# An Examination of the Barachois Pond Ecosystems on the Northeast Avalon Peninsula of Newfoundland and Labrador

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Northeast Avalon ACAP

**Executive Summary**

The Northeast Avalon ACAP (NAACAP) visited 12 barachois ponds located on the Northeast Avalon Peninsula of Newfoundland and Labrador to examine and gather ecological data on these coastal environments. Water quality parameters (temperature, pH, conductivity, salinity, dissolved oxygen, total dissolved solids, nitrate nitrogen, nitrate, un-ionized ammonia, ammonium ion and total phosphate) were recorded for each pond visited, and sampling of aquatic vegetation and benthic macroinvertebrates occurred at some of the barachois ponds, as time restrictions did not allow sampling at them all. Other information was recorded qualitatively, including shoreline vegetation types, anthropogenic influences, underwater observations where possible, and information on the barrier beaches that separated them from the marine environment. A large assortment of photos were also taken at all the ponds.

Our study found that all 12 barachois ponds visited were all different from each other, despite being coastal lagoons. They were all influenced in some way by anthropogenic factors, but in varying ways. There were different aquatic plant assemblages found in them, and they had different water salinities. Macroinvertebrate life sampled was found to vary between ponds and within individual ponds, and organisms identified fell mainly into the classification of having a high or moderate tolerance of pollution.

Of special interest at the offset of the project was the presence of eelgrass, as it is known to serve as important fish habitat, especially for young marine species. We found eelgrass in many of the ponds that had a connection with the ocean. This shows that the barachois ponds play a role in sustaining marine species.

The information collected during the project duration was beneficial in providing an overview of the ecosystems, providing baseline data for areas that in some cases had very little previous data collected for them. More specific projects could follow this one, including habitat studies of particular fish species, or mapping of certain habitat types. Continued monitoring is also necessary to not only detect changes to the systems with time and varying inputs, but also to determine any seasonal variations.

**Acknowledgements**

This project was made possible with the help of various people and organizations. First of all, the members of the NAACAP Board of Directors provided guidance and assistance where possible throughout the projects duration. Funding for this project was primarily from Environment Canada through its Atlantic Ecosystems Initiatives program, as a portion of NAACAP's larger Wetlands Survey project. The Kelligrews Ecological Enhancement Project (KEEP) also supplied a monetary contribution to this project based on common interests with NAACAP, specifically relating to Kelligrews Pond and Lower Gully Pond. KEEP also provided the assistance of their summer staff, Chris Ryan and Alanna Flynn. Nikita Abbott, who was employed with NAACAP through the Canada Summer Jobs program during the field season, assisted with field work and data organization and was fundamental to the completion of this project. Dr. Norm Catto graciously provided answers to preliminary questions regarding the geography of barachois ponds and barrier islands. The Department of Biology at Memorial University permitted use of some of the field equipment used for this project, including a kick net. Bob Helleur of the Chemistry Department, Memorial University assisted with the disposal of waste reagents used during water quality testing with the Hach kits. The Department of Fisheries and Oceans (DFO) provided assistance that allowed studying to reach beyond the shoreline level through the use of a remotely operated vehicle (ROV) and boat. Specific thanks to Terry Fleet, Eugene Lee, Sara Lewis and Brenda Moriarity at DFO for their assistance and expertise.

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*1.0 Introduction:*

Barachois ponds are coastal water bodies separated from the ocean by a barrier beach. As such, they are sometimes known as barrier ponds. In many parts of Newfoundland and Labrador, they are known as barasways. It is correct to refer to them as lagoons rather than ponds (Catto, personal comm. July 10, 2012) because the term pond sometimes gives the impression of an inland water body. However, they will be collectively referred to as barachois ponds in this report as they are locally known as ponds.

Barrier beaches form across inlets or embayments because of deposition of beach material transported by wave action, leaving an enclosed lagoon on the landward side. It is sometimes tempting to refer to them as bars; however, they differ from bars because barriers extend above normal high tide levels and are usually not submerged, while bars are usually submerged for part of a tidal cycle (Bird, 2000).

Barachois pond environments can be dynamic, as they can be meeting areas for fresh and salt water, creating brackish water conditions that solely fit the characteristics of neither fresh nor marine water. However, not all barrier beaches provide an opening between the salt and freshwater environments, with some barachois ponds therefore containing fresh water. A breach in a barrier is usually caused by a flow of freshwater from an inland river that erodes the barrier, not because of erosion from the ocean (Catto, personal comm. July 10, 2012). However, storm surges can result in barrier overtopping and damage, leading to a mixing of salt and fresh water. In some cases, there can be salt water percolation through the barrier, allowing for mixing of salt and fresh water in the lagoon without a barrier breach. The equilibrium between fresh and salt water in these ecosystems can change suddenly, and the organisms living in barachois pond ecosystems must consequently be adaptable to a changing environment, including changing salinity levels.

Barachois ponds, as coastal lagoons, can be similar to estuary environments, and have sometimes been classified as back barrier estuaries (Pritchard, 1967; Fairbridge, 1980 as cited in Bird, 2000). As such, some of the characteristics and inhabitants typical of estuaries are also found in barachois ponds. For example, eelgrass beds are found in both barachois ponds and estuaries. Eelgrass is known to be important habitat for fish growth, including cod, salmon and herring (Newfoundland and Labrador Department of Education, 2009), and juvenile cod in eelgrass beds can increase their survival rates by 17 000 times (Fisheries and Oceans Canada, 2011). There have been previous findings of eelgrass in the barachois ponds in Newfoundland, and specifically within the Northeast Avalon Peninsula in Long Pond (Sargent, 2009).

The town of Conception Bay South (CBS), located on the Northeast Avalon Peninsula of Newfoundland and Labrador, has 11 barachois ponds along its coast. Some of them have salt water influx and others are predominately fresh water. Like many Newfoundland communities, the first inhabitants to what is now the town of CBS settled near the coast. As such, all of the barachois ponds in CBS are surrounded by anthropogenic influences ranging from residences and roads to sewage lift stations to armoured beaches that were put in place to protect the infrastructure of the now defunct railway. There is another barachois pond in Freshwater Bay, located within the municipality of St. John's, one located on the southeastern corner of Kellys Island and one on the southeast side of Little Bell Island in Conception Bay.

The Northeast Avalon ACAP (NAACAP) examined 12 of the barachois ponds on the Northeast Avalon Peninsula to gain a better understanding of the components of these ecosystems in the region. These 12 ponds consisted of 11 within the municipality of Conception Bay South and the one in Freshwater Bay. The barachois ponds at Kellys Island and Little Bell Island were not visited because of difficulty accessing them.

## *2.0 Methods:*

This study investigated near shore aquatic vegetation abundance and richness, shoreline vegetation type, benthic invertebrate richness, substrate characteristics and water quality parameters.

Attempts were made to sample each lagoon to include sample sites on the barrier beach separating the ocean from the lagoon, near any inflow and outflows, and other locations along the inland shoreline. However, the number of sample locations selected and their locations varied slightly between lagoons because of accessibility and time limitations.

### *2.1 Aquatic Vegetation:*

Aquatic plant sampling was performed to gain an understanding of what plant communities were found in the waters of each barachois pond.

A one meter squared quadrat was laid continuously in the water from the shoreline (defined by the water's edge) to a water depth of 0.5m. Percent cover of each plant found in each quadrat was recorded. Plant identification was completed using identification books including: *Field Guide to Tidal Wetland Plants of the Northeastern United States and Neighboring Canada: Vegetation of Beaches, Tidal Flats, Rocky Shores, Marshes, Swamps, and Coastal Ponds* by Ralph W. Tiner and *Aquatic and Wetland Plants of Northeastern North America: A Revised and Enlarged Edition of Norman C. Fassett's A Manual of Aquatic Plants, Volumes 1 and 2,* by Garrett E. Crow.

The plant richness for each sample site was calculated to show the number of different aquatic plants that were found in the near shore areas of the barachois ponds. As aquatic plants serve as fish habitat, the identification can also allow inferences about other aquatic species that may be found in the area.

*2.2 Terrestrial Vegetation:*

The vegetation found along the shoreline of the barachois ponds studied (including along the barrier) were not sampled, but notes were made as to what types of plants were found there. Some plants were easily identified to common name. Those plants that were considered non-native according to a list given to NAACAP in 2011 by John Maunder and the Newfoundland and Labrador Invasive Species Council website were highlighted.

*2.3 Benthic Macroinvertebrates:*

Depending on substrate type at each sample location, one of two methods was used for benthic macroinvertebrate sampling. A kick net was used at locations of sandy or fine sediment substrates, and a serber sampler methodology, involving turning over rocks and scrubbing them to obtain invertebrates, was used to investigate invertebrates in areas with a rocky substrate. As the substrate type determined which method to use, notes on substrate type were also taken while sampling for macroinvertebrates, with substrate type assigned a name based on the size classifications used in the Canadian Aquatic Biomonitoring Network (CABIN) procedures. Macroinvertebrates were identified in the field using various online references, including *Key to Life in the Wetland* developed by the University of Wisconsin in cooperation with the Wisconsin Department of Natural Resources, available online at http://watermonitoring.uwex.edu/pdf/level3/WEPP/WEPPLifeinWetland.pdf; and the River Watch Institute of Alberta's webpage titled *Invertebrate Identification*, available at http://www.riverwatch.ab.ca/how_to_monitor/invert_identifying-ident.cfm.

When a kick net was used, sample effort was kept consistent through the use of a timed sample collection. Substrate was disturbed for thirty seconds and collected in the net by moving the net in a zig-zag motion through the disturbed material. The collected material was then transferred to a white dish pan where macroinvertebrates were identified and returned to the environment.

In areas with rocky substrates a dish pan was partially filled with water from the sample location. An area of approximately 30 square centimetres was selected and rocks within that space were removed from their location and scrubbed into the dish pan to loosen macroinvertebrates which were identified and returned to the environment.

Macroinvertebrates can be indicators of the relative water quality, as some types are more sensitive to pollutants than others. For this study, identified macroinvertebrates were assigned a value of 1, 2 or 3, based on their tolerance to pollution. The assigning of these values was based on the *Biotic Index for Water Quality* taken from the teacher's resource *Finding the Balance: For Earth's Sake* by Dennis Minty, Heather Griffin and Dan Murphy. This Index assigned a value of 1 to invertebrates with a high tolerance of pollution, a value of 2 to those invertebrates that had a moderate tolerance of pollution, and a value of 3 to those invertebrates that had a low tolerance of pollution. Another reference was used to assign values based on pollution tolerance if an organism was not found in this index. This was taken from the guidebook *Volunteer Water Quality Monitoring Part of the Missouri Stream Team Program*, which is a partnership between the Missouri Department of Natural Resources, the Missouri Department of Conservation, and the Conservation Federation of Missouri. The invertebrate scoring was found in Chapter 4, Biological Monitoring and is available online at http://www.dnr.mo.gov/env/wpp/vmqmp/vwqm-intro04.pdf. The scoring located there was opposite to that used in index found in *Finding the Balance: For Earth's Sake*, so it was altered so that scores were assigned the same; a value of 1 to invertebrates with a high tolerance of pollution, a value of 2 to those invertebrates that had a moderate tolerance of pollution, and a value of 3 to those invertebrates that had a low tolerance of pollution. This assigning of scores was slightly challenging, as the above mentioned two references used common names, which can sometimes vary amongst people and geographic area.

