Exposure Pathway Assessment Framework for Aquatic and Non-aquatic Species in Relation to the

Alton Gas Natural Gas Storage Cavern Development At The River Site

December 9, 2015

Contents

Introduction

The intent of this document is to provide an exposure pathway assessment framework for aquatic and non-aquatic species in relation to the Alton Natural Gas Storage (Alton) project at the river site.

In Section 1 the spatial and temporal boundaries are presented for the estuary water intake and the brine outfall.

In Section 2 there are fish species profiles focusing on their swimming ability and salinity tolerance.

Section 3 is the exposure pathway and risk assessment using the information in the previous two sections for each species of fish, birds and plants that were identified as valued or representing and groups of valued species. The answers to the questions posed in the assessment leads to a determination the level of concern associated with the water intake and brine release and is shown in Tables 1 and 2. Table 2 includes risk level classifications, which are adapted from the British Columbia Ministry of Parks 1999 and Canadian Environmental Assessment Agency 2014. The species included in this document are those identified as valued ecosystem components in the exposure pathway assessment for species potentially exposed to the water intake and brine discharge from the proposed Alton Gas Storage facility development from by the Kwilmu'kw Maw-klusuaqn negotiation office in October 2015.

Section 1 Spatial and Temporal Boundaries

Alton River site as built October 2015

This is an outline of the operating conditions for the water intake and brine release based on the pre-operational modeling and the current built structure at the river site. The monitoring plan for the intake, outfall and brine during operations is included. Since the environmental assessment (EA), there have been several design changes to provide operational flexibility and increased mitigation focused on improving the protection of the ecosystem. The following sections provide new information that is based on the project as built to date with the added mitigation.

1. Intake

The intake has been designed to minimize both the entrainment and impingement of aquatic life. There is a large tiered, gabion rock-filled intake wall with 5.56 meters of water on the face at mean high tide, and two meters at lowest water level observed during the past eight years of monitoring. This provides an intake surface area ranging from 244 sq m to 52 sq m respectively depending on the tidal level and river flows. The gabion rock face has 40% openings, 100 mm to 200 mm in size.

The estimated velocities into the gabion wall through this patchwork of openings are much lower than a screen, allowing fish attracted or drawn to the rock face to easily swim away, or, if drawn in, to hold behind a rock until velocities are suitable for escape during the ebb tide. There is a minimum of five meters of rock before the screened intake pipe. Unlike a screen placed directly into the environment, drawing water through the gabion wall will greatly reduce the chance of impingement or full entrainment.

Intake velocities in the openings in the rock face range from a maximum of 0.0012 m/sec (1.2 mm per second) at high tide to a maximum of 0.0056 m/sec (5.6mm per second) at low tide if there is continuous withdrawal of 10,000 cubic meters/day, representing the maximum possible withdrawal rate. This is between seven-fold and one-hundred fold below Department of Fisheries and Oceans (DFO) guidelines for fish screening. The guidelines are set for what DFO terms subcarangiform swimmers, such as trout and salmon, for which the approach velocity should be 0.11 m/s (0.36 ft/s) or less, and for anguilliform swimmers, such as eels, 0.038 m/s (0.12 ft/s (DFO intake screening guidelines 1995).

Withdrawal rates will vary as the project is developed, to a maximum of 10,000 cubic meters per day (Tables 1&2).

These low velocities and the mitigating effect of the gabion wall allow for withdrawals to be timed to best avoid impacts on marine life based on stage of the tide, while staying within guidelines.

Table 1. Mean high tide intake velocity relative to withdrawal rate

Cubic meters/day withdrawal	% spaces in gabion face	Open area sq m	Intake velocity m/sec
10000	40	97.80	0.001227
8000	40	97.80	0.000947
7000	40	97.80	0.000828
6000	40	97.80	0.000710
5000	40	97.80	0.000592
4000	40	97.80	0.000473
3000	40	97.80	0.000355
2000	40	97.80	0.000237
1000	40	97.80	0.000118

Table 2. Lowest observed tide/water level velocity relative to withdrawal rate

Cubic meters / day withdrawal	% spaces in gabion face	Open area sq m	Intake velocity m/sec
10000	40	20.80	0.005564
8000	40	20.80	0.004452
7000	40	20.80	0.003895
6000	40	20.80	0.003339
5000	40	20.80	0.002782
4000	40	20.80	0.002226
3000	40	20.80	0.001669
2000	40	20.80	0.001113
1000	40	20.80	0.000556

The flow through the mixing channel past the face of the intake will be a low of 0.72 m/sec to typical velocity of 0.909 m/sec, and it will be turbulent, which further reduces the effective area of the draw of the intake. It is expected that the intake velocity draw will not be detectable beyond the wire of the gabion baskets, but definitely not more than a few centimeters out into the channel.

The final screening at the two 750 mm diameter intake pipes has 2.03 mm openings, below the DFO specification of 2.54 mm maximum opening. The maximum velocity at the pipe screen is 0.0094 m/sec, again well within DFO guidelines.

The withdrawal rate will increase to the maximum level over time as the caverns are started and grow in size. This will allow for monitoring of the intake for impacts on marine life early in operation when withdrawal rates are low. Flow rates and timing will be adjusted to stay within the DFO guideline velocities. See monitoring plan below.

The influence of the intake velocities will not extend out into the channel more than a few centimeters beyond the gabion wire frames. The expected flow velocities are all well below guidelines.

While all fish species present at the site are capable of swimming against the maximum intake flows, the eggs and early larval stages move passively with the current. Striped bass is the only species known to spawn in the vicinity of the Alton site. Although it is not expected that bass eggs or larvae will be drawn into the intake, as an added protection measure Alton is offering to shut down operations for two weeks during peak spawning and early larvae stages, and additional times as defined in the monitoring plan below.

2. The Brine

The water from the intake enters a settling pond where the silt will settle out, providing clear water to send to the cavern site. This improves the water quality by removing some of the metals detected in the river water samples.

After entering the pipeline, the water quality parameters will not change except for temperature which will be moderated by the ground temperature at 1.8 m depth.

In the caverns the salinity of the water will increase to a maximum of 260ppt. The concentration will vary below this level depending on cavern size and flow rates. Initially the volume and salinity will be low, allowing water in the dispersion channel to be thoroughly tested and discharge protocols refined to ensure salinity never exceeds 7ppt above background to a maximum of 28ppt. Outside of the two-week shutdown period, when lower numbers of Striped bass eggs or larvae are still present, the discharge rate will be reduced to ensure the salinity remains does not exceed 20ppt at five meters from the outfall array. Operations will be adjusted as needed to meet or exceed these requirements.

Data collected to date shows all parameters are below the levels in the river or within the range of specific elements in the river when diluted at the outfall. The only other parameter that will change is temperature, and it will be moderated by heat exchange when it is circulated in and out of the well and through the pipeline, then held at air temperature in the brine pond for several hours. Brine temperature is monitored and is expected to be near river water temperature when released. The dilution in the dispersion array will ensure there is no temperature difference.

There will be no change in pH due to the addition of the salt to the river water. The pH of the brine will be governed by the pH of the river water sent to the caverns so will be within the natural variation in the river.

Water velocities in the channel range from the lowest observed at 0.72 m/sec to typical velocity of 0.91 m/sec. Fish passing through the five meter mixing area with the current may be exposed for 5.5 to seven seconds, and exposure to potential high salinities for this short period would not pose a threat to their health.

Dilution rates and the ability to time the release of the brine will allow for the release to be on the part of the ebb tide that will result in all the brine reaching the Minas Basin before the return tide. With the general counter-clockwise circulation in the basin and Cobequid Bay, no return of water with increased salinity is expected. Monitoring and the limits set in the permits will prevent salinities over 28ppt.

Table 3. Modeled salinity dilution of brine at 260ppt during tidal flows that will leave the estuary

Water depth over discharge	Cross-section area	Lowest observed flow to date 0.72 m /sec	Channel salinity change @ 5m Lowest observed	Main river salinity change Lowest observed	Typical observed flow – average 0.909 m/sec	Channel salinity change @ 5m Typical flow	Main river salinity change typical
Low tide 2m	6m x 2m	8.64 cu m /sec	4.82ppt	0.675ppt	10.91cu m /sec	3.81ppt	0.534ppt
High tide 5.5m	6m x 5.5m	23.76 cu m /sec	1.76ppt	0.024ppt	29.99 cu m/sec	0.24ppt	0.034ppt

The monitoring plan records the salinity in several locations in the channel and in the river: at four different depths immediately on either side of the outfall (channel bottom, 4.5m, 3m and 1.5m depth), and on the bottom of the channel at each end. Additional details of salinity monitoring in the mixing channel and the wider river channel are given in the monitoring plan below.

Computer modeling indicates the influence of the brine salinity is limited to five meters from the outlet dispersion array after which there is no detectable increase in salinity in the river. Salinity will always be no more than 7ppt above background to a maximum of 28ppt. When striped bass eggs are present, this maximum will be 20ppt. This is within the natural range of salinity in the river, and the fish frequenting the site are well adapted to these salinities.

When Striped bass eggs are present, Alton is offering to shut down brining operations for two weeks during peak spawning. In addition, three-day shutdowns will be implemented if there is a peak spawning event outside of the two-week period. During the period before and after this peak spawning, when there are still low numbers of eggs present (less than four percent of the total number of eggs spawned for the year) salinity levels will be kept below the 20ppt tolerance level for the bass eggs. Bass larvae and older life stages are tolerant of salinity levels of 30ppt so the 28ppt limit at the outfall array is considered precautionary. All other species that are regularly present are euryhaline, making them tolerant of salinities ranging from fresh to sea water. See the section on species screening below.

3. Water Quality

Table 4. A comparison of the average metal content of the cavern salt core samples analyzed at 26ppt salt concentration with the nine samples taken over the tidal cycle on July 27th 2015. This was a high runoff, low salinity day, which gives the lowest expected river concentrations of metals. The brine was assumed to be at the maximum salinity of 260ppt. These are Typical of the lowest metal levels expected in the river.

Parameter In ug/L	**Average of 5 cavern core samples**	**Max value**	**Min value**	**River water settled to caverns**	**Brine end of pipe**	**Brine Diluted to 7 ppt** **Contribution to the river water level**	**Average river water July 27 2015**
Total Aluminum	208.25	304	114	23.8	2106.3	56.71	7796.67
Total Antimony	<10	<10	<10	<10	<10	<10	<2
Total Arsenic	<10	<10	<10	<10	<10	<10	6.22
Total Barium	5.5 of 2	6	<5	<5	<5	<5	48.22
Total Beryllium	<2	<2	<2	<2	<2	<2	<2
Total Bismuth	<2	<2	<2	<2	<2	<2	<2
Total Boron	85 of 2	102	<25	370.9	<25	<25	439.56
Total Cadmium	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	0.03
Total Chromium	<1	<1	<1	<1	<1	<1	4.44
Total Cobalt	<1	<1	<1	<1	<1	<1	2.78
Total Copper	5 of 1	5	<1	4.0	<1	<1	4.33
Total Iron	202.7of 3	311	<50				9337.78

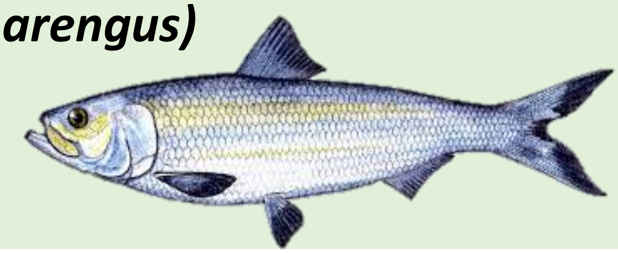
Parameter In ug/L	**Average of 5 cavern core samples**	**Max value**	**Min value**	**River water settled to caverns**	**Brine end of pipe**	**Brine Diluted to 7 ppt** **Contribution to the river water level**	**Average river water July 27 2015**
				152.3	860.1	23.16	
Total Lead	<1	<1	<1	<1	<1	<1	5.64
Total Manganese	10.7 of 3	14	<2	<2	<2	<2	551.67
Total Molybdenum	<10	<10	<10	<10	<10	<10	<2
Total Nickel	<10	<10	<10	<10	<10	<10	8.78
Total Selenium	<2	<2	<2	<2	<2	<2	<1
Total Silver	<5	<5	<5	<5	<5	<5	<0.1
Total Strontium	592.0	1390	57	572	6492.0	174.8	759.11
Total Thallium	<5	<5	<5	<5	<5	<5	<0.1
Total Tin	<2	<2	<2	<2	<2	<2	<2
Total Titanium	<10	<10	<10	<10	<10	<10	116.44
Total Uranium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Vanadium	<2	<2	<2	<2	<2	<2	6.22
Total Zinc	20.5 of 2	28	<5	<5	<5	<5	12.89

Section 2 Species Profiles

Alewife or gaspereau *(Alosa pseudoharengus)*

Blueback herring *(Alosa aestivalis)*

Kaspalew, alanj



Biology and life-cycle

- Alewife and Blueback herring are anadromous, highly migratory, euryhaline, pelagic, schooling species. They spend the majority of their life at sea, returning to freshwater river systems to spawn in late April, early May in the upper Bay of Fundy
- These two species of herring are very similar both in appearance and life-cycle
- Dependable distinction: Lining of belly cavity is blackish in the blueback, pale pink in gaspereau
- Adults average 25cm long and weigh 250g. In Nova Scotia 60% are repeat spawners, most returning to spawn in the rivers where they were hatched. Spawners are three to eight years old
- Filter feeders, at sea eating mostly plankton and mysids. Do not feed during migration up-river, but feed voraciously during post-spawning descent into the estuary; diet includes fish eggs and larvae
- All spawning is in fresh water; the sticky eggs settle to the bottom and hatch in about five days; larvae about 5mm at hatch, juveniles reaching 3-5cm by late summer
- Post-spawning adults quickly return to salt water
- Fresh water is the nursery habitat for larvae and early juveniles with some young juveniles drifting into low salinity brackish water
- Young migrate to sea in July and August, remaining in coastal waters till spring when they join the main population

Habitat

- Widespread in coastal waters from Gulf of St. Lawrence to Florida.
- Alewives migrate as far up as headwater lakes, spawning in lakes and ponds. Bluebacks spawn in slow moving sections of river
- 99% of alewife eggs are found in fresh water (0ppt). Larvae salinities range from 0 to 8ppt, but again, most (82%) are in fresh water. The optimal range for alewife egg development is 0 to 2ppt.
- Juvenile alewife (50 to 60 days post-hatch) transferred from fresh water to saline water (32ppt), and vice versa, experienced zero mortality.

