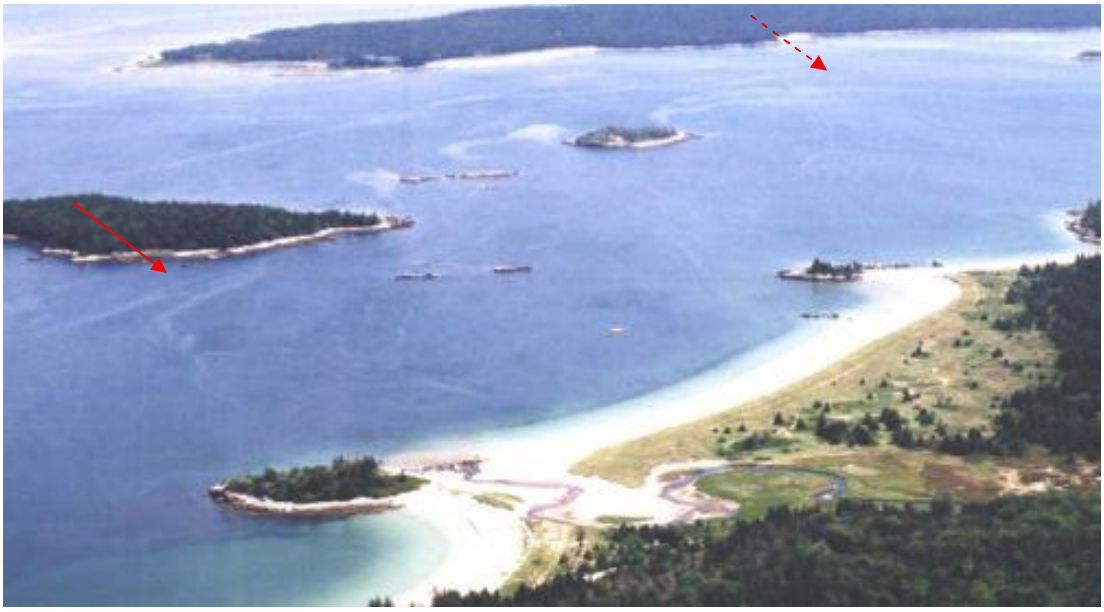
Friends of Port Mouton Bay,
Contribution #17 revised

February 2009

Cumulative Effects of Two Aquaculture Sites in Port Mouton Bay



Carter's Beach, looking out toward Port Mouton Island, showing location of existing and proposed aquaculture sites. (Photo: Linda Ross)

Part I. Nuisance Algae

In recent years the presence of the green algae *Ulva intestinalis* on rocks along beach shorelines at Carter's Beach and Southwest Port Mouton Beach in spring, summer and fall has indicated a continuous source of nitrogen from ocean sources. The salmon aquaculture site at Spectacle Island provides a significant continuous source of nitrogen from the ocean side of these shorelines.

> Under some circumstances, finfish aquaculture has the potential to alter the trophic status of inlets on far-field scales ……Recently the debate has extended to include the possibility that under some conditions intensive finfish aquaculture may contribute to eutrophication in areas hundreds of metres to as much as a few kilometres from the concentration of culture facilities….(DFO, 2005)

A study conducted by the Conservation Council of New Brunswick at Deer Island demonstrated that nuisance algal abundance could reasonably be attributed to increased nutrient load from aquaculture in the area.(Harvey and Milewski, 2007)

Ulva intestinalis on rocks at Carter's Beach, September 2007 (Photo by Robert Ross)

The fish plant in Port Mouton located further west is presently operating at a much-reduced capacity. This beach shoreline adjacent to Spectacle Island is not an area of residential, industrial or agricultural activity so that other sources of nutrients are not significant compared to the 10,000 person equivalents of the proposed fish farm.

Ulva intestinalis on rocks at Southwest Port Mouton beach, late May, 2008 (Photo by Clyde Fisher)

Pilayella littoralis, a nuisance brown macroalgae, has been observed in abundance along the shoreline of Spectacle Island facing the inner harbour for at least four years. *Pilayella littoralis* is associated with eutrophication, fouling of beaches and the decline of *Fucus vesiculosis.* See the following articles for more information.

http://cat.inist.fr/?aModele=afficheN&cpsidt=16719898
http://web.mit.edu/newsoffice/tt/1991/sep11/25307.html

Observations from local fishermen and Irish moss harvesters indicate that *Pilayella littoralis* has progressively spread its radius from the Spectacle Island area[1] throughout and beyond Port Mouton Bay with each successive year. The map below (Figure I.1) illustrates the observed spread of this algae from Spectacle Island into the inner harbour[1], north-easterly along the Bell's Point/River Head shoreline[2], south-easterly to Massacre and Jackie's Islands and the western side

of Port Mouton Island[3], and beyond Port Mouton Bay to Port Mouton Head[4], in Little Port Joli Basin[5] and in lesser amounts toward Black Point[6]. It is possible that the progression of this algae leading to Port Mouton Head and Black Point along the shorelines of the Kejimkujik Seaside National Park, is part of this progression. Accumulation of this algae is not obvious beyond Black Point[6] nor in Port Joli Bay[7].