*2.4 Water Quality:*

Water quality was measured using a Quanta G multi-parameter sonde and a Hach Stream Survey kit. The Quanta G was used in situ, and measured temperature, pH, dissolved oxygen, salinity, conductivity, and total dissolved solids (TDS). Water samples were collected, kept on ice and tested for nitrate nitrogen ($NO_3^-N$), nitrate ($NO_3^-$), un- ionized ammonia ($NH_3$), ammonium ion ($NH_4^+$), and total phosphate ($PO_4$) using a Hach Stream Survey kit. This testing using the Hach kits was not performed in the field due to safety reasons, mainly the hazardous nature of some of the reagents used, and because of the need to boil the sample for the total phosphate test. It was thought that safety could be maintained indoors rather than outdoors.

*2.5 Underwater Observation:*

The Department of Fisheries and Oceans (DFO) assisted with underwater observations in some of the barachois ponds. This allowed for observations other than those that were made from the shoreline.

A remotely operated vehicle (ROV) was used to obtain underwater video. There were some limitations to the use of the ROV, including: that the water had to be a suitable depth; the aquatic vegetation found there could not be too dense; the necessity of a suitable area for launching the ROV (such as a wharf); and that the ROV was best suited to brackish and sea water, and was less effective in freshwater. These limitations meant that the ROV could not be deployed in all of the ponds. The ROV was used in Indian Pond and Seal Cove Pond on July 27, 2012 and again on August 9, 2012 because there were some technical difficulties experienced on the July 27 visit.

In Kelligrews Pond, a Zodiac was used to travel throughout the pond on August 10, 2012. The water was clear and allowed direct observation through to the bottom.

## *3.0 Results*

During visits to the 12 barachois ponds there was both qualitative and quantitative information collected. The sample locations for the quantitative data are shown in Appendix B.

### *3.1 Site Observations*

During the visits to the barachois ponds there was qualitative information gathered that was not expressed numerically, but was valuable in gaining an understanding of the components of each ecosystem. Table 1 contains qualitative information collected from the 12 barachois ponds during visits in 2012. The photos found in Appendix A help to illustrate the results found in Table 1. This information compliments the information gathered from the sampling to form an understanding of each pond ecosystem.

*Table 1. Summary of qualitative characteristics for each of the 12 studied barachois ponds. Non- native plants, according to a list given to NAACAP by John Maunder in 2011 and the Newfoundland and Labrador Invasive Species Council's website, are bolded*

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *1.Topsail Bight* | -Topsail River comes in at southern end via 2 culverts (one large and one small) under Topsail Beach Road | -Yes, towards northeast corner<br>-Flow in breach significant (Figure A1, Appendix A) | -Consisted of beach rocks<br>- Mainly un- vegetated<br>- Patches of vegetation on the lagoonal side to the west of the breach; these were separated by areas of rock that could indicate past barrier over washing (Figure A2, Appendix A)<br>-Scattered individual plants<br>-Vegetation included grasses, potentilla, **morning glory**, Canadian burnet, curled dock, **black knapweed**, roses, beach pea, wild mint (patch at northwest corner on barrier), stinking groundsel and a maple tree | -Trees, shrubs, sedges, grasses and herbaceous plant types (Figure A3, Appendix A) | - Continuation of shoreline vegetation into water<br>-Rushes, sedges | -Topsail Beach Park located at the northeast corner of the lagoon<br>-Residences located on western shore<br>-Northwest corner of lagoon contained machine parts (Figure A4, Appendix A) | -Water levels in lagoon subject to rapid water level change because of hydro operations upstream |
| *2. Chamberlains Pond* | -Fowlers River at northeast corner, smaller inflow at southern end flows under Chaytor's Road from wetland area | -No, but past manmade breaches evidenced by large mounds on barrier (Figure A5, Appendix A) | -Consisted of beach rocks<br>-Mostly un-vegetated<br>-Individual stinking groundsel, lady's thumb and marsh woundwort<br>- Western end had some vegetation patches, consisting of curled dock, grasses, and **morning glory** | -Grasses, irises, sweetgale, **black knapweed**, stinger nettles and rushes | -Continuation of shoreline vegetation into water- rushes, sedges<br>-Submerged pondweed, *Potamogeton perfoliatus*, located throughout most (Figure A6, Appendix A) | -Residences all around<br>-Garbage, some large, including vinyl siding, present (Figure A7, Appendix A)<br>-Feminine hygiene products on ocean side of barrier, from nearby Topsail treatment plant | -Fowlers River was full of small fish at mouth (Figure A8, Appendix A)<br>-Observed fish jumping in pond<br>-Ducks and sand piper present |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *3. Bubble Pond* | -Is the mouth of Manuels River | -Was a small breach located in the northwest corner early in the summer of 2012 ,was no longer visible at the surface later in the Summer of 2012 (Figure A9, Appendix A) | -Consists of beach rocks<br>-Lagoonal side also some smaller gravel<br>-Most vegetation was grouped together near the water (Figure A10, Appendix A)<br>-Woundwort, **morning glory**, Canadian burnett, maple tree, purple bog aster, cow vetch, purple iris, **black knapweed**, meadowsweet, roses, nightshade, butter and eggs, and assortment of grasses | -Lawn of Worsley Park extends along shoreline on eastern side of lagoon. Other vegetation found along the eastern side included **black knapweed**, shrubs, nightshade, sedges, marsh cinquefoil, and seaside plantain<br>-Western side was forested with coniferous trees. Other vegetation included **black knapweed**, asters, sweetgale, grasses, cow vetch, irises, curled dock, marsh woundwort, Canadian burnet, sedges, and horsetails (Figure A11, Appendix A) | -Some shoreline vegetation found extending out into water, including *Scripus pungens and Eleocharis spp., and Juncus spp.*<br>-Pondweed, *Potamogeton perfoliatus*, found on west side | -Worsley Park located on eastern shore (Figure A12, Appendix A) | |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *4. Long Pond* | -Conways Brook flows in at the southwest corner<br>-Smaller inflows at the western side (parallel to Terminal Road), in the southeast corner (under route 60), and on the western shore of the east most lagoon (corner of Bishops Road and Johnson Place) | -Yes, is kept opened manually at western end because of boating and shipping use | -Made of beach rocks<br>-Very steep slope on the lagoonal side<br>-Lots of debris found on western end<br>-Barrier vegetation mainly sparse, but a larger grouping on the eastern end, west of Burnt Island (Figure A13, Appendix A)<br>-Towards the western end of the barrier, on the lagoonal side, there was a hummock that appeared to consist mostly of scotch lovage (Figure A14, Appendix A)<br>- Barrier vegetation included beach pea, sea plantain, stinking groundsel, scotch lovage, crowberry, common juniper, seaside goldenrod, aster, other herbaceous plants | -Mainly herbaceous<br>-Included asters, lady's thumb, **black knapweed**, scotch lovage, irises, stinking groundsel, yarrow, seaside plantain, grasses, curled dock | - *Ulva intestinalis* and rockweed (*Fucus distichus)* observed from shoreline<br>-Eelgrass was observed washed up on shore, indicating that it is present (Figure A15, Appendix A) | -Breakwater installed at the southwest corner of Burnt Island and at the barrier breach<br>-Area of barrier breach is dredged to keep open for boat traffic<br>-Lagoon used for yacht travel and shipping travel. Port located on northwestern shore<br>-Surrounded on all shores by residential and agriculture<br>-Many shores armoured to protect roads that run along the shores<br>-Lift stations at the end of Atkins Road, Perrins Road, Bishops Road, also on Conways Brook Road, near the inflow of Conway's Brook | -Water Levels influenced by the ocean tides, could see water level changes happening (Figure A16, Appendix A)<br>-Jellyfish observed in the water |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *5. Paddys Pond* | -Wetland located at the southern corner could provide an inflow during times of heavy flow | No | -Made up of beach rocks<br>-The top was flattened by ATV traffic<br>-Steep slope on lagoonal side<br>-Was vegetated on the entire length of the lagoonal side, dominantly with morning glory (pink variety that is native) (Figure A17, Appendix A)<br>-Vegetation included irises, butter and eggs, aster, stinging nettles, curled dock, **purple loosestrife**, and marsh woundwort | -**Cattail**, rushes, marsh woundwort, grasses, curled dock, butter and eggs, irises | -Mainly pondweed (*Potamogeton perfoliatus*) | -Agricultural areas located on the eastern and western shores, housing development located to the southwest (Figure A18, Appendix A)<br>-Debris located in the northeast corner, including a tire (Figure A19, Appendix A) | -Numerous birds in the area<br>-Dragonflies numerous in the area<br>-Observed fish in the water (Figure A20, Appendix A), also seen jumping out of the water<br>-Very sandy substrate in northwest corner |