- Adults tolerate salinities 0 to 35ppt

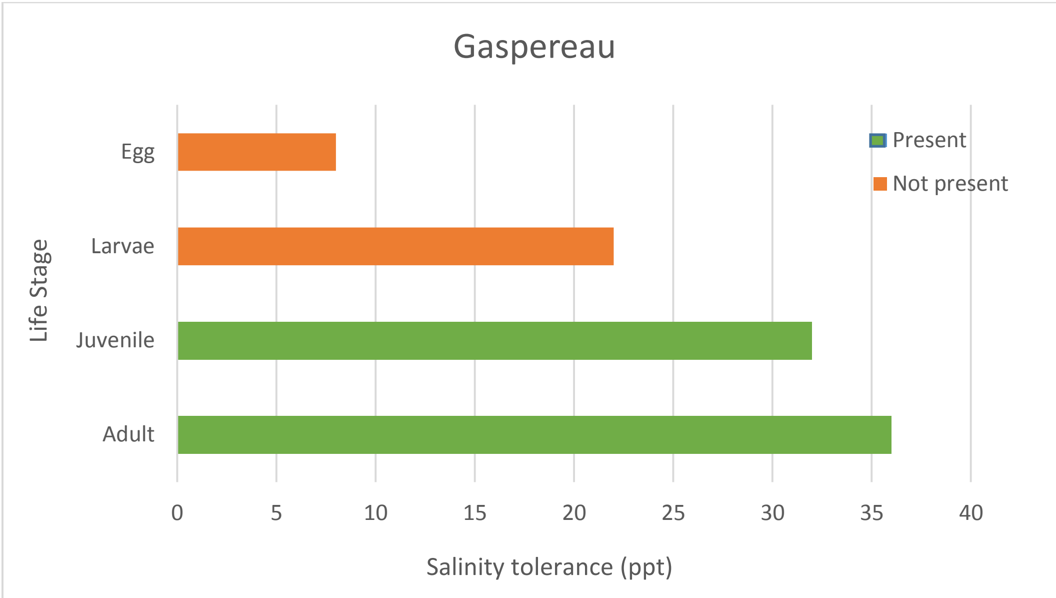
Alton Gas Survey 2008-2015

- Eggs were absent from plankton tows at the Alton site and up-estuary to salt front
- ‘Herring-like’ larvae common in plankton tows at Alton site in May-June at salinities from 0.1 – 25ppt. However, they were likely early juvenile shad, based on salinity tolerance of alewife and blueback herring
- Under-yearling juvenile gaspereau/blueback very common in beach seine net at the Alton site during July-August
- Adults were absent from beach seine net (late-June to Sept), and were caught in plankton net only twice in 2014
- Drift-net fishers at confluence reported ‘good’ catches over past few years; >60% were gaspereau

Implications of Alton Natural Gas Storage Project

- Life stages present - juvenile to adult
- Salinity tolerances - 0.1 to >30ppt, the brine discharge poses no known risk
- Swimming abilities are well above intake velocities and can avoid unsuitable conditions
- They move up and down in the water column based on light levels so will be near the surface in this turbid water, so will be well above the outfall
- On-going monitoring will continue to track gaspereau and herring numbers at the river site through beach seine and plankton net surveys
- The species is widespread in Atlantic Canada; the Shubenacadie River is not the sole nursery habitat

Life Stage Salinity Tolerances



References

Bigelow, H.B. and Schoeder, W.C. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74:1-577.

Greene, K.E., Zimmerman, J.L., Laney, R.W., and Thomas-Blate, J.C. 2009. Atlantic coast diadromous fish habitat: a review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.

Jessop, B. 2001. Gaspereau Maritime Provinces Overview. Fisheries and Oceans Canada Stock Status Report D3-17.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences. 219: 259-283.

American Eel *(Anguilla rostrata)*

Katew

Biology and Life-cycle

- Life expectancy approximately 9 to 22 years, average adult size 50-110cm
- Eat fishes, mollusks, crustaceans, insects, worms and plants
- COSEWIC designated American Eel as threatened in 2012 due to dramatic declines over a significant portion of its distribution and habitat degradation

Habitat

- Mature adults leave estuaries in Nova Scotia around November and migrate ~2000km to spawning grounds in the Sargasso Sea (near Bermuda), dying post-spawning
- Eggs hatch and young eels travel with the current toward North America where they metamorphose into ‘glass eels’ and enter estuaries, gaining the brown pigmentation of ‘elvers’
- Distributed in waters along the western North Atlantic Ocean from Venezuela to Greenland and Iceland
- Elvers are present in estuaries in April, May and June, and are 60 to 65mm long when they enter the estuary. Some stay in the estuaries while most enter rivers and lakes where they grow into juvenile ‘yellow eels’ and subsequently adult ‘silver eels’
- Eels use rock, sand, mud and vegetation for protection, and often overwinter in mud bottoms.
- Salinity tolerance of glass eels and elvers ranges from 0 to 35ppt; yellow eels and silver eels range from 0 to 35ppt but prefer under 25ppt

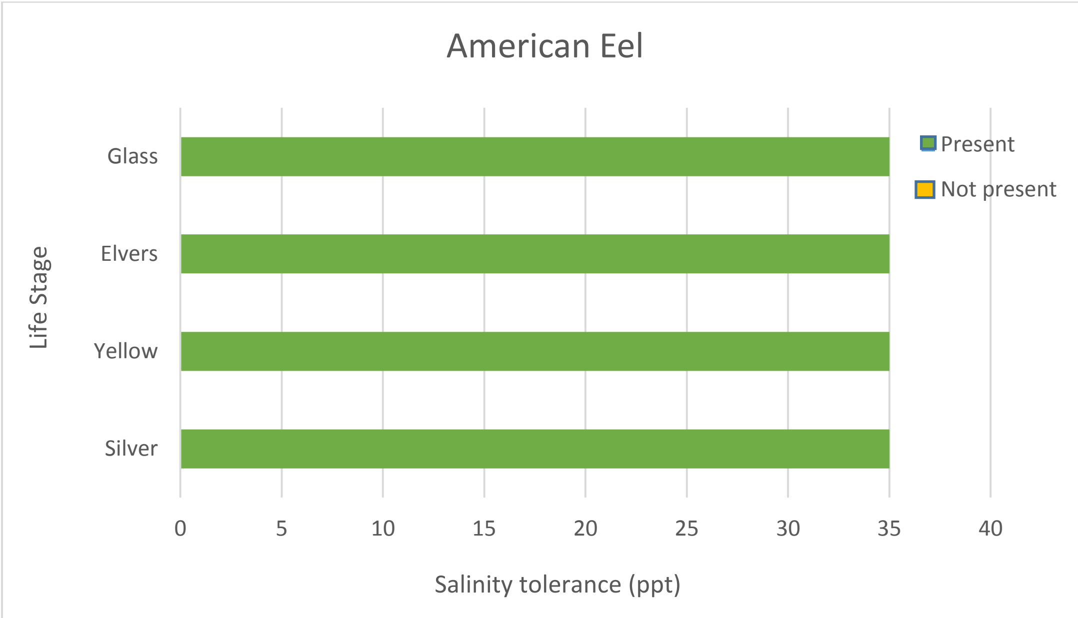
Alton Gas Survey 2008-2015

- Glass eels were present some years in small numbers in plankton tows at the Alton site in May and early June, in a wide range of salinities (5-19ppt)
- Young eels were caught in very low numbers most years (not 2008 or 2013) in beach seine net at Alton Site late-June to Sept
- Adults were absent from beach seine net (late-June to Sept)

Implications of Alton Natural Gas Storage Project

- Life stages present - glass to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities - all stages are well above intake velocities and can avoid unsuitable conditions
- On-going monitoring will continue to track eel numbers at the river site through beach seine and plankton net surveys
- Spawning does not take place in the area and the Shubenacadie River is not the sole habitat

Life Stage Salinity Tolerances



References

COSEWIC. 2006. COSEWIC assessment and status report on the American eel *Anguilla rostrata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 71 pp.

Greene, K.E., Zimmerman, J.L., Laney, R.W., and Thomas-Blate, J.C. 2009. Atlantic coast diadromous fish habitat: a review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.

Mi'kmaq Conservation Group. 2015. Species at Risk Database. http://www.mikmawconservation.ca/sar-database/ Accessed 16/09/15.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

American shad *(Alosa sapidissima)*

Msamu

Biology and life-cycle

- The largest of the herrings, reaching about 45cm (2kg) at first spawning at five years old
- Deep body, but very slim laterally, bright silver flanks, large dark shoulder spot
- Filter feeders, eat mostly plankton and mysids
- Spawns May-June in fresh water, about 100,000 eggs per female. Eggs are not sticky like those of other river herrings, and roll around on hard bottom shallows
- Larvae 9-10mm at hatch, extremely slender

Habitat

- Widespread in coastal waters from Gulf of St. Lawrence to Florida, US and Canadian stocks mix together
- At sea most of their life, but like gaspereau, run up into fresh water in spring to spawn.
- Larvae develop in brackish water, underyearlings remain in estuary until Fall, reaching 4 to 10 cm, then go to sea
- Nine confirmed spawning runs in Maritimes: Shubenacadie, Stewiacke, Annapolis, four in tributaries of the St. John River, NW and SW arms of Miramichi
- Spawns May-June down from Enfield on the Shubenacadie, Nine Mile River, and on the Stewiacke a few km above head of the tide
- Eggs and larvae are most often observed in areas with a salinity of 0 to 7.6ppt. Larvae tolerate salinities as high as 25ppt depending on temperature
- Juveniles and adults tolerate up to 35ppt

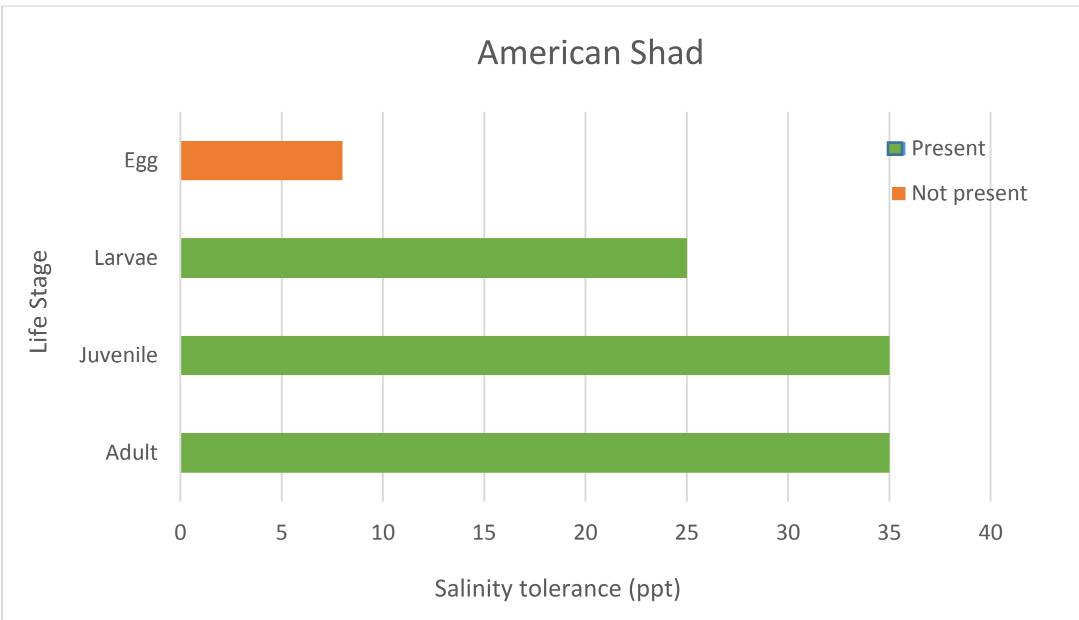
Alton Gas Survey 2008-2015

- Eggs were absent from plankton tows at Alton site and up-estuary to salt front
- ‘Herring-like’ larvae common in plankton tows at Alton site May-June at salinities from 0.1 – 25ppt. Difficult to distinguish but are likely larval shad
- Under-yearling juvenile shad frequently caught in beach seine net at Alton Site during July-Aug
- Adult shad absent from beach seine net (late-June to Sept)
- Drift-net fishers not targeting shad because large-mesh shad net catches too many striped bass

Implications of Alton Natural Gas Storage Project

- Life stages present - larvae to adult
- Salinity tolerances - 0 to >25ppt, the brine poses no known risk
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- They move up and down in the water column based on light levels, so will be near the surface in this turbid water, therefore will be well above the outfall
- On-going monitoring will continue to track numbers of shad at the river site through beach seine and plankton net surveys
- The species is widespread in Atlantic Canada, the Shubenacadie River is not the sole nursery habitat.

Life Stage Salinity Tolerances



References

Bigelow, H.B. and Schoeder, W.C. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74:1-577.

Chaput, G. and Bradford, R.G. 2003. American shad (Alosa sapidissima) in Atlantic Canada. Fisheries and Oceans Canada Science Advisory Secretariat. 71p

Greene, K.E., Zimmerman, J.L., Laney, R.W., and Thomas-Blate, J.C. 2009. Atlantic coast diadromous fish habitat: a review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

Waldman, J., Hasselman, D., Bentzen, P., Dadswell, M., Maceda, L., and Wirgin, I. 2014. Genetic mixed stock analysis of American shad in two Atlantic coast fisheries. North American Journal of Fisheries Management 34: 1190-1198.

