

September 2011

Geochemical and Faunal Sediment Studies in Port Mouton Bay

SUMMARY

Ecosystem health based on benthic status was derived from several observations in Port Mouton Bay on two sampling dates 3 and 15 months post-fallowing. The most useful indicators include sediment sulphides, sediment organic content, benthic community structure and sediment profile images.

Concentrations of organic content after 3 months fallow indicate that the farm region is a zone of higher organic content, with comparable levels to the farm region at kilometre-scale distances. These values were similar near the farm and in the far-field (distance >400 m) and in depositional areas 2 km west and south-east of the farm after 15 months.

The sediment profile images reflect the organic content pattern.

Sediment sulphides after 15 months show greatly enhanced levels at the farm site, with insubstantial concentrations at most other locations except an elevated value 2 km southeast of Spectacle Island and a lesser elevated value 2 km west. Two of three farm stations and one station ~100 m west of the farm also display cover of *Beggiatoa* bacteria.

After 3 months fallow, sediment faunal communities characterized by M-AMBI display the six lowest values of 40 stations at 4 stations on or near the farm site and at 2 stations from 200 to 850 m distant. These values are in the category of 'moderately polluted' on the M-AMBI scale.

After 15 months fallow, there is one low M-AMBI value at the farm; this farm station is the only station to contain substantial numbers of the opportunistic, scavenger polychaete, *Capitella capitata*. Near-field and far-field stations improved over 2009 values a year earlier with the exception of two distant depositional areas 2 km south-east and 2 km west. (Improvement implies prior impact.)

The impact of the farm is still obvious even after 15 months as indicated by geochemical and faunal data. The far-field shows evidence of impact from its organic content, sediment profile images and benthic community structure, but not from sediment sulphides except for 2 distant depositional areas.

Further sampling in 2011 will shed more light on the rate of recovery.

Introduction

A study of sediments in Port Mouton Bay was begun in October 2009 by a team led by Dr. Jon Grant of Dalhousie University's Department of Oceanography. Friends of Port Mouton Bay (FPMB) facilitated and coordinated the field surveys with the cooperation of Cooke Aquaculture.

History of Site

The Spectacle Island fish farm site cultured trout and then salmon continuously for 15 years. The farm was operating at reduced capacity during 2009 and feeding of fish ceased on July 20, 2009 before harvesting the salmon and following the farm.

Methodology

A grid of 40 stations (Figure 1) designed to avoid land-based influences encompassed sand, gravel and mud bottom and included the site of the salmon farm near Spectacle Island. These 40 stations were sampled in 2009 and 23 of these stations were selected for sampling in 2010. Four transects – north, north-west, east, and south/southeast from the farm site were the focus of the 2010 sampling (Figure 1).

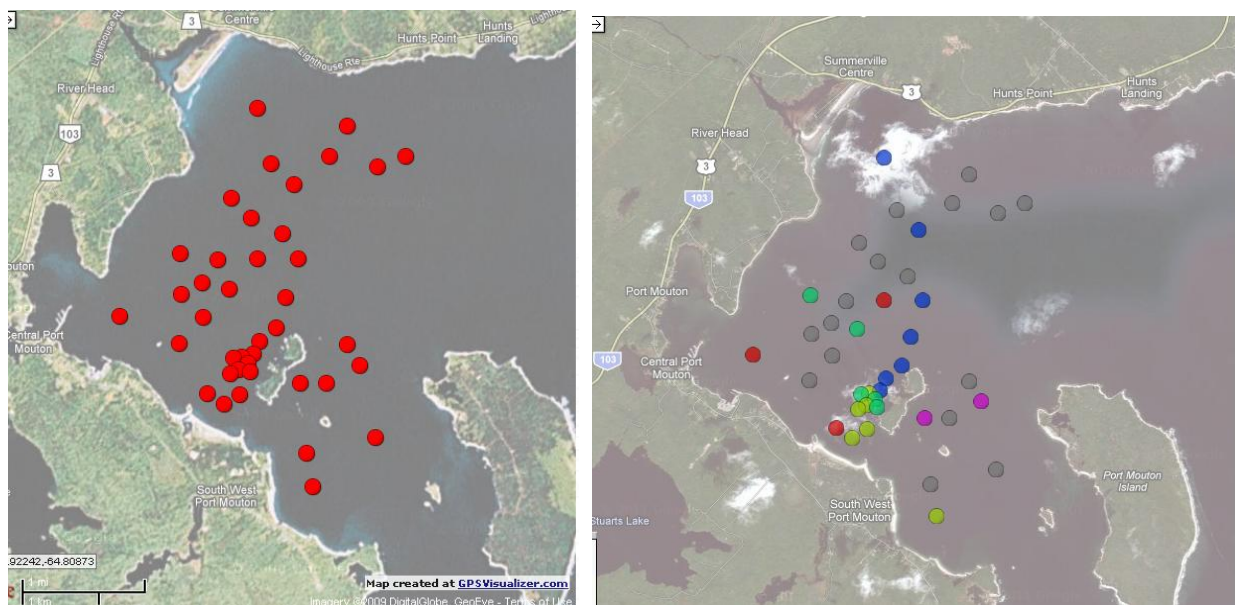


Figure 1. Grid of 40 stations in Port Mouton Bay in 2009 and of 23 stations in 2010 color-coded to indicate transects extending north, north-west, east and south/south-east from farm site.

