

Oceanographic Measurements from Ships of Opportunity, Minas Passage Study Site, July 2010 - January 2011

Submitted to:

Fundy Ocean Research Centre for Energy (FORCE)
January 31, 2011

Submitted by

*Envirosphere Consultants Limited
Windsor, Nova Scotia*

Author: Patrick L. Stewart, M.Sc.

Fundy Ocean Research Centre for Energy (FORCE)
Minas Basin Pulp and Power Company Limited
53 Prince Street
Hantsport, Nova Scotia B0P 1P0

Envirosphere Consultants Limited
P.O. 2906, Unit 5 – 120 Morison Drive
Windsor, Nova Scotia B0N 2T0
Tel: (902) 798-4022
Fax: (902) 798-2614.
www.envirosphere.ca

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
INTRODUCTION	1
METHODS	1
RESULTS AND DISCUSSION	3
CONCLUSIONS AND RECOMMENDATIONS	7
REFERENCES	7

EXECUTIVE SUMMARY

Oceanographic measurements were made on vessels of opportunity in Minas Passage in July, August, and October 2010 and January 2011, to obtain information on water transparency, suspended sediment, and water temperature. Observations were consistent with the seasonal pattern based on earlier observations for the site, which includes high transparency and low suspended sediment levels in summer, reaching low transparency and higher suspended sediment levels in winter. Sea surface temperature showed a late-summer peak, ranging from 16.3 -17.4° C. in August to a low of 3.5 - 4.1° C. in January; and suspended sediment levels ranged from 3.3 to 6.2 mg/L in July - August to levels of 9.4 to 12.5 mg/L in January. Secchi Depth, a measure of water transparency, ranged from 2.75 to 3.5 m in July and August respectively to a low of 1.5 m in January 2011.

INTRODUCTION

Nova Scotia's Bay of Fundy has the highest tides in the world and the greatest potential for generation of electricity from the tides. In 2008, in part to further its commitment to a sustainable energy future for Nova Scotians, the Province of Nova Scotia undertook to establish a research and test facility for tidal power technology development, selecting a local company, Minas Basin Pulp and Power Limited of Hantsport, Nova Scotia, to develop and execute the project. A location in Minas Passage near Cape Sharp was selected and after completion of environmental baseline studies and an environmental assessment, the project was given environmental approval in September 2009. The project has continued under the *aegis* of the newly formed Fundy Ocean Research Centre for Energy (FORCE), the organization constituted for and which is currently operating the project.

In addition to requirements for environmental data to support engineering and design, and regulatory environmental monitoring requirements, FORCE participates in and supports various related scientific studies designed to increase knowledge of the biology and physics of the Inner Bay of Fundy. As part of this role, baseline physical oceanographic measurements of water column temperature, salinity, turbidity and suspended sediment levels were obtained in the summer of 2008 and during the winter and summer of 2009 (Envirosphere Consultants Limited, 2009 & 2010). Several ship-board surveys in the vicinity of the site in 2010-2011 provided an opportunity to obtain additional data on suspended sediment levels, water transparency, and sea surface temperature at the site, information which is useful in understanding the physical oceanography and impacts of tidal projects on sedimentation, but for which there is a limited data record due to the difficult logistics and expense of sampling there. This report presents the results of sampling efforts carried out between July 2010 and January 2011.

METHODS

Sampling Methods

Opportunistic sampling was arranged to take place during vessel-based seabird surveys on July 19th and August 18th, 2010; on a fisheries survey on October 25-26, 2010; and on a geophysical cruise on January 15, 2011. Sampling was coordinated with times of overflights of the European Space Agency's *Envisat* satellite¹ through DFO, Ocean Sciences Division². On each survey, two stations were arranged to coincide with the project site, one on the incoming and one on the outgoing tide. An additional station on each sampling date, except for the October survey, was arranged to be at the vessel location at the time of the *Envisat* overflight. At each sampling location, Secchi Depth (a measure of transparency) was determined immediately upon reaching the station (or at the time of the satellite overpass) by lowering a standard 22 cm diameter Secchi Disk and noting the depth of disappearance and reappearance of the disk, with Secchi Depth reported as the average of the two measurements. A 10 L water sample was then taken in a clean bucket from over the side of the boat and temperature was immediately determined using a YSI Model 85 hand-held Dissolved Oxygen, Conductivity, and Temperature probe. The contents of the bucket were stirred and two, one-Litre samples were withdrawn for Suspended Particulate Matter (SPM) analysis. Bucket samples taken at