Atlantic salmon *(Salmo salar)*

Plamu

Biology and life-cycle

- The Inner Bay of Fundy (IBoF) Atlantic salmon is a genetically discrete population that was healthy in the 1980s, then collapsed, today perhaps less than 200 fish remain
- Spawning occurs in fresh water in late October through November
- Eggs are buried in the gravel cobble river bottom, hatching in mid-April as larvae ('alevins'), which in turn move out of the gravel as 'swim-up fry' within three-six weeks. Fry develop into 'parr, 'a stage that lasts one-three years
- Parr develop into 'smolts', in the spring at two-three years of age, at which point they migrate to sea
- Marine residence is one year for grilse and two to three years of age or more for multi sea year adults before returning to spawn
- Returning grilse and adults migrate into the river from the spring through to fall
- COSEWIC designated IBoF salmon endangered in 2001. This designation remains in place
- IBoF salmon have been protected under the Species At Risk Act (SARA) since 2003

Habitat

- Egg to smolt stages require cool, clear, fresh water for rearing
- The salinity tolerance of parr is good up to 15ppt so some can be found living in the upper estuary conditions, and they can withstand full sea salt for a few hours. Smolt salinity tolerance is high in healthy fish ranging from 0 to 35ppt including rapid changes from fresh to salt water
- The freshwater habitat has long been considered satisfactory due to pH buffering, but this has recently been questioned by evidence of relatively high aluminum and moderate acidification in Atlantic Canada
- The marine habitat is where the IBoF salmon suffer high mortality. The reason is unknown. The marine habitat *per se* may not be 'toxic', smolts may be 'compromised' prior to reaching sea water
- Estuaries are brief habitat for both smolts, as they migrate to sea, and returning adults

Alton Gas Survey 2008-2015

- The EA, approved in 2007, recognizing the endangered status of IBoF salmon, called for a plan to assess the presence of Atlantic salmon eggs and larvae. The closest known salmon spawning locations are over 30 kilometers upstream of the Alton river site, and there is no suitable nursery habitat for Atlantic salmon egg to smolt stages as they require fresh water and do not live within the tidal portion of the Shubenacadie
- In 2008, as part of another study, smolts were fitted with transmitter tags. They moved quickly through the estuary, taking one to three tidal cycles to exit

- Salmonids were absent from all plankton net tows
- Three specimens (not identified to species to minimize handling) were detected in eight years of beach seine surveys in July & August; brief observations indicate these were brown trout (see Brook trout fact sheet for additional information). These salmonids were immediately returned to the river to minimize handling

Implications of Alton Natural Gas Storage Project

- Life stages present - smolt to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- Additional tracking of smolts is planned for the first spring that the channel is open, since the Alton site is on the migration route
- On-going monitoring will also track overall numbers of salmonids through beach seine and plankton net surveys

Life Stage Salinity Tolerances

References

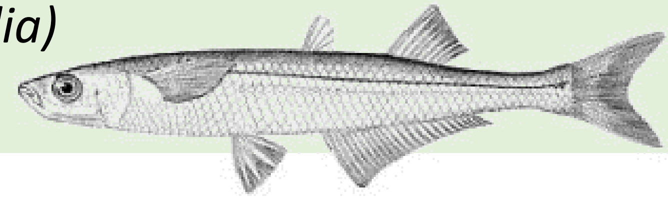
Fisheries and Oceans Canada. 2013. Important marine and estuarine habitat of inner Bay of Fundy Atlantic salmon. Canadian Science Advisory Secretariat Report 2013/054.

Gibson, J. F., Halfyard, E.A., Bradford, R.G., Stokesbury, M.J.W., and Redden, A.M. 2015. Effects of predation on telemetry-based survival estimates: insights from a study on endangered Atlantic salmon smolts. Canadian Journal of Fisheries and Aquatic Sciences 72(5):728-741.

Perry, G. 1960. The development of salinity tolerance in Atlantic salmon (*Salmo salar*) and some related species. Journal of Experimental Biology, 425-434.

Atlantic silverside *(Menidia menidia)*

[Mi'kmaq name]



Biology and life-cycle

- Spiny dorsal fin, no adipose fin and long anal fin distinguish this slim silvery fish from small rainbow smelt
- Small schooling fish. Adults no bigger than 14cm. Matures at one year of age, a few live to two years old
- Omnivores, feeding on copepods, mysids, shrimp. Intense feeding on ebb tide in Minas Basin
- Spawns during May-June in bays and estuaries in brackish water, about 1000 eggs per female. Eggs about 1mm diameter bear sticky filaments, sink and stick in clusters to aquatic vegetation. Annapolis River population returns to sea in July-October. Larvae 4-5mm at hatch, extremely slender, develop in brackish water
- A common fish. No conservation concerns. Small commercial fishery in Prince Edward Island (PEI)

Habitat

- Widespread inshore in waters from Gulf of St. Lawrence to Cape Cod. Never in fresh water
- Big schools in bays close to the water's edge. Caught in huge numbers by beach seine
- Run up into estuaries with the tide
- Overwinters at sea. Found under ice of northern PEI
- Eggs hatch best over 30ppt, decline rapidly to 25% hatch at 20ppt
- Juveniles are most abundant in upper estuary zones with salinity of 8 or 9ppt with arrange of one to 14ppt but can tolerate full sea salt
- Adults can tolerate the full range of salinities but prefer full sea water

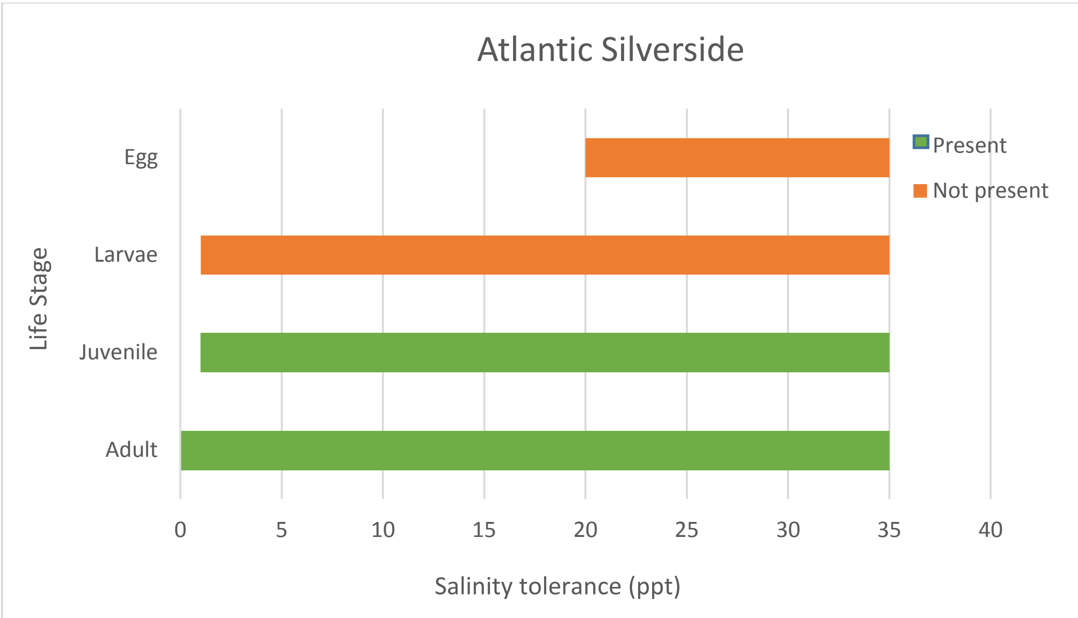
Alton Gas Survey 2008-2015

- Absent from plankton tows
- Under-yearling juveniles commonly caught in beach seine net at Alton site, averaging about 25mm long in July, reaching 60-70mm long in September. Caught in salinities ranging from 0.3 to >20ppt

Implications of Alton Natural Gas Storage Project

- Life stages present - juvenile to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- The species is widespread in Atlantic Canada. Shubenacadie River is not the sole habitat
- They swim near the surface where there is suitable light levels, so will be well above the outfall
- On-going monitoring will continue to track numbers of silverside at the river site through beach seine and plankton net surveys

Life Stage Salinity Tolerances



References

Bigelow, H.B. and Schoeder, W.C. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74:1-577.

Fay C.W., Neves, R.W., and Pardue, G.B. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic) – Atlantic silversides. United States Fish and Wildlife Service U.S. Army Corps of Engineers 82/11.10.

Gilmurray, M.C. and Daborn, G.R. 1981. Feeding relations of the Atlantic silverside *Menidia menidia* in the Minas Basin, Bay of Fundy. Marine Ecology Progress Series 6:231-235.

Jessop, B.M. 1983. Aspects of the life history of the Atlantic silverside (*Menidia menidia*) of the Annapolis River, Nova Scotia. Canadian Manuscript Report of Fisheries and Aquat. Sci. 1694.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

Atlantic sturgeon (Acipenser oxyrhynchus)

Komk-tamu

Biology and life-cycle

- Atlantic sturgeon and other members of the Acipenseridae family are ancient fish, thought to have evolved up to 250 million years ago
- Males are smaller than females; typically reach about three meters in length and weigh 90-135kg, and can live up to 60 years
- Spawn irregularly, females every three-five years and males every one-five years

Habitat

- Anadromous and bottom-dwelling
- Young (up to three-four years) remain in their natal estuaries, whereas movement patterns of adult sturgeon are poorly understood
- Limited knowledge indicates that they migrate extensively and have been found as far offshore as Sable Island; they are also thought to be occasional users of up to 40 river systems
- The St. John and St. Lawrence Rivers are the main systems supporting Atlantic sturgeon spawning in eastern Canada, and fish originating from these two rivers are recognized as distinct populations, both of which have a designation of 'threatened' under COSEWIC
- Spawning occurs in fresh water, with eggs adhering to cobble substrates
- Older juveniles (three-five years) leave fresh water and migrate to sea
- Adults and juveniles have been found in the Minas Basin and as far upriver as Shubenacadie Grand Lake, and are thought to originate from both United States and St. John River spawning populations
- The Shubenacadie-Stewiacke estuary would provide foraging grounds and a migration area for older juveniles and adults
- Salinity is very important to the survival of sturgeon eggs. Eggs are spawned in regions between the salt front and the fall-line of large rivers or estuarine tributaries. Mortality has been documented at salinities as low as 5ppt to 10ppt
- There is a large amount of variation in the salinity tolerance of juvenile Atlantic sturgeon. Some Atlantic sturgeon may occupy freshwater habitats for two or more years, while others move downstream to brackish waters when the water temperature drops. Young-of-the-year juveniles show poor survival at salinities greater than 8ppt, but euryhaline behaviors are exhibited by juvenile's age one and two. The natural high variability of salinity in the Shubenacadie estuary makes it unlikely habitat for juveniles and they would have to stay well above the Alton site

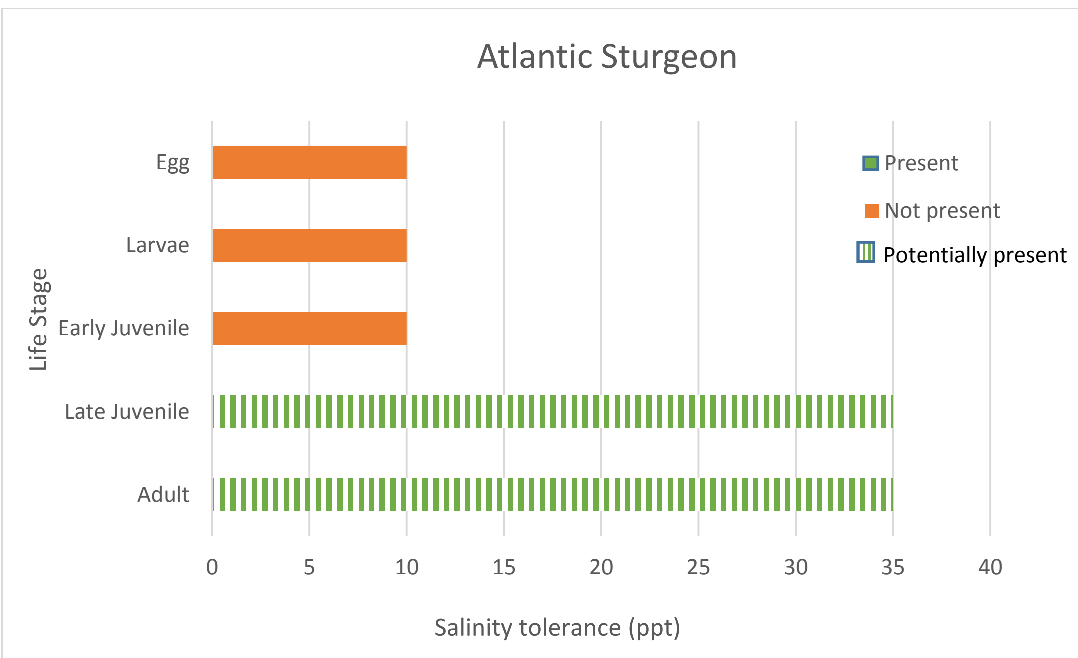
Alton Gas Survey 2008-2015

- No sturgeon have been detected in eight years of monitoring
- This is likely because the Shubenacadie-Stewiacke watershed is not a nursery habitat for this species, and because any adults that do occur in the watershed are relatively occasional visitors

Implications of Alton Natural Gas Storage Project

- Life stages present- possibly juveniles to adult
- Absence of sturgeon in monitoring indicates that any individuals that occur in the estuary are rare visitors
- Salinity tolerance- 0 to >30ppt, the brine poses no known risk
- On-going monitoring will be continue to study all fish species present at the river site through beach seine and plankton net surveys
- Any occurrence of sturgeon in the river would be reported to local communities as well as to government and non-government conservation authorities given the conservation status of Atlantic sturgeon
- Swimming abilities are well above intake velocities and can avoid unsuitable conditions

Life Stage Salinity Tolerances



References

Allan, P.J., Mitchell, Z.A., DeVries, R.J., Aboagye, D.L., Ciaramella, M.A., Stewart, H.A., Shartau, R.B., and

Ramee, S.W. 2014. Salinity effects on Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus* Mitchill, 1815) growth and osmoregulation. Journal of Applied Ichthyology 30:1229-1236.

Apostle, R., Dadswell, M.J., Engler-Palma, C., Litvak, M.K., McLean, M.F., Stokesbury, M.J.W., Taylor, A.D., and VanderZwaag, D.L. 2013. Sustaining Atlantic sturgeon: stitching a stronger scientific and governance net. Journal of International Wildlife Law & Policy 16:2-3,170-197.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2011. COSEWIC Assessment and Status Report on the Atlantic Sturgeon *Acipenser oxyrhynchus* in Canada.

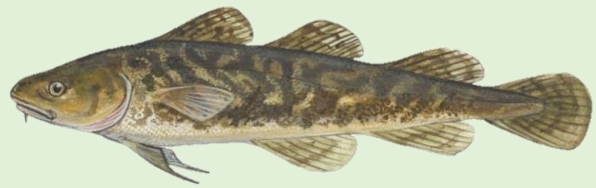
Fisheries and Oceans Canada. 2013. Evaluation of Atlantic sturgeon (*Acipenser oxyrhynchus*) Bay of Fundy population to inform a CITES non-detriment finding. Canadian Science Advisory Secretariat Report 2013/047.

Greene, K. E., Zimmerman, J.L., Laney, R.W., and Thomas-Blate, J.C. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.

Maritime Aboriginal Peoples Council. The Sturgeon's anatomy, life cycle, threats, significance. http://www.ikanawtiket.ca/ Accessed 16/09/15.

Mi'kmaq Conservation Group. 2015. Species at Risk Database. http://www.mikmawconservation.ca/sar-database/ Accessed 16/09/15.