| **Name** | **Inflows** | **Was Barrier Breached During Summer 2012?** | **Barrier Description and Vegetation (Not extensive)** | **Shoreline Vegetation (Other than barrier)** | **Aquatic Vegetation** | **Anthropogenic Influences** | **Other Notes** |
|---|---|---|---|---|---|---|---|
| *6. Butlers Pond* | -Steadywater Brook at the southeast corner | -No, but evidence of past manmade breaching- there were two large piles of gravel on the barrier (Figure A21, Appendix A)<br>-The barrier was very low at the location of this past breach, and it is possible that salt water entered the lagoon during high tide or surges. This was evidenced by the presence of debris and seaweed along the width of the barrier there (Figure A22, Appendix A) | -Made of beach rocks<br>-Sparse vegetation, with some small patches<br>-Vegetation included grasses, scotch lovage, rose, cow vetch, curled dock, **black knapweed**, stinking groundsel | -Meadowsweet, grasses, sweetgale | -*Ulva intestinalis*, *Scirpus americanus*, *Comarum palustre*<br>- Abundant brown scum-like material located on surface (Figure A23, Appendix A) | -Garbage present in water<br>- Concord Drive runs along eastern shore (shoreline armoured to protect road)<br>-Metal garbage located in northwest corner (Figure A24, Appendix A)<br>-Houses on Haggetts Turn and Battens Road border the western shore | - Ducks present<br>-Substrate was very fine silt, very easy to sink in<br>-In the Northwest corner there was a small pool that was cut off from the rest of the lagoon |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *7. Kelligrews Pond* | -Is the mouth of the Kelligrews River, which flows in on the southern end | -Yes, on the western corner.<br>-Trestle runs over breach, supports opening | -The old railway track ran along the barrier<br>-Seaward side of barrier is beach rocks and sand<br>-Lagoonal side of the barrier is similar to the other shorelines, therefore barrier vegetation was included in shoreline vegetation<br>-Erosion evident along lagoonal side of barrier (Figure A25, Appendix A) | -Sweetgale, silverweed, seaside plantain, scotch lovage, grasses, **black knapweed**, curled dock, stinking groundsel, roses | -Eelgrass (*Zostera marina)* throughout<br>-Also *Ulva intestinalis*<br>*-Fucus spiralis, and Fucus spp.* found in mouth of lagoon<br>-Seaside plantain *(Plantago maritime)* found in water, a continuation of shoreline vegetation | -Lift station and overflow culvert located on western side<br>-Sewage treatment plant located to the northwest<br>-Pond Road runs close along the western side<br>-Sewer main runs along barrier, evidenced by the presence of manhole covers (Figure A26, Appendix A)<br>-Various debris observed in the water, including PVC pipe and vinyl siding<br>-Railway track ran along the barrier | -Water levels varied depending on ocean tides, could see the water levels changing between tides<br>-Wetland area located adjacent to the northeast corner was separated when the tide was low by a gravel area that was covered with water at high tide<br>- Erosion evident along western shore (Figure A27, Appendix A), and eastern shore (Figure A28, Appendix A)<br>-Mussels and clams found in the mouth of the lagoon |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *8. Lower Gully Pond* | -The Lower Gully River enters at the southwest corner | -Yes, was breached on western end early in summer, but flow was low<br>-No breach later in summer<br>-Trestle runs over breach site (Figure A29, Appendix A) | -The old railway track ran along the barrier<br>- Seaward side of barrier is beach rocks and sand<br>-Lagoonal side of the barrier is similar to the other shorelines, therefore barrier vegetation was included in shoreline vegetation (Figure A30, Appendix A)<br>-Erosion evident on the lagoonal side of the barrier (Figure A31, Appendix A) | -Grasses, rushes, **black knapweed**, cow vetch, sweetgale, meadowsweet, irises, roses | - Mainly shoreline vegetation that extends into water<br>-Included curled dock *(Rumex crispus)*, small waterwort *(Elatine minima)*, pineapple weed (*Matricaria matricarioides*), *Juncus spp.*, yellow loosestrife *(Lysimachia terrestris)*, toad rush (*Juncus bufonius)*<br>-Mainly found within a meter of the water line | -Gully Pond Place runs along of eastern shore<br>-Surrounded by residential properties<br>-Lift station located on Gully Pond Place, with outflow pipe located in northwest corner of lagoon (Figure A32, Appendix A)<br>-Large rocks line northeast and northwest corners<br>-Old railway track ran along top of barrier | -Fish observed in water<br>-Ducks and sea gulls present |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *9. Lance Cove Pond* | -Wetland located to the south which has a small stream run into it from across Seal Cove Road<br>-A small inflow located in the northeast corner<br>-A small inflow in the northwest corner from the quarry | No | -Old railway track ran along top of barrier<br>-Seaward side consisted of sand and beach rocks<br>-lagoonal side consisted of gravel and beach rocks<br>-Vegetation on lagoonal side included coniferous trees and grasses, herbaceous plants including **black knapweed** (Figure A33, Appendix A)<br>-Evidence of past barrier overtopping- beach rocks covering over the railway track | -Coniferous trees, shrubs and herbaceous plant types | -Survey not completed<br>-Lily Pads observed in northwest and south corners (Figure A34, Appendix A) and along eastern shore (were not in water because of low water levels), sundew also present | -What appeared to be drainage ditches along the eastern shore (Figure A35, Appendix A)<br>-Quarry located adjacent to the northwest corner. Material sorting had water running on it, which then ran into the lagoon (Figure A36, Appendix A)<br>-Residential properties surround lagoon, many have made wharves into the lagoon<br>-Old railway track ran along top of barrier | -Ducks observed |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *10. Seal Cove Pond* | -Is the mouth of the Seal Cove River, which enters at the western end<br>-Billy Brook is a smaller inflow, enters midway along the southern shore after passing through the corner of Hands Road and Seal Cove Road | -Yes, in northwest corner of lagoon<br>-Railway Trestle stabilises the breach | -Old Railway track ran along top of the barrier<br>-Seaward side consisted of beach rocks<br>-Lagoonal side of the barrier very steep, levelled out at bottom before water's edge (Figure A37, Appendix A)<br>-Barrier vegetation included stinking groundsel, seaside plantain, sea lungwort, cow vetch, **black knapweed**, asters | -Coniferous trees, sweetgale, meadowsweet, grasses, rushes, **black knapweed**, cow vetch, asters, common juniper, lady's thumb, scotch lovage<br>-Northeast shore was more sparsely vegetated than other shores (Figure A38, Appendix A) | -Sea lettuce (*Ulva lactuca)* and *Ulva intestinalis* (Figure A39, Appendix A)<br>-Some plants were submerged shoreline plants, including grasses and seaside plantain<br>-Eelgrass (*Zostera marina)* not found in surveys, but was washed up along northern shore in large amounts (Figure A40, Appendix A) and observed in underwater ROV footage | -Old Railway track runs along the barrier<br>-Lift station located at the end of Dowdens Road<br>-Used by small boat traffic<br>-Residential area along the southern shore<br>-What looked like an old quarry site to the north | -Resident said eels used to be plentiful, but they became scarce and that there are some now. Eel(s) was (were) observed on ROV video<br>-Shoreline erosion on north shore<br>-Mink observed amongst rocks in southwest corner |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *11. Indian Pond* | -Quarry Brook comes in on southern end | -Yes, in northeast corner<br>-Railway trestle stabilises the breach | -Old railway track runs along the top of the barrier<br>-Seaward side was beach rocks, did have some vegetation on the top portion<br>-Lagoonal side was made of rocks and gravel, became more sandy as went from east to west<br>-Lagoonal side had a gentle slope<br>-More vegetated on western end than eastern end<br>-Vegetation included hawkweed, scotch lovage, **Canada thistle**, beach pea, coniferous trees, potentilla, cow vetch, seaside plantain, stinking groundsel, pineapple weed | -Included grasses, rushes, **black knapweed**, shrubs, roses, coniferous trees, silverweed, some coniferous trees | - *Ulva intestinalis*, rockweed (*Fucus distichus)*, knotted wrack (*Ascophyllum nodosum*) (Figure A41, Appendix A) . These species also found at river mouth<br>-Eelgrass not observed in surveys, but was found washed up on shores, and was found to be abundant in underwater videos | -Hydro generating plant located to the southwest (Figure A42, Appendix A)<br>-Used for small boat traffic<br>-Small wharves and boat tie ups (Figure A42, Appendix A)<br>-Residential area along the eastern shore<br>-Some garbage and debris found along shores, including what looked like some kind of a cart used with the railway that was located on the lagoonal side of the barrier (Figure A43, Appendix A) | -Jellyfish observed in water and washed up on shore (Figure A44, Appendix A)<br>-Aquatic vegetation washed up along shoreline was an indication that water levels change drastically with the change in ocean tides<br>-Mussels, periwinkles, barnacles, razor and soft bodied clams present throughout lagoon |

| Name | Inflows | Was Barrier Breached During Summer 2012? | Barrier Description and Vegetation (Not extensive) | Shoreline Vegetation (Other than barrier) | Aquatic Vegetation | Anthropogenic Influences | Other Notes |
|---|---|---|---|---|---|---|---|
| *12. Freshwater Bay Pond* | -Leamys Brook comes in from the south | -No | -Large rocks | -Lagoon was surrounded by forest consisting of coniferous trees and shrubs (Figure A45, Appendix A)<br>-Northwest corner had a break in the coniferous trees and there were some shrubs including sweetgale, and some herbaceous plants including grasses, irises, Canadian burnet, **foxglove**, **tansy ragwort** | -Survey not completed, but there was a grass- like plant observed in the water along the barrier (Figure A46, Appendix A) | -Area used as a hiking trail, some garbage left behind, and evidence of past campfires (Figure A47, Appendix A)<br>-Large metal pieces found in the northwest corner of lagoon (Figure A47, Appendix A) | -Substrate in northwest corner was sandy, extended eastward along the barrier shoreline (Figure A48, Appendix A) |

As shown is Table 1, the 12 barachois ponds studied were different in varying ways. Some were open to the ocean during the study period, while others were not. All of the ponds had some degree of obvious anthropogenic influence. There were also a number of non-native plant types identified.

The aquatic vegetation consisted mainly of either three types; a continuation of shoreline vegetation; dominantly pondweed; or mainly seaweed and sea grass. Within such classifications, Topsail Bight, Bubble Pond, Gully Pond, Lance Cove Pond, and Freshwater Bay Pond would be considered to consist mainly of a continuation of shoreline vegetation types. Butlers Pond would also be placed in this category because it does not belong in the other two classifications. Chamberlains Pond and Paddy's Pond were dominantly pondweed. Long Pond, Kelligrews Pond, Seal Cove Pond and Indian Pond contained mainly seaweed and sea grass.

### *3.2 Aquatic Plant and Macro Benthic Invertebrates Richness*

Table 2 displays the aquatic plant and benthic macroinvertebrate richness values, representative of the number of different aquatic plant and invertebrate types identified, for each site where sampling was conducted (Appendix B).

*Table 2. Aquatic plant richness, benthic macroinvertebrate richness and substrate type for the sites where sampling was completed.*

| Site | Aquatic Vegetation Richness | Invertebrate Richness | Substrate Type |
|---|---|---|---|
| TP_A | 0 | 5 | Pebble |
| TP_B | 5 | 9 | Cobble |
| TP_C | 6 | NA | NA |
| TP_D | 6 | 4 | Pebble |
| TP_E | 3 | NA | Sand |
| TP_F | 3 | NA | NA |
| CH_A | 2 | NA | Gravel and Course Sand |
| CH_B | 3 | NA | Coarse Sand |
| CH_C | 1 | NA | NA |
| CH_D | 1 | 5 | NA |
| CH_E | 5 | NA | NA |
| CH_F | 2 | NA | NA |
| CH_G | NA | 6 | NA |
| BP_A | 2 | 6 | Cobble and Pebble |
| BP_B | 1 | NA | NA |
| BP_D | 1 | 5 | Pebble and Sand |
| BP_E | 2 | NA | NA |
| BP_F | NA | 10 | Pebble |
| LP_A | 0 | 7 | Pebble and Gravel |
| LP_C | 0 | NA | Pebble |

| Site | Aquatic Vegetation Richness | Invertebrate Richness | Substrate Type |
|---|---|---|---|
| LP_E | 2 | 2 | Pebble and Gravel |
| LP_F | 1 | 1 | Sand, Gravel and Cobble |
| LP_G | 2 | 11 | Pebble |
| LP_H | 2 | NA | Cobble |
| PP_A | 1 | NA | NA |
| BT_A | 3 | NA | NA |
| BT_B | 3 | NA | NA |
| BT_C | 1 | NA | NA |
| BT_D | 6 | NA | NA |
| KP_A | 5 | 4 | Pebble |
| KP_B | 3 | NA | NA |
| KP_C | 3 | NA | NA |
| KP_D | 4 | NA | NA |
| KP_E | 1 | NA | NA |
| KP_F | 4 | 4 | Cobble |
| KP_G | NA | 8 | Pebble and Gravel |
| GP_A | 3 | NA | NA |
| GP_B | 4 | 7 | Pebble and Gravel |
| GP_C | 6 | NA | NA |
| GP_D | 1 | NA | NA |
| GP_E | 6 | 3 | Cobble and Organics |
| GP_F | NA | 1 | Pebble and Cobble |
| SC_A | 4 | 3 | Gravel and Pebble |
| SC_B | 2 | 2 | NA |
| IP_A | 3 | NA | Pebble and Sand |
| IP_B | 2 | NA | Pebble |
| IP_C | 0 | NA | Pebble |
| IP_D | 0 | NA | Pebble |
| IP_E | 0 | NA | Pebble |

The shoreline vegetation richness values at all the sample sites ranged from 0 to 6. The invertebrate richness found at sample sites ranged from 1 to 11. There was also variation among invertebrate richness values associated with sites within the same barachois pond, with the largest range of values obtained from within a barachois pond occurring at Long Pond. The substrate at the sample locations also varied, and included either sand, gravel, pebble or cobble size.

Table 3 lists the identified benthic macroinvertebrates found within each lagoon, categorized based on their pollution tolerance. Those organisms that were not easily placed in one of the categories were placed under the category of Other.

