baseline program. The primary objective of the 2011 program was to collect marine baseline data relevant to the proposed discharge of treated water from the Tailings Impoundment Area (TIA) into Roberts Bay. Data from this report was used to provide information to support the preparation of the Roberts Bay environmental assessment report that was prepared for the Doris North amendment package (HBML 2011). Data collected in 2011 will be used in the future expanded AEMP should the proposed Doris North amendments be approved.

Currently, the TIA is permitted to be discharged into Doris Creek under the approved Type A Water Licence (2AM-DOH0713). If the proposed modifications to the Doris North Project are approved, additional underground mining at Doris North will encounter deep saline groundwater and saline talik water. HBML is proposing to discharge this additional mine water into the TIA. This saline TIA water could be detrimental to aquatic life if discharged to Doris Creek. A more environmentally appropriate receiving environment is the marine (ocean) environment as the salt content will closely match that of seawater. To accommodate the additional saline TIA water, HBML is proposing to discharge treated TIA water to the marine environment in Roberts Bay via a subsea pipeline and diffuser (HBML 2011).

The 2011 AEMP Marine Expansion Baseline program involved collecting information for the following: the vertical structure and dissolved oxygen content of the water column, water and sediment quality, phytoplankton, and benthic invertebrates. Two distinct marine basins near the Project area were surveyed four times between April and October 2011: Roberts Bay and Reference Bay. Two potential exposure sites were surveyed in Roberts Bay: one at the proposed discharge site (near-field) and one 2 km downstream towards the mouth of Roberts Bay (far-field). One reference site was surveyed in Reference Bay.

The following text provides a brief summary of the various components sampled as part of the 2011 program.

Water Column Structure and Dissolved Oxygen

The water columns in Roberts Bay and Reference Bay were consistently stratified between April and late September 2011, with lower density water sitting above higher density water (i.e., they were two-layer systems). This stratification was weaker during the ice-covered season (April) when there were no freshwater inputs and in late September (open-water) due to low freshwater inputs, decreasing temperatures, and increased wind-driven mixing. This resulted in deep surface mixed layers of 20 to 25 m in September and 30 m in April.

In July and August, the vertical stratification intensified in Roberts and Reference bays due to melting sea ice and increased riverine inputs. The influx of freshwater resulted in shallower pycnoclines (range: 3-10 m) with warmer, fresher water sitting above colder, saltier water at depth. The surface temperatures were warmest in Roberts Bay in August, reaching 10°C.

Both bays had surface layers that were well oxygenated, with surface dissolved oxygen concentrations ranging from about 9 mg/L in August to 12 mg/L in April. Dissolved oxygen concentrations in the bottom waters of Roberts Bay were higher than the minimum concentration of 8.0 mg/L recommended by the Canadian Council of the Ministers of the Environment (CCME) for the protection of marine and estuarine aquatic life. In August, dissolved oxygen concentrations at depths greater than 25 m in Reference Bay were below the guideline of 8.0 mg/L, reaching 6.63 mg/L at 41 m depth.

Light penetration was high during the summer and fall in both Roberts and Reference bays. The euphotic depth (1% light level) was generally deeper than 16 m and usually extended far below the pycnocline. This suggests that net photosynthesis was possible throughout the upper water column in both bays.

Water Quality

Overall, the water quality parameters were similar between Roberts Bay and Reference Bay. Water clarity was high in both bays as total suspended solids were often below analytical detection and turbidity was consistently low. Some nutrients showed vertical concentration gradients, which were most dramatic during July and August. Nitrate and total phosphorus concentrations were generally lower at the surface than in deep waters. During summer, nitrate was usually below analytical detection (>0.006 mg N/L) in the surface layer, while total phosphorus was detectable throughout the water column. Thus, phytoplankton growth was likely controlled by nitrogen availability when sufficient light was present, which is typical of northern, estuarine systems. Vertical gradients of total organic carbon (TOC) exhibited the opposite trend as nutrients as the summer surface concentrations were usually slightly higher than at depth. Vertical gradients characterized by lower nutrients and higher TOC at the surface than at depth are indicative of phytoplankton growth and biological nutrient uptake.

Roberts Bay and Reference Bay can be considered low-metal environments, as all water quality parameters were below their respective CCME guideline for the protection of marine aquatic life. Several metals (e.g., total lead and total zinc) were usually below their analytical detection limit.

Total cyanide was commonly observed at low concentrations during the surveys. The highest concentrations were found in July in the surface waters of Roberts (0.0021 mg/L) and Reference (0.0019 mg/L) bays, and detectable levels were found throughout the Roberts Bay water column in April. Free cyanide made up a very small proportion of the total cyanide pool as there was little detectable free cyanide in either bay.

Sediment Quality

The deep water sediments (42 m) were composed mainly of silt (mean: 54.2%) and clay (mean: 41.3%) in both bays. Roberts Bay sediments had slightly higher mean concentrations of TOC, total chromium, total copper, total lead, and total zinc than the Reference Bay sediments. Conversely, Reference Bay sediments had higher concentrations of total arsenic. The mean arsenic, chromium, and copper levels found in Roberts Bay sediments were higher than CCME interim marine sediment quality guidelines (ISQGs) for these metals. Mean copper levels in Reference Bay were also higher than the ISQG, and the total arsenic concentrations in this bay were particularly high, exceeding both the ISQG and the probable effects level (PEL) for the protection of marine aquatic life.

Phytoplankton

Mean phytoplankton biomass (as chlorophyll *a*) in the Project area was very low at all sites (0.14 to 0.62 µg chl *a*/L), reaching a maximum of 1.5 µg chl *a*/L in Reference Bay in August. The low concentrations reflected the low under-ice light levels in April, and the low surface layer nutrients and stable water column in July and August. In Roberts Bay, the mean phytoplankton biomass was highest in September (0.46 µg chl *a*/L), likely due to the wind-driven transport of nutrients into the surface layer during this time.

Benthos

Mean benthos density was slightly higher in the deep Reference Bay sediments (1,520 organisms/m^2) than in Roberts Bay (1,060 organisms/m^2). Diverse benthos communities were present in both bays, with fewer taxonomic groups being more evenly distributed in Roberts Bay than in Reference Bay. The benthos community in Roberts Bay was largely dominated by families of polychaete worms and small crusteceans, while polychaetes dominated the Reference Bay benthos community.

Acknowledgements

Acknowledgements

Fieldwork was conducted with the enthusiastic and competent assistance of numerous Hope Bay Mining Limited (HBML) field assistants including: Noah Aklah, Robert Maksagak, Leonard Wingnak, and Pamela Gross.

Extensive support was provided by the HBML Environment and Social Responsibility (ESR) Department, the Health, Safety and Loss Prevention (HSLP) Department, and camp management, as well as Great Slave Helicopters, Braden Burry Expediting, and Nuna Logistics.

This report was prepared for HBML by Rescan Environmental Services Ltd. The 2011 AEMP Marine Expansion Baseline fieldwork was conducted by Rescan scientists Soleil Switzer, (M.Sc.), Mike Henry (Ph.D.), Kerry Marchinko (Ph.D., M.Sc.), Craig Hatt (Dip. Eng. Tech.), and Katsky Venter (M.Sc.). The report was written by Mike Henry and Carol Adly (M.Sc.) and reviewed by Deborah Muggli (Ph.D., M.Sc., R.P.Bio.). The project was managed by Deborah Muggli.

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DORIS NORTH GOLD MINE PROJECT

2011 AQUATIC EFFECTS MONITORING PROGRAM (AEMP) MARINE EXPANSION BASELINE REPORT

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Glossary and Abbreviations

Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

Abbreviation/Acronym	**Definition**
AEMP	Aquatic Effects Monitoring Program
BC	Bray-Curtis Dissimilarity Index (also known as Bray-Curtis Similarity Index) or British Columbia
Benthos	benthic invertebrates
CCME	Canadian Council of Ministers of the Environment
Chl *a*	chlorophyll *a*
Chlorophyll *a*	An essential light harvesting pigment for photosynthetic organisms including phytoplankton. Because of the difficulty in direct measurement of plant carbon, chlorophyll *a* has become an established routine ‘proxy’ estimate for plant biomass in aquatic studies.
CTD	conductivity, temperature, depth probe
D	Simpson’s Diversity Index
DO	dissolved oxygen
D_s	Secchi depth
E	Simpson’s Evenness Index
EC	Environment Canada
EEM	Environmental Effects Monitoring
ESR	Environment and Social Responsibility Department
F	family richness
HBML	Hope Bay Mining Limited
HSLP	Health, Safety and Loss Prevention Department
ISQG	interim sediment quality guideline
MMER	Metal Mining Effluent Regulations
n/c	not collected
NIRB	Nunavut Impact Review Board
NTU	Nephelometric Turbidity Units
NWB	Nunavut Water Board
PEL	probable effects level

Pycnocline	The structure of a water column is defined by its density profile, with lower density water sitting above higher density water. The depth zone where the density changes most sharply is referred to as the pycnocline.
QA/QC	quality assurance/quality control
Rescan	Rescan Environmental Services Ltd
Salinity	No units, dimensionless. Historically, many units have been assigned to salinity, for example, parts per thousand (ppt or ‰), Practical Salinity Units (PSU), and Practical Salinity Scale (PSS 78). Salinity is defined on the Practical Salinity Scale (PSS) as the conductivity ratio of a sea water sample to a standard KCl solution. As PSS is a ratio, it has no units.
Talik	A layer of year-round unfrozen ground in an area of permafrost where temperatures are above freezing, allowing water to remain in liquid form.
TIA	Tailings Impoundment Area
TOC	total organic carbon
TSS	total suspended solids

1. Introduction

1. Introduction

The Doris North Gold Mine Project (the Project) is located approximately 125 km southwest of Cambridge Bay, Nunavut, on the south shore of Melville Sound. The nearest communities are Omingmaktok (75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property). Figure 1-1 provides a general location map for the Doris North Project.

The Nunavut Impact Review Board (NIRB) issued a Project Certificate for the Doris North Gold Project on September 15, 2006 and a Type A Water Licence (Water Licence # 2AM-DOH0713) was issued by the Nunavut Water Board (NWB) on September 19, 2007. A requirement of the Water Licence was to develop and conduct an Aquatic Effects Monitoring Program (AEMP). The AEMP Plan was reviewed by Environment Canada (EC) and approved by the Nunavut Water Board (NWB) in early 2010 (Rescan 2010). The first year of the program was initiated in 2010 (Rescan 2011), and a second year was completed in 2011. This plan followed Environmental Effects Monitoring (EEM) protocols as per the *Metal Mining Effluent Regulations* (MMER 2002).

The current Water Licence permits the discharge of water from the Tailings Impoundment Area (TIA) into Doris Creek, upstream of the waterfall. If the proposed modifications to the Doris North Project are approved (HBML 2011), additional underground mining at Doris North will encounter deep saline groundwater and saline talik water. HBML is proposing to discharge this additional mine water into the TIA (HBML 2011). This saline TIA water could be detrimental to aquatic life if discharged to Doris Creek. A more environmentally appropriate receiving environment is the marine (ocean) environment as the salt content will closely match that of seawater. To accommodate the additional saline TIA water, HBML is proposing to discharge treated TIA water to the marine environment in Roberts Bay via a subsea pipeline and diffuser (HBML 2011). This proposal was part of the Doris North amendment package submitted to NIRB and NWB in November 2011.

The current AEMP will need to be modified if the Doris North amendment package is approved. A proposed expanded program was included in the Doris North amendment package, and a final expanded program will be developed in consultation with EC.

The purpose of collecting AEMP-compatible data in Roberts Bay in 2011 was to provide information to support the preparation of the Roberts Bay environmental assessment report that was prepared for the Doris North amendment package. Data collected in 2011 will also hopefully be used in the future expanded AEMP should the proposed Doris North amendments be approved.

The 2011 AEMP Marine Expansion Baseline program was run concurrently with the approved Doris North AEMP, and followed the same methods (Rescan 2010, 2011). Baseline data were collected for the following parameters as part of the 2011 AEMP Marine Expansion program:

- water quality and water column structure;
- sediment quality;
- primary producers (phytoplankton); and
- benthic invertebrate community (abundance and taxonomy).

PROJECT # 1009-002-01 *ILLUSTRATION #* a23708w-DN May 21 2009

Figure 1-1

Doris North Project Location

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An extensive physical oceanographic program was also conducted in Roberts Bay in 2011 to collect ocean current data so the circulation and flushing rate of the inlet could be modelled. Details of this work will be provided in separate Roberts Bay physical oceanography and Roberts Bay circulation reports.

Chapter 2 of this report presents the methods used during the 2011 AEMP Marine Expansion Baseline program, and Chapter 3 presents graphical results. All raw data are provided in appendices. Much of the information collected was used for the Doris North amendment package, and only brief summaries of results are provided in this report.