Atlantic tomcod *(Microgadus tomcod)*



Blamuch

Biology and Life Cycle

- Life expectancy is approximately four years, average size 30-33 cm
- Eat small crustaceans (e.g. amphipods, shrimp), fishes (gaspereau, herring, smelt, stickleback, striped bass), and other aquatic organisms (worms, squid, mollusks)
- Spawn in winter and the Mi'kmaq name for January (Punamujuiku's) relates specifically to the time of spawning of tomcod
- Tomcod are voracious predators, but also common food items for other fishes
- Have been poorly studied, with a relative lack of scientific literature focusing specifically on this species

Habitat

- Shallow, near-shore marine waters such as Cobequid Bay and Minas Basin
- Broadly distributed from southern Labrador to North Carolina
- Migrate to low salinity brackish or freshwater areas in winter to spawn
- Their eggs settle and adhere to cobble-bottomed areas prior to hatching
- Larvae remain in fresh or low salinity water
- Local anglers indicate tomcod spawn in Rines Creek, a freshwater tributary of the Shubenacadie upstream of the Alton Gas site
- Eggs and larvae develop best when in salinities of 0 to 15ppt, but tolerate salinity up to 30ppt on high tides
- Juveniles stay in estuary water above 10ppt to full salt
- Adults are tolerant of all salinities 0 to 35ppt

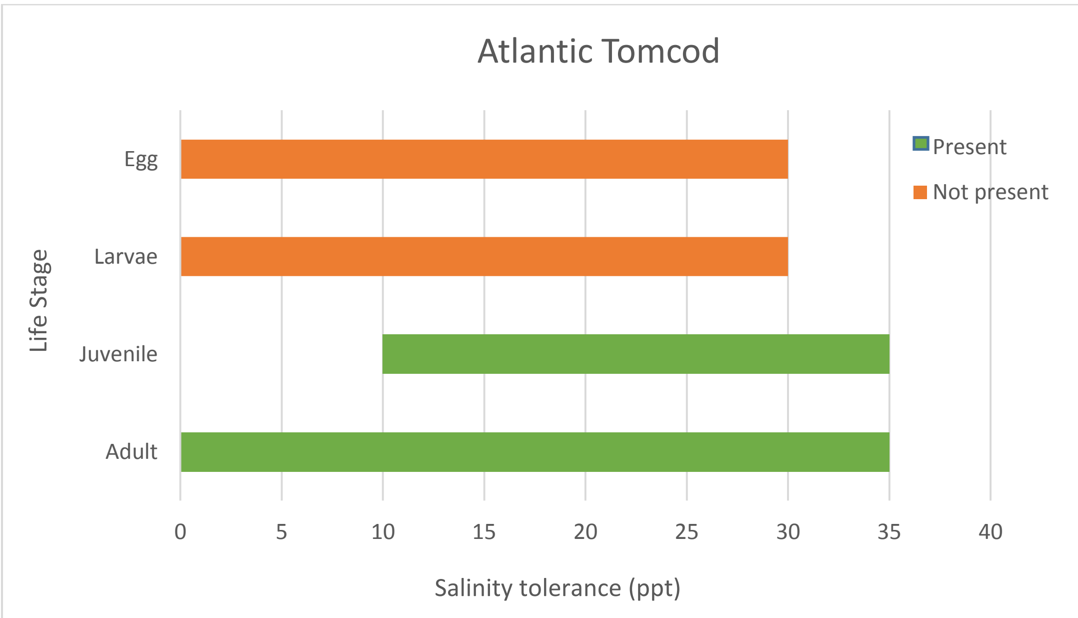
Alton Gas Storage Survey 2008 - 2015

- Tomcod eggs and larvae have not been detected in plankton net tows at the Alton site or up-estuary to the salt front
- Juveniles are commonly caught in plankton net and seine net during the sampling season (June – August) but there are notable absences in some years (zero individuals caught in 2008, 2009 and 2014; 12 to 136 individuals caught in other years)
- Reason for the variation in numbers and absence in some years is unclear

Implications of Alton Gas Storage Project

- Life stages present- juvenile to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities are well above intake velocities and can avoid unsuitable conditions
- Numbers of tomcod at the river site will continue to be tracked through the on-going monitoring program using beach seine and plankton net surveys
- Tomcod are widespread in Atlantic Canada, and the Shubenacadie River is not the sole nursery habitat

Life Stage Salinity Tolerances



References

Bleakney, G.S., and McAllister, D.E. 1973. Fishes stranded during extreme low tides in Minas Basin, Nova Scotia. Canadian Field Naturalist 87:371-376.

Heimbuch, D.G. 2008. Potential effects of Striped Bass predation on juvenile fish in the Hudson River. Transactions of the American Fisheries Society 137:1591-1605.

Juanes, F., Marks, R.E., McKown, K.A., and Conover, D.O. 1993. Predation by age-0 bluefish on age-0 anadromous fishes in the Hudson River estuary. Transactions of the American Fisheries Society 122:348-356.
Mi'kmaq Spirit. 2013. Mi'kmaq Lunar Calendar. http://www.muiniskw.org/pgCulture1a.htm, Accessed 11/09/15.

Peterson, R.H., Johansen, P.H., and Metcalfe, J.L. 1980. Observations on early life stages of Atlantic tomcod, *Microgadus tomcod.* Fishery Bulletin 78:147-158.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

Stewart, L. and Auster, PJ. 1987, Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic) – Atlantic tomcod. United States Fish and Wildlife Service U.S. Army Corps of Engineers 82/11.76.

Brook trout *(Salvelinus fontinalis)*

Atoqwa'su [general name for trout]

Biology and life-cycle

- A colourful fish, length up to 40cm and weight 1.4kg, lifespan up to six years
- Spawn in late fall in Atlantic Canada
- Eggs incubate through the winter buried in the bottom of freshwater streams
- Eat invertebrates and small fishes
- Rainbow trout (*Oncorhynchus mykiss*) and Brown trout (*Salmo trutta*) are introduced species from western North America and Europe, respectively, with similar biology and therefore potential competitors
- Conservation status in Nova Scotia: listed as ‘secure’ but ‘sensitive’ due to cold water preference

Habitat

- Widely distributed in eastern North America from Labrador to Cape Cod, preferring cool streams and lakes below 20°C
- Anadromous, some living and feeding at sea for two-three months per year, others remaining in fresh water
- Sea-going trout grow to a larger size due to higher nutrient content of marine diet
- Eggs deposited in gravel freshwater stream beds in late fall, hatching occurs in spring at temperatures approximately 5-10°C
- Egg salinity tolerance up to 6ppt, once the eggs are eyed they can tolerate levels up to 12ppt. Rearing below 10ppt is best and tolerance increases with size. One- and two-year olds and adults can tolerate up to full sea salt but prefer 10-15ppt

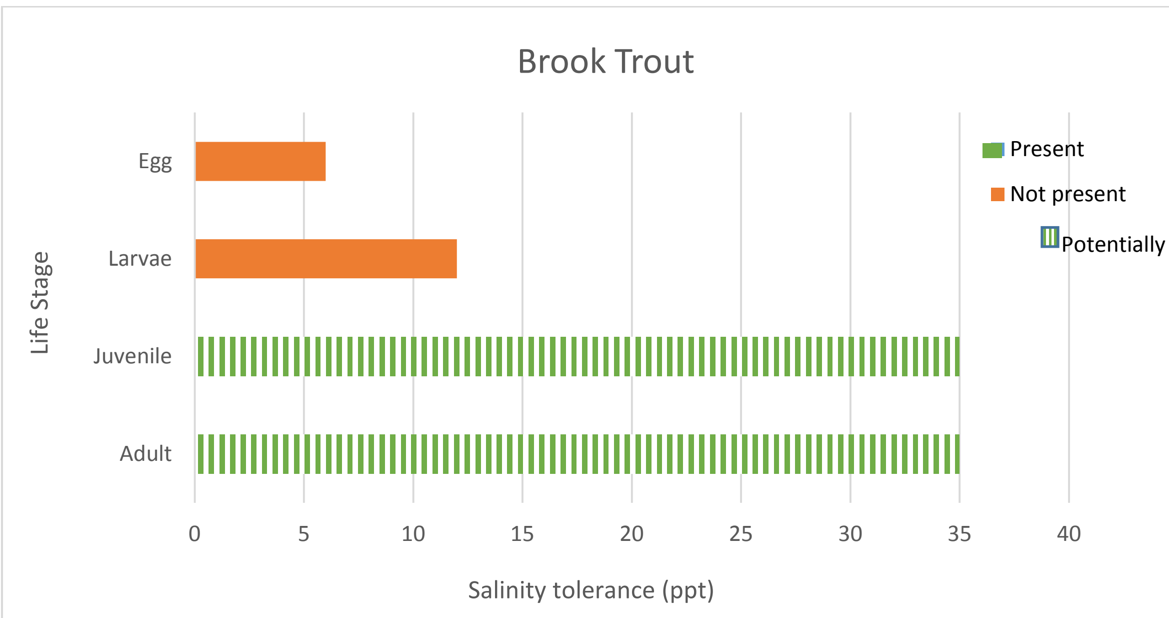
Alton Gas Survey 2008-2015

- Monitoring program protocol has been to minimize handling and immediately return any salmonid species to the river without identification to species, based on conservation status of Atlantic salmon and to minimize stress
- three salmonids recorded in beach seine surveys in July and August 2008-2015 at temperatures >20°C
- These individuals were likely brown trout based on quick observation of relatively dull colouration and tolerance for turbid, warm waters

Implications of Alton Natural Gas Storage Project

- Life stages present - possibly juvenile to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- Shubenacadie-Stewiacke estuary is not typical habitat for brook trout other than as a potential migration route for adults
- On-going monitoring will continue to track numbers of salmonids present through beach seine and plankton net surveys
- Brook trout locate their prey visually, so sea-run trout are unlikely in the estuary because of the high turbidity and poor visibility. This area is migration only

Life Stage Salinity Tolerances



References

Atlantic Conservation Data Centre. 2014. Rarity ranks and legal status by province. Nova Scotia Vertebrates. http://www.accdc.com/webranks/NSVERT.htm; Accessed 15/09/15.

Bigelow, H.B. and Schoeder, W.C. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74:1-577.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

Sutterlin, A.M., P. Harmon, and H. Barchard. 1976. The culture of brook trout in salt water. Environment Canada Fisheries and Marine Service Technical Report 636.

Brown bullhead (*Ameiurus nebulosus*) [Glatpedaw (catfish)]

Biology and life-cycle

- Size up to approximately 20cm and lifespan up to seven years
- Sensory barbels around the mouth are used to locate prey, as bullhead eyesight is poor
- Spawn from April through June in fresh water
- Omnivorous bottom-feeders, eating algae, insect and crustacean invertebrates, fishes
- Conservation status: secure throughout its range, invasive in some regions

Habitat

- Widely distributed in fresh water and slightly brackish waters throughout North America
- Females build nests in protected areas in sand, gravel, mud or vegetation
- Species is generally tolerant of poor water quality conditions, including high temperature and low dissolved oxygen

Alton Gas Survey 2008-2015

- No bullhead have been observed at the river site during the eight-year monitoring program, 2008-2015

Implications of Alton Natural Gas Storage Project

- Salinity tolerances have not been well studied but brown bullhead is a freshwater species
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- Shubenacadie-Stewiacke estuary is not typical habitat for brown bullhead because they are a freshwater species
- On-going monitoring will continue to track all fish species, including any occurrences of bullhead, through beach seine and plankton net surveys

Life Stage Salinity Tolerances

- Because brown bullhead is a freshwater species, no research has been on salinity tolerance thresholds but they have been observed in low salinity water

- They would avoid the tidal portion of the Shubenacadie River because of the natural salinity conditions in the area

References

Atlantic Conservation Data Centre. 2014. Rarity ranks and legal status by province. Nova Scotia Vertebrates. http://www.accdc.com/webranks/NSVERT.htm; Accessed 15/09/15.

Chesapeake Bay Program. 2015. Brown bullhead, *Ameiurus nebulosus.* http://www.chesapeakebay.net/fieldguide/critter/brown_bullhead; accessed 11 November 2015.

Museum of Zoology. 2015. Animal Diversity Web: *Ameiurus nebulosus,* Brown catfish. University of Michigan

Smooth & Winter Flounder

(Pleuronectes putnami, Pseudopleuronectes americanus)

Anakwe'j

Biology and life-cycle

- Smooth flounder generally smaller than winter flounder (up to 30cm and 40cm total length, respectively)
- Smooth more distinctly mottled, grey to brown, whereas winter flounder are reddish-brown
- Spawning occurs in late winter to early spring
- Newly hatched larvae two-three mm total length
- Eat crustaceans, worms and other marine invertebrates
- Live 11-12 years
- Conservation status: not assessed by COSEWIC

Habitat

- Widely distributed bottom-dwelling in shallow coastal waters, with smooth flounder more likely in softer substrates and winter flounder over harder substrates
- Spawning occurs in shallow coastal or estuarine areas
- Smooth flounder more likely found in estuaries than winter flounder, primarily found in coastal waters
- Winter flounder migrate offshore in winter, returning to nearshore in summer
- Tolerant of wide range of temperatures and brackish to full sea water
- Winter flounder eggs are found in salinities range between 10 and 30ppt
- Larvae and juvenile inhabit open water in salinities ranging from 4 to 30ppt
- Adults are also found in salinities between 5.5 and 36ppt

Alton Gas Survey 2008-2015

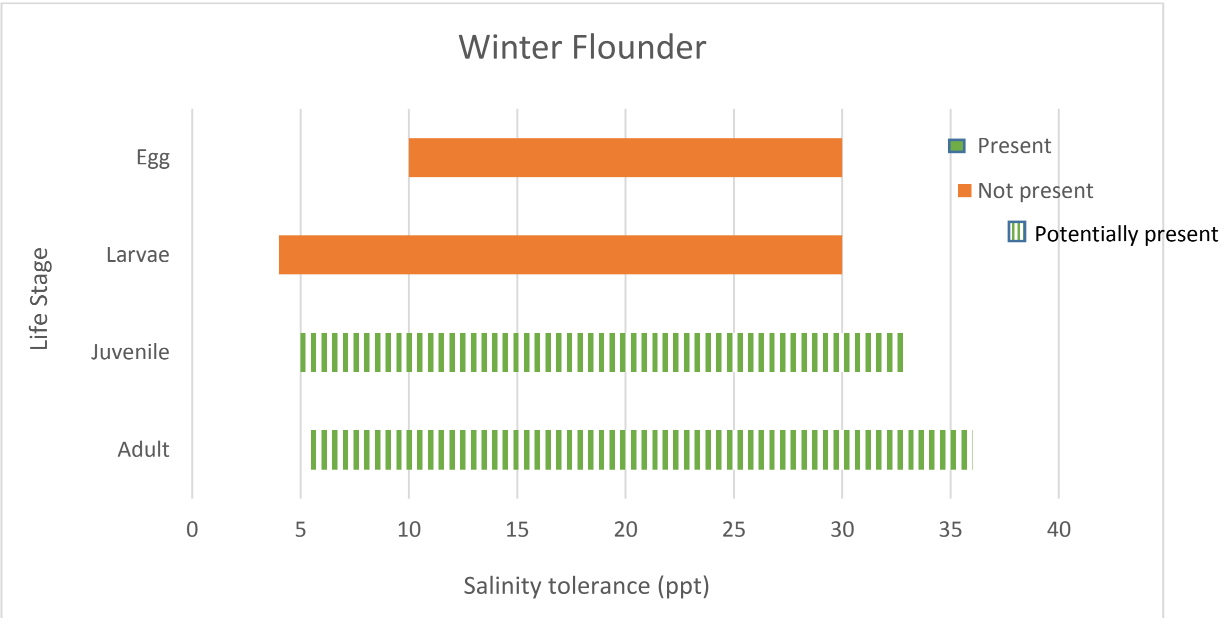
- Small number of flounder found in beach seine survey on west sand bank opposite Alton site 2008-2015, <10 individuals per year

Implications of Alton Natural Gas Storage Project

- Life stages present - possibly juvenile to adult
- Salinity tolerances - 0.1 to >30 ppt, the brine poses no known risk
- Swimming abilities are well above intake velocities and can avoid unsuitable conditions.