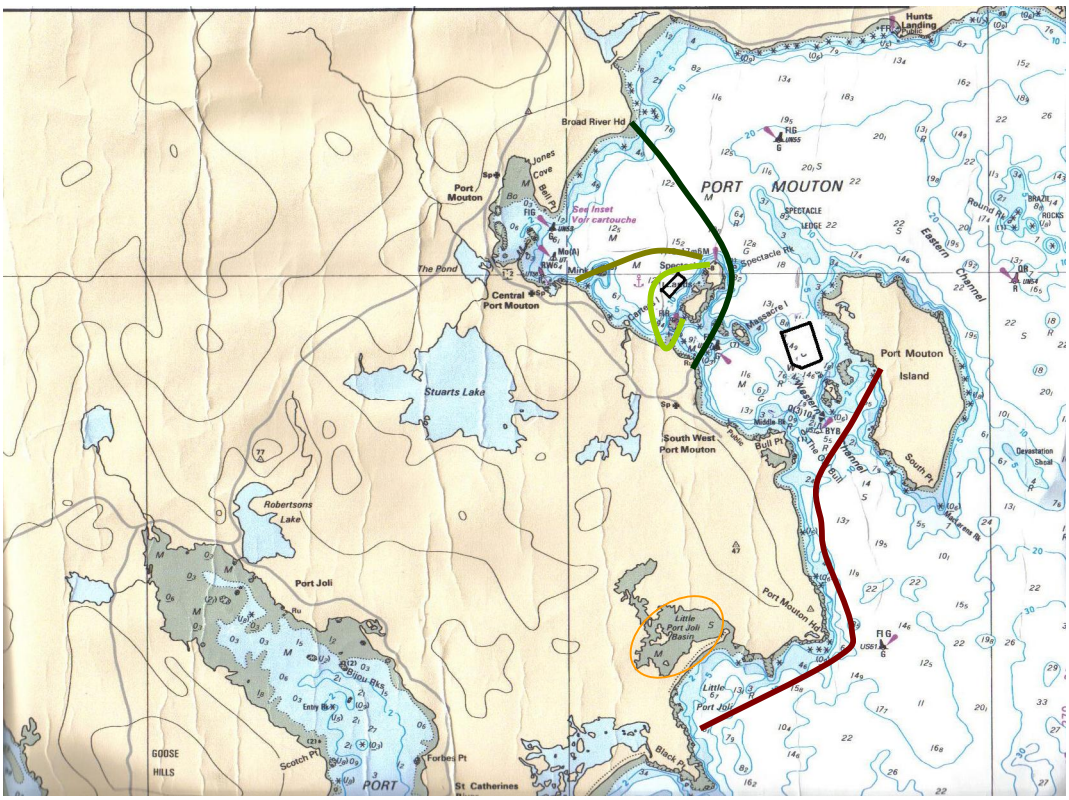
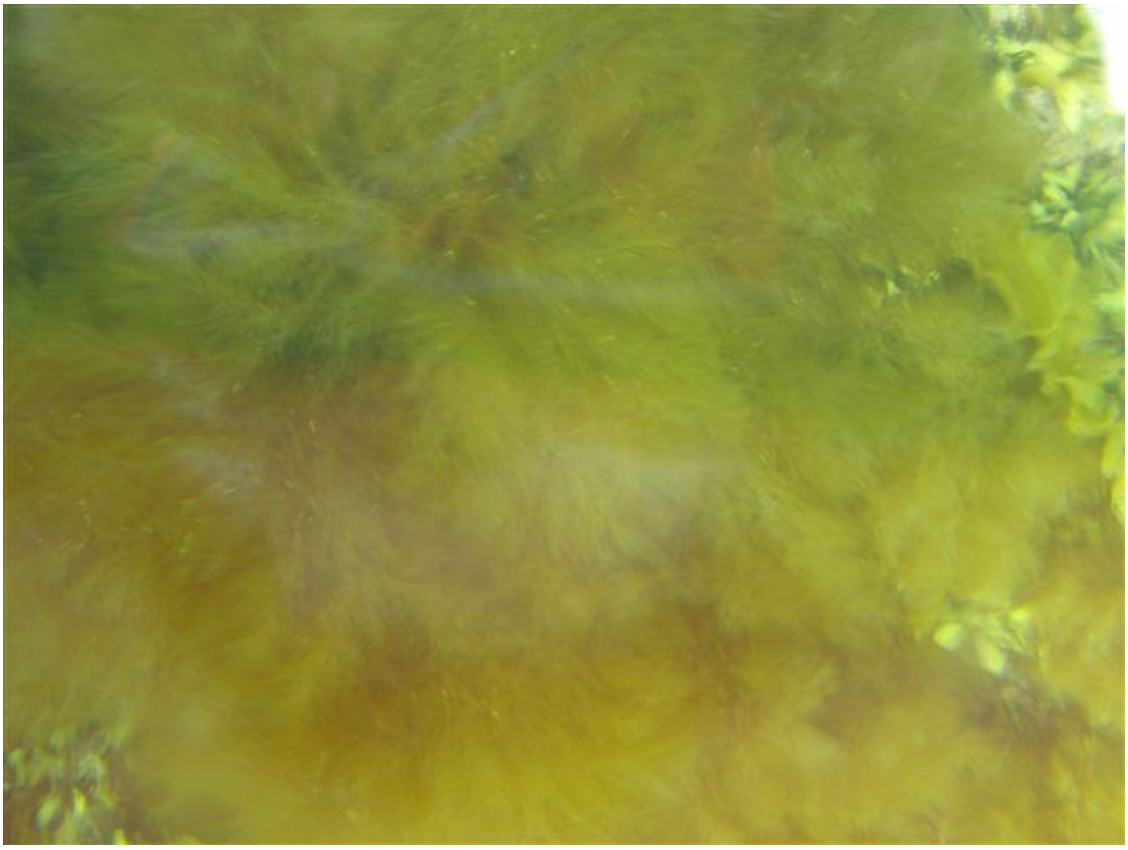