Grab samples of sediment were collected at 33 stations on October 7, 2009, 7 stations on November 7-8, 2009 (approximately 3 months after fallow) and at 23 stations on October 14, 2010.(approximately 15 months after fallow). Sediment cores using the diver-operated 'Hargrave' wedge corer were photographed at each station on November 7-8, 2009 and on October 31, 2010.

A portion of the top 2 centimeters of each grab sample was reserved for grain size, organic matter and porosity analyses in 2009 and for organic matter, porosity, redox and sulphide analyses in 2010 at a Dalhousie University Department of Oceanography laboratory. The remainder of each grab sample was sieved to separate benthic fauna which were preserved for later analysis at Dalhousie University Oceanography Department in 2009 and at MacGregor Geosciences Ltd., Halifax in 2010.

Interpretation of sediment core imagery was done at Dalhousie University, Department of Oceanography. FPMB undertook requisition of trace metal analysis for samples from 10 stations in 2009 and 9 stations in 2010 at Research Productivity Council Laboratory in Fredericton.

Results

Grain Size of Sediments

The relative grain size of sediments is shown in Figure 3. Largest grain size indicates a greater proportion of sand, smallest grain sizes indicate silt or mud. Smaller grain sizes retain greater amounts of organic matter and indicate depositional areas. The smallest grain sizes are found west of Spectacle Island extending beyond the farm site in north-west, west, south, and south-east directions, and are classified as sandy mud (very fine sandy very coarse silt). More distant sites are classified as muddy sand (very coarse silty very fine sand) with largest grain sizes (north) near Hunts Point and (east) near Port Mouton Island classified as sand.

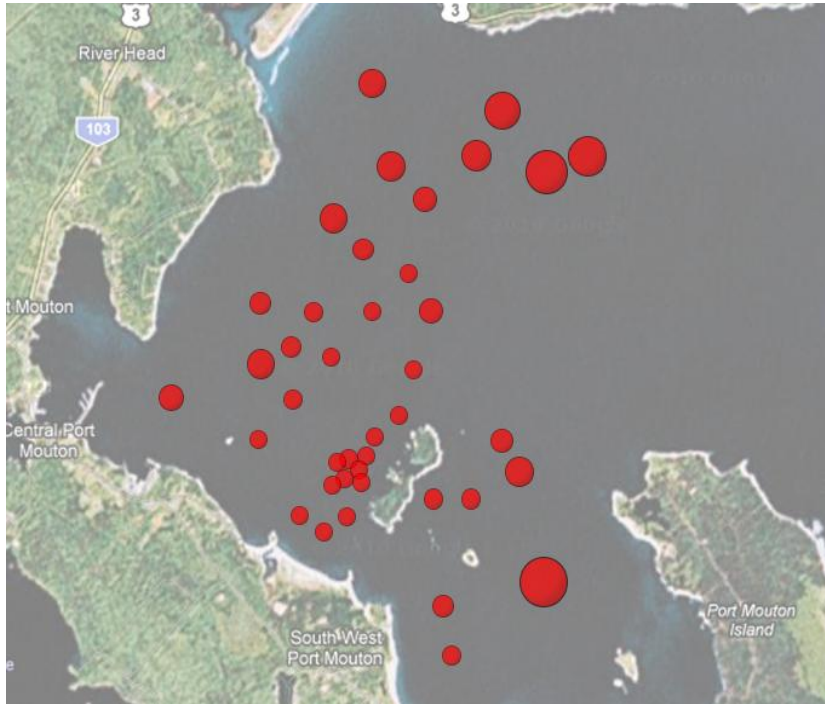


Figure 2 Median grain size of sediments (47 -143 μm) in Port Mouton Bay after 3 months of fallow (2009).

Organic Matter

The organic matter content (Figure 3) reflects the degree of organic enrichment and is a natural function of grain size. After 3 months of fallow in 2009 the farm site was the region of highest organic content (10-12%) with lesser but elevated amounts extending north, south and south-east at distances from 500 to 2000 m. After 15 months of fallow in 2010 enhanced amounts of organic matter near the farm site (9-11%) are still apparent but levels extending northward are reduced and levels extending west, south and south-east have increased suggesting distribution of waste sediments from the farm site.. One of the farm site samples from 2010 was lost in the laboratory analysis.