¹ The *Envisat* satellite carries MERIS, a programmable, medium-spectral resolution, imaging spectrometer operating in the solar reflective spectral range, which provides data which can be used to measure suspended sediment levels. Data obtained in the present survey provides ground-truthing for the satellite sensor.

² Times for the satellite overflight were provided by Dr. Gary Bugden, Fisheries and Oceans Canada, Ocean Sciences Division, Bedford Institute of Oceanography, and the results were routinely forwarded to him.

the surface in Minas Passage are representative of the water column, due to the high degree of vertical mixing occurring at the site, demonstrated in earlier surveys. Water samples were stored in a cooler and returned to the laboratory at the end of the survey, usually within 10 hours of sampling, and held at 2-8 °C. prior to analysis, which typically took place within 24 hours of delivery³. Position was logged from the vessel's positioning system. Time was measured by a digital watch which was checked to be accurate to within 15 seconds of the NRCan Time Signal broadcast (July & August); the consultant's watch likely to be accurate to within 5 minutes (October); and the geopositioning system, likely to be within a second of absolute time (January 2011). The accuracy of the thermometer in the YSI probe was determined in the lab to be within 0.1 °C of an NIST traceable thermometer with an accuracy of 0.05 °C.

Survey Details

July 19th and August 18th— Sampling was carried out by EnviroSphere Consultants Limited's technologist Matt MacLean, during seabird and marine mammal surveys on the *Lady Chantel*, a chartered lobster boat out of Scots Bay (Figure 1). One of the stations on each date was occupied at the time the *Envisat* satellite was directly overhead. Clear skies and good visibility on July 19th made for a good correlation with the satellite; while conditions early in the day on August 18th and at the time the overflight were foggy, although the skies cleared in the afternoon—consequently the observations may not be as useful.

October 26th—The survey vessel (MV *Carmelle* #2) conducted trawl and acoustic fish surveys from approximately 1930 hrs (ADT) on October 25 to around noon on October 26, 2010, during which the vessel was in the Minas Channel / Minas Passage area, departing from and docking in Hantsport. Fisheries biologist Norval Collins of CEF Consultants took water samples, and Secchi Depth and instrument measurements as per instructions and with equipment supplied. In the absence of a functioning satellite for this cruise, a third station was occupied in Minas Basin on the return trip to Hantsport (Figure 2, Table 1)

January 15th, 2011— Seaforth Geosurveys Inc. of Dartmouth, Nova Scotia, chartered the survey vessel *Fundy Spray* (Huntsman Marine Science Centre, St. Andrews) to conduct a geophysical (sidescan and underwater video) survey on Saturday, January 15, 2011, during which surface water samples were taken for Suspended Particulate Matter, and temperature and Secchi Depth were measured (Andrew Campbell, Marine Geologist, Seaforth Geosurveys) as per instructions and with equipment supplied (Figure 3). Water sampling took place from 1000 to 1420 hrs (AST), during which the vessel was in the Minas Channel/Minas Passage area. One of the samples coincided with the *Envisat* satellite overpass (1130 hrs versus the satellite overhead at 1121) but the weather, although calm, was overcast. High tide was at approximately 0804 hrs and low tide at 1425 hrs.