Figure I.1. Chart of Port Mouton Bay showing observations of progressive spread of abundant nuisance algae *Pilayella littoralis* **from the Spectacle Island area** (circa 2005), **into the inner harbour** (circa 2006), **along the Bell's Point/River Head Point shoreline** (circa 2007) and **presently on the western side of Port Mouton Island, Southwest Port Mouton shoreline and beyond Port Mouton Bay to a portion of the Kejimkujik Seaside shoreline** (2007-8).



Pilayella littoralis near aquaculture site at Spectacle Island, June 2008.
(Photo by Clyde Fisher)

Pilayella littoralis near west side of Port Mouton Island (vicinity of proposed aquaculture site), June 2008. (Photo by Clyde Fisher)

Pilayella litorallis in Little Port Joli Basin May 27-28, 2008 (Photo by Aimee Pelletier)

All of the shorelines mentioned above are important to lobster fishermen and moss harvesters. Little Port Joli Basin is habitat for soft-shelled clams, eelgrass and is an important stop-over point for migrating shorebirds.

Twenty-one fishermen from Port Mouton Bay have in the past depended on the areas west of Port Mouton Island and Spectacle Island for Irish moss (*Chondrus crispus*) harvest (FPMB Survey of Fishers and Mossers in Port Mouton Bay). Rockweed (*Fucus vesiculosis)* is also harvested in Port Mouton Bay.

Lobster fishermen report an abundance of this algae fouling their traps and point out that this algae was not obvious in preceding years within the memory of two generations [1]. Nuisance algae are routinely pressure-hosed off farm nets at the existing site.

Irish moss harvesters have reported in recent years that the abundance of *Pilayella littoralis* around Spectacle Island smothers Irish

moss and has reduced moss harvest to 30% of normal levels on the north-west side of the island facing the inner harbour. Reduction of moss harvesting associated with the spread of this algae in the remaining areas within Port Mouton Bay has continued to the point that in 2008, moss harvesting activity was concentrated on shorelines outside of the bay (the outer shoreline of Port Mouton Island, and the shorelines beyond Bull Point).[8] In 2008, sub-tidal habitat for Irish moss was observed to be barren along portions of the Bell's Point/Summerville shoreline[9].

Pilayella littoralis has fouled the tidal pool in Carter's River at Carter's Beach for the past two years. This algae has a reputation of providing smelly, rotting wrack on foreshores. At low tide, bands of *Pilayella* can be seen approximately 10 m from the foreshore along the shorelines of Carter's Beach during July and August, 2008.

Pilayella littoralis in tidal pool at Carter's Beach, June 2007 (Photo by Ruth Smith)

Pilayella littoralis 10 m from foreshore, Carter's Beach, July 2008. (Photo, Clyde Fisher).

Similarly, observations of abundant *Pilayella littoralis* originating in the vicinity of Spectacle Island in 2002 and *progressively* outward to islands in the basin west of Port Mouton Island cannot be associated with any apparent sources from residential, industrial or agricultural activity.

There is no evidence of domestic sewage supporting nuisance algae at these aquaculture sites. There is no residential housing within 1.8 km of the proposed fish farm. No persons live within 1 km of the existing fish farm. Elevated fecal coliform levels may be associated with nutrient sources from human activity, but there are no shellfish closures in these areas due to elevated levels of fecal coliforms with the exception of the unofficial shellfish closure around the existing fish farm. The nutrients released by the existing farm at a 200,000 fish stocking capacity are equivalent to 5,000 persons; the proposed expansion would release nutrients equivalent to 10,000 persons (approximately equivalent to the entire population of Queens County) at a stocking capacity of 600,000. FPMB point out that the existing fish

farm has the worst environmental record with respect to sediment sulphide concentrations of any in Nova Scotia as shown on the Nova Scotia Fisheries and Aquaculture website. http://www.gov.ns.ca/fish/aquaculture/EMPSummaryReport.pdf.

Since other candidate point sources for nutrients in these areas of Port Mouton Bay are negligible or non-existant,, since these algae were not observed prior to the existence of the fish farm and since *Pilayella* first became obvious in the vicinity of the existing fish farm throughout spring, summer and fall which includes the seasons when background ocean nutrient levels are limited, it is reasonable to attribute increased nutrient sources to this aquaculture site.

Conclusion

The fact that *Ulva intestinalis* presently occurs both on Carter's and Southwest Port Mouton beaches and that *Pilayella littoralis* has spread from the Spectacle Island area and is now abundant in the area of the proposed aquaculture site at Port Mouton Island and beyond on shorelines of Kejimkujik Seaside Park indicates the potential for significant cumulative effects of nuisance algae from two aquaculture sites in Port Mouton Bay.