2. Methods

2. Methods

2.1 STUDY AREA AND SAMPLING LOCATIONS

The AEMP Marine Expansion Baseline study area included areas in Roberts Bay anticipated to be potentially influenced by the treated TIA discharge and an area beyond any TIA discharge influence (reference area). Two potential exposure sites (RB1 and RB2) in Roberts Bay and one reference site (REF-Marine 2) were sampled in 2011 (Figure 2.1-1). The two exposure sites were situated to acquire baseline information downstream of the proposed treated TIA discharge location. RB1 was considered a near-field exposure site and was in the immediate proposed receiving area (~100 m) of the proposed diffuser. RB2 was considered a far-field exposure site and was 2 km north of the proposed discharge location and 2.3 km from the mouth of Roberts Bay to Melville Sound. The reference site REF-Marine 2 was located in southern Reference Bay for comparability with the two exposure sites in Roberts Bay. This reference site was sufficiently far away from the influence of mining activity and resembled, as much as possible, the hydrological and habitat features of the exposure areas. Figure 2.1-1 shows the sampling sites, the parameters collected, and the Doris North Project infrastructure as of 2011. It also shows the location of the proposed TIA discharge pipeline. A summary table (Table 2.1-1) provides details for the rational of the site selections.

Table 2.1-1. Marine AEMP Expansion Baseline Sampling Locations, Descriptions, and Purpose, Doris North Project, 2011

AEMP Expansion Site	Coordinates	Bottom Depth	Description	Purpose
RB1	431936 E 7565566 N	42 m	100 m away from the diffuser	Exposure site located as close to the proposed diffuser as safely and logistically possible
RB2	432304 E 7567343 N	71 m	~2 km seaward of the proposed diffuser, in the center of Roberts Bay	Central monitoring site on seaward side of proposed diffuser; midway between southern shore of Roberts Bay and Melville Sound; 2 stations are already in place in the nearshore environment
REF-Marine 2	441984 E 7565159 N	42 m	~2.3 km seaward from existing Reference Site (REF-Marine 1)	To provide a reference station for the 2 new proposed AEMP stations in Roberts Bay, particularly Station RB1

Coordinates are in NAD83 UTM Z13N.

2.2 2011 SAMPLING SCHEDULE

The 2011 AEMP Marine Expansion Baseline sampling schedule paralleled that of the 2011 Doris North AEMP program. Sampling commenced in April and ended in late September. Physical oceanographic characteristics (e.g., temperature, salinity, dissolved oxygen) and water quality (e.g., nutrients and metals) were collected in Roberts Bay four times during the sampling period. These were collected not less than one month apart (whenever possible), thereby complying with MMER guidelines (Schedule 5, s.7 (1-2)) and the 2011 Doris North AEMP program. In Reference Bay, water quality samples were collected three times in 2011 (July, August, and September) and physical profiles were collected twice (July, August). Phytoplankton biomass (as chlorophyll *a*) was collected in each bay during the three open-water surveys (July, August, and September) and sediment quality and benthos samples were collected once in summer (August).

Table 2.2-1 lists the parameters measured for each marine environmental component during 2011. The under-ice, April sampling was designed to collect water when dissolved oxygen concentrations would be lowest (due to reduced photosynthesis and the absence of oxygen diffusion from the atmosphere), and nutrient and metal concentrations would be highest (due to limited biological uptake and solute extrusion during ice formation).

Table 2.2-1. Environmental Components and Sampling Time, AEMP Marine Baseline Expansion, 2011

Sampled Parameters	April	July	August	September
Water Column Structure				
Salinity	X	X	X	X
Temperature	X	X	X	X
Dissolved Oxygen	X	X	X	X
Euphotic Zone Depth		X	X	X
Water Quality				
Physical, Anions, and Nutrients	X	X	X	X
Metals (Total)	X	X	X	X
Sediment Quality				
Particle Composition, % Moisture			X	
Organic Content, Nutrients			X	
Total Metals			X	
Biology				
Phytoplankton Biomass	X	X	X	X
Benthos Abundance, Taxonomy, and Diversity			X	

2.3 SAMPLING METHODS

Table 2.3-1 provides a summary of sampled parameters, replication, sampling dates, and sampling equipment used. Full descriptions are provided in the following text.

2.3.1 Physical Oceanography and Light Penetration

In Roberts Bay, physical oceanographic profiles (e.g., salinity, temperature, and dissolved oxygen) were collected once during the under-ice season (April) and three times during the open-water season (July, August, and September) in 2011 (Table 2.3-2). Physical profiles were collected in Reference Bay in July and August.

In April, the under-ice water was accessed by drilling a 25-cm diameter hole through the ice. The ice thickness was recorded and a vertical profile of temperature, salinity, and conductivity was collected using an *in situ* conductivity, temperature, and depth probe (CTD; RBR-420). The probe was lowered through the water column at an approximate speed 0.5 m/s to within 1 m of the sea floor. The data logged during this process were immediately transferred to a computer in the field. Data from the downcast were used to derive physical profiles. Following the CTD casts, vertical profiles of dissolved oxygen concentration and percent saturation were collected using a YSI dissolved oxygen meter lowered at 1 m intervals to within 1 m of the sediments.

During the open-water surveys (July-September), CTD and dissolved oxygen profiles were collected from the side of an aluminum boat. The logged and recorded data were processed using the same methods in April.

PROJECT #1009-007-05 GIS # HB-28-043

December 06 2011

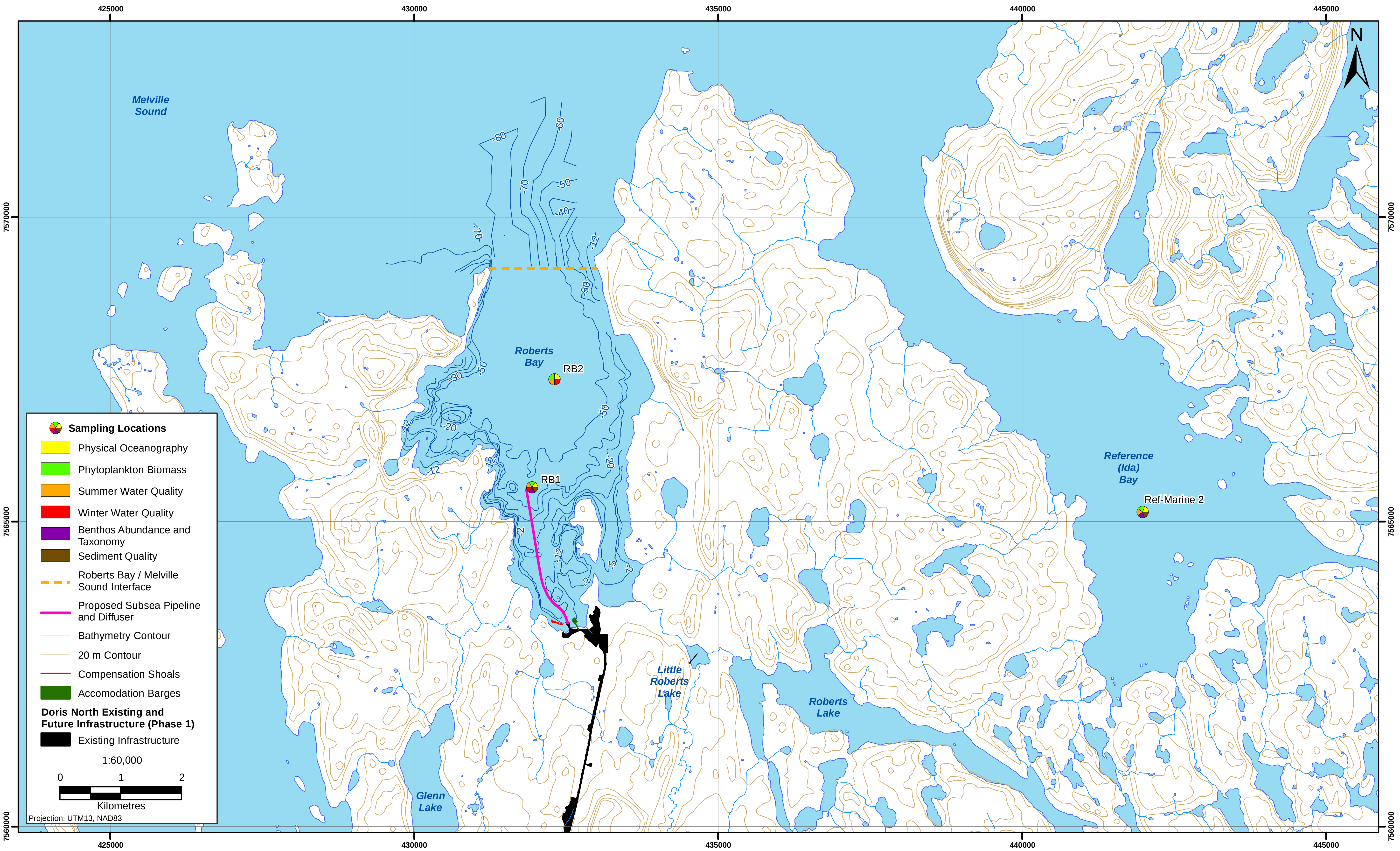

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Figure 2.1-1

Marine AEMP Expansion Sampling Locations, Doris North Project, 2011

Table 2.3-1. Summary of the Marine AEMP Expansion Baseline Sampling Program, Doris North Project, 2011

Monitoring Parameter	Sampling Frequency	Sample Replication and Depths	Sampling Dates/Timing	Sampling Device
Physical Oceanography				
Temperature, salinity, and dissolved oxygen profiles, Secchi depth	4 x	Entire water column; n = 1/site	April, July, August, September	Conductivity-Temperature-Depth (CTD) probe; dissolved oxygen meter
Water Quality				
Physical, nutrients, cyanides, total metals, radium 226	4 x	4 depths; n = 1/depth @ 1 m below the surface, 4 m above pycnocline, 4 m below pycnocline, mid-deep layer + 20% replication	April, July, August, September	2.5 L Niskin (April); 5 L GO-FLO sampling bottle (July-Sept)
Sediment Quality				
Physical, particle size, nutrients, metals, total organic carbon (TOC)	1 x	n = 3/site	August; coincident with August marine survey	Petite Ponar grab
Phytoplankton Biomass				
Chlorophyll *a*	3 x	n = 3/site @ 1 m below the surface	July, August, September; coincident with water quality surveys	2.5 L Niskin (April); 5 L GO-FLO sampling bottle (July-Sept)
Benthos				
Abundance and taxonomy	1 x	n = 5/site (3 subsamples/replicate)	August; coincident with August survey	Petite Ponar grab; 500 μm sieve

Table 2.3-2. 2011 Physical Oceanography Sampling Dates, Marine AEMP Expansion Program

Site	CTD and DO Sampling Date	Secchi Depth Sampling Date
RB1 (Roberts Bay)	23-Apr-11	n/c
	21-Jul-11	22-Jul-11
	14-Aug-11	14-Aug-11
	22-Sep-11	22-Sep-11
RB2 (Roberts Bay)	23-Apr-11	n/c
	22-Jul-11	22-Jul-11
	14-Aug-11	14-Aug-11
	22-Sep-11	22-Sep-11
REF-Marine 2 (Reference Bay)	n/c	n/c
	27-Jul-11	27-Jul-11
	19-Aug-11	19-Aug-11
	n/c	25-Sep-11

DO - dissolved oxygen; n/c - not collected

Secchi depths were measured during July, August, and September to determine the light penetration at each site during the open-water season. A 30-cm white disk was placed over the shaded side of the boat and lowered until it disappeared from sight. It was raised into view and lowered until it disappeared a second time. This was recorded as the Secchi depth (D_s). The 1% ($Z_{1\%}$) euphotic zone depth was computed by first calculating the light extinction coefficient (k) from D_s, and then calculating the euphotic zone depth based on the appropriate light extinction coefficient. The 1% euphotic depth is the depth of the water column where 1% of the surface irradiance reaches. It represents the depth at which the integrated gross water column photosynthetic production is equivalent to the integrated gross water column respiration; thus, there is net photosynthesis above this depth. The 1% euphotic depth is often known as the compensation depth, and is calculated as follows (Parsons et al. 1984):

Light extinction coefficient:

$$\mathrm{k}\ (m^{-1}) = 1.7/D_s$$

Euphotic Depth (1%):

$$Z_{1\%}\ (m) = 4.6/\mathrm{k}$$

2.3.2 Water Quality

Water quality samples were collected at RB1 and RB2 during the under-ice season in April, and at all three AEMP Expansion sites during the open-water season in July, August, and September 2011. As much as possible, samples at a specific site were collected more than one month apart to conform to EEM recommendations (Environment Canada 2002a). Depths of water quality sampling were determined based on the water column structure (as determined by the CTD profiles initially collected at a specific site). At each site, four depths were sampled: 1 m below the surface, 4 m above the pycnocline, 4 m below the pycnocline, and at mid-depth of the deep layer. The pycnocline was defined as the depth zone where the density changed most sharply. Ultimately, the four depths were distributed to best approximate the water column structure as determined by the CTD profiles. The sampling dates and depths for all water quality sampling are presented in Table 2.3-3 and the analyzed parameters are summarized in Table 2.3-4. All sampling locations are presented in Figure 2.1-1. The sampling procedures used are described below.