Laboratory Analysis

SPM measurements were obtained in the lab by filtering approximately 1 L of each sample (actual volume filtered was measured in a 1L graduated cylinder) through pre-rinsed (deionized water), pre-weighed Millipore 0.45 µm membrane filters, followed by 3 x 10 mL rinses with deionized water. Filters were dried for 1 hour at 65 °C. EnviroSphere Consultants Limited is accredited for this analysis by Canadian Association for Laboratory Accreditation (CALA).

³ The January 2011 samples reached the laboratory 72 hrs after sampling due to the travel time from St. Andrews, N.B. and were analysed 24 hrs later.

RESULTS AND DISCUSSION

Measurements made during the surveys provide additional information to assist in calibrating numerical models of suspended sediment distribution in Minas Passage, for which limited observational data, particularly in winter, is available. In addition, measurements coincident with the *Envisat* satellite overpass, provide ground-truthing to assist in improving predictions of suspended sediments levels and ocean temperature for the area based on satellite remote-sensing data. Sample locations are presented in Figures 1-3, and measurements obtained in the survey are presented in Table 1. Both the October and January sampling filled gaps for those months in the seasonal data record. Measurements were consistent with the seasonal pattern which is emerging for the site, which includes high transparency and low suspended sediment levels in summer, reaching low transparency and higher suspended sediment levels in winter. Sea surface temperature showed a late-summer (August) peak where temperatures ranged from a peak of 16.3 - 17.4° C. to a low of 3.5 - 4.1° C. in January (Table 1, Figure 4). Peak temperatures were comparable to those observed in earlier studies at the site, while temperature recorded in the January survey is not as low as has been recorded later in the winter (February-March) in previous surveys. Suspended sediment levels ranged from 3.3 to 6.2 mg/L in the July to August period with elevated January levels of 9.4 to 12.5 mg/L (Figure 5). January levels were below those observed in the earlier surveys in February – March, while the July to October levels were lower than observed previously for the same period. Secchi Depth as a measure of transparency ranged from 2.75 to 3.5 m in July and August to a low of 1.5 m in January 2011 (Table 1). All measurements of transparency were lower than the highest values measured at the study site (5.8 m at Station 19 in June 2009)(Figure 6).

Table 1. Oceanographic Measurements, Minas Passage and Minas Basin, July 2010 to January 2011.
 Values of duplicate samples for SPM are shown in brackets.

Date (m/d/y)	Station	Location	Time (ADT)	Secchi Depth (m)	Temperature (°C.)	SPM (mg/L)	Detection Limit (mg/L)
7/19/2010	19 (ebb)	45 22.28 64 25.32	1000	2.75	15.3	4.8 (4.6)	0.5
“	Satellite	45 23.06 64 33.17	1213	2.75	16.0	5.6 (4.0)	0.5
“	19 (flood)	45 22.32 64 25.36	1650	2.75	15.4	3.6 (6.2)	0.5
8/18/2010	19 (ebb)	45 22.098 ² 64 25.679	940 ¹	3.50	16.3	3.5 (3.3)	0.5
“	Satellite	45 22.92 64 30.62	1130	3.05	16.6	3.7 (3.7)	0.5
“	19 (flood)	45 22.098 ² 64 25.679	1730 ¹	3.25	17.4	3.3 (6.2)	0.5
10/26/2010	19 (ebb)	45 22.098 64 25.679 ²	0840	--	12.8	6.3 (4.2)	0.5
“	19 (flood)	45 22.098 64 25.679 ²	1105	2.0	12.9	6.1 (5.2)	0.5
“	Minas Basin	45 14.477 64 16.495	1230	--	13.1	6.2 (5.3)	0.5
1/15/2011	19 (ebb)	45 22.1132 64 25.7303	1000 (AST)	1.5	4.0	11.6 (12.5)	0.5
“	Satellite	45 21.9191 64 27.2292	1130 (AST)	1.5	4.1	9.7 (9.4)	0.5
“	19 (low)	45 22.0933 64 25.6753	1420 (AST)	1.5	3.5	11.1 (10.8)	0.5