Endnotes

1,2. Richard Broome, Robin Fisher, Brian Fisher, Clyde Fisher, Michael Swim (pers. comm.)
3. Todd Leslie, Clyde Fisher (pers. comm.)
4. Clyde Fisher, Todd Leslie, Philip Hupman, Donaldson Fisher (pers. comm.)
5. Philip Huphman, Brian Fisher, Earl Fisher Jr., Donaldson Fisher (pers. comm.)
6. Aimee Pelletier (pers. comm.)
7. Earl Fisher, Donaldson Fisher, Jeff and Darlene Norman (pers. comm.)
8. Todd Leslie, Earl Fisher Jr., Donaldson Fisher, Clyde Fisher (pers.comm.)
9. Todd Leslie (pers. comm.)

Part II. Dissolved Oxygen in the Waters of Port Mouton Bay, September 9th and 10th, 2008

Introduction

Dissolved oxygen concentrations can exhibit wide swings in situations where algae are plentiful, such as near fish farms in places where flushing rates are low. A time series of oxygen concentrations near a fish farm in the presence of abundant algae would show the highest concentrations usually occurring after a period of sunlight and photosynthesis, which produces oxygen and the lowest concentrations usually occurring at daybreak after dark hours of respiration.

The evidence indicates that flushing/dilution rates at Port Mouton Bay are low, so nutrients from a fish farm, not being rapidly diluted, could stimulate accumulations of nuisance algae. Such accumulations are described in Part I above. The purpose of this oxygen reconnaissance in Port Mouton Bay was to determine whether algae accumulations are large enough to draw oxygen concentrations down to levels which adversely affect marine animals.

Procedure

On two successive days, casts through the water column to depths of 7 m were made with a YSI Model 550A instrument measuring temperature, salinity and dissolved oxygen. The instrument was calibrated at the Saint Mary's University Community-Based Environmental Monitoring Centre. Water at 10 m depth was sampled using a improvised sampling bottle. The first reconnaissance 'cruise' was made in sunlight at various stations in the vicinity of Spectacle Island, Massacre Island and at the location of the proposed site for fish farm expansion near Port Mouton Island. The second reconnaissance was made before and slightly after daybreak in cloudy weather, and was concentrated around Spectacle Island and three beaches – Southwest Port Mouton, Wobamkek and Carter's.

From the DFO siting guidelines:

> Dissolved oxygen…..is one of the few options available for monitoring over hard bottoms. It is also useful for predicting and assessing far-field effects in environments where oxygen levels may be a concern. DFO(2005).

The location of depleted oxygen in the water column was over a hard rock and gravel bottom where natural flows occur at high water - 250 m directly downstream of the existing fish farm which was operating at reduced capacity. There was an abundance of algae present to create a sustained oxygen demand at this location.

Results

The results of our dissolved oxygen observations, twenty-three profiles through the water column, are tabulated in the Appendix.

The oxygen results for the September 9th survey in sunlight in the vicinity of Spectacle Island and also at the proposed expansion near Port Mouton Island ranged between 7.4 and 8.2 mg DO / L over the various locations and depths from 0 to 10 m. The dissolved oxygen saturation was between 91.7% and 102.7%. Salinity and temperature also showed limited ranges – 30.60 to 30.89 parts per thousand and 16.6 to 17.9 °C respectively with very little stratification.

The results for the September 10th survey, before and after daybreak (0627 to 0831 hours) and at a different stage of tide, were similar to those for September 9th for temperature and salinity, but not for dissolved oxygen. For temperature the range was 16.1 to 17.6 °C. The salinity the range was 30.50 to 30.92. The range of oxygen concentrations was 5.3 to 8.5 mg DO/L, and as a percentage of saturation value, 66% to 104%. Drawn-down oxygen concentrations (6.3 mg/L, 79% saturation and 5.3 to 6.1 mg/L, 66% to 76% saturation) were found at two stations located near the eastern end of the gut or high water channel, Spectacle Island (Figure II.1). At one of these stations, oxygen concentrations were relatively low throughout the water column (Appendix); at the other, at the surface only.

Late summer is the critical season for oxygen depletion and for an oxygen survey, because of warmer water temperatures and intensive feeding of the salmon in the fish farm with resulting oxygen demand. There was a 'natural mode' of 88 to 104% saturation and the depleted mode of 66 to 79% saturation. Some estimate of natural variance might be gained from the 21 profiles making up the natural mode.

The scope of human activity at this location is described above – there is little or no residential, industrial or agricultural activity within effective range of the existing fish farm which itself is a huge source of nutrients.