Table 2.3-3. 2011 Water Quality Sampling Dates and Depths, Marine AEMP Expansion Program

Site	Sampling Date	Depth (m)
RB1 (Roberts Bay)	24-Apr-11*	1, 25, 33, 48
	22-Jul-11	1, 7, 15, 40
	14-Aug-11	1, 6, 14, 35
	22-Sep-11	1, 8, 21, 40
RB2 (Roberts Bay)	23-Apr-11*	1, 35, 44, 48
	22-Jul-11	1, 7, 15, 40
	14-Aug-11	1, 7, 15, 40
	22-Sep-11	1, 9, 21, 40
REF-Marine 2 (Reference Bay)	27-Jul-11	1, 8, 20, 38
	19-Aug-11	1, 6, 14, 40
	25-Sep-11	1, 8, 20, 40

** April surface water quality samples were collected from 1 m below the ice.*

In April, the underlying water was accessed through a hole following the temperature, CTD, and dissolved oxygen profiles. An adapted 2.5 L ‘skinny’ Niskin bottle was used to collect water during winter sampling. This bottle is designed to ‘trip’ and collect discrete samples during freezing temperatures. To avoid metal contamination, the tripping mechanism used acid-cleaned silicone tubing within the interior of the bottle. A dual rope system was used to achieve bottle closure and to ensure the collection of discrete samples. During the summer and fall sampling, all water samples were collected using an acid-washed 5 L GO-FLO sampling device. The GO-FLO was securely attached to a metred cable line and was then lowered to the appropriate sampling depth. It was allowed to equilibrate for one minute, at which time it was triggered closed using a brass messenger. The GO-FLO was then raised and brought into the boat for subsampling. Each GO-FLO cast represented one replicate.

Table 2.3-4. Marine AEMP Expansion Water Quality Parameters and Realized Detection Limits, Doris North Project, 2011

Parameter	Units	Realized Detection Limits	Parameter	Units	Realized Detection Limits
Physical Tests			***Total Metals*** (cont'd)		
Hardness (as $CaCO_3$)	mg/L	4.3	Copper (Cu)	mg/L	0.000050
pH	pH	0.10	Gallium (Ga)	mg/L	0.00050
Salinity (Electrical Conductivity)	g/L	1.0	Iron (Fe)	mg/L	0.010
Total Suspended Solids	mg/L	2.0 to 4.0	Lead (Pb)	mg/L	0.000050
Turbidity	NTU	0.10	Lithium (Li)	mg/L	0.020
Anions			Magnesium (Mg)	mg/L	1.0
Alkalinity, Total (as $CaCO_3$)	mg/L	2.0	Manganese (Mn)	mg/L	0.000050
Bromide (Br)	mg/L	5.0	Mercury (Hg)	mg/L	0.000010
Chloride (Cl)	mg/L	50	Mercury (Hg) (ultra low-level)	µg/L	0.00050
Fluoride (F)	mg/L	0.03 or 0.75	Molybdenum (Mo)	mg/L	0.0020
Sulphate (SO_4)	mg/L	50	Nickel (Ni)	mg/L	0.000050
Nutrients			Phosphorus (P)	mg/L	1.0
Ammonia (as N)	mg/L	0.0050	Potassium (K)	mg/L	20
Nitrate and Nitrite (as N)	mg/L	0.0060	Rhenium (Re)	mg/L	0.00050
Nitrate (as N)	mg/L	0.0060	Rubidium (Rb)	mg/L	0.0050
Nitrite (as N)	mg/L	0.0020	Selenium (Se)	mg/L	0.00040
Total Phosphorus	mg/L	0.0020	Silicon (Si)	mg/L	0.50
Cyanides			Silver (Ag)	mg/L	0.00010 or 0.00020
Total Cyanide	mg/L	0.0010	Sodium (Na)	mg/L	20
Free Cyanide	mg/L	0.0010 or 0.0050	Strontium (Sr)	mg/L	0.010 or 0.050
Organics			Tellurium (Te)	mg/L	0.00050
Total Organic Carbon	mg/L	0.50	Thallium (Tl)	mg/L	0.000050
Total Metals			Thorium (Th)	mg/L	0.00050
Aluminum (Al)	mg/L	0.0050	Tin (Sn)	mg/L	0.0010 or 0.0020
Antimony (Sb)	mg/L	0.00050	Titanium (Ti)	mg/L	0.0050
Arsenic (As)	mg/L	0.0004	Tungsten (W)	mg/L	0.0010
Barium (Ba)	mg/L	0.0010	Uranium (U)	mg/L	0.000050
Beryllium (Be)	mg/L	0.00050	Vanadium (V)	mg/L	0.00050
Bismuth (Bi)	mg/L	0.00050	Yttrium (Y)	mg/L	0.00050
Boron (B)	mg/L	0.10	Zinc (Zn)	mg/L	0.00080
Cadmium (Cd)	mg/L	0.000020	Zirconium (Zr)	mg/L	0.00050
Calcium (Ca)	mg/L	0.50	***Speciated Metals***		
Cesium (Cs)	mg/L	0.00050	Methylmercury (Total)	µg/L	0.000050
Chromium (Cr)	mg/L	0.00010 to 0.00050	***Radiochemistry***		
Cobalt (Co)	mg/L	0.000050	Radium-226	Bq/L	0.005

Subsamples for the various water quality parameters (e.g., physical parameters/major ions, nutrients, and total metals) were drawn from the GO-FLO/Niskin bottles. All sample bottles were rinsed three times prior to filling with care being taken not to bring the bottle or cap into contact with the plastic spigot or other possible sources of contamination. The appropriate preservatives provided by the analytical laboratory (ALS Laboratory Group, Burnaby, British Columbia) were added in the field after collection.

All samples were kept cold and in the dark while in the field and were refrigerated at camp prior to transport. Samples were transported in coolers with freezer packs to ALS, Burnaby for all analyses. The parameters analyzed and applicable detection limits are summarized in Table 2.3-4.

All water quality parameters were screened against the Canadian Council of the Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life (CCME 2011a).

2.3.3 Sediment Quality

Sediment quality samples were collected at RB1 (Roberts Bay) and REF-Marine 2 (Reference Bay) during the open-water season in August 2011. This sampling coincided with benthic invertebrate sampling. The sampling dates and depths for each of the two sites are presented in Table 2.3-5 and the analyzed parameters are summarized in Table 2.3-6. All sampling locations are presented in Figure 2.1-1. The sampling procedures are described below.

Table 2.3-5. 2011 Sediment Quality and Benthic Invertebrate Sampling Dates and Depths, Marine AEMP Expansion Program

Site	Sampling Date	Depth (m)
RB1 (Roberts Bay)	23-Aug-10	42
REF-Marine 2 (Reference Bay)	24-Aug-10	42

Table 2.3-6. Marine AEMP Expansion Sediment Quality Parameters and Realized Detection Limits, Doris North Project, August 2011

Parameter	Units	Realized Detection Limits	Parameter	Units	Realized Detection Limits
Moisture	%	0.25	***Metals*** **(cont'd)**		
pH	pH	0.10	Cobalt (Co)	mg/kg	0.10
Particle Size			Copper (Cu)	mg/kg	0.50
% Gravel (>2 mm)	%	0.10	Iron (Fe)	mg/kg	50
% Sand (2.0 mm - 0.063 mm)	%	0.10	Lead (Pb)	mg/kg	0.50
% Silt (0.063 mm - 4 µm)	%	0.10	Lithium (Li)	mg/kg	1.0
% Clay (<4 µm)	%	0.10	Magnesium (Mg)	mg/kg	20
Nutrients			Manganese (Mn)	mg/kg	1.0
Total Nitrogen	%	0.020	Mercury (Hg)	mg/kg	0.0050 or 0.015
Organic / Inorganic Carbon			Molybdenum (Mo)	mg/kg	0.50
Total Organic Carbon	%	0.10	Nickel (Ni)	mg/kg	0.50
Plant Available Nutrients			Phosphorus (P)	mg/kg	50
Available Ammonium-N	mg/kg	1.6 or 2.4	Potassium (K)	mg/kg	100
Available Nitrate-N	mg/kg	4.0 or 6.0	Selenium (Se)	mg/kg	0.20
Available Nitrite-N	mg/kg	0.80 or 1.2	Silver (Ag)	mg/kg	0.10

(continued)

Table 2.3-6. Marine AEMP Expansion Sediment Quality Parameters and Realized Detection Limits, Doris North Project, August 2011 (completed)

Parameter	Units	Realized Detection Limits	Parameter	Units	Realized Detection Limits
Available Phosphate-P	mg/kg	4.0 or 6.0	Sodium (Na)	mg/kg	100
Metals			Strontium (Sr)	mg/kg	0.50
Aluminum (Al)	mg/kg	50	Sulphur (S)	mg/kg	500
Antimony (Sb)	mg/kg	0.10	Thallium (Tl)	mg/kg	0.050
Arsenic (As)	mg/kg	0.050	Tin (Sn)	mg/kg	2.0
Barium (Ba)	mg/kg	0.50	Titanium (Ti)	mg/kg	1.0
Beryllium (Be)	mg/kg	0.20	Uranium (U)	mg/kg	0.050
Bismuth (Bi)	mg/kg	0.20	Vanadium (V)	mg/kg	0.20
Cadmium (Cd)	mg/kg	0.050	Zinc (Zn)	mg/kg	1.0
Calcium (Ca)	mg/kg	50	***Speciated Metals***		
Chromium (Cr)	mg/kg	0.50	Methylmercury	mg/kg	0.000050

Marine sediment quality samples were collected in triplicate using a Petite Ponar grab sampler, with replicates spaced 20 to 50 m apart. Each sediment sample was carefully transferred onto a white, plastic tray, and the top 2 cm of sediment was scraped into a bowl, homogenized, and then placed into two Whirl-Pak bags: one for grain size, and one for sediment chemistry. All samples were refrigerated (in darkness) until they were shipped to ALS in Yellowknife, NT, for analysis on the first available flight out of Doris camp.

All sediment quality parameters were screened against the CCME quality guidelines for the protection of aquatic life (CCME 2011b).

2.3.4 Phytoplankton

Phytoplankton biomass (as chlorophyll *a*) samples were collected at RB1 and RB2 in Roberts Bay during April, July, August, and late September. Samples were collected at REF-Marine 2 in Reference Bay in July, August, and late September. Triplicate samples were collected at 1 m depth using a 5 L GO-FLO water sampler. All samples were transferred into 1 L plastic bottles and stored in a cool, dark cooler until being returned to camp later in the day. Once at camp, the samples were filtered onto 0.45 μm filters, which were wrapped into aluminum foil, and stored frozen. Chlorophyll samples were hand carried to Vancouver, BC, to ensure they remained frozen and sent to ALS (Burnaby, BC) for analysis. The sampling dates are presented in Table 2.3-7 and all sampling locations are presented in Figure 2.1-1.

2.3.5 Benthos

Benthic invertebrate samples were collected during summer at the shallower AEMP site in Roberts Bay (RB1) and at the reference site in Reference Bay (REF-Marine 2). This coincided with the sediment quality sampling. All field sampling devices and methods for the AEMP Expansion benthos sampling were designed to comply with EEM guidance documents (Environment Canada 2002a). Sampling dates and depths for each of the two sites are presented in Table 2.3-5 and all sampling locations are indicated in Figure 2.1-1.

Samples were collected with a Petite Ponar dredge. To comply with EEM requirements, three separate subsamples were collected and pooled for each replicate sample, and five replicates were collected at each site. Each replicate was collected approximately 20 to 50 m apart. The Petite Ponar was carefully set open, lowered gradually onto the sediment using a metred cable line, and triggered closed. Once at the surface, each sediment sample was transferred into a 500 µm sieve bucket and rinsed with site-specific water until free of sediments. The material retained within the sieve was then placed into a labelled plastic jar and filled with 10% buffered formalin. All benthos samples were sent to Columbia Science (Courtney, BC) for enumeration and identification, and community descriptors were calculated as described below. Benthos density was calculated by dividing the total benthos counts by the surface area of the of the Petite Ponar sampler (0.023 m^2).

Table 2.3-7. 2011 Phytoplankton Biomass Sampling Dates and Depths, Marine AEMP Expansion Program

Site	Sampling Date
RB1 (Roberts Bay)	23-Apr-11 23-Jul-11 14-Aug-11 22-Sep-11
RB2 (Roberts Bay)	23-Apr-11 23-Jul-11 14-Aug-11 22-Sep-11
REF-Marine 2 (Reference Bay)	21-Jul-11 19-Aug-11 25-Sep-11

Several community descriptors were calculated from the taxonomic results, including benthos density, family richness, Simpson's Diversity and Evenness indices, and the Bray-Curtis Index. Cyclopoid and calanoid copepods were not included in the community metrics as they are generally planktonic. Nematodes and harpacticoid copepods were excluded as they are considered meiofauna (invertebrates between 63 µm and 500 µm) and were not adequately sampled using a 500 µm sieve bucket. Those organisms that could not be identified to at least the family level, and made up less than 2% of the benthos counts in each replicate, were also excluded from the community analysis. Family richness was calculated as the total number of benthic invertebrate families present in each replicate sample, and the Simpson diversity index was calculated as:

$$\textit{Simpson Diversity Index (D)} = 1 - \sum_{i=1}^{F} p_i^2$$

where F is the number of families present (i.e., family richness), and p_i is the relative abundance of each family calculated as n_i/N, where n_i is the number of individuals in family i, and N is the total number of all individuals. Simpson's Evenness Index was calculated as:

$$\textit{Simpson Evenness Index (E)} = 1/\sum_{i=1}^{F} p_i^2/F$$

A complete dissimilarity matrix was also generated that included pair-wise comparisons of all samples using the Bray-Curtis Index (Environment Canada 2002a). This index takes into account the number of families and the total number of individuals within each replicate sample and compares it to a single median reference community composition. This reference composition was generated from the median abundance of each represented family from all of the reference site replicates. Since the median reference composition was generated from the reference site replicates, the comparison of an actual reference site replicate community to the median reference community composition will produce a dissimilarity value (although generally a much lower value than exposure sites). Because the Bray-Curtis Index measures the percent difference between sites, the greater the dissimilarity value between a site and the median reference community, the more dissimilar those benthos communities are. This index is calculated as:

$$\textit{Bray-Curtis Index (BC)} = \sum_{i=1}^{n} |y_{i1} - y_{i2}| \ / \ \sum_{i=1}^{n} (y_{i1} + y_{i2})$$

where BC is the Bray-Curtis distance between sites 1 and 2, *n* is the total number of families present at the two sites, y_{i1} is the count for family *i* at site 1, and y_{i2} is the count for family *i* at site 2.