- The species is very widespread, spawning could not take place in the area
- On-going monitoring at the river site will continue to track numbers of all fish species, including flounder species, through beach seine and plankton net surveys

Life Stage Salinity Tolerances



References

Bigelow, H.B. and Schoeder, W.C. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74:1-577.
Essential Fish Habitat (EFH) Assessment Gloucester Harbor, Massachusetts. 2001. Maguire Group Inc. 225

Foxborough Blvd., Foxborough, MA 02035.

Laroche, W.A. 1981. Development of larval smooth flounder, *Liopsetta putnami*, with a description of winter flounder, *Pseudopleuronectes americanus* (Family Pleuronectidae). Fishery Bulletin 78:897-909.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

Mummichog (*Fundulus heteroclitus*)
Banded killifish (*Fundulus diaphanus*)
Amjlakwe'j [general name for minnow]

Biology and life-cycle

- Mummichog and banded killifish are similar in appearance, mummichog more stout and darkly coloured
- Can be distinguished by number of gill rakers (8-12 in mummichog and 4-6 in killifish)
- Live three-four years, reaching sizes of ~10cm
- Feed on a range of aquatic invertebrates depending on their size
- Spawn adhesive eggs which adhere to plants over relatively long spring-summer period
- Conservation status: Secure

Habitat

- Both euryhaline species, but mummichog are more common in brackish environments such as marshes, ponds and other areas with submergent and emergent vegetation, whereas killifish are more confined to freshwater environments
- Spawn in warm waters, 20°C or more, in dense vegetation
- Mummichog widely distributed in coastal areas from the Gulf of St. Lawrence to Texas; Banded killifish occur from Manitoba eastward to the Maritimes, with an isolated Newfoundland population
- Both species are tolerant of stagnant, low oxygen conditions, and a wide range of salinities (from fresh water up to >100ppt) and temperatures up to mid-30°C range in moderate (14ppt) salinity

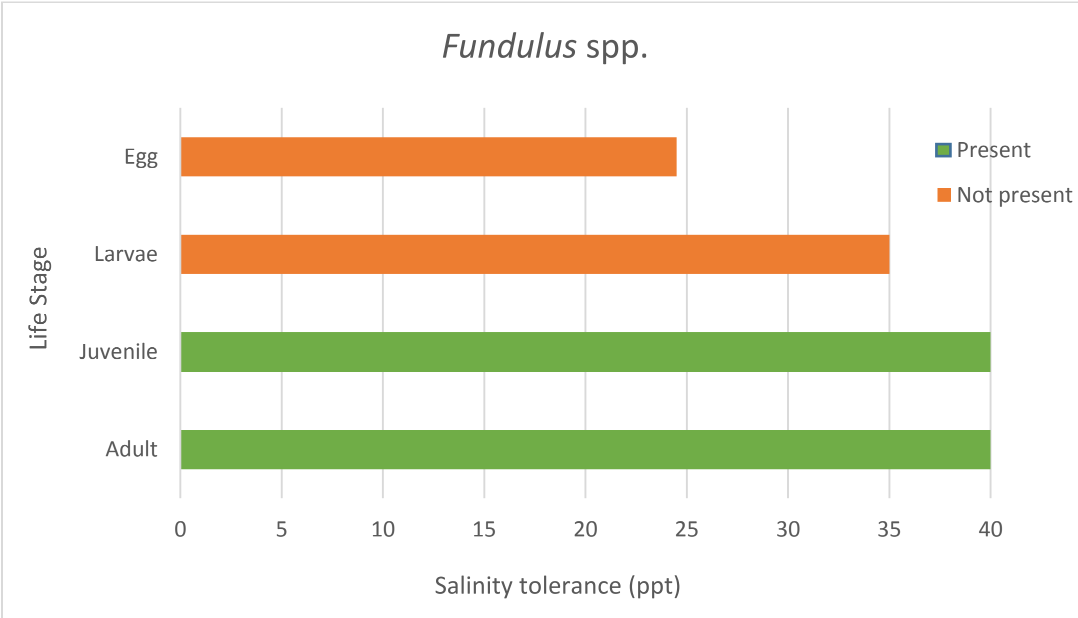
Alton Gas Survey 2008-2015

- Small numbers of both species found in seine net hauls during July – August 2008-2015, with a catch per unit effort of < 1

Implications of Alton Natural Gas Storage Project

- Life stages present - possibly juvenile to adult
- Salinity tolerances - 0 to >30 ppt, the brine poses no known risk
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- On-going monitoring at the river site will continue to track numbers of all fish through beach seine and plankton net surveys, including mummichog and killifish
- These species are very widespread, spawning could not take place in the area

Life Stage Salinity Tolerances



References

Bigelow, H.B. and Schoeder, W.C. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74:1-577.

Nordlie, F.G. 2006. Physicochemical environments and tolerances of cyprinodontoid fishes found in estuaries and salt marshes of eastern North America. Reviews in Fish Biology and Fisheries 16:51-106.

Richardson, L.R. 1939. The spawning behaviour of Fundulus diaphanus (Le Sueur) Copeia 3:165-167.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

Species at Risk Public Registry. 2015. Banded killifish mainland populations. http://www.registrelep-sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=466. Accessed 17/09/2015.

Northern pipefish *(Syngnathus fuscus)*

[Mi’kmaq name]

Biology and life-cycle

- Unusual elongated fish grows to a length of about 20cm
- Unusual reproductive cycle; female deposits a few eggs (1mm) at a time into the brood pouch of the male. After a 10 day incubation period in the male pouch, 8-9mm larvae emerge
- Eats mostly plankton
- Spawns June-July
- Larvae 9-10mm at hatch, extremely slender
- COSEWIC: Not listed

Habitat

- Uncommon but widespread in coastal waters from Gulf of St. Lawrence to Florida, mainly in beds of seaweed and eelgrass, salt marshes and estuaries
- Larvae develop in brackish water
- Adults usually found in salt water, sometimes in brackish water, not in fresh water
- Specimens reported locally at Bass River, Minas Basin, Cobequid Bay, Annapolis Basin
- Spawns May-June down from Enfield on the Shubenacadie, Nine Mile River, and on the Stewiacke a few km above head of the tide

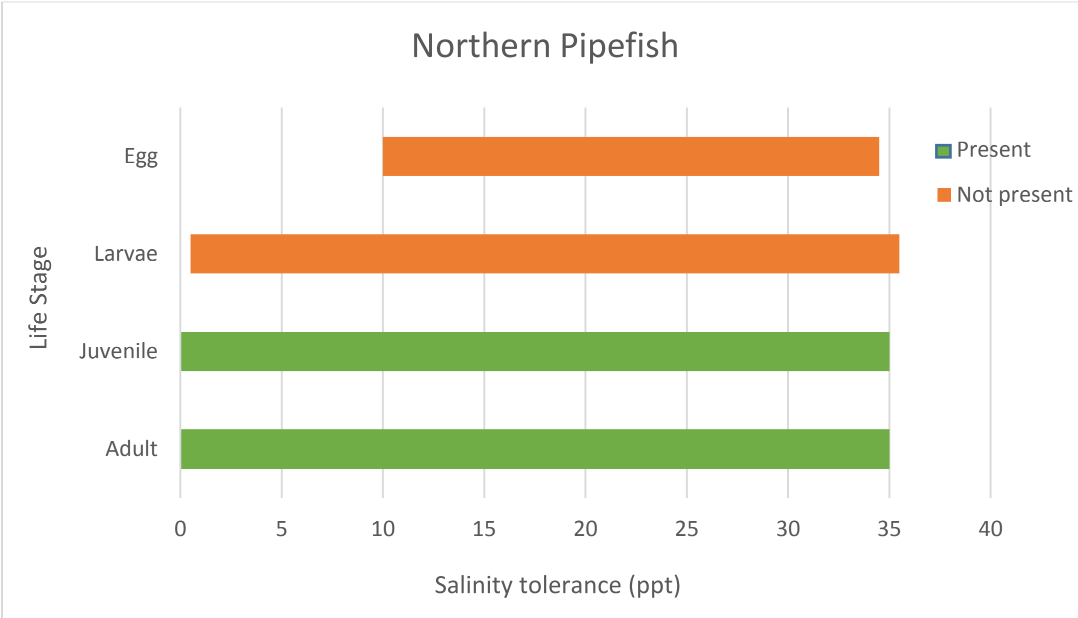
Alton Gas Survey 2008-2015 .

- Ten specimens have been caught in eight years in both plankton net tows at the Alton site and seine net hauls ranging from Alton to the estuary mouth. Caught in range of salinity 4 to 23ppt, 16 to 23oC, June 17 to Sept 27. The record was four pipefish caught in one seine net haul at Blackrock Sept 27, 2010 (16oC, 22ppt)

Implications of Alton Natural Gas Storage Project

- Life stages present - possibly juvenile to adult
- Salinity tolerances - ~2 to >30ppt, the brine poses no known risk
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- Spawning could not take place in the area because habitat is unsuitable
- On-going monitoring at the river site will continue to track numbers of all fish through beach seine and plankton net surveys, including pipefish

Life Stage Salinity Tolerances



References

Azzarello, M. 1991. Some questions regarding the Syngnathidae brood pouch. Bulletin of Marine Science 49(3):741-747.

Bigelow, H.B. and Schoeder, W.C. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74:1-577.

Campbell, B.C. and Able, K.W. 1998. Life history characteristics of the Northern Pipefish, Syngnathus fuscus, in southern New Jersey. Estuaries 21:470-475.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences. 219:259-283.

Rainbow smelt *(Osmerus mordax)*

Kakpesa

Biology and life-cycle

- Long, slender fish with an average length of 15-20 cm.
- Spawn in early spring and larvae are 5-6 mm in length at hatching
- Larvae and juveniles feed on copepods, whereas larger juveniles and adults eat crustaceans (shrimp, amphipods), polychaete worms, and small fishes (e.g. silverside, alewife)
- Conservation status: smelt are considered common in Nova Scotia, with a provincial ranking of 'secure'

Habitat

- Rainbow smelt are widely distributed along the Atlantic coast from Labrador to Delaware, and are also found in inland waters such as the Great Lakes
- Rainbow smelt on the Atlantic coast are anadromous
- Spawning occurs in water temperatures from 4-9 °C, usually in late April and May in Atlantic Canada
- Smelt migrate to freshwater environments above the head of the tide to spawn
- Eggs are not tolerant of salinities higher than 15ppt
- Larvae to adults tolerant of full sea salt >30ppt
- Larvae drift downstream into tidal portions of estuaries as they grow
- Juveniles and adults migrate to sea following spawning, and return to estuaries in the fall where they overwinter
- Exact location(s) of spawning in the Shubenacadie-Stewiacke watershed are unknown, but are likely well above the head of the tide due to the low salinity tolerance of eggs

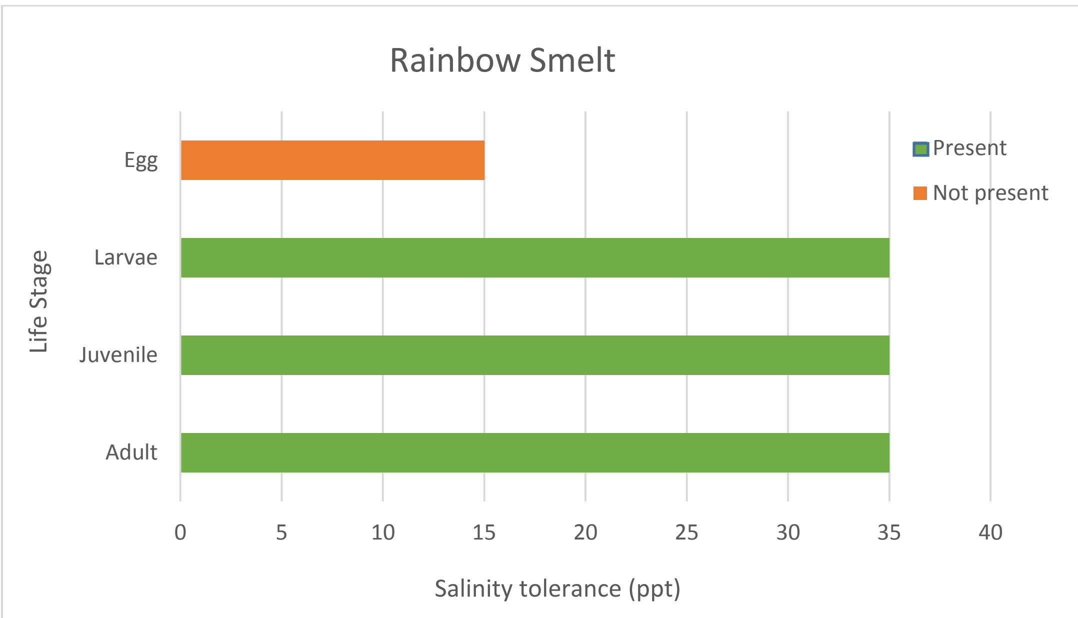
Alton Gas Survey 2008-2015

- Beach seine sampling within the Shubenacadie estuary shows that numbers of young-of-year smelt vary, from a catch per unit effort low of 0.1 in 2014, to a high of 3.9 in 2008
- Larvae and early juveniles were also occasionally caught in plankton net tows around the Alton Gas site in all years, at salinities ranging from 0 to > 20ppt
- Larvae of rainbow smelt among most abundant fishes caught in beach seine surveys in Cobequid Bay/Minas Basin in 2015

Implications of Alton Natural Gas Storage Project

- Life stages present- larvae to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities are well above intake velocities and can avoid unsuitable conditions
- The species is very widespread, spawning could not take place in the area
- On-going monitoring will continue to track numbers of smelt at the river site through beach seine and plankton net surveys

Life Stage Salinity Tolerances



References

Atlantic Conservation Data Centre. 2014. Rarity ranks and legal status by province. Nova Scotia Vertebrates. http://www.accdc.com/webranks/NSVERT.htm; Accessed 15/09/15.

Buckley, J.L. 1989. Species profiles: Life histories and environment; requirements of coastal fishes and invertebrates (North Atlantic)-rainbow smelt. United States Fish and Wildlife Service Biology Report 82(11.106). U.S. Army Corps Engineers, TR EL-82-4.