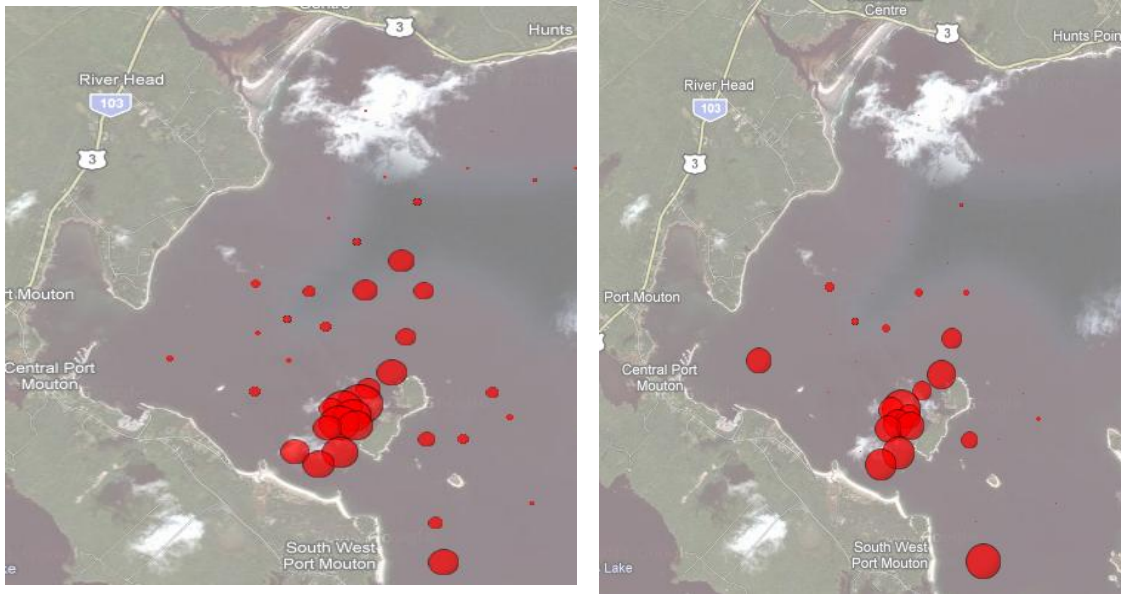


Figure 3. Organic matter content in Port Mouton Bay after 3 months (0.7-12%) and 15 months (1.5-11.1%) of fallow.

A plot of 2009 organic matter values and grain sizes (Figure 4) shows that the amount of organic matter at stations on the farm site and stations north, south and south-east of the farm site are disproportionately greater in relation to grain size and therefore indicate organic enrichment from a source such as aquaculture waste.

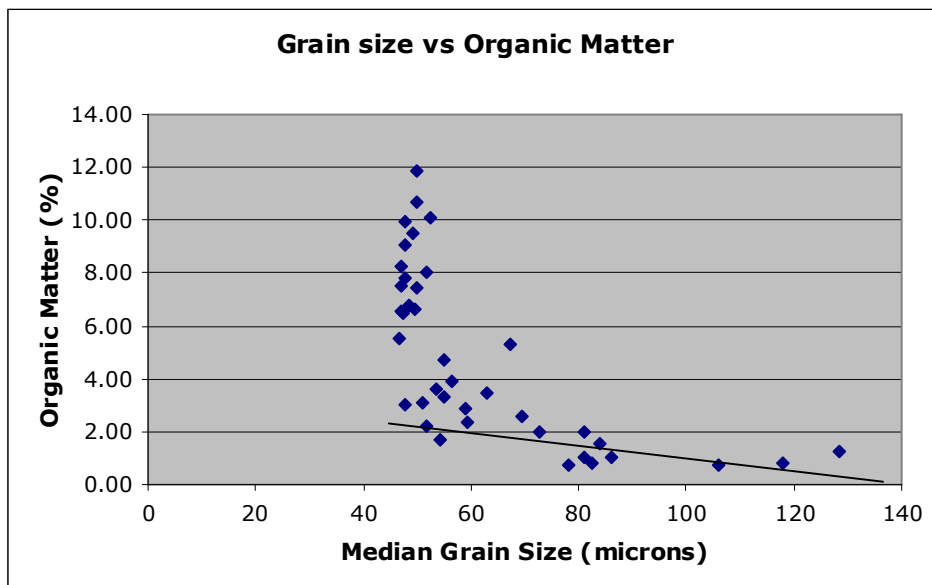


Figure 4. Organic matter as a function of grain size, 3 months after fallow

Sulphides

Sediment sulphides in 2010 after 15 months of fallow show greatly enhanced levels at the farm site – 3000 μM and 4000 μM at 2 of 3 stations there – and insubstantial concentrations at most other locations, except for an elevated value 2 km southeast of Spectacle Island and a lesser elevated value 2 km west. (Figure 5).

The 2 farm stations and one station ~100 m west of the farm also display cover of *Beggiatoa* bacteria.