*Table 3. Benthic macro-invertebrates found in each lagoon, classified based on pollution tolerance*

| **Barachois Pond Name** | **High Tolerance of Pollution (1 point)** | **Moderate Tolerance of Pollution (2 points)** | **Low Tolerance of Pollution (3 points)** | **Other** |
|---|---|---|---|---|
| *Topsail Bight* | Pouch Snail<br>Threadworm<br>Midge larvae<br>Orb Snail | Amphipod (Scud)<br>Beetle (Family Dytiscids)<br>Caddis Fly larvae | Black Fly larvae | Springtail<br>Nematode<br>Mosquito Pupae<br>Springtail |
| *Chamberlains Pond* | Threadworm<br>Midge larvae | Damselfly nymph<br>Amphipod (Scud) | | Waterboatmen |
| *Bubble Pond* | Midge larvae<br>Threadworm | Waterboatmen<br>Caddis Fly egg sac<br>Damselfly nymph | Black Fly larvae | Water flea<br>Horsefly larvae<br>Fly Pupae (unable to identify)<br>Mosquito larvae<br>Nematode |
| *Long Pond* | Threadworm<br>Orb snail<br>Midge larvae | Amphipod (Scud)<br>Aquatic Sowbug<br>Gilled Snail | | Bristleworm<br>Beach Flea (order Amphopoda)<br>Nematode |
| *Kelligrews Pond* | Threadworm<br>Midge larvae | Aquatic Sowbug<br>Amphipod (Scud) | | Bristleworm<br>Seed Shrimp<br>Waterboatmen<br>Nematode |
| *Gully Pond* | Threadworm<br>Midge larvae | Gilled Snail<br>Dragonfly larvae | | Springtail<br>Nematode<br>Waterboatmen |
| *Seal Cove Pond* | Threadworm | Gilled snail<br>Mussel | | Backswimmer |
| *Indian Pond* | | Periwinkle<br>Mussel<br>Amphipod (Scud) | | Barnacle<br>Water Strider |

Of the organisms that could be classified based on their pollution tolerance, the majority were found within the categories of high or moderate tolerance to pollution. However, organisms identified at Topsail Pond and Bubble Pond fell within the low tolerance to pollution category.

### *3.3 Water Quality*

Table 4 displays water quality information collected from the various barachois ponds using a Quanta G multiparameter sonde. It is important to note that these measurements are representative of the moment in time and values could vary at other times. This is necessary to stress because of the dynamic nature of barachois pond environments with varying salt and fresh water inputs.

*Table 4. Water quality parameters measured using the Quanta G multi-parameter sonde. Paramaters measured were temperature, conductivity, dissolved oxygen (DO), pH, total dissolved solids (TDS) and salinity. Values in bold red font exceed guidelines set for aquatic life in freshwater. The salinity values are color coded based on classifications given by the Windows to the Universe website (Bergman, 2001). The classification is as follows: green text indicates freshwater with a salinity less than 1,000ppm (1PSS), purple text indicates slightly saline water with a salinity from 1,000 ppm to 3,000ppm (1PSS to 3PSS), blue text indicates moderately saline water with a salinity from 3,000 ppm to 10,000ppm (3PSS to 10PSS), and orange text indicates highly saline water with a salinity from 10,000 ppm to 35,000 ppm (10PSS to 35PSS).*

| Site | Date | Temperature (°C) | Conductivity (mS/cm) | DO (mg/L) | DO (%) | pH | TDS (g/L) | Salinity (PSS) |
|---|---|---|---|---|---|---|---|---|
| TP_A | 21_08_12 | 18.89 | **8.640** | 9.00 | 99.3 | 7.50 | **5.5** | 4.75 |
| TP_C | 21_08_12 | 18.39 | 0.534 | 9.46 | 100.6 | 7.22 | 0.6 | 0.28 |
| TP_D | 21_08_12 | 19.39 | **5.340** | 9.45 | 103.9 | 7.51 | **3.4** | 2.84 |
| TP_E | 21_08_12 | 18.77 | **2.610** | 9.63 | 104.1 | 7.45 | **1.8** | 1.33 |
| TP_G | 21_08_12 | 19.85 | 0.975 | 9.01 | 98.9 | 7.10 | 0.6 | 0.48 |
| CH_A | 21_08_12 | 21.98 | **6.730** | 8.82 | 102.7 | **9.10** | **4.3** | 3.66 |
| CH_D | 21_08_12 | 20.37 | **2.920** | 10.64 | 116.6 | 8.75 | **2.5** | 1.37 |
| CH_G | 21_08_12 | 21.93 | **7.230** | 8.92 | 104.7 | 8.67 | **4.6** | 3.59 |
| BP_A | 11_07_12 | 19.22 | **2.370** | 8.71 | 94.7 | 7.72 | **1.5** | 1.22 |
| BP_D | 11_07_12 | 18.91 | **2.430** | 8.22 | 88.8 | 7.80 | **1.6** | 1.24 |
| BP_F | 11_07_12 | 19.14 | **2.530** | 8.33 | 90.2 | 7.77 | **1.6** | 1.30 |
| LP_A | 23_08_12 | 19.23 | **44.900** | 6.02 | 77.9 | 7.73 | **28.7** | 28.76 |
| LP_B | 23_08_12 | 18.40 | **45.300** | 8.29 | 106.0 | 8.00 | **29.0** | 29.00 |
| LP_C | 23_08_12 | 18.75 | **44.700** | 7.57 | 96.6 | 7.99 | **28.5** | 28.52 |
| LP_D | 23_08_12 | 17.76 | **46.500** | 8.92 | 112.4 | 8.11 | **29.8** | 29.83 |
| LP_E | 23_08_12 | 19.58 | **45.000** | 8.89 | 115.8 | 8.06 | **28.8** | 28.85 |
| LP_F | 23_08_12 | 18.59 | **45.900** | 8.41 | 107.7 | 8.08 | **29.4** | 29.59 |
| LP_G | 23_08_12 | 19.35 | **37.700** | 8.74 | 110.1 | 8.13 | **24.5** | 23.77 |
| LP_H | 23_08_12 | 20.88 | **41.600** | 12.15 | 160.5 | 8.34 | **26.6** | 26.49 |
| LP_I | 23_08_12 | 20.68 | **46.000** | 9.62 | 128.2 | 8.21 | **29.4** | 29.69 |
| PP_A | 29_08_12 | 23.98 | **12.750** | 9.17 | 113.5 | 8.56 | **8.2** | 7.30 |
| BT_A | 29_08_12 | 22.95 | **22.600** | 7.75 | 97.9 | 7.48 | **14.5** | 13.58 |
| BT_D | 29_08_12 | 22.23 | **38.400** | 7.65 | 106.1 | 7.82 | **24.6** | 24.22 |
| BT_E | 29_08_12 | 26.96 | **39.700** | 17.04 | 247.4 | 8.37 | **25.3** | 25.37 |
| BT_F | 29_08_12 | 30.60 | **41.300** | 14.83 | 232.8 | 7.93 | **26.6** | 26.64 |
| KP_A | 27_08_12 | 18.33 | **47.000** | 9.62 | 123.1 | 7.94 | **30.1** | 30.22 |
| KP_B | 27_08_12 | 22.37 | **45.200** | 11.20 | 154.9 | 8.06 | **29.0** | 29.18 |
| KP_D | 27_08_12 | 25.79 | **41.600** | 7.47 | 109.2 | 7.61 | **26.8** | 26.89 |
| KP_E | 27_08_12 | 19.54 | **46.300** | 10.39 | 136.3 | 8.02 | **29.6** | 29.84 |
| GP_A | 27_08_12 | 21.95 | 0.187 | 9.26 | 105.5 | 7.24 | 0.1 | 0.09 |

| Site | Date | Temperature (°C) | Conductivity (mS/cm) | DO (mg/L) | DO (%) | pH | TDS (g/L) | Salinity (PSS) |
|---|---|---|---|---|---|---|---|---|
| GP_D | 27_08_12 | 19.99 | 0.402 | 9.74 | 106.9 | 7.34 | 0.3 | 0.19 |
| GP_E | 27_08_12 | 19.91 | 0.464 | 9.42 | 103.5 | 7.35 | 0.3 | 0.22 |
| LC_A | 29_08_12 | 22.03 | 0.387 | 8.27 | 94.6 | 7.18 | 0.3 | 0.19 |
| LC_B | 29_08_12 | 23.12 | 0.384 | 8.95 | 104.3 | 7.60 | 0.2 | 0.18 |
| LC_C | 29_08_12 | 23.20 | 0.390 | 8.00 | 94.1 | 7.22 | 0.3 | 0.19 |
| SC_A | 29_08_12 | 18.26 | **44.800** | 8.97 | 114.9 | 7.69 | **28.8** | 28.43 |
| SC_C | 29_08_12 | 18.89 | **45.700** | 6.73 | 87.1 | 7.63 | **29.3** | 29.32 |
| SC_D | 29_08_12 | 18.87 | **38.200** | 6.99 | 87.6 | 7.63 | **24.5** | 24.03 |
| SC_E | 29_08_12 | 21.31 | **44.900** | 8.37 | 112.1 | 7.79 | **28.7** | 28.78 |
| IP_A | 14_08_12 | 20.03 | **43.700** | 8.23 | 108.5 | 8.06 | **28.0** | 27.94 |
| IP_B | 14_08_12 | 20.90 | **43.200** | 8.18 | 109.3 | 8.17 | **27.6** | 27.62 |
| IP_C | 14_08_12 | 21.21 | **43.600** | 7.85 | 105.0 | 8.12 | **27.9** | 27.92 |
| IP_D | 14_08_12 | 19.98 | **44.500** | 7.22 | 94.1 | 8.00 | **28.5** | 28.51 |
| IP_E | 14_08_12 | 21.74 | **43.500** | 7.78 | 104.7 | 8.10 | **27.8** | 27.87 |
| FB_A | 16_08_12 | 20.67 | **1.760** | 8.42 | 94.5 | 7.04 | **1.1** | 0.89 |

All of the sites had dissolved oxygen levels that were above the lowest acceptable level in warm water of 6.0mg/L for early life stages and 5.5mg/L for other life stages suggested in the CCME Water Quality Guidelines for the Protection of Aquatic Life (CCME, 1999). Most of the sites had pH values that were within the range of 6.5-9 suggested in the CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2006). The one exception was sample site CH_A at Chamberlains Pond, where a pH of 9.10 was recorded.

Many of the sample sites exceeded the recommended ranges in freshwater for conductivity and total dissolved solids (TDS) of 0.050 – 1.5 mS/cm and 0-1g/L respectively (Province of British Columbia, 1998). These higher values of conductivity and TDS can be related to the salinity values recorded for these sites, as generally salt water has a higher conductivity and TDS than fresh water. All of the sites with conductivity and TDS values higher than those recommended for freshwater had salinity values that fell within the classification ranges other than that of freshwater (Bergman, 2001). For the purposes of this study, the classifications can be combined so that the classifications of slightly saline, moderately saline and highly saline are representative of brackish water. With this generalization, Topsail Bight, Chamberlains Pond, Bubble Pond, Long Pond, Paddys Pond, Butlers Pond, Kelligrews Pond, Seal Cove Pond and Indian Pond contain brackish water. Lower Gully Pond, Lance Cove Pond, and Freshwater Bay Pond contain fresh water. The highest salinity, TDS and conductivity values were found in Long Pond, Butlers Pond, Kelligrews Pond, Seal Cove Pond and Indian Pond. The distribution of salinity classifications for each lagoon can be found in Appendix B.

Water quality parameters determined using Hach Stream Survey kits are given in Table 5 for each water quality testing site.