Fuda, K.M., Smith, B.M., Lesser, M.P., Legare, B.J., Breig, H.R., Stack, R.B., and Berlinsky, D.L. 2007. The effects of environmental factors on rainbow smelt *Osmerus mordax* embryos and larvae. Journal of Fish Biology 71:539-549.

Sea lamprey *(Petromyzon marinus)*

Kopsikwedum

Biology and life-cycle

- Ammocoetes sea lamprey spend six-eight years in fresh water before metamorphosing and migrating to sea
- Metamorphosis involves the radical transformation from a substrate-dwelling, filter feeder into a free-swimming, parasitic feeder
- Eel-shaped body with distinct, jawless mouth with suckers to adhere to fish and other organisms
- Larvae feed on plankton filtered through their mouths
- Adults generally prey upon or parasitize many fish species, especially salmonids
- Spawn at six-eight years of age, usually in spring or early summer but timing is variable
- Eggs hatch into larval form which takes six-eight years to reach sexual maturity
- Both males and females reach ~70cm total length, < 1kg at spawning
- Conservation status: secure

Habitat

- Wide-ranging in the Atlantic from southern Greenland to Florida, in many watersheds of the Maritimes
- Anadromous, in Nova Scotia spawning in freshwater streams in spring but feeding at sea as adults
- Spawning occurs in fresh water over stony or gravel and sand substrates in shallow water; nests are 15cm deep; eggs adhere to substrate and are not buoyant
- Larvae live in burrows in sand, muddy freshwater stream bottoms until six-eight years of age when they migrate to sea to spawn
- Ammocoetes do not survive with salinities greater than 10ppt, whereas survival in high salinity (>25–35ppt) increased with increased degree of (five-six stage) metamorphosis in transformers
- Live in fresh water until metamorphosis when they head to sea and are fully salt tolerant

Alton Gas Survey 2008-2015

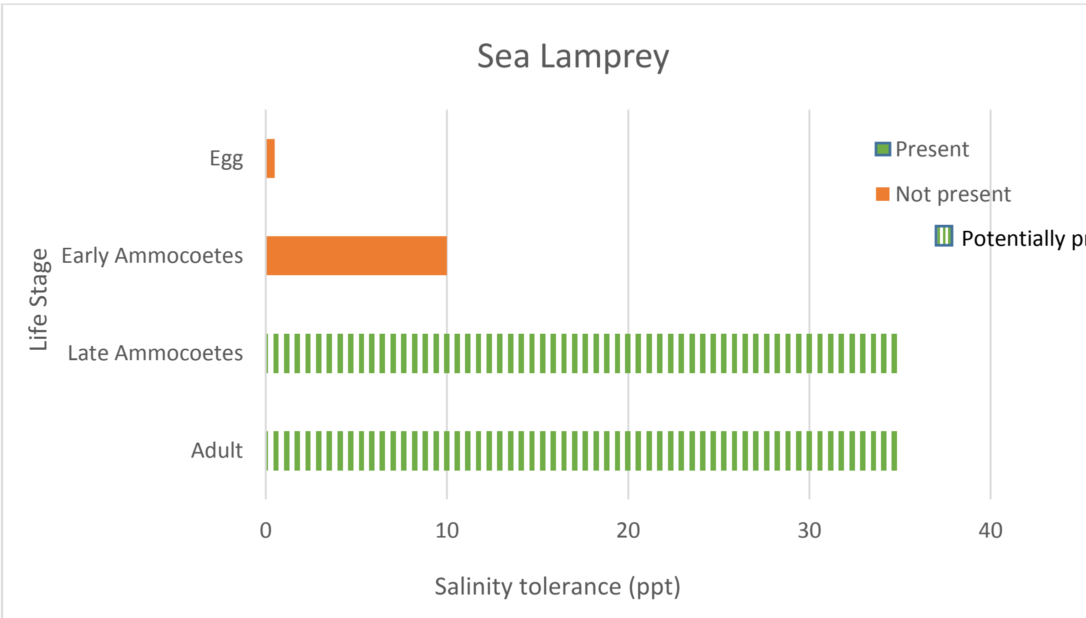
- Not detected in monitoring 2008-2015

Implications of Alton Natural Gas Storage Project

- Life stages present - juvenile to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- The species is widespread, spawning could not take place in the area

- Monitoring will continue to track numbers of all fish species, including any occurrence of sea lamprey, through beach seine and plankton net surveys

Life Stage Salinity Tolerances



References

Atlantic Conservation Data Centre. 2014. Rarity ranks and legal status by province. Nova Scotia Vertebrates. http://www.accdc.com/webranks/NSVERT.htm; Accessed 15/09/15.

Reis-Santos, P., McCormick, S.D., and Wilson, J.M. 2008. Ionoregulatory changes during metamorphosis and salinity exposure of juvenile sea lamprey (Petromyzon marinus L.). Journal of Experimental Biology 211:978-988.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

Stickleback species (Family Gasterosteidae)

[Mi'kmaq name]

Biology and Life-cycle

- Threespine, Fourspine, Ninespine and Black spotted sticklebacks are all thought to be present in local habitat
- Stickleback are small (usually 3-6 cm) schooling fish
- Body color varies from silvery to mottled green and brown
- Spawning is generally from April to July in brackish to fresh water. Males build a nest using algae or plants in a shallow depression near rocks or vegetation. The male entices a female to enter the nest and deposit her eggs for him to fertilize and guard
- Exact location(s) of spawning in the Shubenacadie-Stewiacke watershed are unknown, but are likely well above the head of the tide due to the need for a nest to stay intact
- COSEWIC: Not listed. A common fish. No conservation concerns

Habitat

- Marine, estuary and freshwater habitats
- Widely distributed in the northern hemisphere
- Some species are anadromous, living and feeding at sea and migrating to fresh water to spawn, while others remain in fresh water

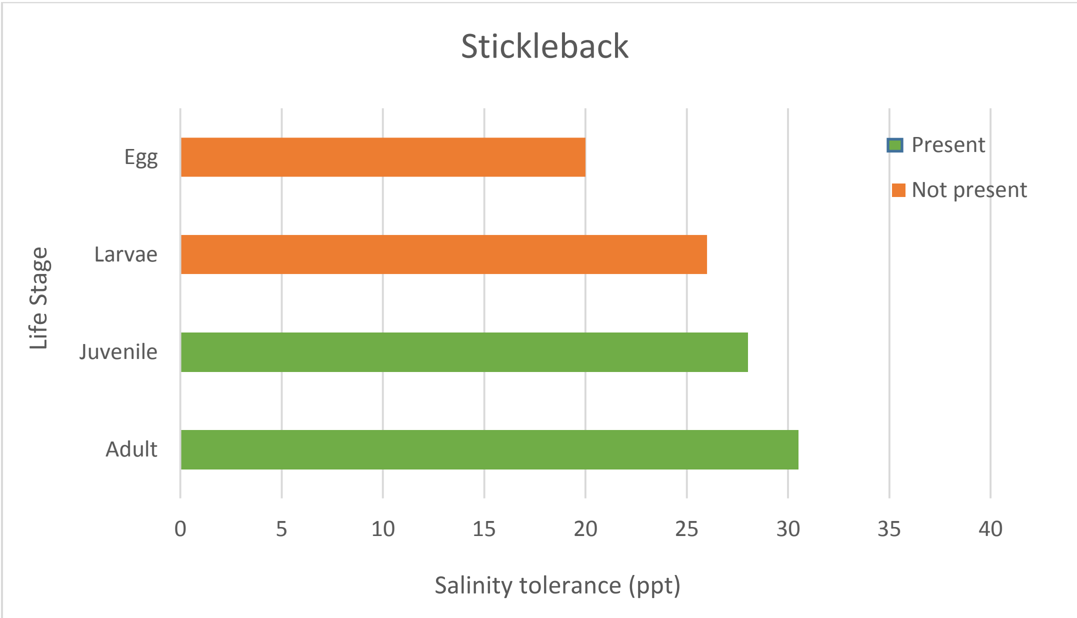
Alton Gas Survey 2008-2015

- Stickleback are present in small numbers in plankton tows at Alton site and up-estuary to salt front
- Beach seine sampling within the Shubenacadie estuary shows that numbers of stickleback varied little, from a catch per unit effort low of 0.15 in 2008, to a high of 0.88 in 2014
- Stickleback were caught at salinities ranging from 0 to >20ppt

Implications of Alton Natural Gas Storage Project

- Life stages present - possibly juvenile to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- The species is very widespread, spawning could not take place in the area and the Shubenacadie River is not the sole habitat
- Monitoring will continue to track all fish species numbers at the river site, including sticklebacks, through beach seine and plankton net surveys

Life Stage Salinity Tolerances



References

Campeau, S., Guderley, H., and Fitzgerald, G. 1983. Salinity tolerances and preferences of fry of two species of sympatric sticklebacks: possible mechanisms of habitat segregation. Canadian Journal of Zoology 62:1048-1051.

Hatfield, T. 2009. Identification of critical habitat for sympatric Stickleback species pairs and the Misty Lake parapatric stickleback species pair. Fisheries and Oceans Canada Science Advisory Secretariat Research Document 2009/056.

Scott, W.B. and Scott, M.G. 1988. Atlantic Fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:259-283.

Poulin, R. and Fitzgerald, G.J. 1989. Early life histories of three sympatric sticklebacks in a salt marsh. Journal of Fish Biology 34(2):207–221.

Striped bass *(Morone saxatilis)*

Ji'kaw

Biology and life-cycle

- Large (up to 30kg) long-lived (30 years), repeat spawner, ~1 million eggs per female per year.
- Spawn May-June in tidal fresh water of estuaries. Eggs suspended in water column hatch in two-three days
- Larvae 4mm at hatch, develop in brackish water over broad range of salinities, but absent from freshwater
- Underyearlings need to reach 10cm long to survive first winter
- COSEWIC: Bay of Fundy population status was raised in 2012 from 'threatened' to 'endangered' because only one known spawning location (Stewiacke River) where it continues to be susceptible to exploitation from recreational fishing, by-catch in commercial fisheries, and from poaching. Habitat degradation continues in areas of historical spawning (Annapolis and St. John rivers), limiting recovery potential

Habitat

- Species widespread in coastal waters from Gulf of St. Lawrence to South Carolina
- Local population overwinters in Grand Lake, and also in Minas Basin (from recent evidence)
- Adults congregate in estuaries in early spring, spawning in tidal freshwater in Stewiacke River in May-June. Gulf population spawns in the Miramichi River
- Nursery habitat is estuarine brackish water
- Egg and larvae survival is highest between 2 and 20ppt and is reduced in salinities of 30ppt or higher. The early life stages of the local population has a higher salinity tolerance than US populations
- Underyearling juveniles broadly distributed in the estuary and Cobequid Bay
- Adults abundant in summer around Maritime coast, likely a mix of Bay of Fundy, Gulf, and US fish

Alton Gas Survey 2008-2015

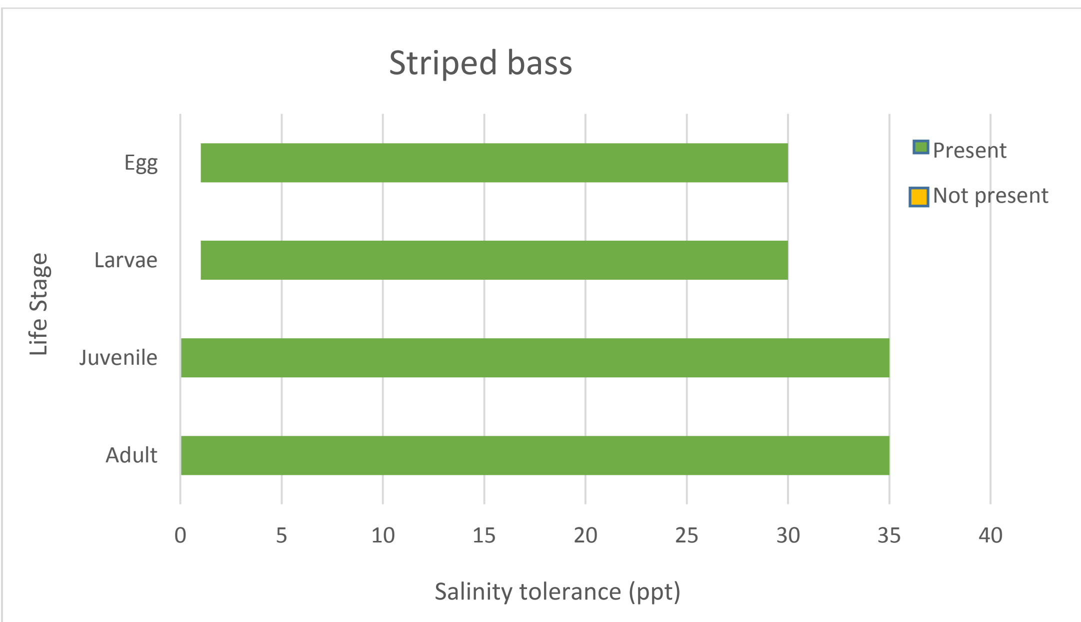
- Eggs highly abundant in plankton net tows at Alton site on both flood and ebb tides between 0.5 and 15ppt salinity. Spawning mostly May 15 to June 10, timing strongly influenced by warming above 12^oC
- Larvae abundance much lower than eggs and varies greatly between years. Abundance greater when May and June are warm and dry and salinity high, lower when freshwater discharge is high associated with flushing of larvae out of the estuary
- Growth of larvae is poor in June due to low copepod prey density, 5-6mm larvae drift in main channel

- Growth improves in early-July associated with migration out of main channel into margins

Implications of Alton Natural Gas Storage Project

- Life stages present - egg to adult
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- Swimming abilities - eggs and larvae drift back and forth past Alton site and with none-to-limited swimming ability
- On-going monitoring of all striped bass life stages is planned before and during operation
- New data on numbers of all life stages will be tracked and compared to data from 2008-2015 to determine whether any new trends emerge

Life Stage Salinity Tolerances



References

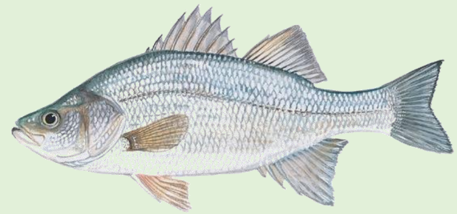
Bradford, R.G. , Leblanc, P., and Bentzen, P. 2013. Update status report on Bay of Fundy striped bass (*Morone saxatilis*). Fisheries and Oceans Canada Science Advisory Secretariat Research Document 2012/021.

Cook, A.M., Duston, J., and Bradford, R.G. 2010. Temperature and salinity effects on the survival and growth of early life stage Shubenacadie River striped bass. Transactions of the American Fisheries Society 139:749-757.