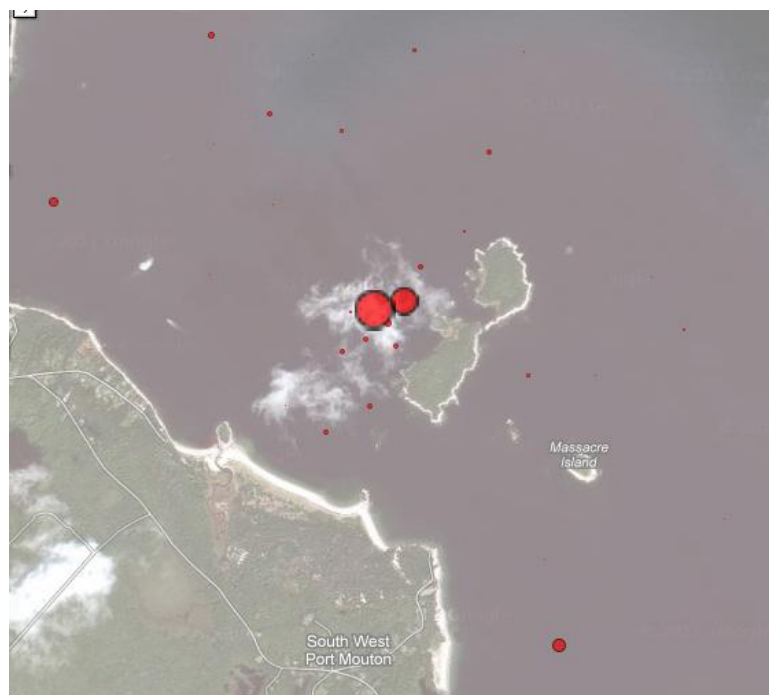


Figure 5. Sediment sulphide values (3-4000 μM) after 15 months of fallow.

Benthic Taxonomy

The response of bottom sediment (infaunal) animals to organic enrichment is an important tool that is applied to marine environmental assessment. Figure 6 shows the number of different species identified in sediments in Port Mouton Bay 3 months after fallow in 2009. A total of 88 different species (ranging from 8 to 37 species at individual stations) was identified in 2009 and a total of 93 species (ranging from 12 to 45 species at individual stations) was identified after 15 months of fallow in 2010. In both years lowest numbers were at the farm site. One of the farm stations in 2010 is the only location to show substantial numbers of the opportunistic polychaete, *Capitella capitata*.

Figures 7a and 7b show the gradient of species numbers along each transect extending outward and generally increasing from the farm site. Numbers of species show improvement in 2010 over 2009 at distances of 1000-1700 m with the exception of the depositional area 2000m south-east of the farm site.

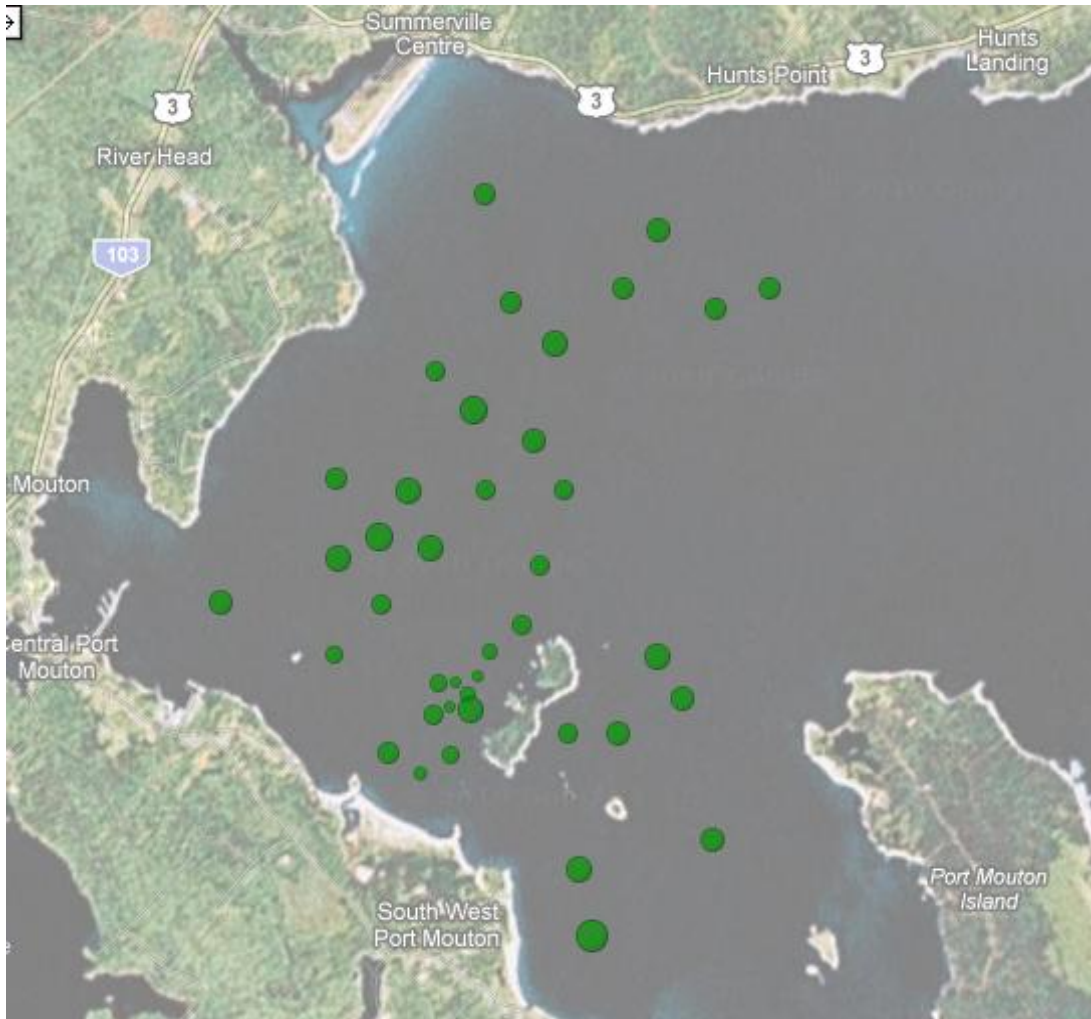
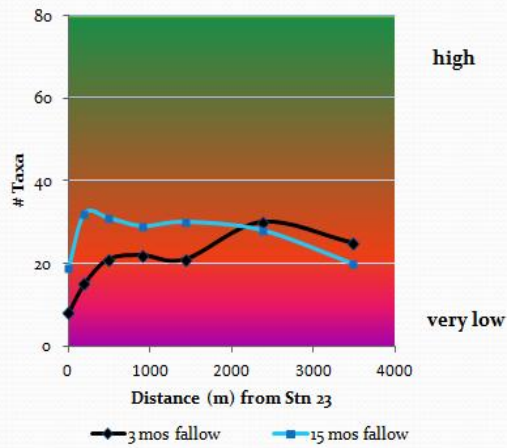
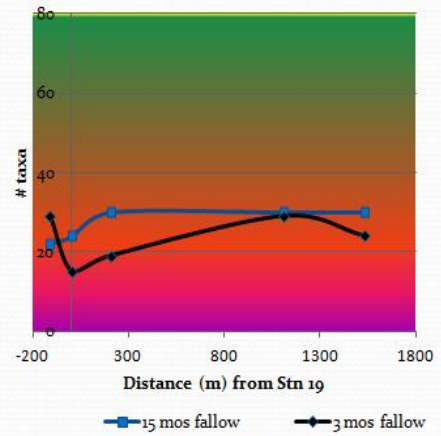