1. Estimated. 2. Nominal position.

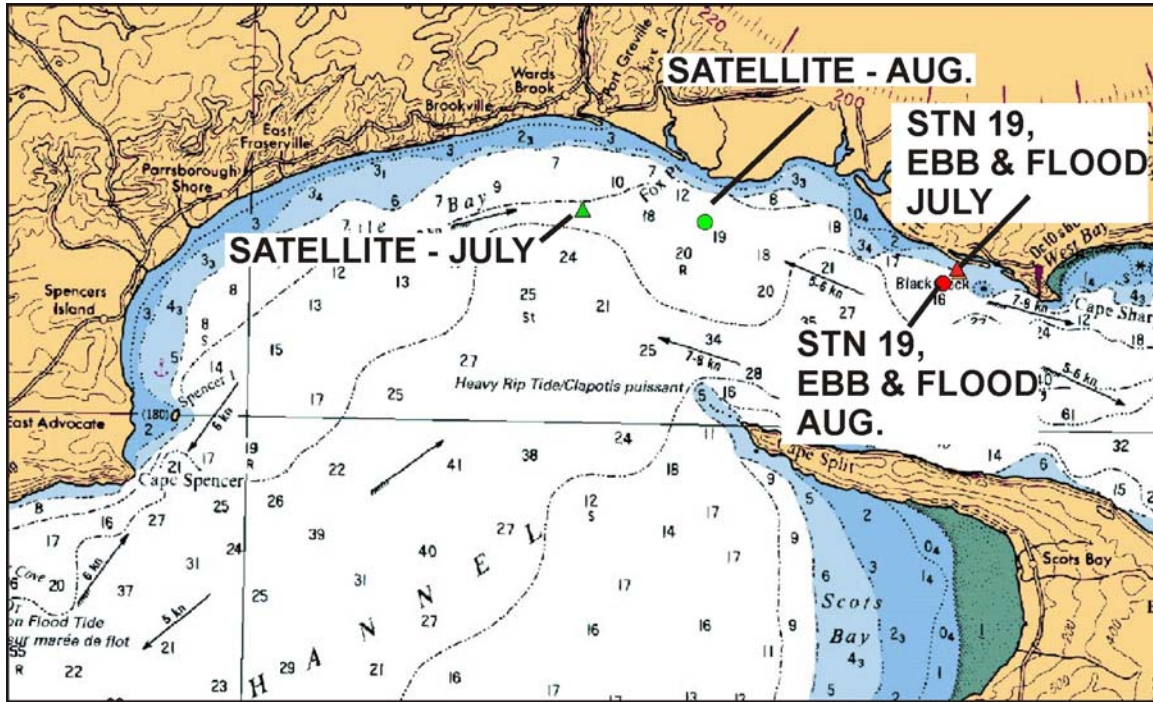


Figure 1. Sampling locations in Minas Passage, July 19 & August 18, 2010.