2.3.6 Quality Assurance and Quality Control (QA/QC)

A quality assurance and quality control (QA/QC) program was incorporated into the design of this study to track samples, account for within site variability, and identify potential sources of contamination from sampling equipment, sample transportation, or sample processing. This included the use of chain of custody forms, replicate samples, and sample blanks.

2.3.6.1 Water Quality QA/QC

All water quality samples were recorded on chain of custody forms before being sent to ALS laboratories. Replicate samples accounted for approximately 20% of water samples collected during each sampling period. These replicate samples were collected from multiple depths.

Equipment, field and travel blanks (13% of total samples) were processed and submitted with the water samples as part of the QA/QC program. These blanks identified potential sources of contamination to the field samples.

Equipment blanks were designed to identify possible contamination of the sampling equipment, including the sampling bottle (GO-FLO or Niskin). These were collected in the field by first thoroughly rinsing an acid-washed GO-FLO with double de-ionized water (provided by ALS), then filling the GO-FLO bottle with double de-ionized water. The water remained in the GO-FLO for one minute (as would occur with a real sample) until sub-samples were drawn from the sampling bottle. Equipment blanks were preserved and handled in the same manner as water quality samples.

Field blanks were designed to identify possible contamination from the exposure of the sample to ambient conditions at the sampling site. These were processed in the field by opening the bottles provided by ALS (containing double de-ionized water) and exposing the sample to ambient air for one minute. The bottles were preserved and handled in the same manner as water quality samples.

Travel blanks were designed to identify potential contamination from the transportation of samples from the sampling location to ALS laboratories. These bottles contained double de-ionized water and were provided by ALS. They were never opened in the field, and were returned to ALS with the other water quality samples. The blanks were analyzed for the same parameters as the regular water samples.

2.3.6.2 Sediment Quality QA/QC

The sediment quality QA/QC program included the use of chain of custody forms for all samples, and the collection of triplicate sediment samples at all sites to account for within-site variability.

2.3.6.3 Aquatic Biology QA/QC

Chain of custody forms were used for all aquatic biology samples. All samples had replication; triplicate samples were taken for chlorophyll *a* analysis (phytoplankton biomass), and five replicates of three composite samples were collected for benthos. Additional QA/QC measures were used by the benthos taxonomist to ensure consistent and accurate sorting of benthos samples. These procedures are outlined below.

Benthos Sorting QA/QC

As part of the QC program, the re-sorting of benthic sample residues was conducted on a randomly selected 10% of the benthos samples to determine the level of sorting efficiency. The criterion for an acceptable sorting was that more than 90% of the total number of organisms found in both the initial and QA/QC sort were recovered during the initial sort, as required by Environment Canada for invertebrate community surveys (Environment Canada, 2002b). This was calculated by the following equation:

$$\%\ \textit{Sorting Efficiency} = [1 - (\#\ \textit{in QA/QC re-sort} \ / \ (\#\ \textit{sorted originally} + \#\ \textit{QA/QC resort}))] \times 100$$

Any sample not meeting the 90% removal criterion was re-sorted a third time. The 90% minimum efficiency was attained for all benthos samples in this study.

3. Results

3. Results

3.1 PHYSICAL OCEANOGRAPHY AND LIGHT PENETRATION

Figures 3.1-1 to 3.1-3 provide graphical results of temperature, salinity, and dissolved oxygen. Table 3.1-1 provides a summary of measured Secchi depths, euphotic zone depths, and pycnocline depths. All raw data are provided in appendices, and a summary of the results is provided below.

Table 3.1-1. Marine AEMP Expansion Secchi Depths, Euphotic Zone Depths, and Estimated Pycnocline Depths, Doris North Project, 2011

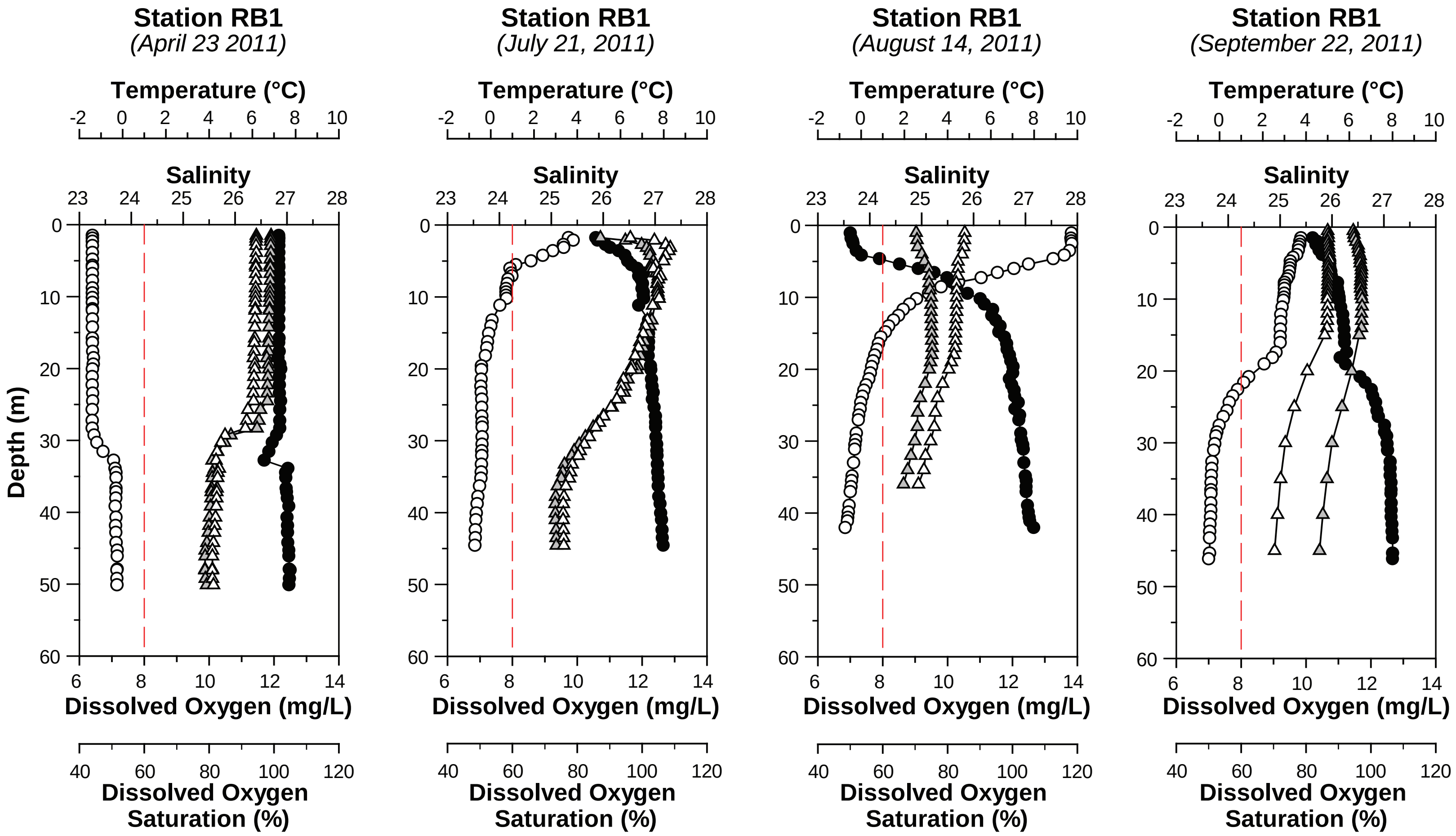
Site	Depth (m)	Secchi Depth (m)			Euphotic Zone Depth (m)			Pycnocline Depth (m)*		
		July	August	September	July	August	September	July	August	September
Roberts Bay										
RB1	42	7	11.3	11	18.9	30.6	29.8	6.0	10.2	17.4
RB2	71	7.9	14.3	10.5	21.4	38.7	28.4	6.6	7.2	22.2
Reference Bay										
REF-Marine 2	42	7.1	6.6	6	19.2	17.9	16.2	5.2	3.0	26.9

** Pycnocline depths are estimates where the deepest portion of the surface density gradient was selected.*

In April, the Roberts Bay water column was weakly stratified below the snow and ice, with a deep mixed layer extending to 30 m. The surface salinity was near 26.8, and increased little to 27.1 below 30 m. April water temperatures were approximately -1.4°C to -1.3°C in the upper 30 m and -0.60°C to -0.25°C in bottom waters. Dissolved oxygen concentrations reached 11.9 mg/L just below the sea ice and declined steadily to 9.2 mg/L in deeper waters.

During the summer, vertical stratification intensified in Roberts and Reference bays due to melting sea ice and increased riverine inputs. The influx of freshwater resulted in shallower pycnoclines (range: 3-10 m) with warmer, fresher water (lower density) sitting above colder, saltier (higher density) water at depth. The surface layer salinities were between 23 and 24 in July and August, with deep water salinities near 27.1. Temperatures were warmest in the surface water during August, reaching 10°C. Dissolved oxygen concentrations were lowest during this month, with a maximum surface concentration of 9.53 mg/L in Robert Bay, and a minimum deep water concentration of 6.63 mg/L in Reference Bay (41 m). This was below the recommended CCME marine water quality guideline for the protection of aquatic life (8.0 mg/L). The dissolved oxygen minimum in Roberts Bay was 8.24 mg/L at 60 m and was within the natural range for healthy coastal waters.

The strong summer stratification lasted approximately two months before the higher winds and lower temperatures in September began to mix the stable surface layer. Very strong winds were present during the September sampling and Roberts and Reference bays were laterally well mixed, with vertical mixed layer depths reaching 20 m in Roberts Bay and extending to 25 m in Reference Bay. Surface salinities increased during this period, ranging from 25.6 to 25.8. The surface temperatures ranged from 3.2°C to 3.8°C. Deep water temperatures and salinities were very similar to those in the winter and summer, approaching -0.6°C and 27.4. Dissolved oxygen concentrations reached 11.7 mg/L in the surface waters of Roberts Bay, and were 10.2 mg/L at depth.



Notes: Dashed lines represent the CCME interim water quality guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).

- ● Salinity
- ○ Temperature (°C)
- ▲ Dissolved Oxygen (mg/L)
- △ Dissolved Oxygen Saturation (%)

Figure 3.1-1

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Temperature, Salinity, and Dissolved Oxygen Profiles at Marine AEMP Expansion Site RB1, 2011

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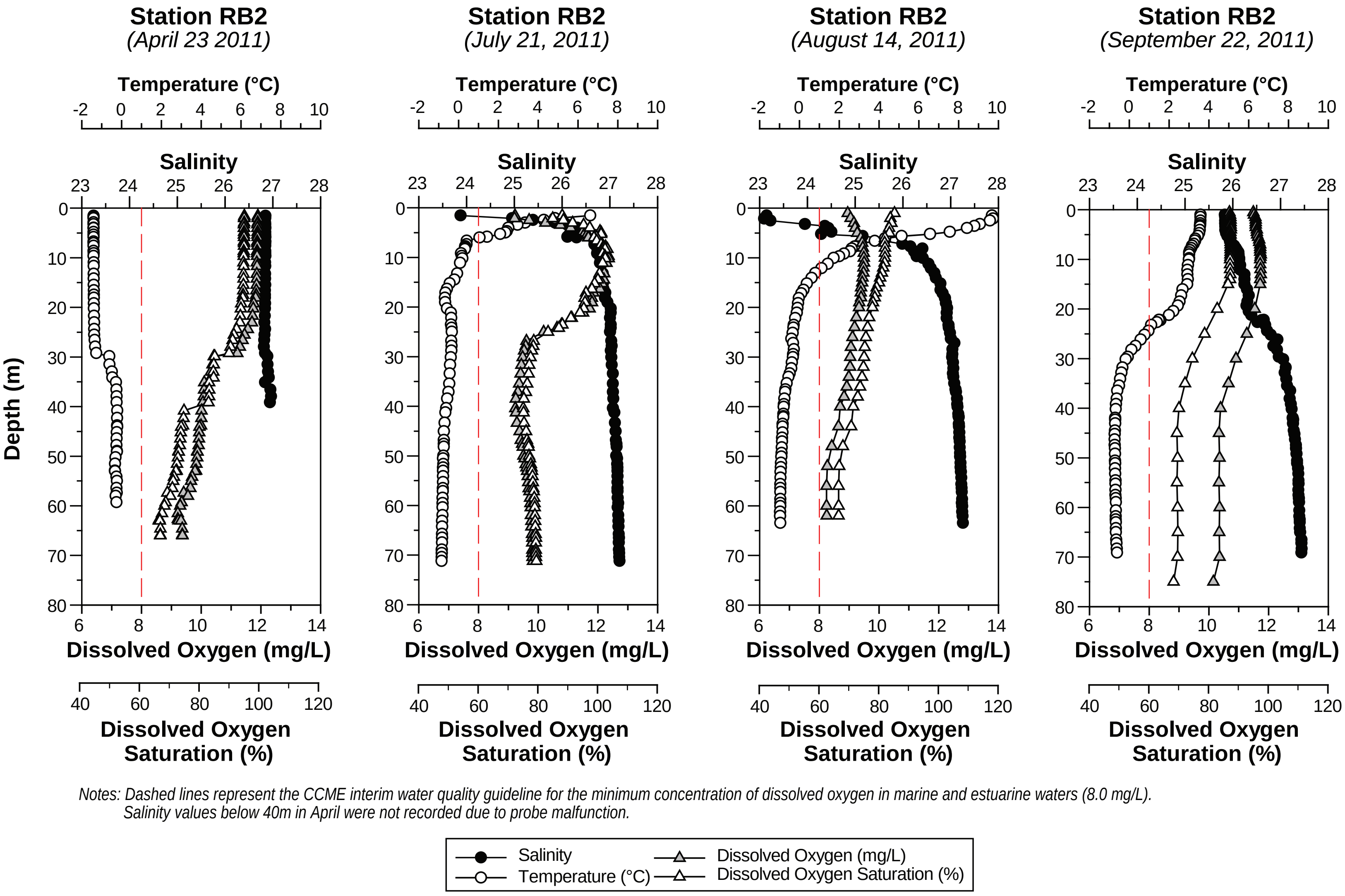

Notes: Dashed lines represent the CCME interim water quality guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).
Salinity values below 40m in April were not recorded due to probe malfunction.