Figure 6. Number of bottom sediment species (8-37) at stations in Port Mouton Bay in 3 months after fallow in 2009.

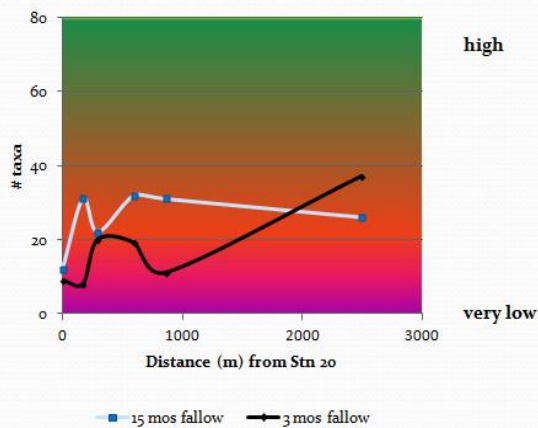
Farm site N toward Summerville Beach



Farm site W to Bell's Pt.



Farm site S & E toward SW Port Mouton



Farm site E toward Port Mouton Island

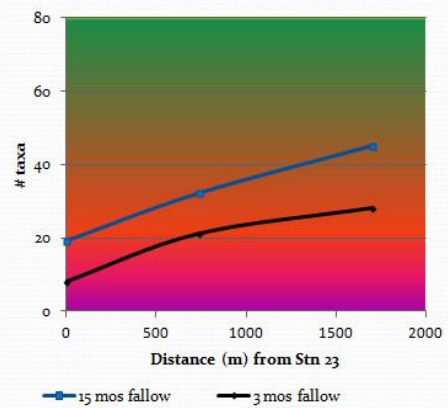


Figure 7. Transects north, west, south/south-east and east from farm site showing the gradient in the number of species with distance after 3 and 15 months fallow.

Benthic Biodiversity

Shannon-Wiener Index

This index measures biodiversity of species and their relative population sizes (Figure 8). After 3 months fallow in 2009, lowest indices are at the farm site and some locations north of the farm site. Figure 9 shows the gradient of biodiversity values on transects extending outward from the farm site. The indices show improvement in 2010 over 2009 at distances of 200-1500 m.