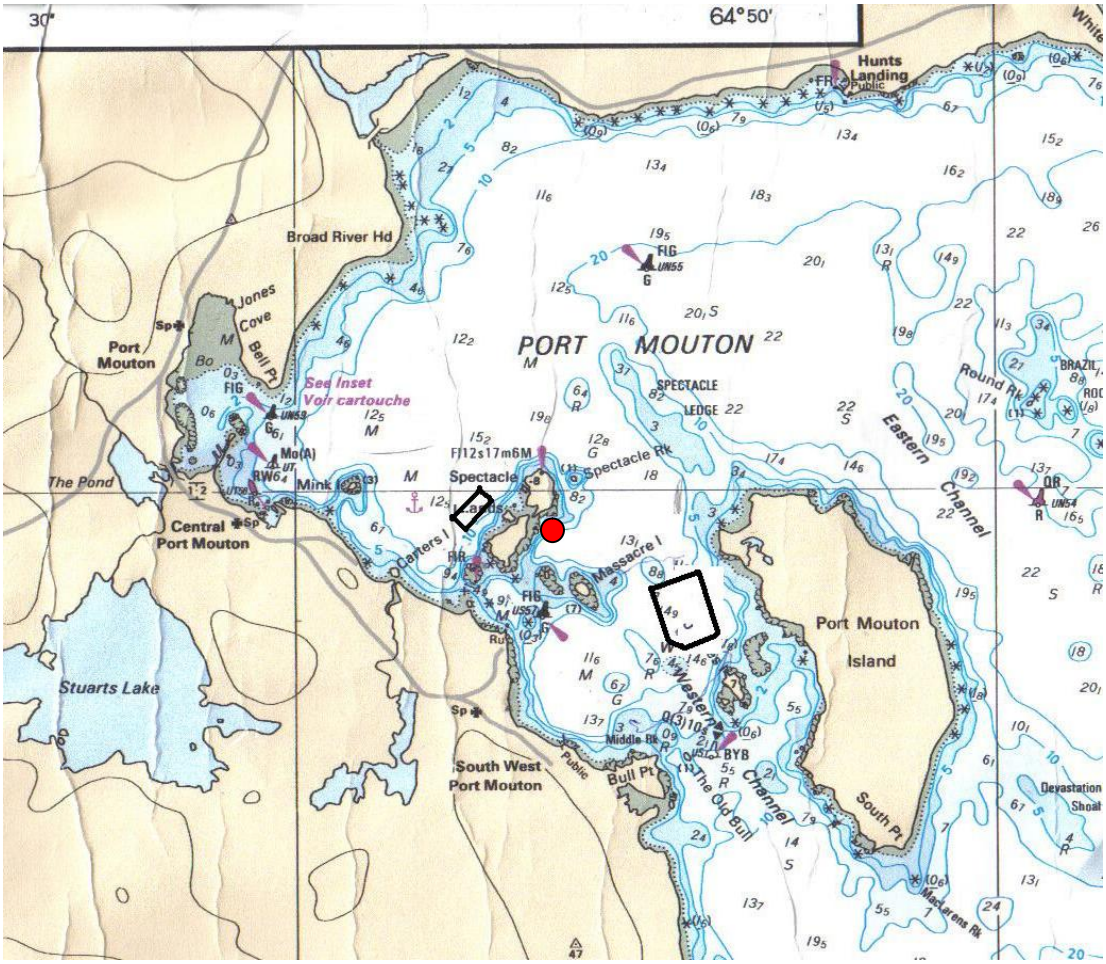


Figure II.1 Location of observed oxygen depletion (red circle), Sept 10, 2008.

Interpretation

The sunlight survey of September 9th did not produce oxygen (super) saturations as high as values that can be found in the literature. However the daybreak survey of September 10th showed lower limits for oxygen that are of concern. As mentioned, these low oxygen concentrations were observed on the east side of Spectacle Island near the gut or high water channel (Figure II.1).

This low oxygen event should also be considered in the context of the fish farm at Spectacle Island presently operating at what appears to be considerably less than full capacity. The sampling stations, including

those with lowest oxygen concentrations, were located several hundred metres from the fish farm. This east side of Spectacle Island and the basin is a prime lobster fishing area and juvenile lobsters are frequently observed here by Irish Moss harvestors; it is also habitat for mackerel and herring.

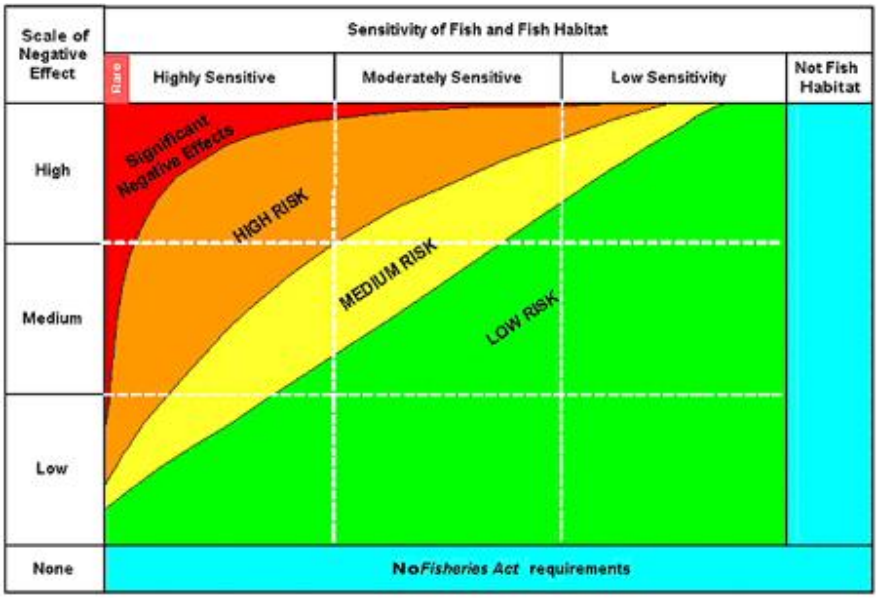


Figure II.2 A risk assessment diagram (from the Practitioners Guide to the Risk Management Framework for DFO Habitat Management Staff).