Figure 3.1-2

NEWMONT NORTH AMERICA

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine AEMP Expansion Site RB2, 2011

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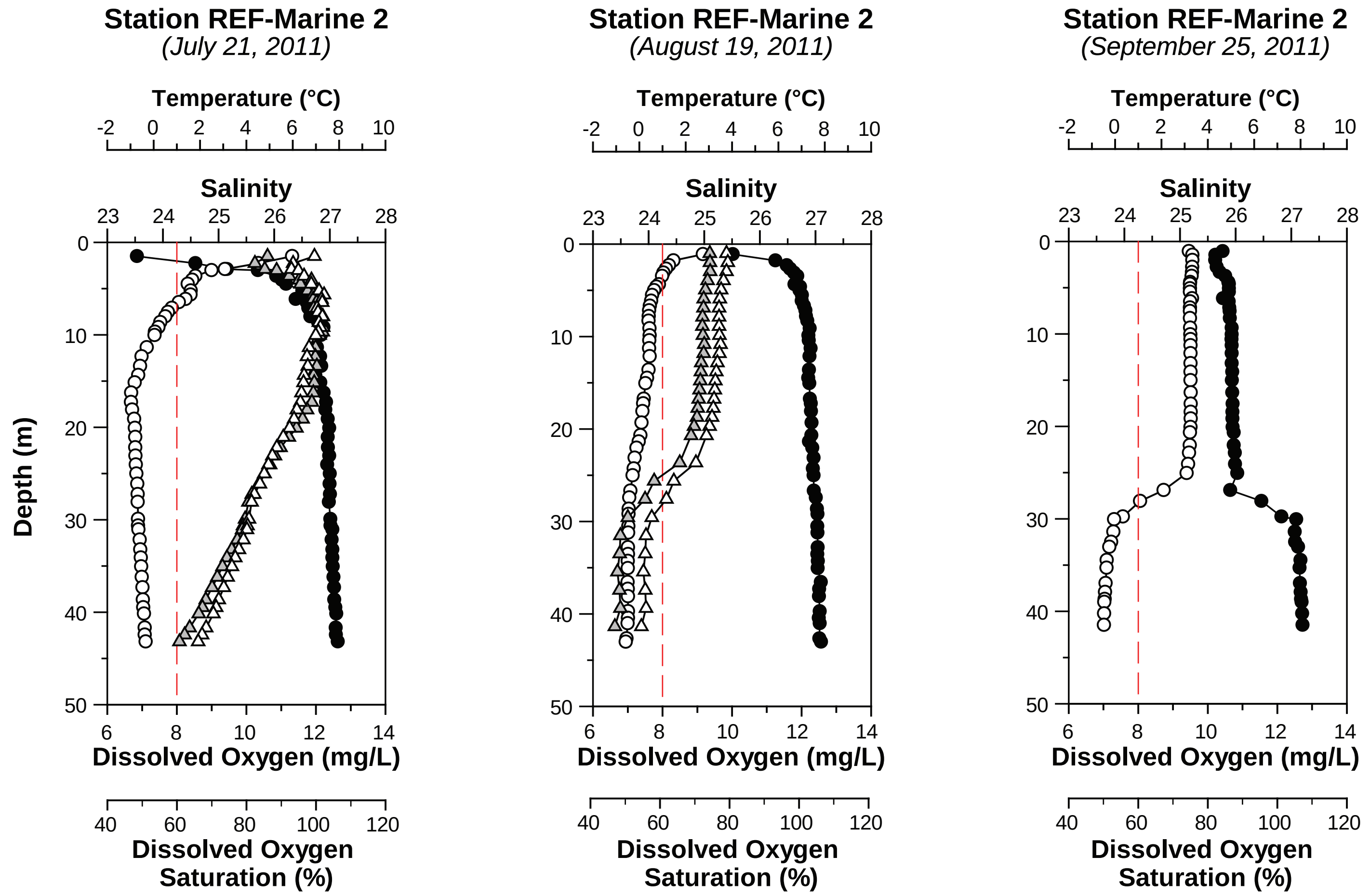


Notes: Dashed lines represent the CCME interim water quality guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).
April profiles were not collected and dissolved oxygen values are missing in September due to probe malfuntion.

● Salinity	△ Dissolved Oxygen (mg/L)
○ Temperature (°C)	△ Dissolved Oxygen Saturation (%)

Figure 3.1-3

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine AEMP Expansion Site REF-Marine 2, 2011

Light penetration was high during the summer and fall in both Roberts and Reference bays. The euphotic depth (1% light level) was generally deeper than 16 m and usually extended far below the pycnocline. This suggests that net photosynthesis was possible throughout the upper water column in both bays.

3.2 WATER QUALITY

All water quality parameters with CCME guidelines are presented graphically in Figures 3.2-1 to 3.2-10 and all raw water quality data and QA/QC results are in Appendices 3.2-1 and 3.2-2. All water quality parameters with CCME guidelines are presented graphically in Figures 3.2-1 to 3.2-10 and all raw water quality data are in Appendix 3.2-1.

Overall, the water quality parameters were similar between Roberts Bay and Reference Bay. pH averaged 7.8 across all sites and depths in winter and 7.9 in summer. Water clarity was high in both bays as total suspended solids (TSS) and turbidity levels were consistently low (mean: 0.46 NTU). Some nutrients showed vertical concentration gradients, which were most dramatic during July and August. Nitrate and total phosphorus concentrations were generally lower at the surface than in deep waters. During summer, nitrate was usually undetectable (>0.006 mg N/L) in the surface layer, while total phosphorus was detectable throughout the water column, averaging 0.038 mg/L over all sites and depths. Thus, phytoplankton growth was likely controlled by nitrogen availability when sufficient light was present, which is typical of northern, estuarine systems. Vertical gradients of total organic carbon (TOC) exhibited the opposite trend as nutrients as the summer surface concentrations were usually slightly higher than at depth. Vertical gradients characterized by lower nutrients and higher TOC at the surface than at depth are indicative of phytoplankton growth and biological nutrient uptake.

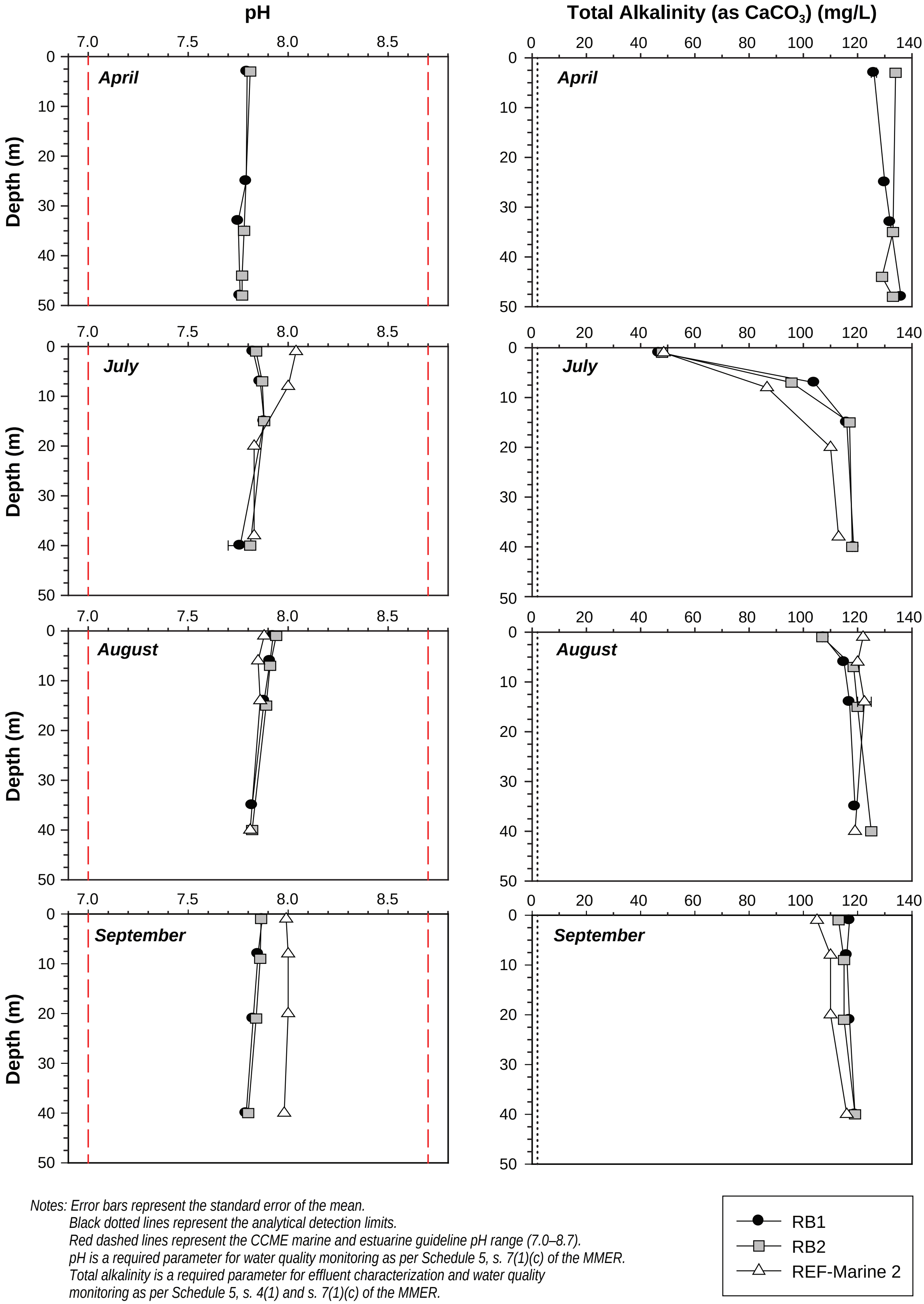
Roberts Bay and Reference Bay can be considered low-metal environments, as all water quality parameters were below their respective CCME guideline for the protection of marine aquatic life. Total aluminum and iron were below detection at all depths in April and often above detection during the open-water season indicating that aerial and riverine transport were responsible for delivering these metals into Roberts and Reference bays. Cadmium, molybdenum, and nickel tended have lower concentrations in the surface waters than at depth, suggesting biological uptake or dilution from freshwater inputs. Trace amounts of radium-226 were found at all sites during most seasons, except in southern Roberts Bay in August and September. The highest concentration occurred in Reference Bay in July (0.02 mg/L at 20 m). Total lead and zinc concentrations were usually below analytical detection limits.

Total cyanide was commonly observed at low concentrations during the surveys. The highest concentrations were found in July in the surface waters of Roberts (0.0021 mg/L) and Reference (0.0019 mg/L) bays, and detectable levels were found throughout the Roberts Bay water column in April. Free cyanide made up a very small proportion of the total cyanide pool as there was little detectable free cyanide in either bay.

3.3 SEDIMENT QUALITY

Graphical results of sediment quality data are provided in Figures 3.3-1 through 3.3-3. All raw data are provided in appendices, and a summary of the results is provided below.