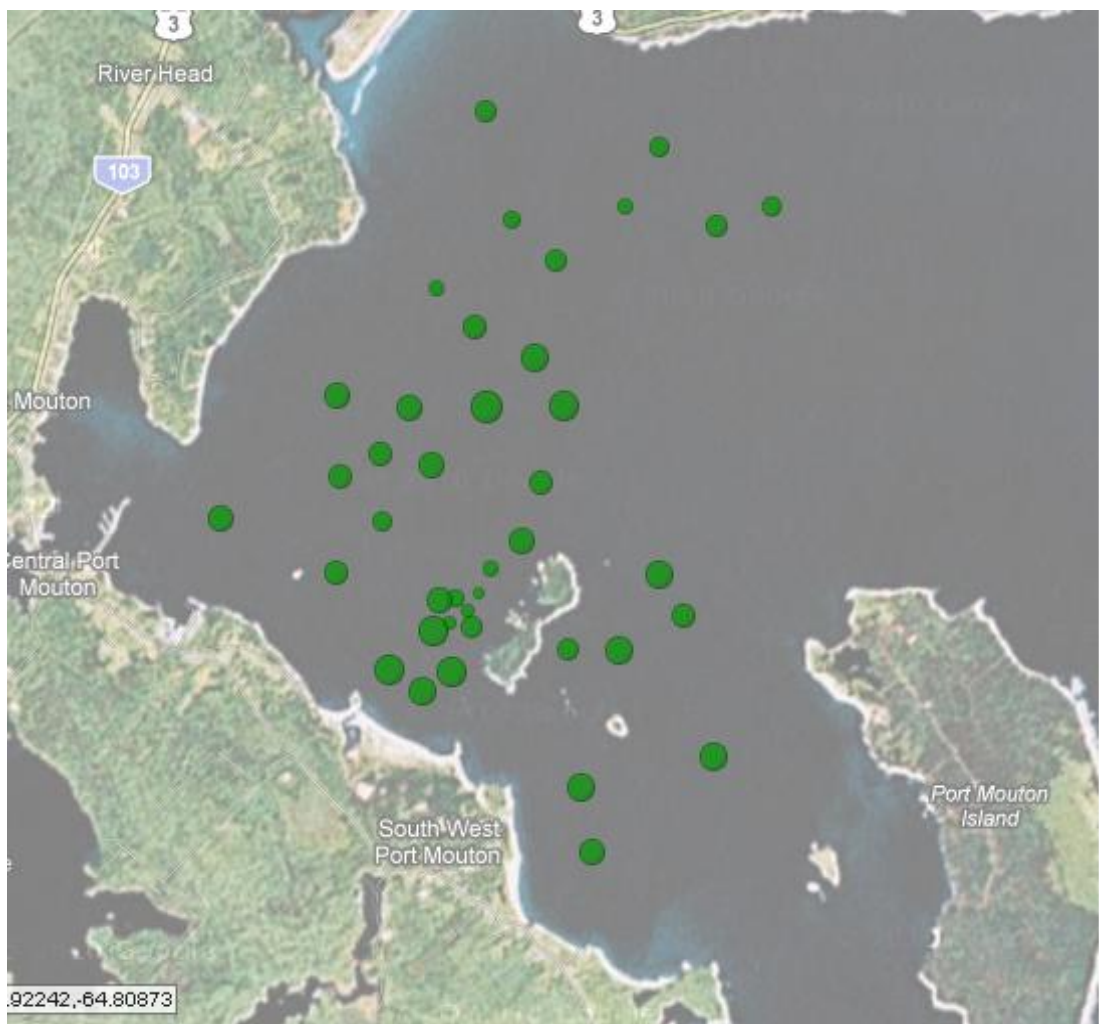


Figure 8. Biodiversity (Shannon-Wiener) Indices (0.8 to 2.6) in Port Mouton Bay 3 months after fallow in 2009.