(Diaz and Rosenberg 1995) describe hypoxic levels which "suffocate" marine life. Sub-lethal effects on marine life at hypoxic levels have not been extensively studied. Fish including salmon, mackerel and herring require oxygen concentrations higher than the lowest oxygen levels observed. Marine animals are highly sensitive to depleted concentrations of dissolved oxygen – the horizontal axis of Figure II.2. In the context of the existing fish farm operating at reduced capacity in September 2008, and the proposed fish farm operating at three times the full capacity of the existing farm, the potential for cumulative effects reducing already depleted oxygen is a reasonable assumption. Even with rotational fallowing, both sites will be operating two-thirds of the time.

The Canadian Water Quality Guidelines for Marine Aquatic Life (CCME, 1999) recommend 8 mg/L as a minimum guideline for dissolved oxygen in marine waters and a range of 9.5 mg/L for early life stages and 6.5 mg/L for other life stages. The Decision Support System

(DSS) for aquaculture siting states that a large proportion of marine species experience severe deleterious effects at a dissolved oxygen level <6.4 mg/L. The minimum dissolved oxygen concentration is a critical variable not only for cultured species but for the ecosystem as a whole (Hargrave, 2002).

The scale of the negative impact – the vertical axis of Figure II.2 - of depleted oxygen concentrations would be higher if both the Spectacle Island farm site and the Port Mouton Island farm site were operating at capacity. Then, as indicated in Figure II.2, the assessment for the ecosystem as a whole would be high risk or worse.

Conclusion

In September, 2008, a low oxygen event was observed on the east side of the western edge of the Port Mouton Island Basin, an area where nuisance algae are now widespread.

This raises concern for future cumulative effects: If the fish farm expansion in Port Mouton Island Basin were to be approved, the waters of the Basin are in position to receive nutrients from both the existing farm and the expansion farm. Two farm sites in operation would mutually increase the likelihood of a state of eutrophication in the Basin.

Part III. Surface Drifters at Proposed Aquaculture Site near Port Mouton Island

Surface currents, which transport nutrients and floatables, have been partially explored for some wind conditions. Surface drifters were released on July 7 and July 31, 2008 from the proposed aquaculture site at Port Mouton Island to demonstrate pathways of dissolved nutrients and floatable debris from this location.

Surface drifter prepared for release near Port Mouton Island
(Photo by Brian Fisher)

On July 7, under conditions of light southwest winds and moderate tides, 25 drifters were released from the vicinity of the proposed site. Within 3 hours 24 drifters were recovered on Southwest Port Mouton beach.

On July 31, 18 drifters were released under conditions of light south-west winds and large tides again from the vicinity of the proposed site. Thirteen drifters were recovered over a period 3 to14 days – 6 between Willow Cove and the Breakwater Wharf at Central Port Mouton, 2 at Wobamkek Beach (Carter's Beach), 3 at Southwest Port Mouton Beach and 1 at Port Mouton Island near Schooner Cove and one at Port Joli Beach approximately 3 km into Port Joli Bay (see Figure III.1 below).

The Western Head lighthouse and weather station is 14 km distant and visible from Port Mouton Bay and reported light winds from the southwest on July 7, 2008, Port Mouton fishermen generally observe that southwest winds recorded at Western Head are not consistent with winds in Port Mouton Island basin due to the sheltering influence of land and seabreeze effects.

On July 31, winds at Western Head were also light - 6-7 km/h from the southwest. On August 1, winds were 9-11 km/h from the northeast. A plausible scenario is that July 31 tides positioned the drifters so that winds on August 1 brought them ashore inside Spectacle Island. The DFO windrose statistics for Nova Scotian Shore show east winds occurring for 37 to 88 hours per month in the period March to October. Over the same period, northeast winds occurred for 37 to 66 hours per month. This frequency of occurrence of easterly winds indicates the potential for wastes discharged into the Port Mouton Basin to reach the vicinity of the Spectacle Island fish farm leading to cumulative effects from the two sites.

We note that these surface drifters were accompanied for the first nine hours after release by 10 m deep drogues (FPMB, 2009). These drogues demonstrated two features; they drifted toward Spectacle Island, and remained within the basin which over time would lead to recirculation, reloading and build-up of concentration of wastes or their products.

Circulation throughout the water column is addressed in our previous report on current meter and drogue data (FPMB, 2008) and in our latest report, an analysis of current meter and drogue data from Summer 2008 (FPMB, 2009).

Figure III.1 (on following page) Chart showing release of surface drifters from the proposed Port Mouton Island aquaculure site on July 7 (blue) and July 31 (red) and locations of retrieval.