Duston, J., MacInnis, G.M., and Reesor, C.M. 2015. Early life history of striped bass in the macrotidal Shubenacadie River. Transactions of the American Fisheries Society, in review (submitted 2015).

White perch (*Morone americana*)

[Mi'kmaq name]



Biology and life-cycle

- Lengths reaching up to 45cm or more
- Northern populations spawn in March-April
- Older juveniles and adults are omnivorous, feeding on aquatic invertebrates and smaller fishes

Habitat

- Spawning occurs in fresh or brackish water at salinities up to approximately 4ppt
- Eggs are laid over firm clay or sandy bottoms
- Some are landlocked while others inhabit a range of environments from fresh water to sea water
- There is evidence that even sea-dwelling white perch prefer moderate salinities between 5-18ppt
- Widespread in coastal and inland waters of eastern North America from the Maritimes to South Carolina

Alton Gas Survey 2008-2015

- No white perch have been detected in eight years of monitoring

Implications of Alton Natural Gas Storage Project

- It is possible that juvenile or adult stages could occur at the river site
- Salinity tolerances of these life stages overlap with those at the river site and swimming abilities would allow white perch to avoid any higher salinities they encounter
- Swimming abilities are well above intake velocities and can avoid unsuitable conditions
- On-going monitoring will continue to track numbers of all fish species observed in the river through beach seine and plankton net surveys, including white perch if any do occur

Life Stage Salinity Tolerances

References

Hardy, J.D., Jr. 1978. Development of fishes of the mid-Atlantic Bight-an atlas of egg, larval, and juvenile stages. Vol. 111. Aphredoderidae through Rachycentridae. U.S. Fish and Wildlife Service, Biological Services Program, FWS/OBS-78/12.

Scott, W.B. and Crossman, E.J. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Setzler-Hamilton EM. 1991. White perch. *In*: Funderbank, S.L., Mihursky, J.A., Jordan, S.J., and Riley, D. (eds). Habitat requirements for Chesapeake Bay living resources. Chesapeake Bay Research Consortium, Inc., Annapolis, MD.

Stanley, J.G. and Danie, D.S. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates - White perch. United States Fish and Wildlife Service Biology Report 82(11.7). U.S. Army Corps Engineers, TR EL-82-4.

White sucker (*Catostomus commersoni*) [Qunqwej]

Biology and life-cycle

- Lengths reaching 25 to 46cm
- Tubular body shape with dark brown to more copper-coloured smooth skin
- Bottom-feeders, eating mainly algae and benthic invertebrates

Habitat

- Spawning occurs in fresh water over sand or gravel bottoms
- Species occurs in lakes, rivers and streams
- Widespread in freshwater habitats throughout North America, introduced to some western watersheds

Alton Gas Survey 2008-2015

- No white sucker life stages have been detected in eight years of monitoring

Implications of Alton Natural Gas Storage Project

- Swimming abilities are well above intake velocities and can avoid unsuitable conditions
- On-going monitoring will continue to track numbers of all fish species observed in the river through beach seine and plankton net surveys, including any potential occurrences of white sucker

Life Stage Salinity Tolerances

- Because white sucker is considered a freshwater species, no research has been done on salinity tolerance thresholds
- Despite the lack of information available on white sucker salinity tolerance, they would avoid the tidal portion of the Shubenacadie River because of the high natural salinity conditions in the area

References

New Hampshire Fish and Game. 2015. Common White Sucker. http://www.wildlife.state.nh.us/fishing/profiles/common-white-sucker.html; accessed 11 November 2015.

United States Geological Survey. *Catostomus commersonii* (Lacepede 1803). http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=346

Yellow perch (*Perca flavescens*)

Ajùguluech

Biology and life-cycle

- Small member of the Percidae family, with golden colouration and dark, greenish vertical bands
- Lengths reaching up to 30cm, with females larger than males
- Spawn in April-May
- Larvae 5mm at hatch, feeding on zooplankton
- Older juveniles and adults feed more on aquatic invertebrates and small fishes; cannibalism is common

Habitat

- Very widespread in lakes, slow-moving rivers and brackish waters of North America
- Spawning occurs in freshwater shallow areas of lakes or slow-moving streams over sand, gravel, rubble or vegetation
- Most are not migratory and remain in fresh water, but can be found in brackish or salt water <10ppt
- Considered an invasive species in some areas (e.g. western United States, northern and western Canada) because of its considerable range expansion in recent decades
- Tolerant of a wide range of conditions, up to 25°C, salinity 0 to < 12ppt
- Strong diel behavior, with high levels of activity during daylight and little to no activity at night

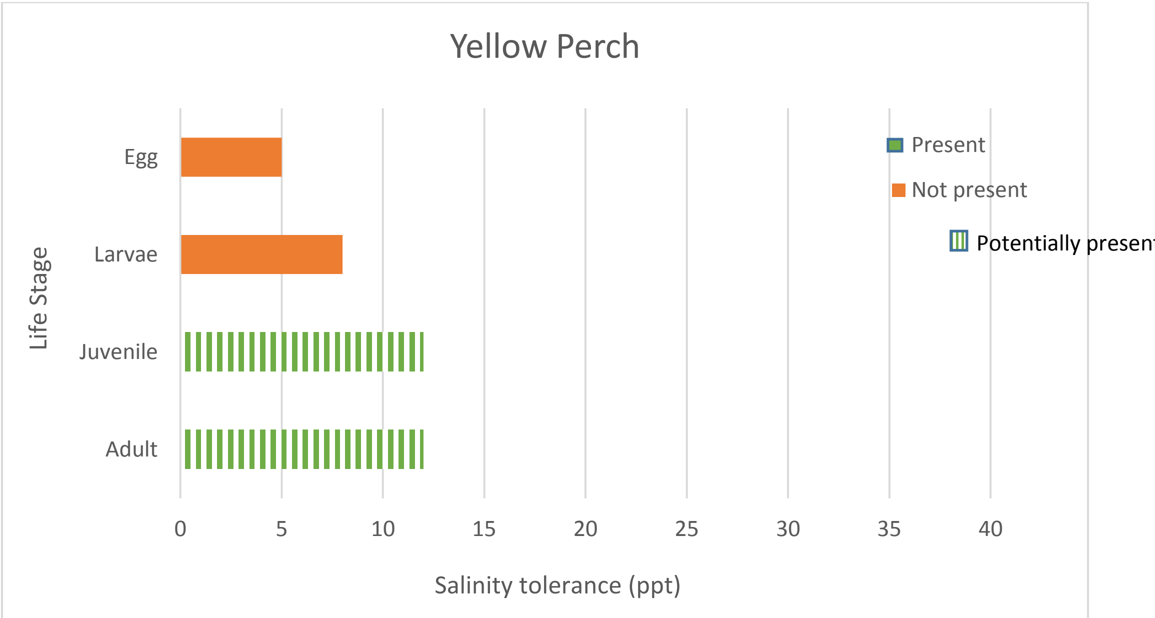
Alton Gas Survey 2008-2015

- The tidal portion of the Shubenacadie River is not typical habitat for yellow perch
- No yellow perch life stages were detected in eight years of monitoring

Implications of Alton Natural Gas Storage Project

- Life stages present - possibly juvenile to adult
- Salinity tolerances - 0 to <12ppt, salinities at the Alton site are higher than their tolerance naturally
- Swimming abilities - well above intake velocities and can avoid unsuitable conditions
- On-going monitoring will continue to track numbers of all fish species observed in the river through beach seine and plankton net surveys, but yellow perch are unlikely to spend time at the river site because the habitat is not ideal for this species

Life Stage Salinity Tolerances



References

Brown, T.G., Runciman, B., Bradford, M.J., and Pollard, S. 2009. A biological synopsis of yellow perch (*Perca flavescens*). Canadian Manuscript Report of Fisheries and Aquatic Sciences 2883.

Scott, W.B. and Crossman, E.J. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Victoria, C.J., Wilkerson, B.S., Klauda, R.J., and Perry, E.S. 1992. Salinity tolerance of Yellow perch eggs and larvae from coastal plain stream populations in Maryland, with comparison to a Pennsylvania lake population. American Society of Ichthyologists and Herpetologists 3:859-865.

Copepod 'zooplankton'

[Mi'kmaq name]

Biology and life-cycle

- Copepods are tiny (1mm) crustacea that play a critically important role in aquatic ecosystems, serving as an important food source for larval fish
- The high incidence of empty guts among first feeding stage striped bass larvae in the Shubenacadie River estuary In May-June led us in 2013 to extend our survey to count and identify the plankton
- Prior to our work, only two papers had been published on plankton in the Shubenacadie River, Willey (1923) and Jermolajev (1958) analyzing samples provided by A.H. Leim
- *Scottolana canadensis* and *Pseudodiaptomus pelagicus* were found to be the two dominant species of copepod in the Shubenacadie estuary when striped bass larvae were at the first feeding stage. Their low abundance, <200/m^3, explains the low incidence of feeding striped bass larvae. By comparison, in other striped bass nursery habitats, such as the Miramichi and Chesapeake Bay, copepods are highly abundant, up to 10,000/m^3, *Eurytemora affinis* being dominant
- Copepods are an important prey for striped bass in the Shubenacadie from first feeding (5mm body size) to late summer when *Acartia tonsa* becomes super-abundant, >20,000/m^3

Alton Gas Survey 2013-2015

- *Pseudodiaptomus pelagicus* is adapted to turbid and turbulent estuarine conditions such as occurs in the Shubenacadie River estuary. It has a global distribution. In the Shubenacadie estuary it was distributed over a broad range of salinities 2-20ppt from May to November
- *Scottolana canadensis* is an epibenthic harpacticoid widespread in estuaries along the east and west coasts of North America. In the Shubenacadie River it was distributed between 1 and 15ppt salinity with highest abundance, up to 280/m^3, around 3ppt in mid-June close to the salt-front
- *Acartia tonsa* was absent in the estuary in May and June, and was not an available prey for first feeding striped bass. Abundance increased rapidly from mid-July, present over a broad range of salinities from 5 to >20ppt

Implications of Alton Natural Gas Storage Project

- Life stages present - all stages
- Salinity tolerances - 0 to >30ppt, the brine poses no known risk
- On-going monitoring will continue to track copepod populations at the river site through plankton net surveys

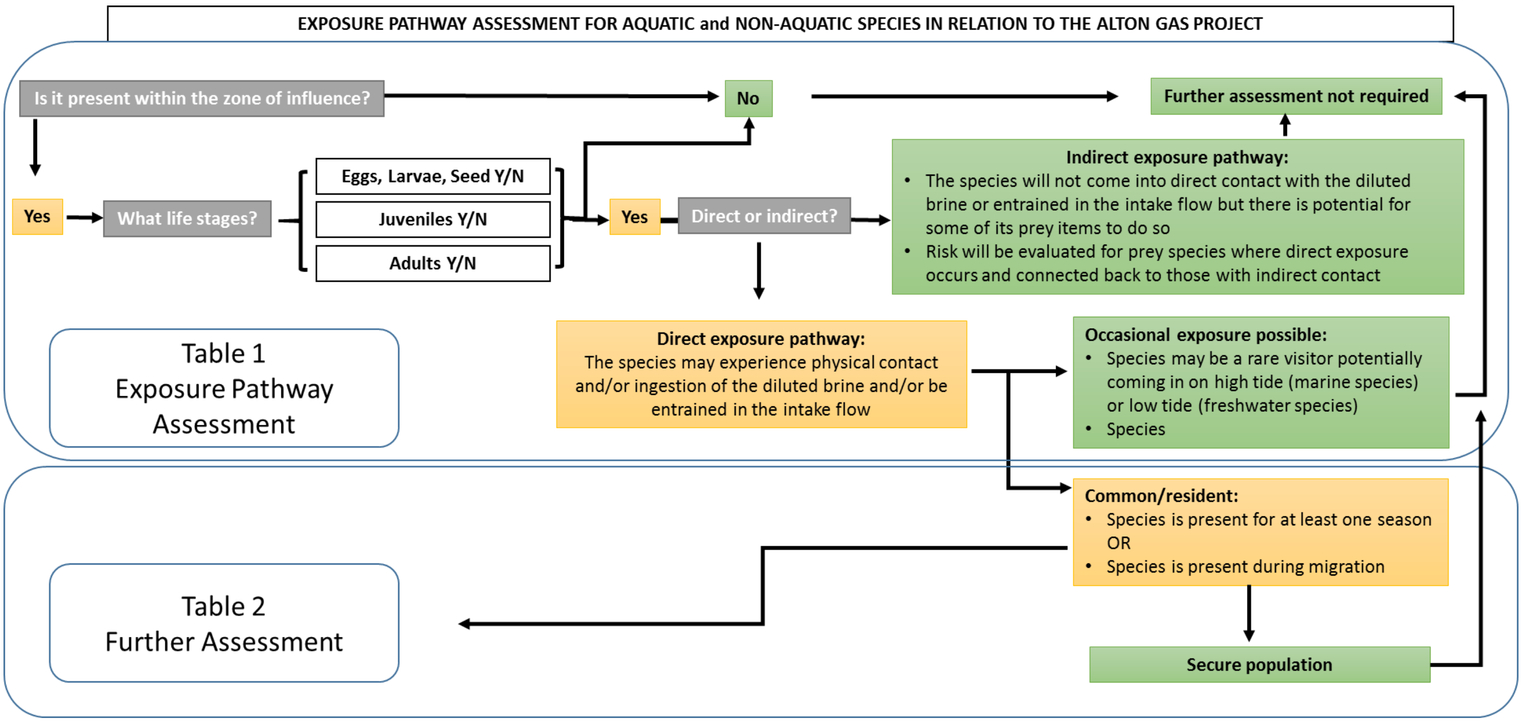
- Swimming abilities - generally free floating with the water current

References

Jermolajev, E.B. 1958. Zooplankton of the Inner Bay of Fundy. Journal of the Fisheries Research Board of Canada 15(6):1219-1228.

Willey, A. 1923. Notes on the distribution of free-living Copepoda in Canadian waters. Contributions to Canadian Biology and Fisheries 1(16):303-324.