*Table 5. Water quality parameters, nitrate nitrogen ($NO_3^-$–N), nitrate ($NO_3^-$), un-ionized ammonia ($NH_3$), ammonium ion ($NH_4^+$) and total phosphate ($PO_4^{3-}$) tested using the Hach Stream Survey test kits for water quality sample sites at the 12 studied barachois ponds on the Northeast Avalon Peninsula. Values in red text exceed guideline values given for freshwater in the CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life.*

| Site | Date | $NO_3^-$-N (mg/L) | $NO_3^-$ (mg/L) | $NH_3$ (mg/L) | $NH_4^+$ (mg/L) | $PO_4^{3-}$ (mg/L) |
|---|---|---|---|---|---|---|
| TP_A | 21_08_12 | 0.00000 | 0.00000 | 0.00161 | 0.12826 | 0.08000 |
| TP_C | 21_08_12 | 0.12000 | 0.52800 | 0.00065 | 0.12930 | 0.04000 |
| TP_D | 21_08_12 | 0.04000 | 0.17600 | 0.00322 | 0.25652 | 0.08000 |
| TP_E | 21_08_12 | 0.08000 | 0.35200 | 0.00102 | 0.12890 | 0.04000 |
| TP_G | 21_08_12 | 0.06000 | 0.26400 | 0.00047 | 0.12949 | 0.04000 |
| CH_A | 21_08_12 | 0.02000 | 0.08800 | **0.03768** | 0.08918 | 0.04000 |
| CH_D | 21_08_12 | 0.06000 | 0.26400 | **0.02398** | 0.10403 | 0.04000 |
| CH_G | 21_08_12 | 0.00000 | 0.00000 | 0.01849 | 0.10997 | 0.04000 |
| BP_A | 11_07_12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.04000 |
| BP_D | 11_07_12 | 0.00000 | 0.00000 | 0.00253 | 0.12726 | 0.04000 |
| BP_F | 11_07_12 | 0.00000 | 0.00000 | 0.00186 | 0.12726 | 0.04000 |
| LP_A | 23_08_12 | 0.02000 | 0.08800 | 0.00372 | 0.25597 | 0.08000 |
| LP_B | 23_08_12 | 0.00000 | 0.00000 | 0.00396 | 0.12571 | 0.04000 |
| LP_C | 23_08_12 | 0.00000 | 0.00000 | 0.00792 | 0.25142 | 0.00000 |
| LP_D | 23_08_12 | 0.00000 | 0.00000 | 0.01850 | 0.36995 | 0.04000 |
| LP_E | 23_08_12 | 0.00000 | 0.00000 | 0.01372 | 0.37514 | 0.04000 |
| LP_F | 23_08_12 | 0.00000 | 0.00000 | 0.00396 | 0.12571 | 0.00000 |
| LP_G | 23_08_12 | 0.00000 | 0.00000 | 0.00708 | 0.12233 | 0.00000 |
| LP_H | 23_08_12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| LP_I | 23_08_12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| PP_A | 29_08_12 | 0.00000 | 0.00000 | **0.02080** | 0.10700 | 0.16000 |
| BT_A | 29_08_12 | 0.04000 | 0.17600 | 0.00274 | 0.25700 | 0.00000 |
| BT_D | 29_08_12 | 0.00000 | 0.00000 | 0.00773 | 0.25200 | 0.00000 |
| BT_E | 29_08_12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| BT_F | 29_08_12 | 0.14000 | 0.61600 | 0.00892 | 0.12000 | 0.00000 |
| KP_A | 27_08_12 | 0.00000 | 0.00000 | 0.00396 | 0.12600 | 0.00000 |
| KP_B | 27_08_12 | 0.00000 | 0.00000 | 0.00526 | 0.12400 | 0.04000 |
| KP_D | 27_08_12 | 0.14000 | 0.61600 | 0.00566 | 0.25400 | 0.00000 |
| KP_E | 27_08_12 | 0.00000 | 0.00000 | 0.00914 | 0.25000 | 0.00000 |
| GP_A | 27_08_12 | 0.06000 | 0.26400 | 0.00098 | 0.12900 | 0.00000 |
| GP_D | 27_08_12 | 0.04000 | 0.17600 | 0.00118 | 0.12900 | 0.00000 |
| GP_E | 27_08_12 | 0.06000 | 0.26400 | 0.00235 | 0.25700 | 0.08000 |
| LC_A | 29_08_12 | 0.00000 | 0.00000 | 0.00197 | 0.25800 | 0.00000 |
| LC_B | 29_08_12 | 0.00000 | 0.00000 | 0.00215 | 0.12800 | 0.00000 |
| LC_C | 29_08_12 | 0.00000 | 0.00000 | 0.00100 | 0.12900 | 0.04000 |

| Site | Date | $NO_3^-$-N (mg/L) | $NO_3^-$ (mg/L) | $NH_3$ (mg/L) | $NH_4^+$ (mg/L) | $PO_4^{3-}$ (mg/L) |
|---|---|---|---|---|---|---|
| SC_A | 29_08_12 | 0.00000 | 0.00000 | 0.00482 | 0.38500 | 0.00000 |
| SC_C | 29_08_12 | 0.00000 | 0.00000 | 0.00322 | 0.25700 | 0.00000 |
| SC_D | 29_08_12 | 0.00000 | 0.00000 | 0.00161 | 0.12800 | 0.00000 |
| SC_E | 29_08_12 | 0.00000 | 0.00000 | 0.00337 | 0.12600 | 0.00000 |
| IP_A | 14_08_12 | 0.09000 | 0.39600 | 0.00000 | 0.00000 | 0.08000 |
| IP_B | 14_08_12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| IP_C | 14_08_12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.04000 |
| IP_D | 14_08_12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| IP_E | 14_08_12 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.04000 |
| FB_A | 16_08_12 | 0.09000 | 0.39600 | 0.00047 | 0.12949 | 0.04000 |

The CCME Water Quality Guidelines for the Protection of Aquatic Life have recommendations for levels of nitrate nitrogen, nitrate and unionized ammonia. There are no guidelines for ammonium ion, as the unionized form ($NH_3$) is believed to be the better indicator of ammonia toxicity (Environment Canada, 1999; Frias-Espericueta et al., 1999; EPA, 1998 as cited in CCME, 2010), or phosphate, as phosphorus is essential for life and the levels that cause problems can vary amongst different ecosystems (CCME, 2004). The CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life present a framework for phosphorus levels, where it is not recommended that values exceed “trigger ranges” or increase more than 50% over baseline values (CCME, 2004). The values of ammonium ion data collected here is valuable as baseline data to compare with any future readings, as it is a component of the nitrogen cycle and may be useful if looking at nitrogen supply.

All of the values recorded for nitrate nitrogen and nitrate were below the respective values of 3.0 mg/ L and 13mg/L recommended for fresh water and the values of 45mg/L and 200mg/L recommended for marine environments in the CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2012). The un-ionized ammonia amounts for CH_A and CH_D at Chamberlains Pond and the PP_A site at Paddy’s Pond exceeded the CCME Canadian Water Quality Guideline for the Protection of Aquatic Life of 0.019 mg/L (CCME, 2010). Of these sites, the highest value (0.03768 mg/L) was at the CH_A sample site. The only other sample site for Chamberlains Pond, CH_G, had a value of un-ionized ammonia of 0.01849, which does not exceed the guideline, but is slightly below it.

### *3.4 Underwater Observation*

With the use of DFO’s ROV and Zodiac, and the assistance of DFO staff, observations were made other than those made onshore at Kelligrews Pond, Seal Cove Pond, and Indian Pond.

On July 27, 2012 and August 9, 2012 the ROV was deployed in Indian Pond from a small wharf located on the barrier towards the northeast corner of the lagoon. The underwater video revealed that there was a mud and silt bottom with scattered rocks. There were sticklebacks and what appeared to be a flounder swimming in the water and sea stars located on the bottom.

There was eelgrass growing in small patches in some areas, while there were other larger meadows of eelgrass also present.

The ROV was deployed in Seal Cove Pond on July 27, 2012 and August 9, 2012, but because of technical issues video was only recorded on August 9. The ROV was deployed first from a small wharf located on the southern shore at the end of Dowden's Road in the southwest corner of the lagoon. The underwater video revealed that there was a mud and silt bottom with some rocks close to shore. There was a continuous eelgrass meadow across the pond (south to north) and areas that contained *Ulva intestinalis*. There was some debris found at the bottom, including what appeared to be some kind of wheel, and some PVC pipe. The ROV was also deployed from the upstream side of the wharf area at the end of Stage Head Road. There was eelgrass observed in this portion of the lagoon as well. A large eel was observed multiple times in the video footage. There was also debris found there, including fish pans and a sneaker. There were portions of the video that were difficult to focus; this was because of a fresh water lens that came from the inflow of the Seal Cove River.

On August 10, 2012 a Zodiac was used to travel throughout Kelligrews Pond for underwater observation, as the lagoon was too shallow for ROV usage. The water was clear enough to see to the bottom, which appeared muddy. There were patches of eelgrass and brown algae located throughout the lagoon. There were jellyfish observed, along with young of the year fish, soft bodied clams, and a flounder swimming under the old railway track trestle.

## *4.0 Discussion*

All of the barachois ponds sampled were altered from their natural condition. They were all surrounded by anthropogenic features that could impact the ecosystem or showed evidence of direct changes or influences to the ponds from human sources. While all were coastal lagoons, they were very different in their components and characteristics, making each pond a unique ecosystem.

There are some anthropogenic features that were repeatedly found at the different ponds. Residential areas and roads surrounded all of them except for Freshwater Bay Pond. Some form of garbage or debris was noted at all of them. Many of the barachois ponds had their barrier breached or altered in some way for human benefits, ranging from dredging to excavation for flood prevention, to having the railway track run along the top, stabilizing the dynamic nature of the barrier and its breach. The presence of non-native plants along the shores of the ponds could also be linked to anthropogenic influence, with human activities promoting the establishment of such plants.

There are some connections that can be made between water quality and aquatic plant type found in the barachois ponds. Those ponds classified as freshwater were all found to have a continuation of shoreline vegetation as the dominant aquatic plant type found. Those ponds with the highest salinity readings had seaweed and sea grass as the dominant aquatic vegetation type. These ponds had continuous interaction with the ocean because the breach locations remained open due to anthropogenic influences, and hence should be viewed as an integral part of habitat for marine species. Chamberlains Pond and Paddys Pond had pondweed as their dominant vegetation type and also had the high readings of unionized ammonia. While unionized ammonia at the levels detected there are deemed to be toxic to aquatic life, there was a dense abundance of the pondweed and there were fish observed in each lagoon, suggesting that the toxic effects to aquatic life were minimal. The amounts of both unionized ammonia and ammonium could have been lower than that detected in the samples, as the Hach procedure for testing them was designed for salt water and stated that it is possible for values to be higher than actual if used in brackish water (error less than 10%) or freshwater (error possibly as much as 16%). Also, levels of toxic ammonia can vary as the equilibrium with ammonium ion can change drastically with a change in pH or temperature (CCME, 2010). Ammonia and ammonium levels are also subject to change due to nitrification, where $NH_4^+$ is oxidized to $NO_3^-$, and ammonification, where organics are converted to $NH_4^+$. Rates of ammonification and nitrification can change seasonally, and can be influenced by aquatic plants growing in a lagoon (Caffrey and Kemp, 1990). The oxygen released from the aquatic vegetation in Chamberlains Pond and Paddys Pond could have contributed to an increased rate of ammonification, and could therefore be a reason for increased levels of ammonia. As Chamberlains Pond and Paddy's Pond had no opening in the barrier to connect it with the ocean there may have been an accumulation of organics, which were then converted to $NH_4^+$ and resulted in increased levels of ammonia in the form of $NH_3$.

*5.0 Suggested Further Research*

The barachois pond environments studied in this report were all very different from each other and modified from their original condition in various ways. Future monitoring of these environments is necessary to determine any changes from the data collected during the summer of 2012. This is especially the case for water quality, as the parameters recorded gave a view of one point in time and are subject to change. It would be interesting to determine seasonal changes in water quality. The complex nature of the nitrogen and phosphorus cycles could also be better understood with increased monitoring. Sampling from areas other than the shoreline would provide insight into the quality of the whole lagoon. Water quality monitoring in any inflow streams would help to determine the input that freshwater inflows have on water quality and provide insight into the condition of the entire watershed.