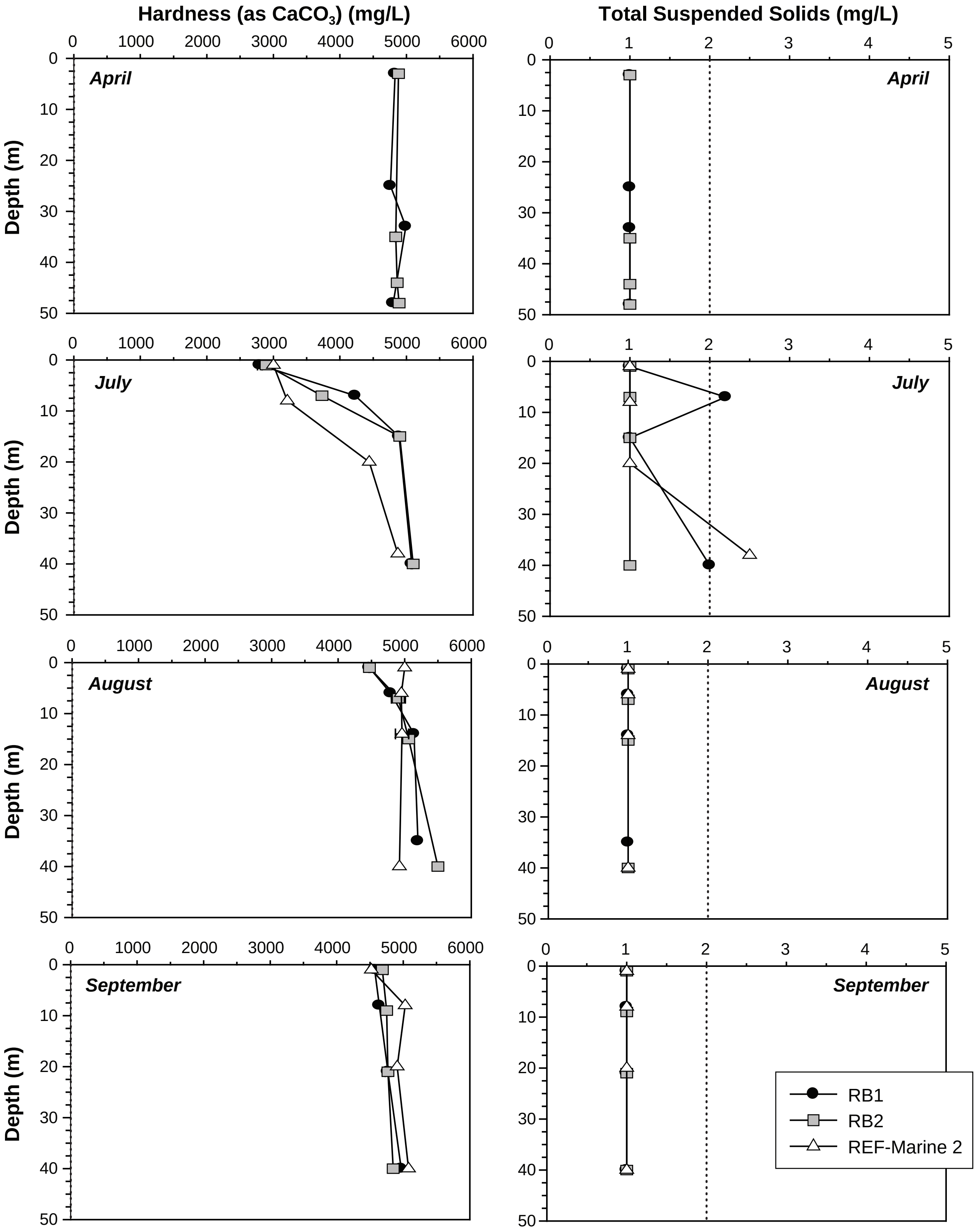
All sediment quality parameters were screened against the CCME sediment quality guidelines for the protection of aquatic life (CCME 2011b). Summaries of CCME exceedances can be found in Tables 3.3-1 and 3.3-2.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits.
Red dashed lines represent the CCME marine and estuarine guideline pH range (7.0–8.7).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

Figure 3.2-1

pH and Total Alkalinity at Marine AEMP Expansion Sites, 2011



Notes: Error bars represent the standard error of the mean.

Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.

The CCME marine guideline for total suspended solids is dependent upon background levels.

Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Hardness and Total Suspended Solids at Marine AEMP Expansion Sites, 2011

Figure 3.2-2

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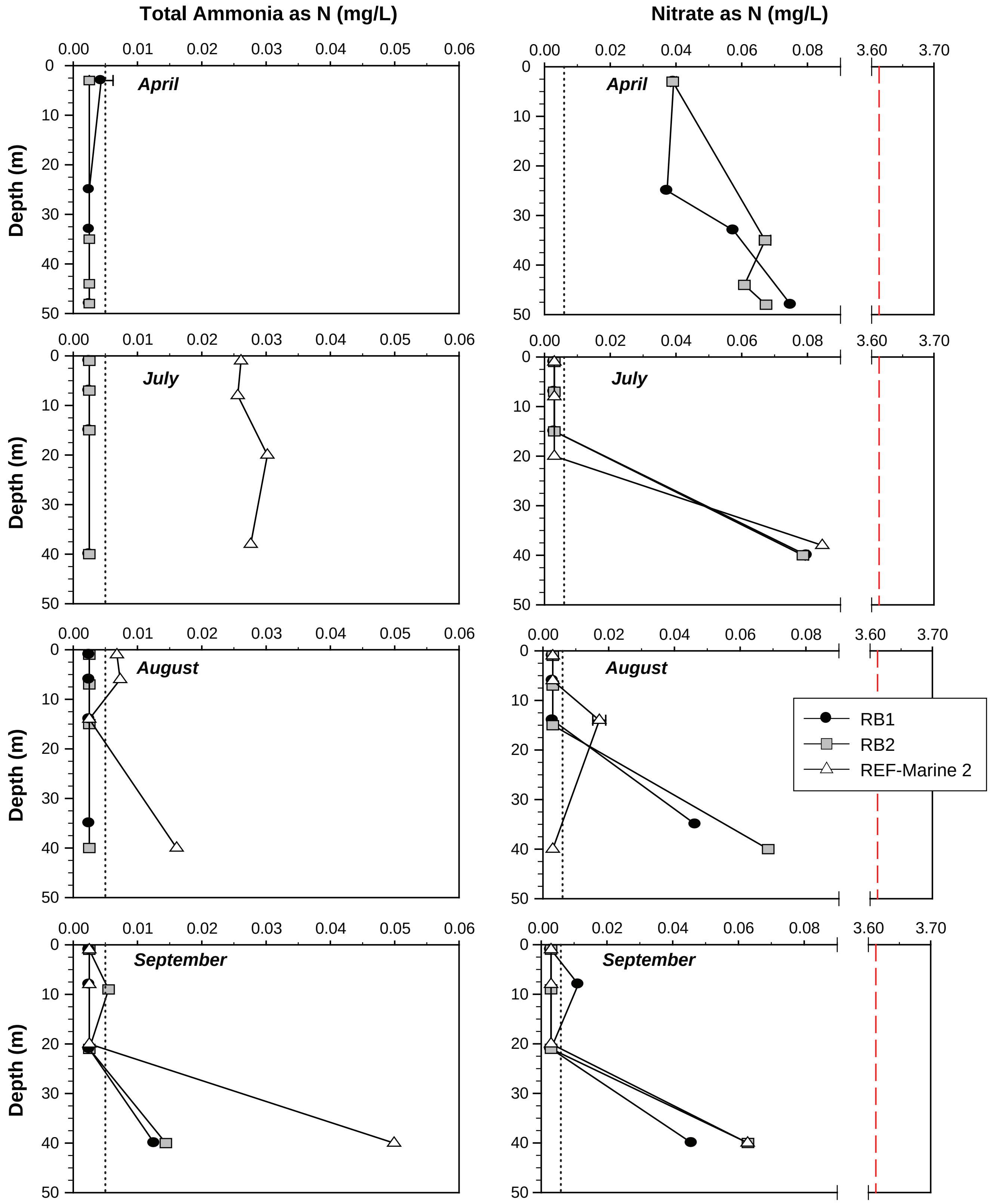

Notes: Error bars represent the standard error of the mean.

Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.

Red dashed line represents the interim CCME marine guideline for nitrate as N (3.612 mg/L).

Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia and Nitrate Concentrations at Marine AEMP Expansion Sites, 2011

Figure 3.2-3

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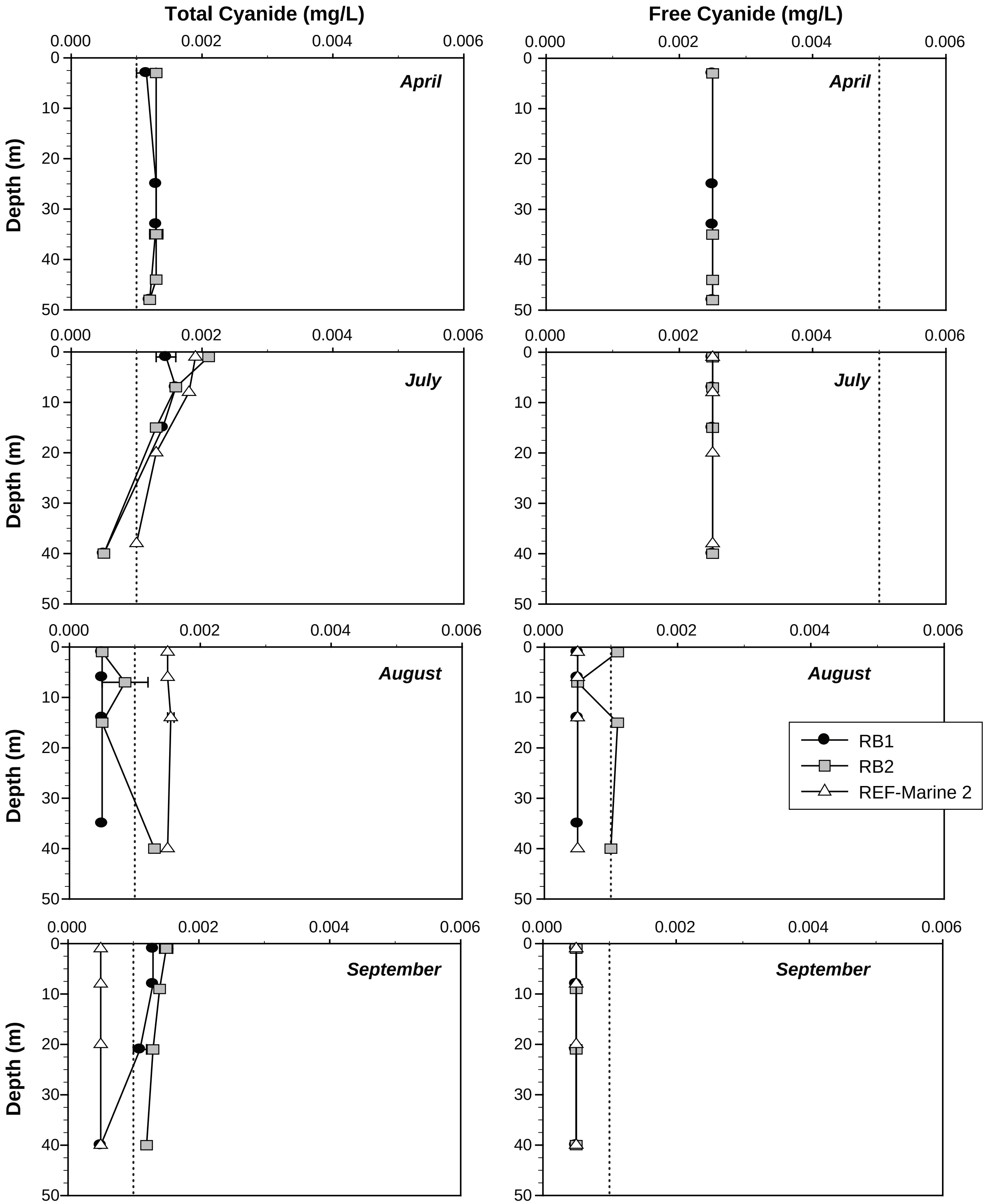