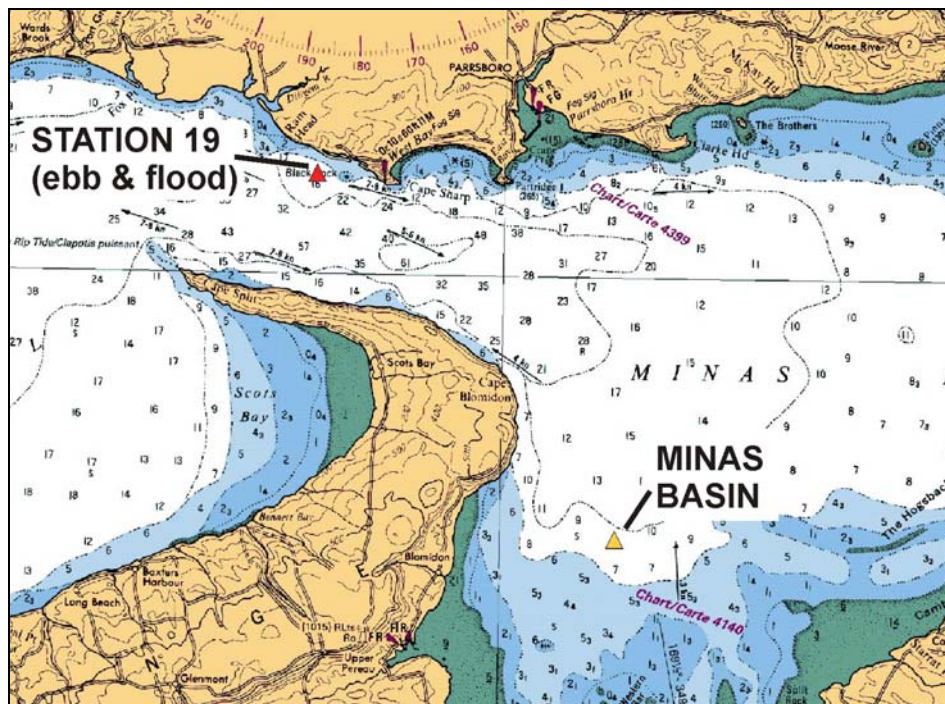


Figure 2. Sampling locations in Minas Passage & Minas Basin, October 26, 2010.

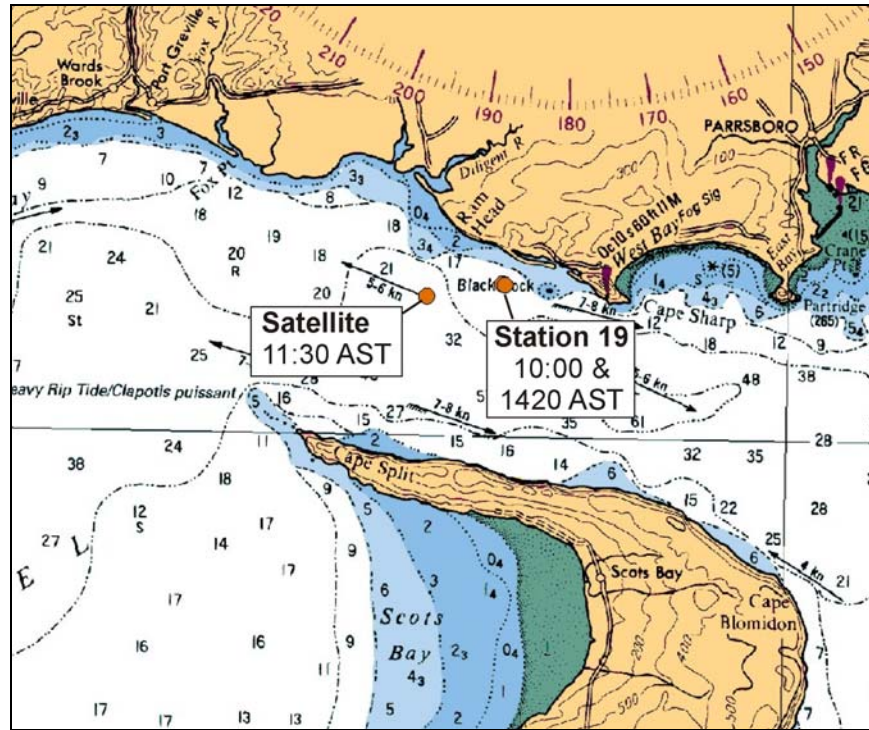


Figure 3. Sampling locations in Minas Passage, January 15, 2011.