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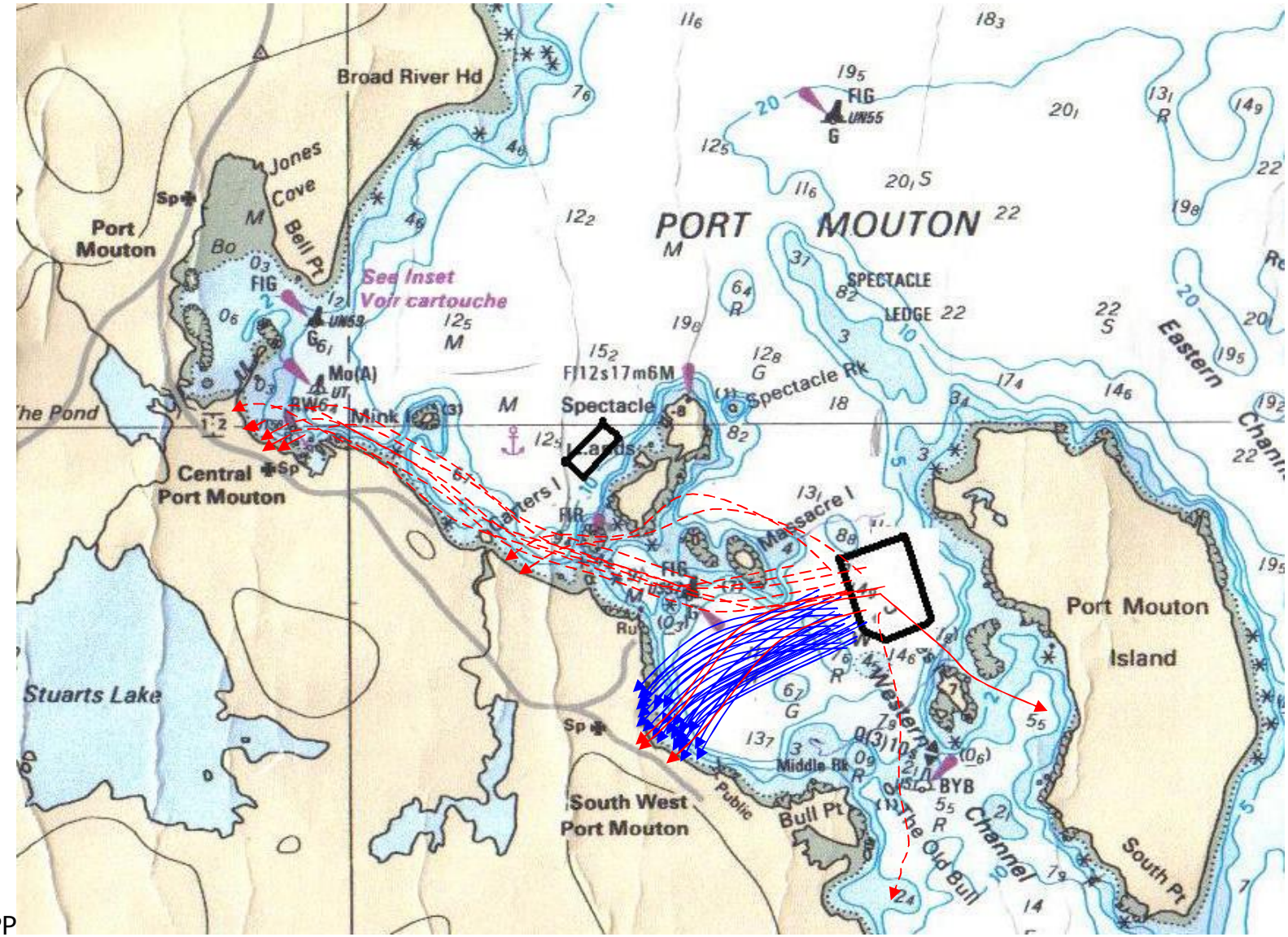
Broad River Hd
Jones Cove
Bell Pt
Port Mouton
See Inset
Voir cartouche
PORT MOUTON
SPECTACLE
LEDGE
Eastern
Spectacle Rk
Spectacle
Mink I
Carters I
Massacre I
Western
Middle Rk
Bull Pt
The Old Bull
Channel
South Pt
Port Mouton Island
Central Port Mouton
Stuarts Lake
South West Port Mouton
Public
The Pond

Conclusions

Eight of the thirteen drifters - recovered between Willow Cove and the Breakwater Wharf, and at Carter's Beach - had moved into the zone of influence of the existing Spectacle Island aquaculture site, indicating the significant potential for cumulative effects from the two sites. The large number of drifters on Southwest Port Mouton beach also indicates that this shoreline is a receptacle for waste in the surface layers of water from the proposed aquaculture site at Port Mouton Island.

Summary

There are no other coastal activities in Port Mouton Bay that discharge nutrients equivalent to thousands of persons. Other candidate point sources for nutrients in the area of the fish farm sites in Port Mouton Bay are negligible or non-existent.

There is evidence of the spread of nuisance algae beyond the existing fish farm site (Part I). In one area on the edge of the Basin which now exhibits an abundance of nuisance algae, oxygen concentrations were found to be depleted to deleterious levels (Part II). Surface drifters released from the site of the proposed expansion were retrieved within range of the existing farm site as well as on beaches around the Basin (Part III). Taken together, the evidence to date suggests that, were the proposed site to be approved, the ecosystem of the Port Mouton Island Basin would be at high risk of cumulative habitat degradation.

Ronald H. Loucks, Ph.D.

Ruth E. Smith

Science Committee
Friends of Port Mouton Bay

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Hargrave, B.T. 2002. A Traffic Light Decision System for Marine Finfish Aquaculture Siting. Ocean and Coastal Management 45, 215-235.