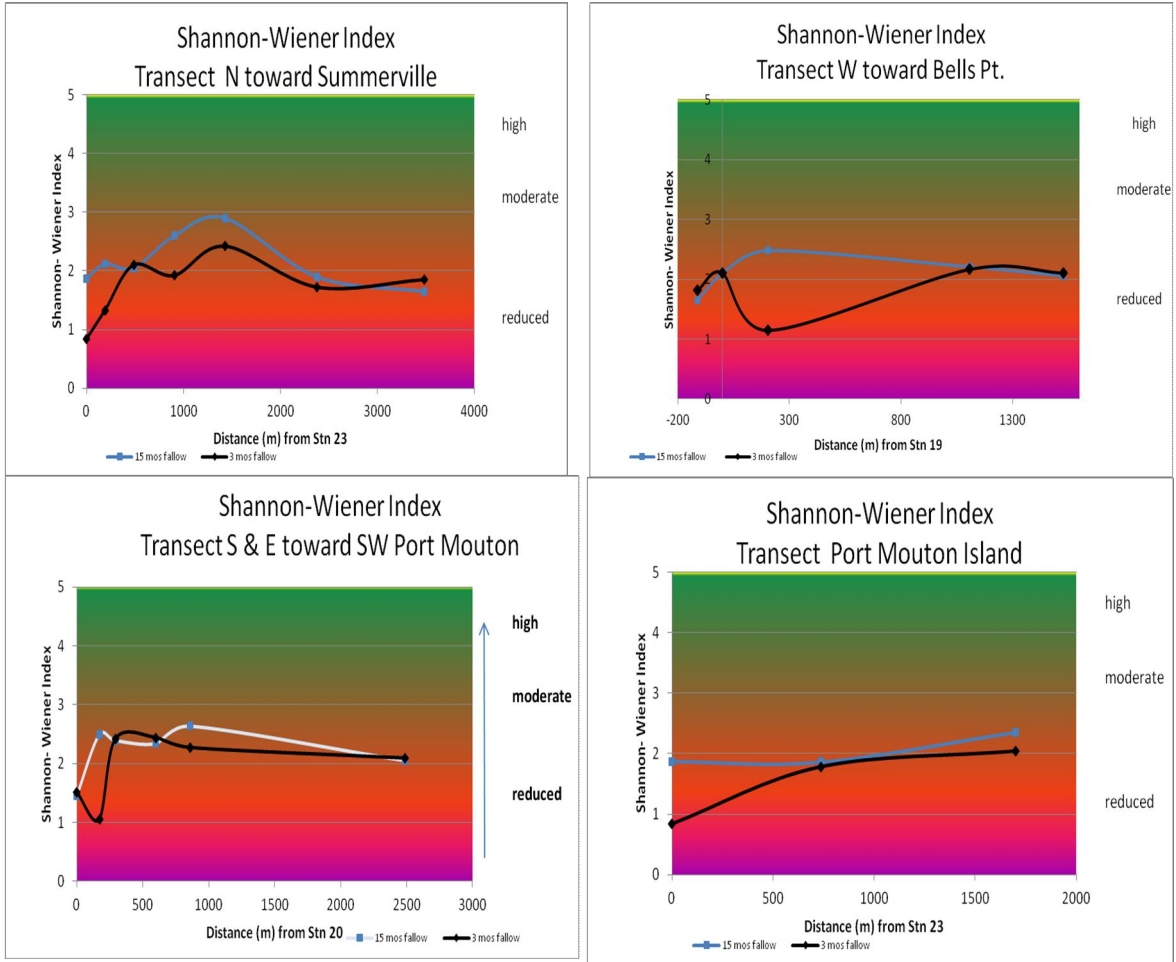


Figure 9. Transects north, west, south/south-east and east from farm site showing the gradient in Shannon-Wiener biodiversity values with distance after 3 and 15 months fallow.

M-AMBI

The Multivariate Assessment of Marine Benthic Index (M-AMBI) is an index of sediment health, including the number and biodiversity of species, and a ranking of species from opportunist (scavenger) to more sensitive types. After 3 months fallow, sediment faunal communities characterized by M-AMBI display the six lowest values of 40 stations at 4 stations on or near the farm site and at 2 stations from 200 to 850 m distant. These values are in the category of 'moderately polluted' on the M-AMBI scale.

After 15 months fallow in 2010, there is one low M-AMBI value at the farm; this farm station is the only station to contain substantial numbers of the opportunistic, scavenger polychaete, *Capitella capitata*. Near-field and far-field stations improved over 2009 values with the exception of two distant depositional areas 2 km south-east and 2 km west.

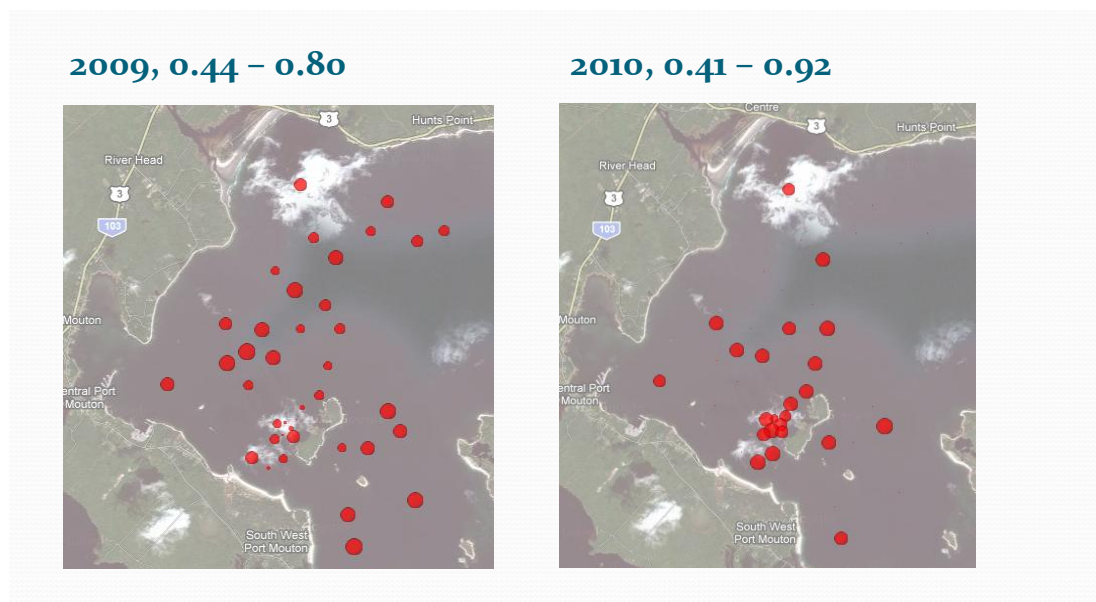


Figure 10. M-AMBI indices in Port Mouton Bay, 3 and 15 months after fallow.