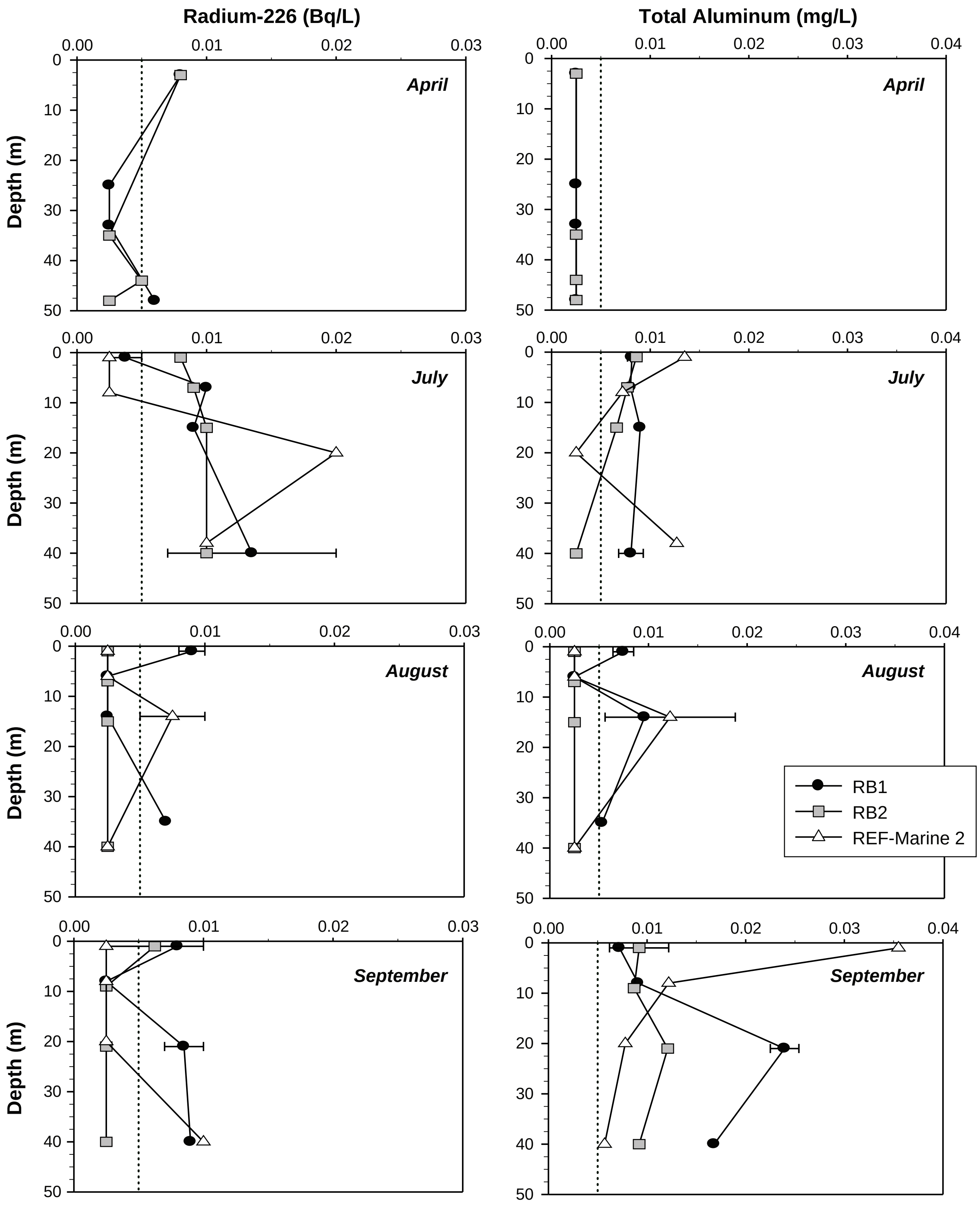
Notes: Error bars represent the standard error of the mean.

Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.

Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

Figure 3.2-4

Total Cyanide and Free Cyanide Concentrations at Marine AEMP Expansion Sites, 2011



Notes: *Error bars represent the standard error of the mean.*

Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.

Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Radium-226 and Total Aluminum Concentrations at Marine AEMP Expansion Sites, 2011

Figure 3.2-5

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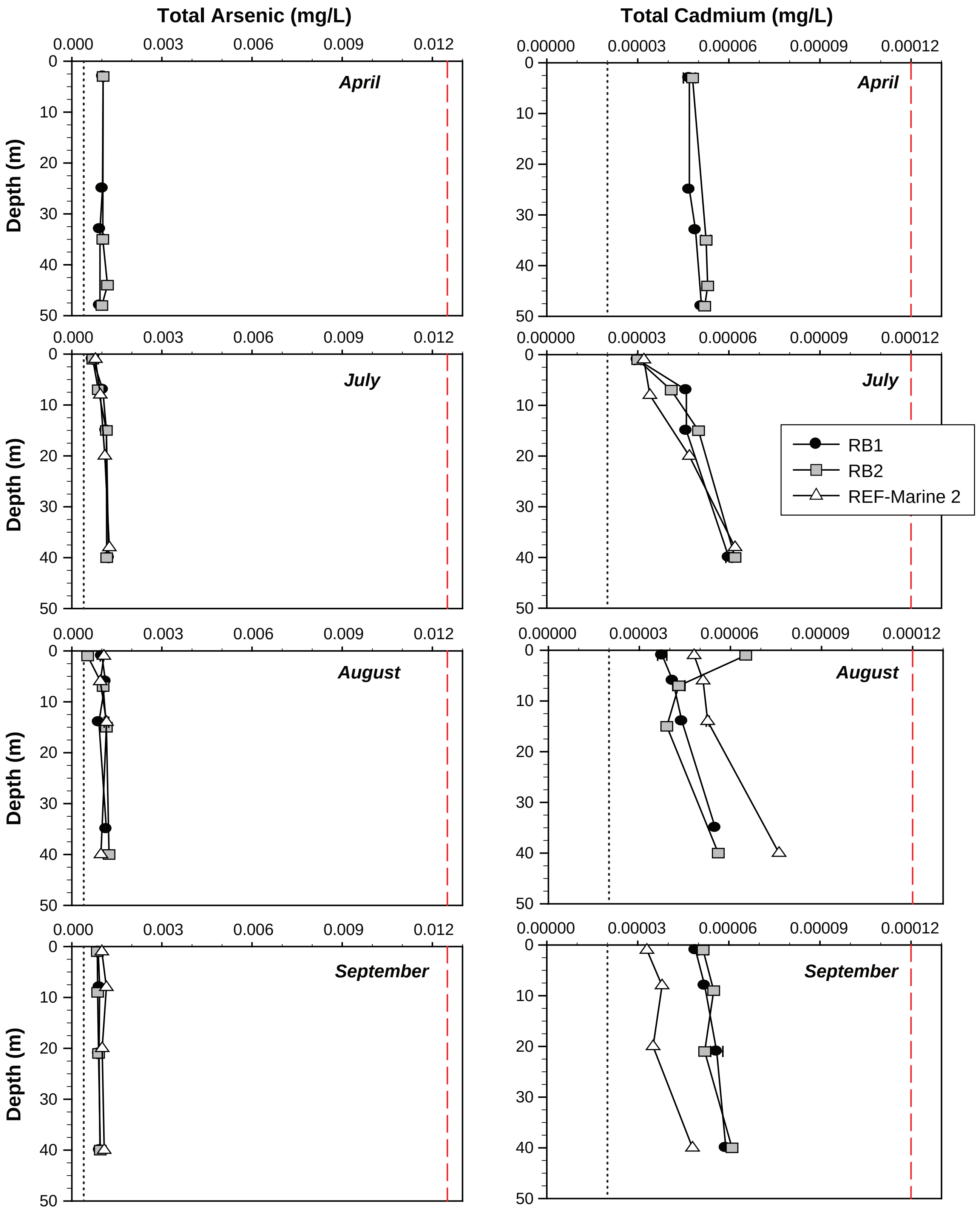

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the interim CCME marine guideline for arsenic (0.0125 mg/L) and the
CCME marine guideline for cadmium (0.00012 mg/L).
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Arsenic and Total Cadmium Concentrations at Marine AEMP Expansion Sites, 2011

Figure 3.2-6

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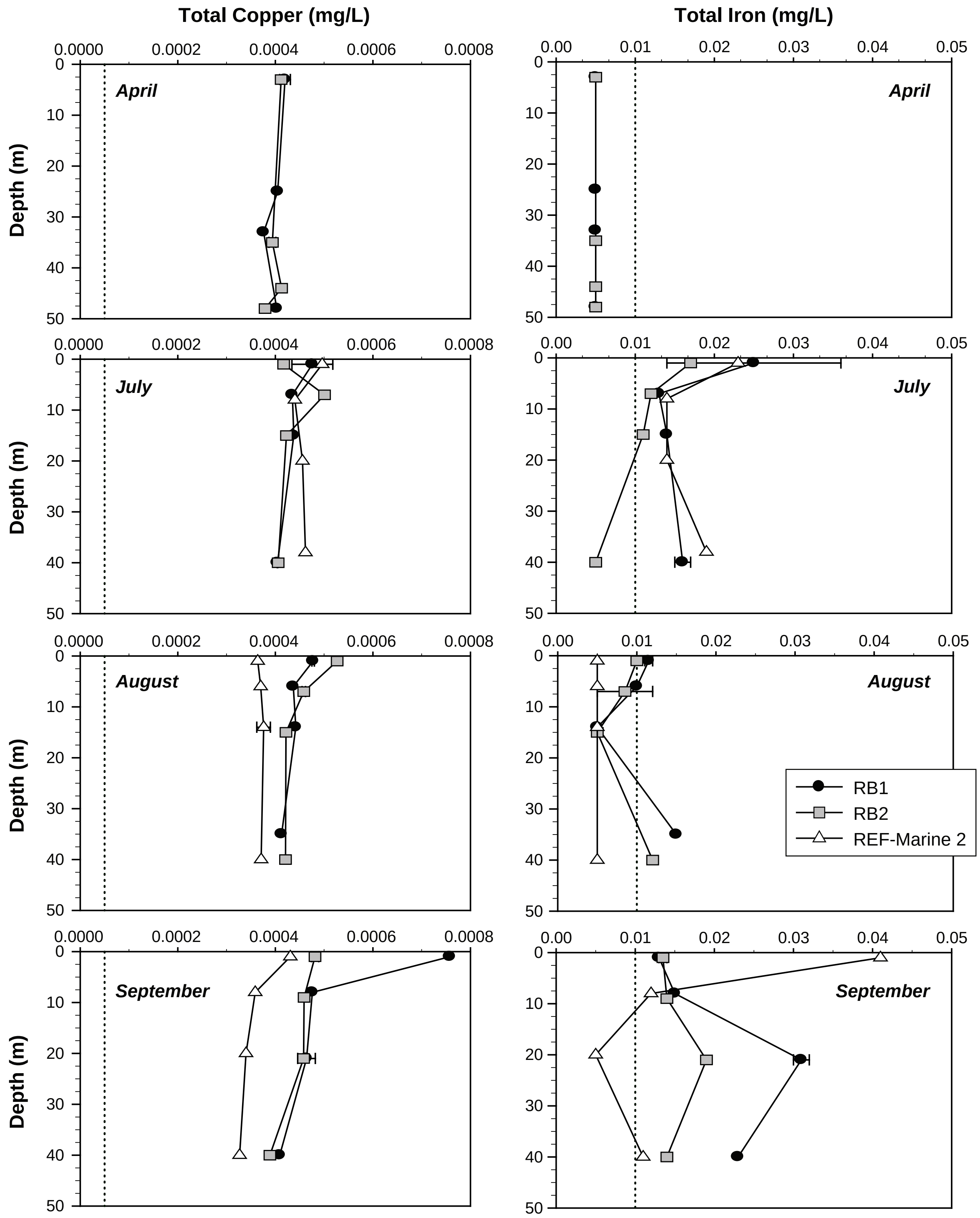

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Copper and Total Iron Concentrations at Marine AEMP Expansion Sites, 2011

Figure 3.2-7

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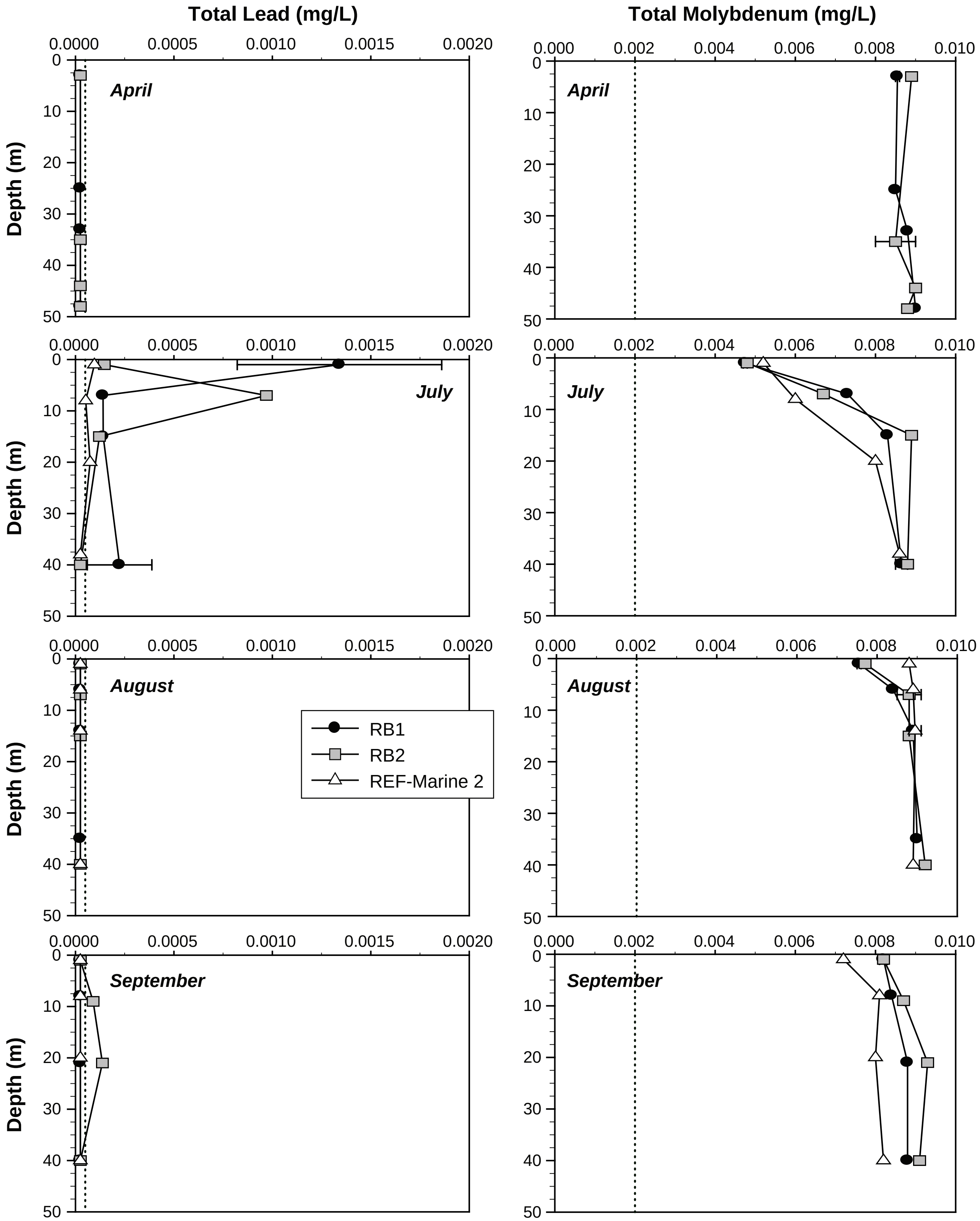