Appendix: Dissolved Oxygen Observations

			Sept.9	2008				
Time	Lat.	Long.	Depth metres	Temp. deg.C	Sal.ppt	DOsat.%	DOconc. mg/L	
909	43 54.888	64 48.914	0	17.90	30.71	98	7.8	off Spec.
910	43 54.888	64 48.914	7	16.80	30.79	92	7.4	Island
914	43 54.964	64 48.882	7	16.60	30.89	92	7.9	
928	43 54.964	64 48.882	0	17.40	30.73	99	7.9	
933	43 54.964	64 48.882	10	17.30	30.60	100	8.0	
936	43 54.964	64 48.882	10	17.20	30.71	101	8.0	
943	43 55.061	64 48.617	0	17.30	30.64	101	8.1	
945	43 55.061	64 48.617	7	17.10	30.79	100	8.0	
947	43 54.980	64 48.530	0	17.30	30.67	103	8.2	
950	43 54.980	64 48.530	7	17.10	30.79	97	7.7	
954	43 54.980	64 48.530	10	16.90	30.70	101	8.1	
1014	43 54.375	64 48.191	0	17.40	30.69	100	8.0	centre PM
1018	43 54.375	64 48.191	7	17.30	30.72	100	7.9	Island
1025	43 54.424	64 48.134	7	17.30	30.74	99	7.9	
1032	43 54.499	64 48.045	10	17.30	30.60	98	7.8	

			Sept.10		2008.		
Time	Lat.	Long.	Depth	Temp.	Sal.ppt	DOsat.%	DOconc.

			metres	deg.C			mg/L	
632	43 55.018	64 48.614	7	16.19	30.82	93	7.5	
638	43 55.018	64 48.614	10	16.77	30.70	99	8.0	
641	43 54.939	64 48.532	0	16.93	30.62	99	8.0	
644	43 54.939	64 48.532	7	16.07	30.89	88	7.2	
654	43 54.939	64 48.532	10	16.45	30.64	96	7.9	water in
657	43 54.859	64 48.598	0	16.87	30.62	97	7.8	
700	43 54.859	64 48.598	7	16.05	30.87	92	7.5	
703	43 54.859	64 48.598	10	16.16	30.78	101	8.3	air in
707	43 54.805	64 48.598	0	16.86	30.68	97	7.8	
711	43 54.805	64 48.598	7	16.19	30.87	92	7.5	
715	43 54.805	64 48.660	10	16.13	30.87	104	8.5	air in
717	43 54.805	64 48.660	7	16.08	30.90	93	7.6	
719	43 54.805	64 48.660	5	16.21	30.92	91	7.4	
725	43 54.921	64 48.399	0	17.62	30.56	94	7.5	
726	43 54.921	64 48.399	3	17.22	30.74	94	7.5	
727	43 54.921	64 48.399	2	17.40	30.76	89	7.1	
728	43 54.921	64 48.399	1	17.56	30.54	90	7.1	
735	43 54.957	64 48.094	0	17.11	30.78	94	7.5	
736	43 54.957	64 48.094	2	17.16	30.77	96	7.7	
737	43 54.957	64 48.094	4	17.17	30.77	93	7.5	
738	43 54.957	64 48.094	5	17.17	30.77	93	7.4	
740	43 54.627	64 48.261	0	17.28	30.69	79	6.3	
741	43 54.627	64 48.261	1	17.17	30.70	92	7.4	
742	43 54.627	64 48.261	3	17.19	30.75	90	7.2	

745	43 54.841	64 48.304	0	17.36	30.55	66	5.3	
747	43 54.841	64 48.304	1	17.34	30.72	76	6.1	
750	43 54.841	64 48.304	2	17.34	30.78	75	6.0	
753	43 54.841	64 48.304	2	17.34	30.78	74	5.9	
755	43 54.692	64 48.366	0	17.13	30.71	94	7.5	
757	43 54.692	64 48.366	2	17.16	30.76	96	7.7	
758	43 54.692	64 48.366	3	17.11	30.77	94	7.5	
800	43 54.546	64 48.497	0	16.97	30.69	95	7.6	
803	43 54.546	64 48.497	3	16.99	30.70	94	7.5	
805	43 54.546	64 48.497	7	16.55	30.81	90	7.3	
806	43 54.393	64 48.240	0	17.07	30.73	97	7.8	
808	43 54.393	64 48.240	4	17.07	30.76	96	7.0	
809	43 54.393	64 48.240	7	16.90	30.80	94	7.7	
		South	West	Port	Mouton	Beach	Wind	8mphNW
810	43 54.069	64 48.303	0	16.70	30.63	96	7.5	
812	43 54.069	64 48.303	5	16.70	30.73	95	7.7	
814	43 54.069	64 48.303	7	16.67	30.78	94	7.6	
820	43 54.366	64 48.676	0	16.52	30.82	93	7.6	
822	43 54.366	64 48.676	3	16.63	30.78	88	7.2	
			Wobamkek		Beach			
826	43 54.468	64 48.984	0	16.58	30.62	99	8.0	
828	43 54.468	64 48.984	3	16.71	30.63	97	7.9	
			Carters		Beach			
831	43 54.605	64 49.457	0	16.57	30.50	99	8.0	
833	43 54.605	64 49.457	3	16.49	30.58	97	7.8	
835	43 54.605	64 49.457	4	16.47	30.60	94	7.6	