The extent of floral and faunal sampling was limited in this study. More extensive faunal sampling, including fish, would be an indicator of the level of biodiversity. The ability to map the abundance and distribution of aquatic plants could allow a connection to be drawn between habitat type and fish species found.

Tracking geographical changes to the lagoons over time could also provide information on the dynamics of the systems. This would include tracking changes between open and closed barrier breaches and any changes in their locations.

**References:**

Bergman, J. (2001, August 30). Salinity - Dissolved Salts, Measuring Salinity. Retrieved March 1, 2013 from http://www.windows2universe.org/earth/Water/dissolved_salts.html

Bird, E. (2000). *Coastal Geomorphology An Introduction.* Chinchester, England: John Wiley & Sons Ltd. pp. 163-177, 221-248.

Caffrey, J. M.; Kemp, W. Michael. (1990). Nitrogen cycling in sediments with estuarine populations of *Potamogeton perfoliatus* and *Zostera marina. Marine Ecology Progress Series, 66*, 147-160. Available online March 7, 2013 at http://www.int-res.com/articles/meps/66/m066p147.pdf

Canadian Council of Ministers of the Environment. (1999). Canadian Water Quality Guidelines for the Protection of Aquatic Life: Dissolved Oxygen (freshwater). In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment. 2004. Canadian water quality guidelines for the protection of aquatic life: Phosphorus: Canadian Guidance Framework for the Management of Freshwater Systems. In: Canadian environmental quality guidelines, 2004, Canadian Council of Ministers of the Environment, Winnipeg.

CCME Canadian Council of Ministers of the Environment (2006). Canadian Water Quality Guidelines for the Protection of Aquatic Life Summary Table. In: Canadian environmental quality guidelines, 1999. Winnipeg, MN: Canadian Council of Ministers of the Environment.

Canadian Council of Ministers of the Environment. 2010. Canadian water quality guidelines for the protection of aquatic life: Ammonia. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Canadian Council of Ministers of the Environment. 2012. Canadian water quality guidelines for the protection of aquatic life: Nitrate. In: Canadian environmental quality guidelines, Canadian Council of Ministers of the Environment, Winnipeg.

Fisheries and Oceans Canada. (2011). *Nearshore Habitats: Sanctuary for Juvenile Cod.* Retrieved online January 15, 2013 from http://www.dfo-mpo.gc.ca/science/Publications/article/2008/24-06-2008-eng.htm

Newfoundland and Labrador Department of Education. (2009). *Toward a Sustainable Future: Challenges Changes Choices*. St. John’s, NL: Government of Newfoundland and Labrador Queens Printer. Pp. 504- 558. Retrieved online June 11, 2012 from http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool/ES3205_student_text_chapter_15.pdf

Province of British Columbia (1998). Guidelines for Interpreting Water Quality Data. Retrieved March 1, 2013 from http://archive.ilmb.gov.bc.ca/risc/pubs/aquatic/interp/index.htm

Sargent, Philip. (2009, February 2). A few facts about eelgrass [Letter to the editor]. *The Telegram*. Available online at http://www.thetelegram.com/Opinion/Letters-to-the-editor/2009-02-02/article-1459099/A-few-facts-about-eelgrass/1

**Appendix A- Site Photos**

*Topsail Bight:*


Figure A1. Looking towards the barrier and the breach in the barrier from the northeast shore of Topsail Bight.


Figure A2. View of the barrier to the west of the breach site taken from the northeastern shore of Topsail Bight. There is a belt of vegetation towards the bottom of the barrier, with breaks in it that could demonstrate past barrier over wash events


Figure A3. Shoreline vegetation along the eastern shore, looking south from northeastward. Trees, shrubs, grasses and other herbaceous plant types present.

Figure A4. Some of the debris found in the northwest corner of Topsail Bight.

*Chamberlains Pond:*

Figure A5. Photo taken from western side of the barrier looking southeast. Mounds of gravel along the barrier at Chamberlains Pond, evidence of past man made breaches

Figure A6. Dense growth of pondweed, taken from the northeast corner of Chamberlains Pond.


Figure A7. An example of debris, in this case vinyl siding, found in the water along the western shoreline of Chamberlains Pond.


Figure A8. Photo taken of a school of fish at the mouth of Fowlers River where it enters Chamberlains Pond.

*Bubble Pond:*

Figure A9. Photo taken of the area of the barrier breach at Bubble Pond. There was flow from the lagoon into the bay early in the summer, but later in the summer, as illustrated in the photo, the flow was cut off before reaching the bay.

Figure A10. Looking west across the lagoonal side of the barrier at Bubble Pond from the eastern most end of the barrier. Note the continuous patch of vegetation near the water.

Figure A11. Looking southward along the western shoreline of Bubble Pond. Shoreline vegetation included coniferous trees and herbaceous plants

Figure A12. Worsely Park as viewed from the water's edge on the eastern shore of Bubble Pond.

*Long Pond:*

Figure A13. Vegetation located on the lagoonal side of the barrier at Long Pond, just to the west of Burnt Island.

Figure A14. Hummock- like area located towards the western end of the barrier at Long Pond. The hummock area was vegetated more densely than the rest of the barrier adjacent to it was.

Figure A15. Photo taken from the northeast corner of Long Pond, at the end of Atkins Road. The large amounts of eel grass washed up on the shoreline were evidence that it grows in the pond, although none was located while doing nearshore aquatic vegetation surveys.

Figure A16. Quadrat placed at the water's edge for aquatic plant sampling in Long Pond, at the end of Perrins Road. This photo illustrates the rapid change in water levels. The shore edge of the one meter quadrat was placed at the water's edge, in seconds the water level had receded approximately half a meter.

*Paddys Pond:*


Figure A17. Barrier vegetation at Paddys Pond, looking from the western corner towards the east. Vegetation consisted mainly of morning glory.


Figure A18. Looking southward along the eastern shore of Paddys Pond from the northeast corner. The eastern shore was bordered by agricultural areas, and there were houses to the southwest.


Figure A19. Photo taken of the northeast corner of Paddys Pond. Tire located in the water.  In the background is the barrier and it's vegetation.


Figure A20.  Fish observed in the northeast corner of Paddys Pond.  An arrow has been drawn to a fish in this photo to make it's location more visible.

*<u>Butlers Pond:</u>*


Figure A21. Photo taken from the eastern shore of Butlers Pond, looking at the location on the barrier where there likely was a past man made breach, as evidenced by the mounds of gravel.


Figure A22. Debris and seaweed washed up on the barrier at the location of the past artificial breach at Butlers Pond. This photo was taken standing at the edge of the water in the lagoon facing the bay.


Figure A23. Brown scum- like material that was found throughout Butlers Pond. This photo was taken in the northeast corner of Butlers Pond.


Figure A24. Metal debris located in the northwest corner of Butlers Pond.

*Kelligrews Pond:*

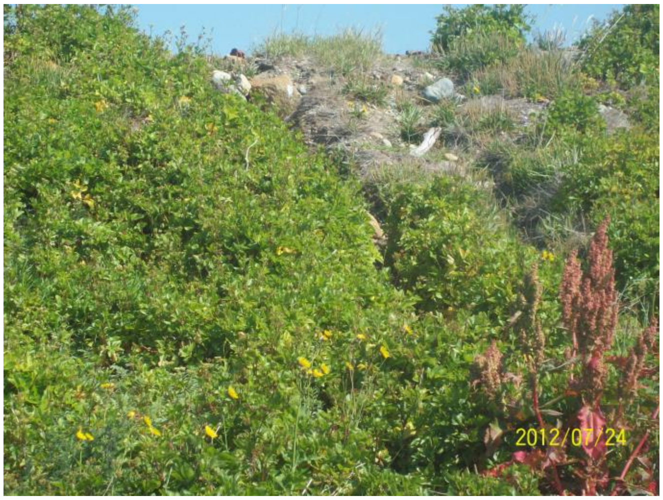


Figure A25. Erosion along the lagoonal side of the barrier at Kelligrews Pond. The old railway track is located at the top of the barrier in this photo.


Figure A26. Manhole located on the lagoonal side of the barrier at Kelligrews Pond, evidence of the sewer main passing along there.


Figure A27. Shoreline erosion along the western shore of Kelligrews Pond. At the top of the bank is Pond Road.


Figure A28. Erosion along the eastern shoreline of Kelligrews Pond.

*Lower Gully Pond:*


Figure A29. The railway trestle that runs over the barrier breach at Lower Gully Pond, viewed from the lagoon side.


Figure A30. Looking west along the lagoonal side of the barrier at Lower Gully Pond from the east. The barrier vegetation was similar to the shoreline vegetation elsewhere around the lagoon.


Figure A31. Erosion on the lagoonal side of the barrier at Lower Gully Pond. Photo taken from the old railway track at the top of the barrier.


Figure A32. Lift station overflow and storm water outflows located on the northwest shore of Lower Gully Pond.

*<u>Lance Cove Pond:</u>*


Figure A33. Photo looking northwestward towards the lagoonal side of the barrier at Lance Cove Pond, taken from the eastern shore. Barrier vegetation included coniferous trees and herbaceous plant types.


Figure A34. Photo, taken from the southern end of Lance Cove Pond, looking north. Lily pads were present in the water at the southern end of the pond.


Figure A35. Disturbed area, possibly for drainage, located on the eastern shore of Lance Cove Pond


Figure A36. Photo, taken from the northwest corner of Lance Cove Pond, of the quarry located at the end of Lance Cove Road. The screen at the left of the photo had water running over it, likely for dust control. The water ran off the screen and to the right, where it was directed to the pipe with water flowing out of it, located to the middle right of the photo

*Seal Cove Pond:*


Figure A37. Looking southward along the barrier at Seal Cove Pond. The old railway track runs along the top of the barrier, and the slope on the lagoonal side is steep, with a flattening before the water's edge. The barrier breach and the trestle are behind the photographer.


Figure A38. Section of the northern shoreline at Seal Cove Pond, looking east. The area in the foreground contained less shoreline vegetation

Figure A39. *Ulva intestinalis* observed in the southwest portion of Seal Cove Pond.

Figure A40. Eel grass washed up near the northern shore of Seal Cove Pond

*Indian Pond:*

Figure A41. Rockweed and knotted wrack located along the eastern shore of Indian Pond

Figure A42. Looking southwest from near the northeast corner of Indian Pond. The hydro generating plant is located in the background. The shoreline in the left of the photo is the barrier. Also, small wharves and boats located in the area are shown in the photo.

Figure A43. Debris, possibly a relic of the old railway, located along the barrier at Indian Pond.

Figure A44. Large jellyfish washed up along the barrier at Indian Pond.

*Freshwater Bay Pond:*

Figure A45. Western shore of Freshwater Bay Pond as seen from the northwest corner. Shoreline vegetation included coniferous trees and shrubs. The color variations on the rocks along the water's edge are indicators of low waters during the summer of 2012.

Figure A46. Aquatic vegetation observed in Freshwater Bay Pond midway along the barrier.

Figure A47. Metal debris and campfire remnants found in the northwestern corner of Freshwater Bay Pond.

Figure A48. Looking east from the northwest corner of Freshwater Bay Pond. The sandy shoreline on the lagoonal side of the barrier would likely be underwater if summer weather included more precipitation.

# Appendix B Sample Locations for Each Barachois Pond Visited


Figure B1. Sample locations in Topsail Bight, Chamberlains Pond, and Bubble Pond.

Figure B2. Sample Site locations for Long Pond, Paddys Pond, and Butlers Pond.

Figure B3. Sample site locations for Kelligrews Pond and Lower Gully Pond.


Figure B4. Sample site locations for Lance Cove Pond and Seal Cove Pond.