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Lead and Total Molybdenum Concentrations at Marine AEMP Expansion Sites, 2011

Figure 3.2-8

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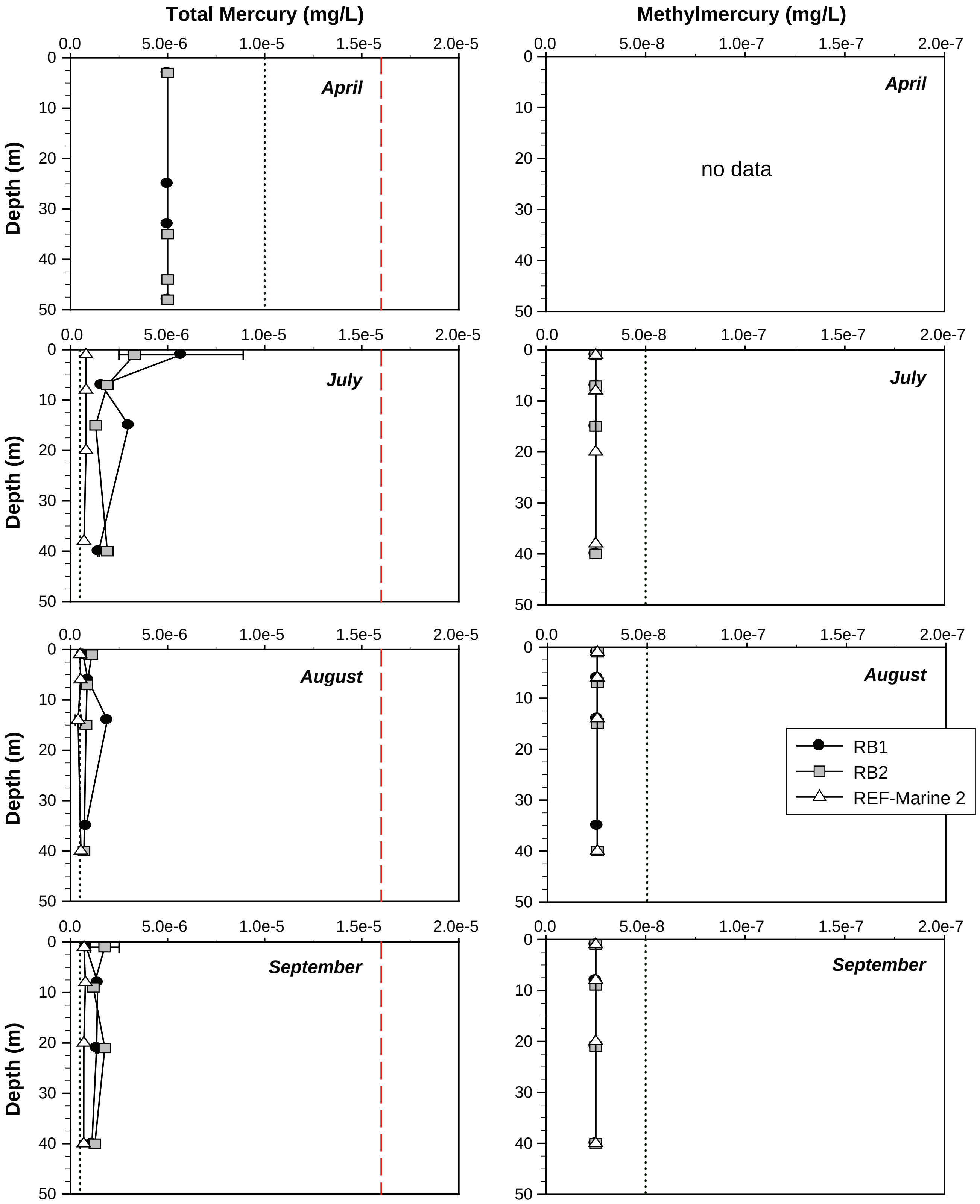

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed line represents the interim CCME marine guideline for inorganic mercury (0.000016 mg/L).
Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Mercury and Methylmercury Concentrations at Marine AEMP Expansion Sites, 2011

Figure 3.2-9

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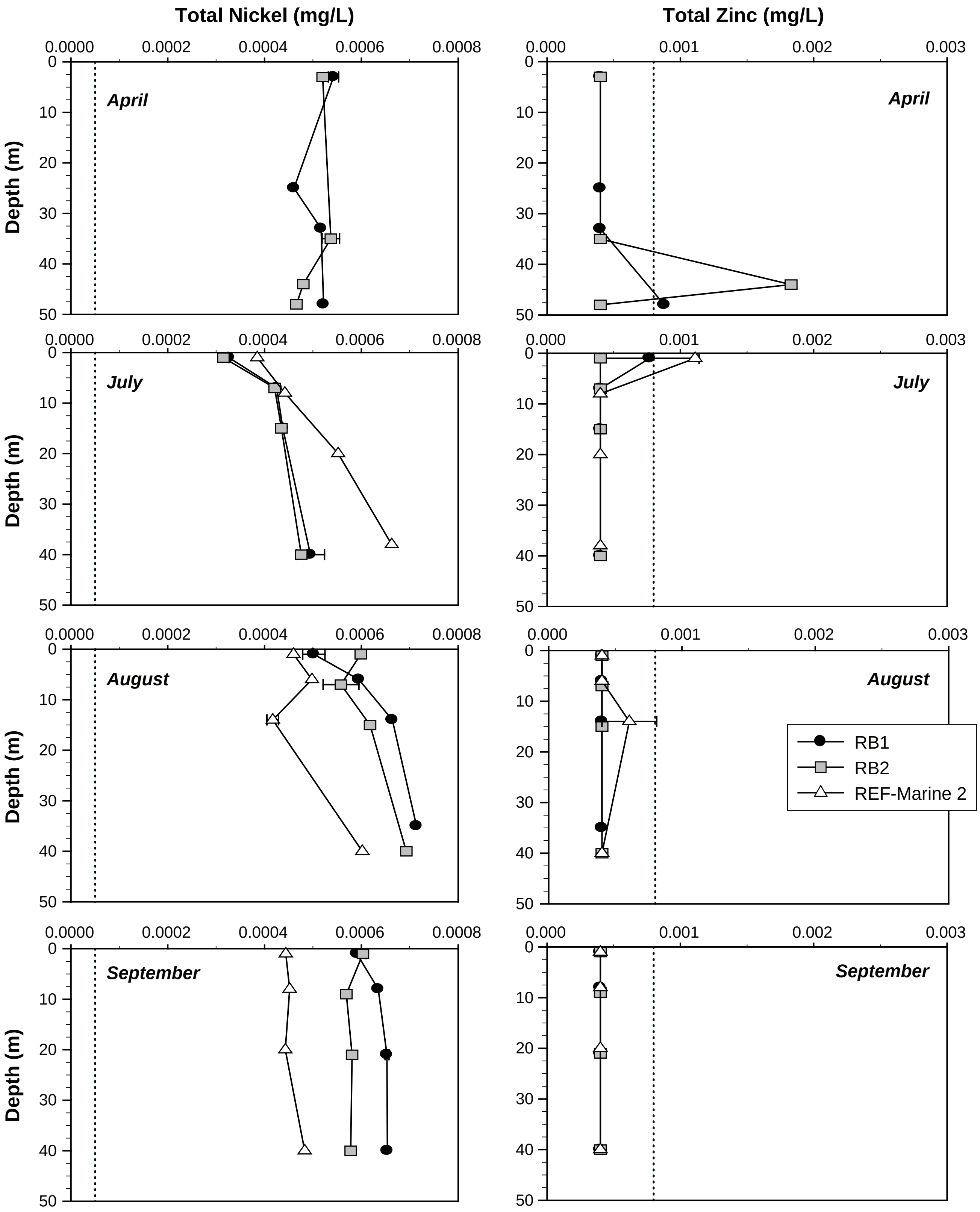

Notes: Error bars represent the standard error of the mean.

Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.

Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Nickel and Total Zinc Concentrations at Marine AEMP Expansion Sites, 2011

Figure 3.2-10

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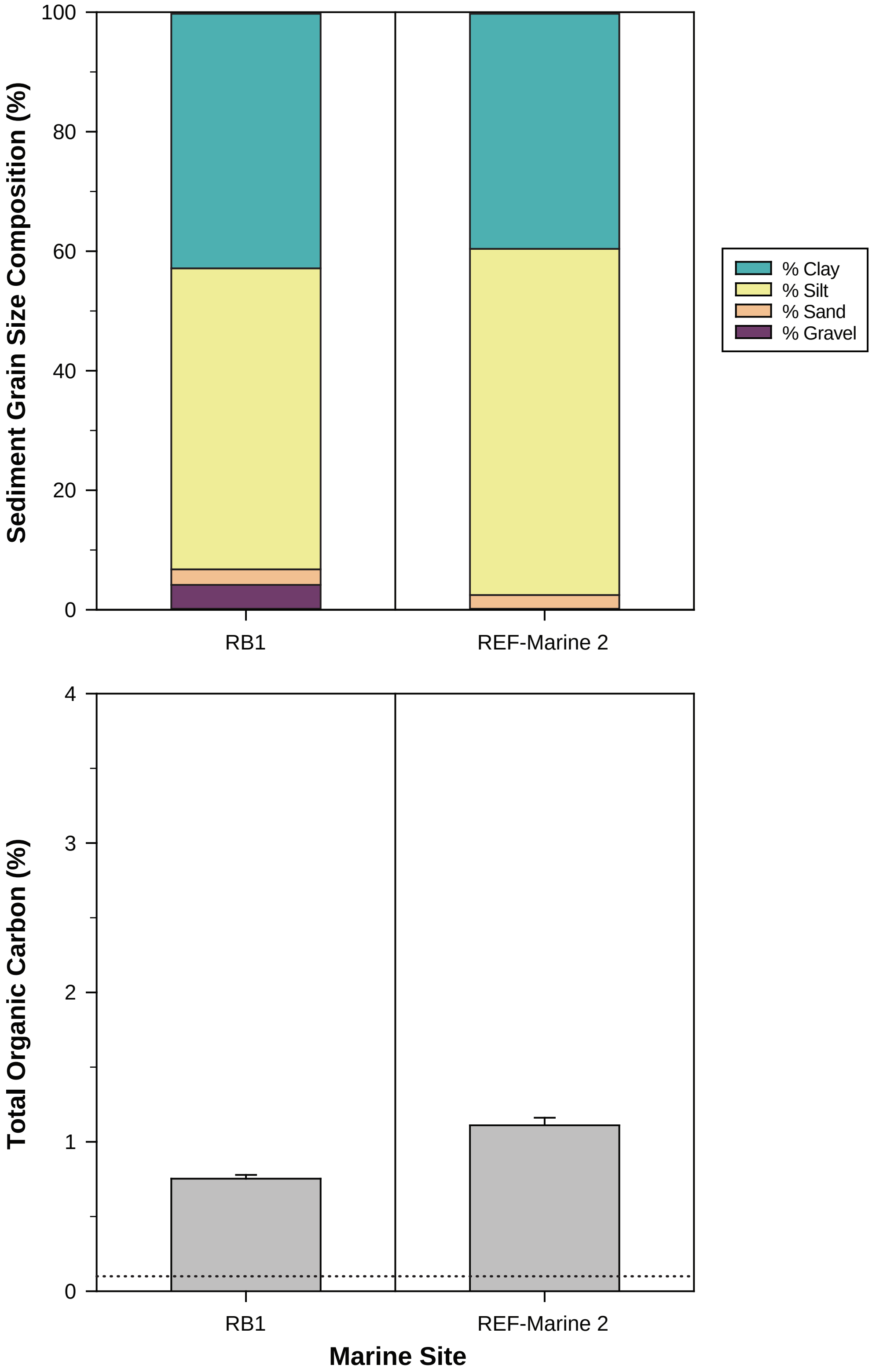

Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.
Black dotted line represents the analytical detection limit;
values below the detection limit are plotted at half the detection limit.

NEWMONT NORTH AMERICA

Grain Size and Total Organic Carbon Concentrations at Marine AEMP Expansion Sites, 2011

Figure 3.3-1

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