Sediment Profile Images

Core samples were digitally photographed to record the sediment profiles. A sediment profile index (SPI) was determined by measuring the area of oxidized sediment from the surface downward in a standardized image width. Dividing the area by the width yielded the average depth of oxidized sediment.

Figure 11 shows the sediment profile indices for 2009 and 2010 (3 and 15 months after fallow) color coded to indicate the depth of the oxidized sediment. Sediment profiles in red exhibit no oxidized sediment. Figure 12 shows a core with oxidized surface sediment and one of the cores from the farm site with no oxidized sediment. Figure 13 shows a core with undetermined status.

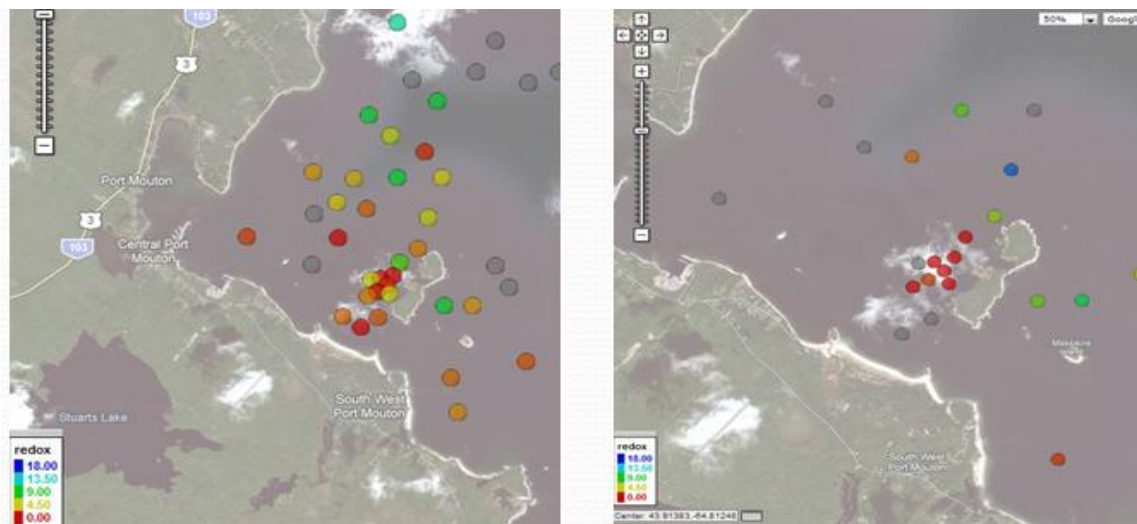


Figure 11.. Sediment Profile Indices (SPI) in Port Mouton Bay 3 months (left) and 15 months (right) after fallow. Chart reflects depth (cms) of of oxic layer at sediment surface. Oxic layer depths range from 0-7.7 cm. Sediment profiles in red exhibit no oxidized sediment. Undetermined core samples are colored grey.



Figure 12. Sediment profile images with oxidized surface sediment (left) and no oxic layer (right).

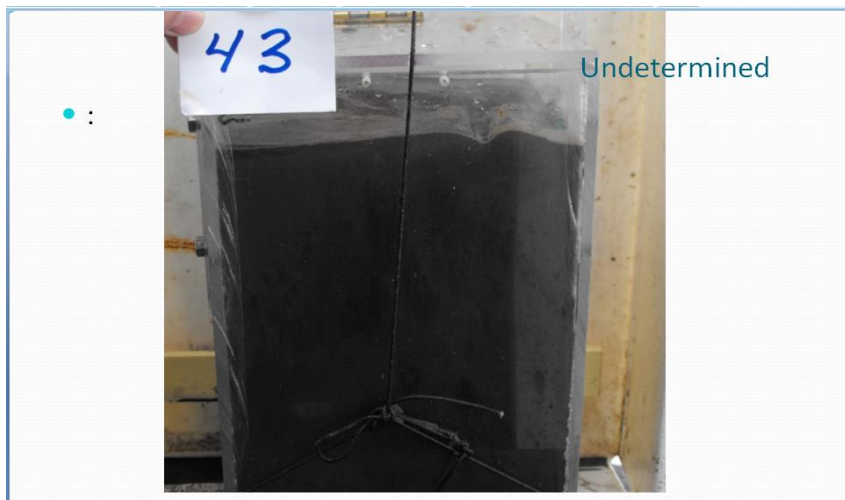


Figure 13. A sediment profile image of undetermined status.

A metrestick measure at a farm station determined that soft silty sediment was deeper than the metrestick. Fishermen report that previous to the fish farm there was ‘bottom’ here suitable for setting traps and gill nets.

Conclusion

The impact of the farm is still obvious even after 15 months of fallow as indicated by geochemical and faunal data. The far-field shows evidence of impact from its organic content, sediment profile images and benthic community structure, but not from sediment sulphides except for 2 distant depositional areas.

Further sampling in 2011 will shed more light on the rate of recovery.

Trace Metals

An analysis of trace metals in sediments is found in a separate report **Trace Metals in Sediments of Port Mouton Bay**.