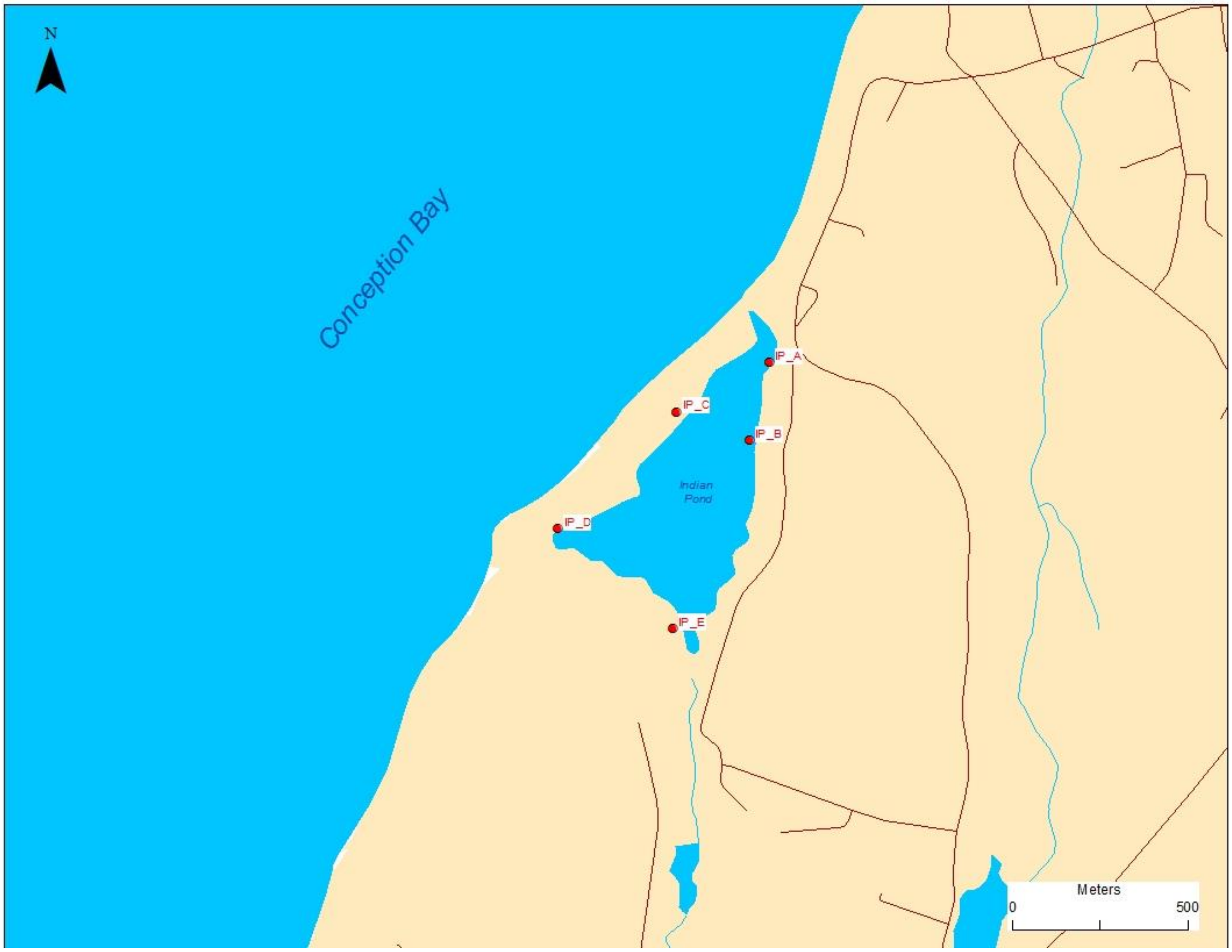


Figure B5. Sample site locations for Indian Pond.

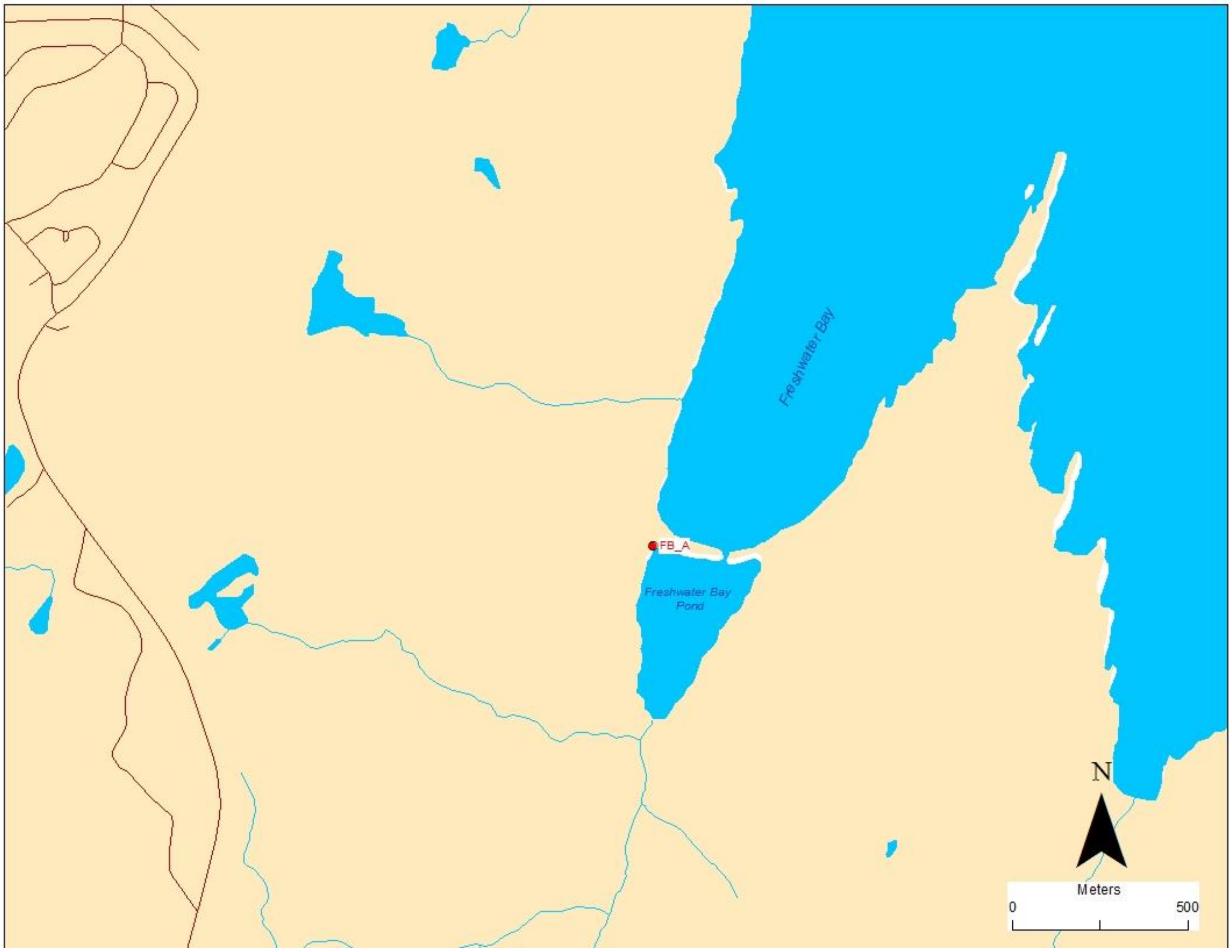


Figure B6. Sample site location for Freshwater Bay Pond.

# Appendix C Maps Showing Salinity Classifications

*Figure C1. Water quality sample locations for Topsail Bight, Chamberlains Pond, and Bubble Pond, colored based on which classification their salinity reading fell into.*

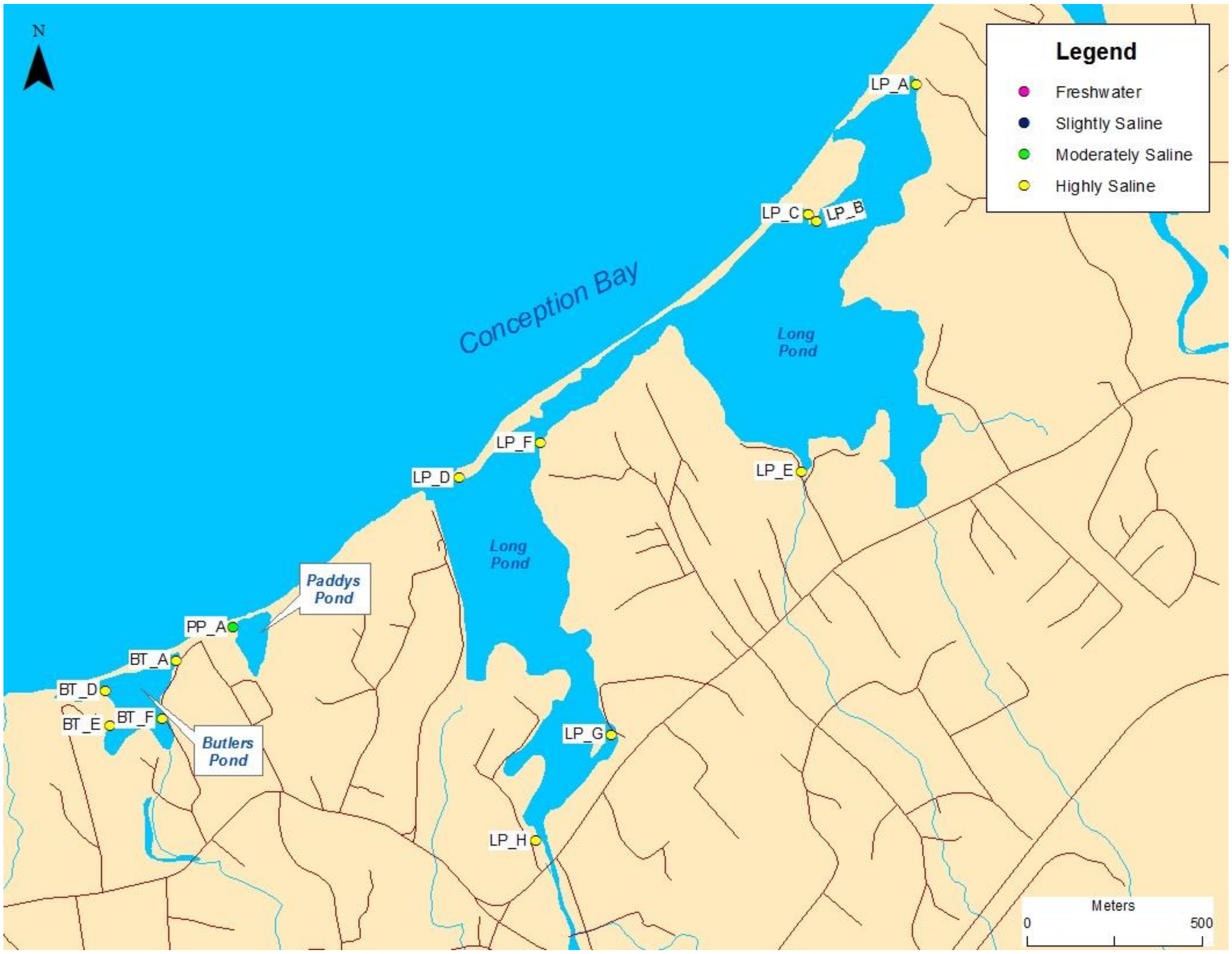

*Figure C2. Water quality sample locations for Long Pond, Paddys Pond and Butlers Pond, colored based on which classification their salinity reading fell into.*