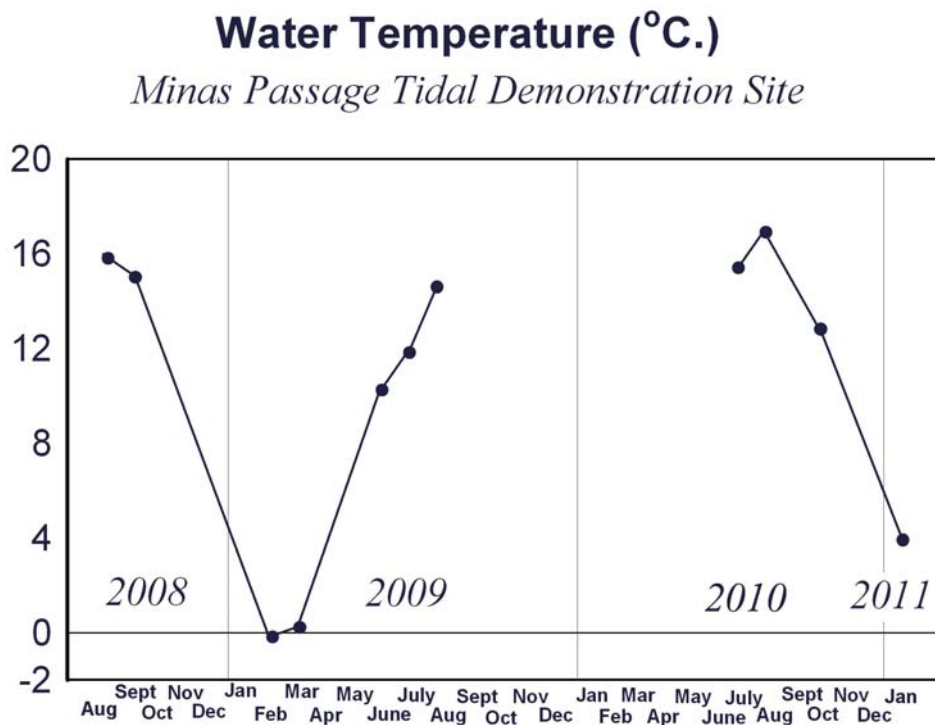


Figure 4. Seasonal pattern in surface water temperature, Minas Passage, from data obtained during Fundy Tidal Energy Demonstration Project, August 2008 to January 2011.

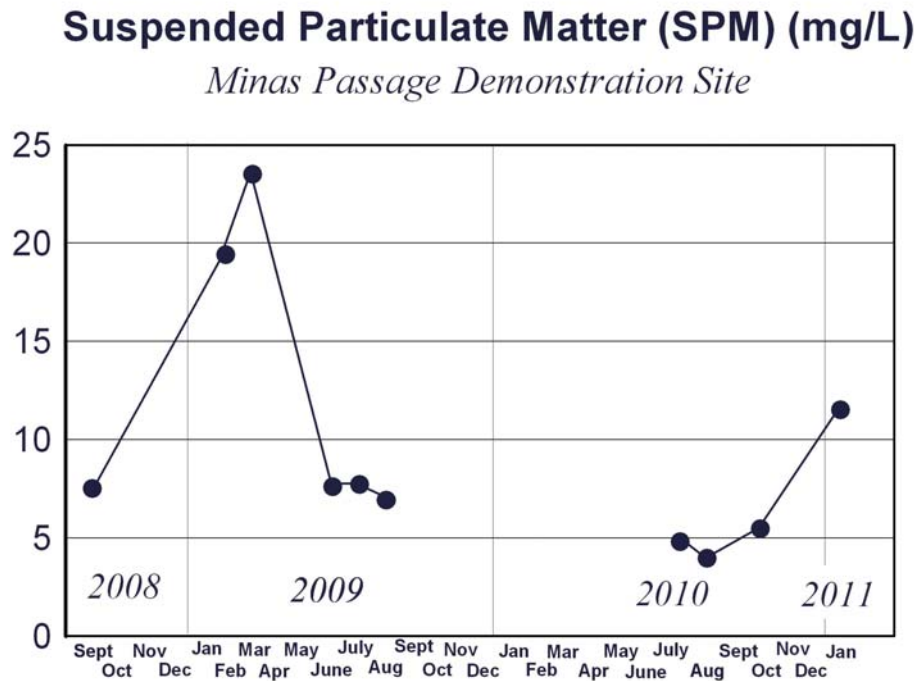


Figure 5. Seasonal pattern in suspended particulate matter (SPM) concentrations in Minas Passage, from data obtained during Fundy Tidal Energy Demonstration Project, August 2008 to January 2011.