Section 3 Exposure Pathway Assessment



Assessment tables for Valued Ecosystem Components (VECs) in relation to the Alton Natural Gas Cavern Development Project

Table 1: Exposure Pathway Assessment

Species	Present in spatial/temporal boundaries of project? Yes/No	What is the exposure pathway? Direct, Indirect, Occasional visitor, or Not applicable			Is further consideration required? Yes/No If Yes, continue to Table 2	Notes
		Eggs, larvae, or seed	Juveniles	Adults		
Atlantic salmon	Yes	Not present	Direct – smolt	Direct	Yes	
Atlantic sturgeon	Possible	Not present	Occasional direct	Occasional Direct	No	Species has not been observed during monitoring but is euryhaline
American eel	Yes	Not present	Direct – glass eels, elvers	Direct	Yes	
Yellow perch	Possible	Not present	Occasional direct	Occasional direct	No	Habitat unsuitable Occasional presence possible during high freshwater run-off
Brown bullhead	Possible	Not present	Occasional direct	Occasional direct	No	Habitat unsuitable Occasional presence possible during high freshwater run-off
Chain pickerel	Possible	Not present	Occasional direct	Occasional direct	No	Habitat unsuitable Occasional presence possible during high freshwater run-off
White perch	Possible	Not	Occasional	Occasional	No	Habitat unsuitable

Species	Present in spatial/temporal boundaries of project? Yes/No	What is the exposure pathway? Direct, Indirect, Occasional visitor, or Not applicable			Is further consideration required? Yes/No If Yes, continue to Table 2	Notes
		present	direct	direct		Occasional presence possible during high freshwater run-off
White sucker	Possible	Not present	Occasional direct	Occasional direct	No	Habitat unsuitable Occasional presence possible during high freshwater run-off
Smallmouth bass	Possible	Not present	Occasional direct	Occasional direct	No	Habitat unsuitable Occasional presence possible during high freshwater run-off
Atlantic tomcod	Yes	Not present	Direct	Direct	Yes	
Rainbow trout	Possible	Not present	Occasional direct	Occasional direct	No	Non-native species; habitat within spatial and temporal project boundaries is not ideal for trout
Brook trout	Possible	Not present	Occasional direct	Occasional direct	No	Habitat within spatial and temporal project boundaries is not ideal for trout
Brown trout	Possible	Not present	Occasional direct	Occasional direct	No	Non-native species; habitat within spatial and temporal project boundaries is not ideal for trout
Sea lamprey	Possible	Not present	Occasional direct	Occasional direct	No	Species has not been observed during monitoring but is euryhaline
American	Yes	Not	Direct	Direct	Yes	

Species	Present in spatial/temporal boundaries of project? Yes/No	What is the exposure pathway? Direct, Indirect, Occasional visitor, or Not applicable			Is further consideration required? Yes/No If Yes, continue to Table 2	Notes
shad		present				
Gaspereau (Alewife)	Yes	Not present	Direct	Direct	Yes	
Blueback herring	Yes	Not present	Direct	Direct	Yes	
Rainbow smelt	Yes	Not present	Direct	Direct	Yes	
Stickleback species	Yes	Not present	Direct	Direct	Yes	
Striped bass	Yes	Direct	Direct	Direct	Yes	
Atlantic silverside	Yes	Not present	Direct	Direct	Yes	
Mummichog	Yes	Not present	Direct	Direct	Yes	
Rock Bass	This species is either a reference to striped bass or white perch listed separately rock bass *Ambloplites rupestris are not in Nova Scotia*					
Mud flat invertebrates	Possible	Not present	Occasional direct	Occasional direct	No	Habitat outside of levels above background
Flag root (Sweet Flag)	No	Not present	N/A	Not present	No	
Mayflower	No	Not present	N/A	Not present	No	
Sweetgrass	Possible	Indirect	N/A	Indirect	Yes	Can grow at the upper edge of high salt marsh
Spruce gum	No	Not present	N/A	Not present	No	
Raspberry	No	Not present	N/A	Not present	No	
Strawberry	No	Not present				
Blackberry	No	Not	N/A	Not	No	

Species	Present in spatial/temporal boundaries of project? Yes/No	What is the exposure pathway? Direct, Indirect, Occasional visitor, or Not applicable			Is further consideration required? Yes/No If Yes, continue to Table 2	Notes
		present		present		
Gold Thread	No	Not present	N/A	Not present	No	
Labrador tea	No	Not present	N/A	Not present	No	
Cow parsnip	Possible	Indirect	N/A	Indirect	No	
Blueberry	No	Not present	N/A	Not present	No	
Wild Cherry	No	Not present	N/A	Not present	No	
Cranberry	No	Not present	N/A	Not present	No	
Otter	Possible	N/A	Occasional direct	Occasional direct	No	Typically found in freshwater habitat, but generally mammals do not have problems with saline solutions even those much greater than expected in the channel
Harbour seal	Possible	N/A	Occasional direct	Occasional direct	No	Mammals do not have problems with saline solutions even those much greater than expected in the channel
Harbour Porpoise	Possible	N/A	Occasional direct	Occasional direct	No	Mammals do not have problems with saline solutions even those much greater than expected in the channel
Mink	Possible	N/A	Occasional direct	Occasional direct	No	Typically found in freshwater habitat, but generally mammals do not have problems with saline solutions even

Species	Present in spatial/temporal boundaries of project? Yes/No	What is the exposure pathway? Direct, Indirect, Occasional visitor, or Not applicable			Is further consideration required? Yes/No If Yes, continue to Table 2	Notes
						those much greater than expected in the channel
Common Nighthawk	No	N/A	N/A	N/A	No	
Great Blue Heron	Possible	N/A	N/A	Direct	No	
Bald Eagle	Possible	N/A	N/A	Indirect	No	
Osprey	Possible	N/A	N/A	Indirect	No	

Table 2: Species from Table 1 requiring additional consideration

The numbers in brackets refer to the references that follow this table and used to support the decision

Species	**Life stage**	**When are they present?**	**Conservation status & CRA* species**	**Intake notes & references**	**Brine notes & references**	**Risk Level (*1, 2*)****	**Monitoring**
Atlantic salmon	Smolt	Migration only	• Endangered ***(3)*** • Important aboriginal and recreational species	Swimming ability exceeds intake velocity ***(4)***	Life stages in question are naturally euryhaline ***(5)***	None	Alton monitoring plan ***(6) and (4)*** See above ***(4)***
	Adult					None	
American eel	Glass eel	Migration only	• Threatened ***(7)*** • Important aboriginal and recreational species	Swimming ability exceeds intake velocity ***(4)***	Life stages in question are naturally euryhaline ***(8)***	None	
	Elver	Migration only		Swimming ability exceeds intake velocity ***(4)***		None	
	Adult	Migration and/or foraging		Swimming ability exceeds intake velocity ***(4)***		None	
Atlantic tomcod	Juvenile	Common/resident	Secure ***(9)***	Swimming ability exceeds intake velocity ***(4)***	Life stages are naturally euryhaline ***(10)***	None	
	Adult	Common/resident		Swimming ability exceeds intake velocity ***(4)***		None	
American shad	Juvenile	Common/resident	Secure ***(9)***	Swimming ability exceeds intake velocity ***(4)***	Life stages are naturally euryhaline ***(8, 11, 12)***	None	
	Adult	Common/resident		Swimming ability exceeds intake velocity ***(4)***		None	
Gaspereau (Alewife)	Juvenile	Common/resident	Secure ***(9)***	Swimming ability exceeds intake velocity	Life stages are naturally euryhaline	None	

Species	Life stage	When are they present?	Conservation status & CRA* species	Intake notes & references	Brine notes & references	Risk Level (*1, 2*)**	Monitoring
				(4)	***(8)***		
	Adult	Common/resident		Swimming ability exceeds intake velocity ***(4)***		None	
Blueback herring	Juvenile	Common/resident	Secure ***(9)***	Swimming ability exceeds intake velocity ***(4)***	Life stages are naturally euryhaline ***(8)***	None	
	Adult	Common/resident		Swimming ability exceeds intake velocity ***(4)***		None	
Rainbow smelt	Juvenile	Common/resident	Secure ***(9)***	Swimming ability exceeds intake velocity ***(4)***	Life stages are naturally euryhaline ***13)***	None	
	Adult	Common/resident		Swimming ability exceeds intake velocity ***(4)***		None	
Mummichog	Juvenile	Common/resident	Secure ***(9)***	Swimming ability exceeds intake velocity ***(4)***	Life stages are naturally euryhaline ***13)***	None	
	Adult			Swimming ability exceeds intake velocity ***(4)***		None	
Stickleback species	Juvenile	Common/resident	Secure ***(9)***	Swimming ability exceeds intake velocity ***(4)***	Life stages are naturally euryhaline ***(14)***	None	
	Adult	Common/resident		Swimming ability exceeds intake velocity ***(4)***	Life stages are naturally euryhaline ***(15, 16)***	None	
Striped bass	Eggs & larvae	Common/resident	• Endangered ***(15)***	• Small proportion of	• Egg survival	Low during	

Species	Life stage	When are they present?	Conservation status & CRA* species	Intake notes & references	Brine notes & references	Risk Level (*1, 2*)**	Monitoring
			• Important aboriginal and recreational species	eggs and larvae may be entrained during operation • Water withdrawal will not take place during peak egg abundance ***(16)***	highest between 2-20ppt • Pre-feeding larvae survive up to 30 ppt • Older larvae survival up to 35ppt ***(18)***	operation; none during shutdown	
	Juvenile	Common/resident		Swimming ability exceeds intake velocity ***(4)***	• Early juveniles 0 – 30ppt ***(19)*** • Older juveniles grow normally in both freshwater and sea water ***(20)***	None	
	Adult	Common/resident		Swimming ability exceeds intake velocity ***(4)***	Adult stage fully euryhaline (overwinters in freshwater, feeds during summer at sea) ***(21, 22)***	None	
Atlantic silverside	Juvenile	Common/resident	Secure ***(9)***	Swimming ability exceeds intake velocity ***(4)***	Life stages are euryhaline ***(23)***	None	
	Adult	Common/resident		Swimming ability exceeds intake velocity		None	

Species	Life stage	When are they present?	Conservation status & CRA* species	Intake notes & references	Brine notes & references	Risk Level (*1, 2*)**	Monitoring
				(4)			
Sweetgrass	Seed	Potential for presence from spring to fall	Secure ***(24)***	This plant was not seen on the site.	No brine solution would be thought to interact with this plant species in potential habitat areas.	None	Will continue to verify its absence until operation
	Mature Plant	Potential for presence	Secure ***(24)***			None	

*CRA: commercial, recreational and aboriginal fisheries

** Risk levels have been adapted from References 1 and 2, and are defined as follows:

None	Risk is negligible
Low	Minimal or no impairment of component's function or process (e.g., for wildlife, a species' reproductive capacity, survival or habitat suitability; or, for soil, ability of organic soil to fix nitrogen)
Moderate	Measurable change in component's function or process in the short and medium duration; however, recovery is expected at pre-project level
High	Measurable change in component's function or process during the life of the project or beyond (e.g., for wildlife, serious impairment to species' productivity or habitat suitability)

References

1. British Columbia Ministry of Environment, Lands and Parks. 1999. BC Parks Impact Assessment Process Part 2 Users Guide. <http://www.env.gov.bc.ca/bcparks/conserve/impact/ia_proc/ia_guid.pdf>; Accessed 19 October 2015.
2. Canadian Environmental Assessment Agency. 2014. Cumulative Effects Assessment Practitioners' Guide. <http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=43952694-1&offset=7>; Accessed 18 October 2015.
3. Species at Risk Public Registry. 2015. Atlantic Salmon Inner Bay of Fundy Population. <http://www.registrelep-sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=672>; accessed 19 October 2015.
4. Department of Fisheries and Oceans. 1995. Freshwater intake end-of-pipe fish screen guideline. Ottawa, ON, Catalogue No. Fs 23-270/1995E.
5. Perry, G. 1960. The development of salinity tolerance in Atlantic salmon (*Salmo salar*) and some related species. Journal of Experimental Biology: 425-434.
6. Alton Natural Gas Storage LP. 2014. Alton Natural Gas Estuary Monitoring Plan.
7. COSEWIC. 2012. COSEWIC assessment and status report on the American Eel *Anguilla rostrata* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 109 pp.
8. Greene, K.E., Zimmerman, J.L., Laney, R.W., and Thomas-Blate, J.C. 2009. Atlantic coast diadromous fish habitat: a review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.
9. Atlantic Canada Conservation Data Centre. 2014. Rarity ranks and legal status by province. Nova Scotia Vertebrates. <http://www.accdc.com/webranks/NSVERT.htm>; accessed 15 September 2015.
10. Stewart, L.L. and Auster, P.J. 1987. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic) – Atlantic Tomcod. United States Fish and Wildlife Service U.S. Army Corps of Engineers 82/11.76.
11. Chittenden, M.E. 1973. Salinity tolerance of young American shad, *Alosa sapidissima*. Chesapeake Science 14(3):207-210.
12. Zydlewski, J. and McCormick, S.D. 1997. The ontogeny of salinity tolerance in the American shad, *Alosa sapidissima*. Canadian Journal of Fisheries and Aquatic Sciences 54:182-189.
13. Fuda, K.M., Smith, B.M., Lesser, M.P., Legare, B.J., Breig, H.R., Stack, R.B., and Berlinsky, D.L. 2007. The effects of environmental factors on rainbow smelt *Osmerus mordax* embryos and larvae. Journal of Fish Biology 71:539-549.
14. Campeau, S., Guderley, H., and Fitzgerald, G. 1983. Salinity tolerances and preferences of fry of two species of sympatric sticklebacks: possible mechanisms of habitat segregation. Canadian Journal of Zoology 62:1048-1051.
15. Hatfield, T. 2009. Identification of critical habitat for sympatric Stickleback species pairs and the Misty Lake parapatric stickleback species pair. Fisheries and Oceans Canada Science Advisory Secretariat Research Document 2009/056.

16. Poulin, R., and Fitzgerald, G.J. 1989. Early life histories of three sympatric sticklebacks in a salt-marsh. Journal of Fish Biology 34(2):207-221.
17. COSEWIC. 2012. COSEWIC assessment and status report on the Striped Bass *Morone saxatilis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. iv + 82 pp.
18. Alton Natural Gas Storage LP. 2015. DRAFT review of the Conestoga-Rovers & Associates third party review findings.
19. Cook, A.M., Duston, J., and Bradford, R.G. 2010. Temperature and salinity effects on the survival and growth of early life stage Shubenacadie River striped bass. Transactions of the American Fisheries Society 139:749-757.
20. Duston, J., Astatkie, T., and MacIsaac, P.F. 2004. Effect of body size on growth and food conversion of juvenile striped bass reared at 16-28°C in fresh water and sea water.
21. Madsen, S.S., McCormick, S.D., Young, G., Endersen, J.S., Nishioka, R.S. and Bern, H.A. 1994. Physiology of seawater acclimation in the striped bass, *Morone saxatilis*. Fish Physiology and Biochemistry 13:1-11.
22. Bradford, R.G. Leblanc, P., and Bentzen, P. 2013. Update status report on Bay of Fundy striped bass (*Morone saxatilis*). Fisheries and Oceans Canada Science Advisory Secretariat Research Document 2012/021.
23. Fay C.W., Neves, R.W., and Pardue, G.B. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (mid -Atlantic) – Atlantic silversides. United States Fish and Wildlife Service U.S. Army Corps of Engineers, 82/11.10.
24. Atlantic Canada Conservation Data Centre. 2014. Rarity ranks and legal status by province. Nova Scotia Vascular Plants http://accdc.com/webranks/NSVASC.htm