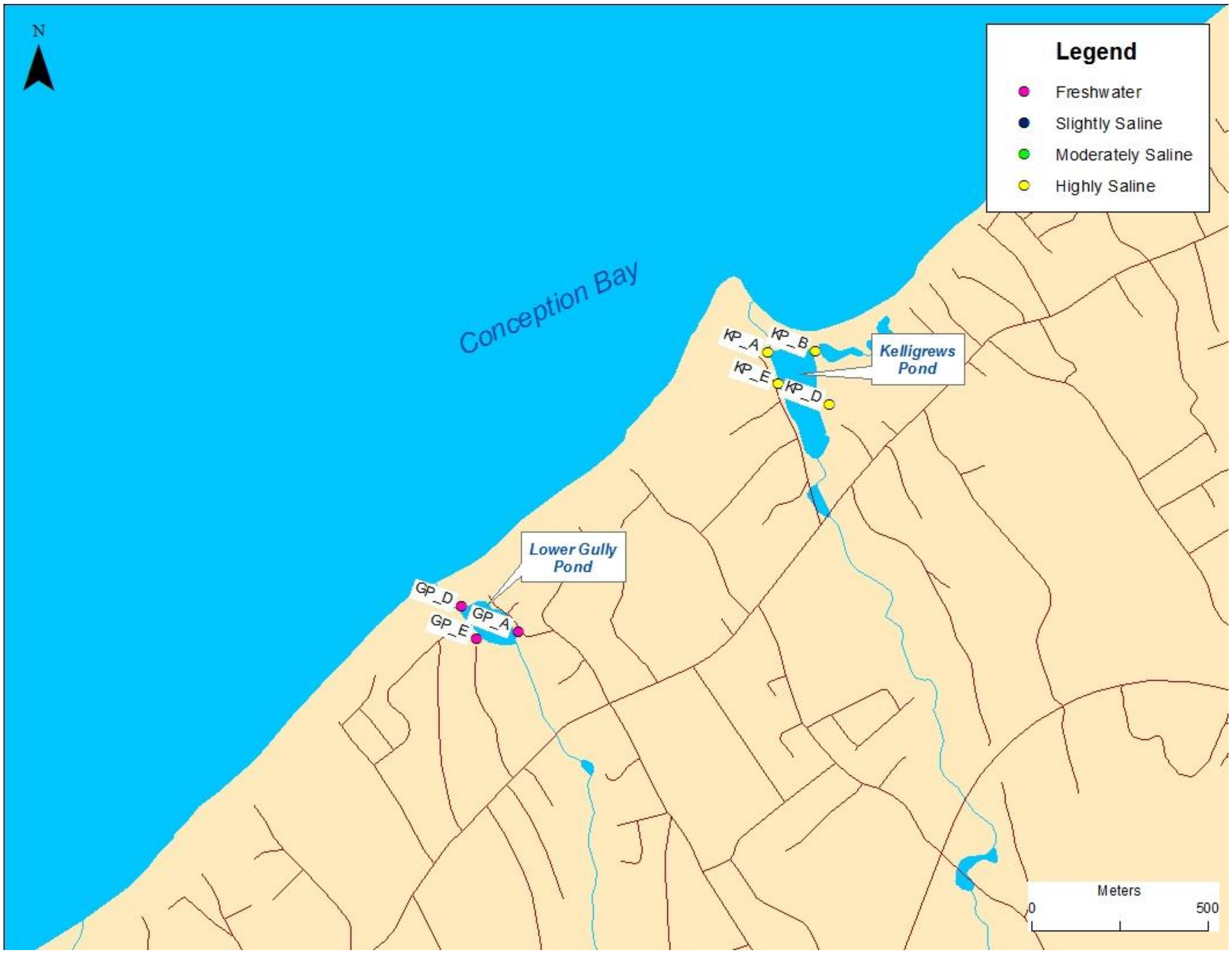

*Figure C3. Water quality sample locations for Kelligrews Pond and Lower Gully Pond, colored based on which classification their salinity reading fell into.*

*Figure C4. Water quality sample locations for Lance Cove Pond and Seal Cove Pond, colored based on which classification their salinity reading fell into.*

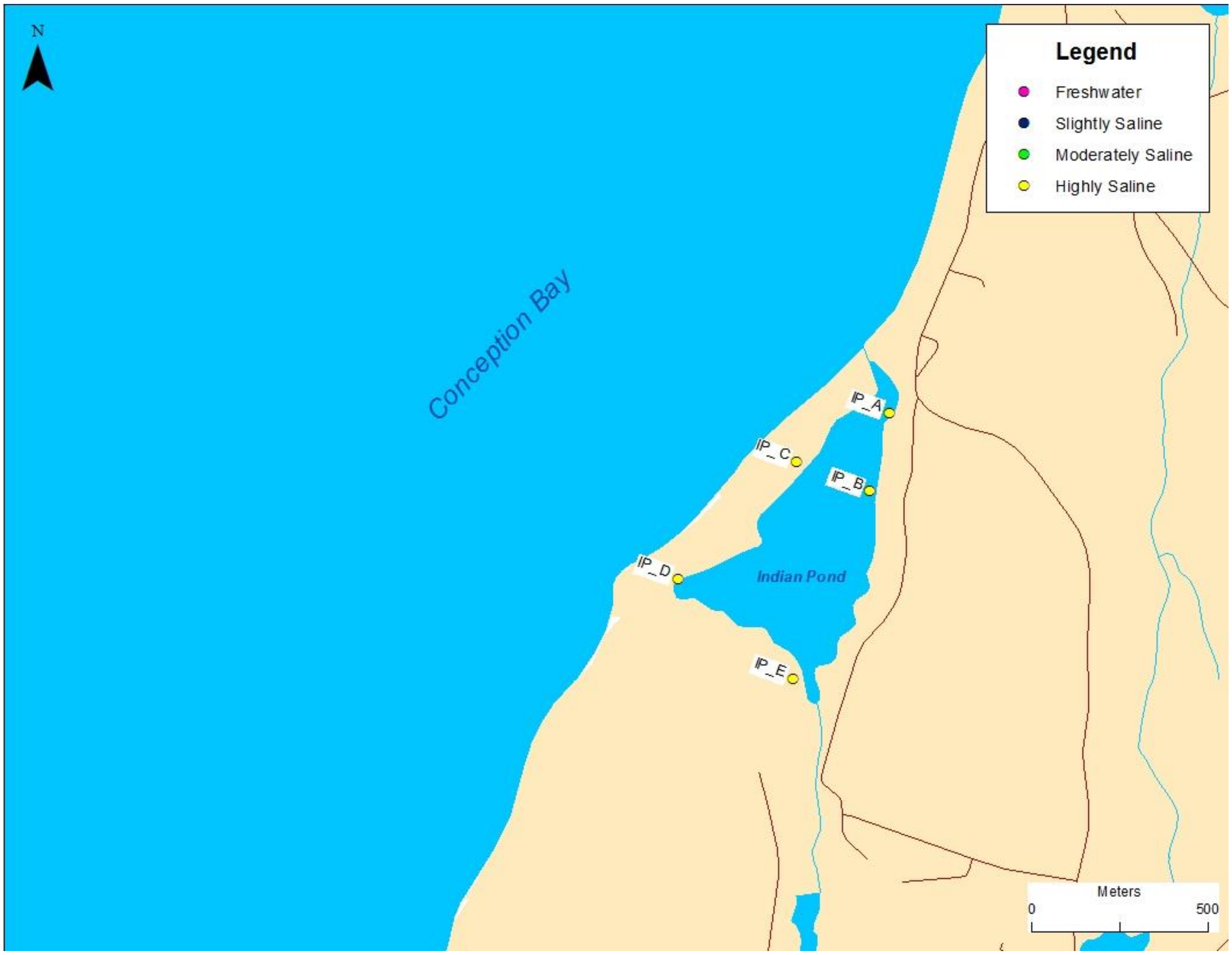


*Figure C5. Water quality sample locations for Indian Pond, colored based on which classification their salinity reading fell into.*

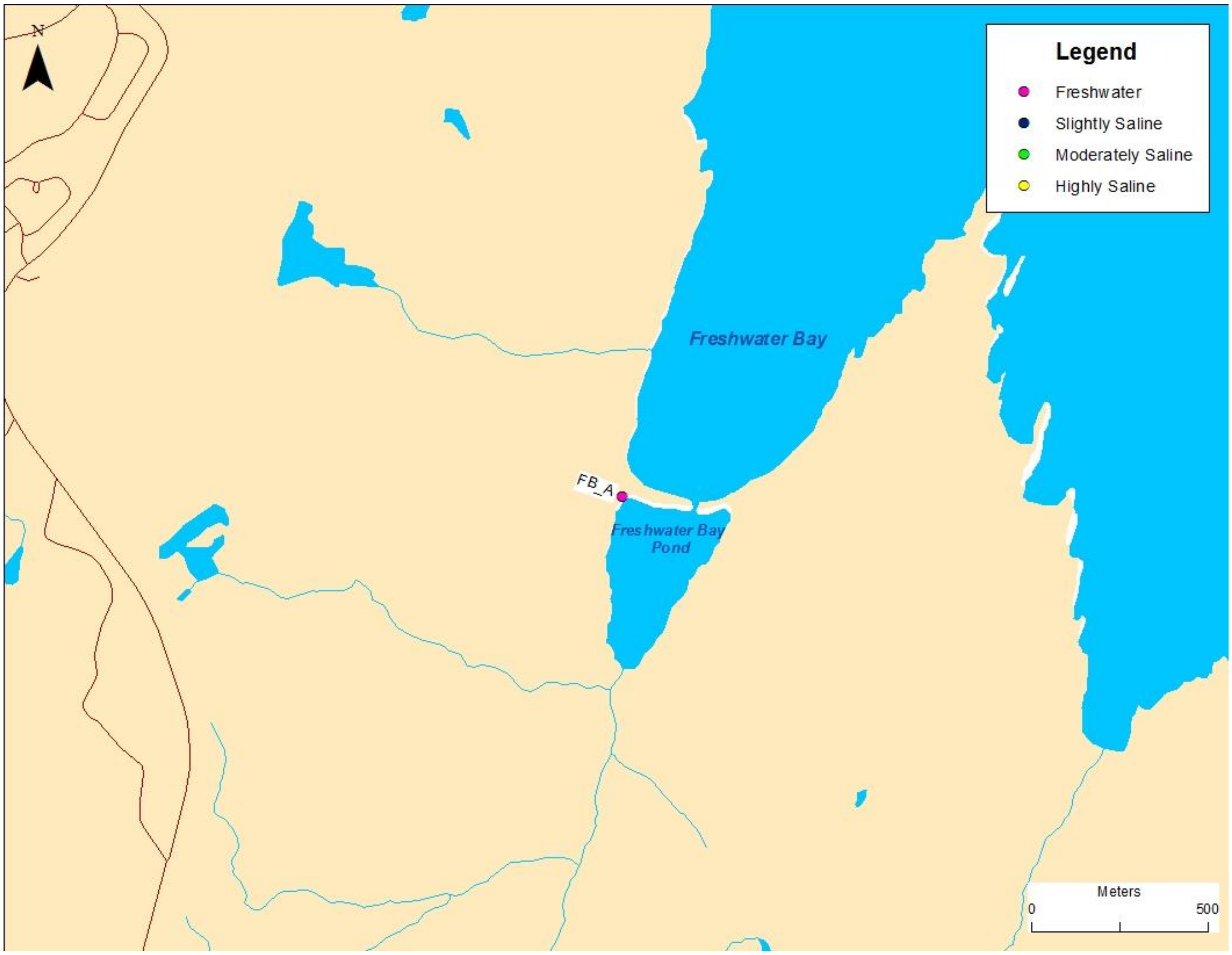


*Figure C6. Water quality sample location for Freshwater Bay Pond colored based on which classification its salinity reading fell into.*