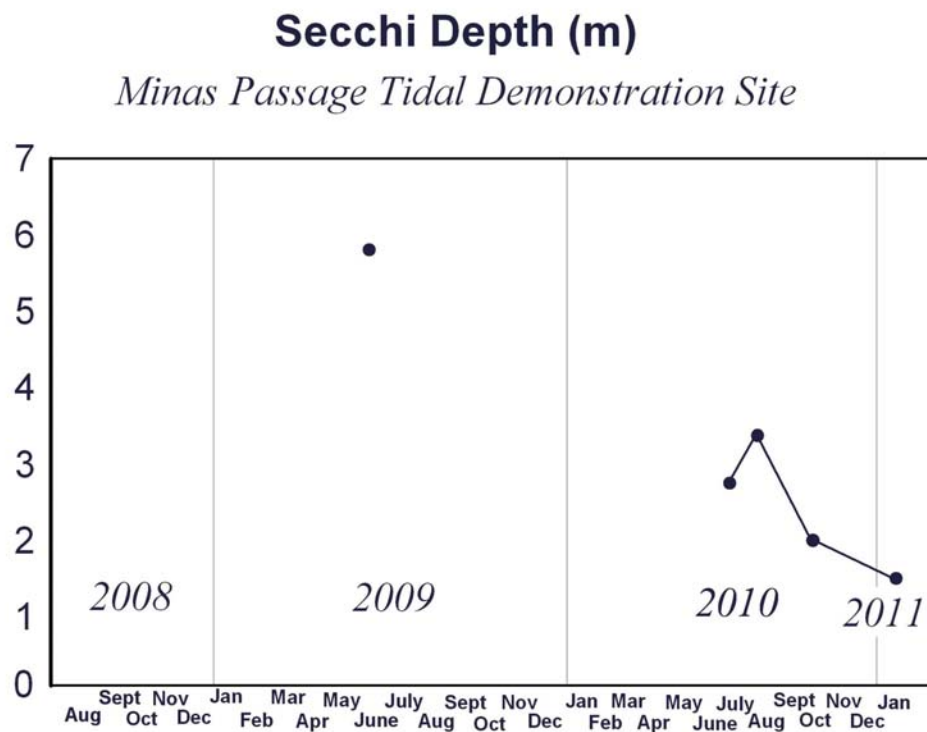


Figure 6. Seasonal pattern in Secchi Depth (m) in Minas Passage, from data obtained during Fundy Tidal Energy Demonstration Project, June 2009 to January 2011.

CONCLUSIONS AND RECOMMENDATIONS

The ‘ships of opportunity’ program carried out in 2010 was successful in providing high quality data at low cost, in particular to address data gaps in the seasonal pattern of water temperature, suspended particulate matter, and transparency, in Minas Passage. The sampling program will be continuing in 2011 and obtaining data in the winter-spring (January-May) period remains an important objective. Opportunities will continue to be examined for sampling in conjunction with other research and monitoring projects being carried out in Minas Passage this year.

REFERENCES

Envirosphere Consultants Limited. 2009. Oceanographic Survey, Oceanographic Measurements—Salinity, Temperature & Turbidity, Minas Passage Study Site. August 2008-March 2009. Revised Report to Minas Basin Pulp and Power Co. Ltd., December 18, 2009.

Envirosphere Consultants Limited. 2010. Oceanographic Measurements—Salinity, Temperature, Suspended Sediment & Turbidity, Minas Passage Study Site. June - August 2009. Report to Fundy Ocean Research Centre for Energy (FORCE). May 31, 2010.