OCCURRENCE AND MIGRATION OF FISHES IN MINAS PASSAGE AND THEIR POTENTIAL FOR TIDAL TURBINE INTERACTION

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INTRODUCTION

The objective of this review was to identify the movement and migration of fishes in Minas Passage by species and seasonal occurrence based on the available published and unpublished literature. An annotated list was compiled from sources available since the 1800's as well as personnel observations based on fisheries research in Minas Basin since 1980. There are numerous good publications on the marine fishes of Atlantic Canada and for different regions of the Bay of Fundy and its tributaries as well as research works on individual species many of which are Honors, Masters and Ph. D. Theses completed at Acadia and Dalhousie Universities and the University of New Brunswick.

SOURCES OF DATA

Leim and Scott (1966) compiled approximately 60 years of observations on marine fishes of Atlantic Canada resulting from the fisheries work at the Biological Station, St. Andrews, NB. Their book includes considerable specific references to the populations of fishes found in the Bay of Fundy and Minas Basin and is often more complete than Scott and Scott (1988), which although excellent, has lost some of the local detail available in the earlier work. Scott and Scott (1988) is excellent with respect to the up-to-date taxonomy of Atlantic fishes, their biology and North Atlantic distribution. The systematic arrangement in this annotated work is based on Moyle and Cech (1996).

Perley (1852) was the first to describe the fish and fisheries of the inner Bay of Fundy (iBoF). His observations form the baseline to which later works can be compared. Huntsman (1922) was the first modern work on the fishes of the inner Bay of Fundy. Bousfield and Liem (1959) provided more information on the fishes of the iBoF and their work was followed with studies by Bleakney and McAllister (1973), Dadswell and co-workers (1984a) and Dadswell and Rulifson 1994. Bleakney and McAllister (1973) described the fishes that were stranded by extreme low tides at Kingsport in Minas Basin. Dadswell and co-workers (1984) and Dadswell and Rulifson (1994) detailed seven years of study on the iBoF including Cumberland Basin and Minas Basin and sampling using drift gill nets (6cm – 14cm stretched mesh), drags (small mesh, 5cm stretched) and mid water trawls (5cm stretched mesh), shore seines and intertidal weirs. Wehrell (2005) surveyed fishes captured by a rock hopper drag (a specialized "Yankee 35" drag, 12.7 stretched mesh) from June to September in the southern Bight of Minas Basin and Scots Bay. Dyer and co-workers (2005) detailed the fisheries for the region from Minas Channel to Minas Basin.

Fisheries and Oceans Canada (DFO) conducts yearly, routine stock assessments cruises and ichthyoplankton surveys in the Bay of Fundy (Scott 1987; Scott 1988; Simon and Comeau 1994). These surveys are conducted using a standard Yankee '35' drag, 12.7cm stretched mesh with a smaller mesh, cod-end liner and with 330um 'bongo' plankton nets. There are approximately 22 stations occupied in the Bay of Fundy from Scots Bay to the Lurcher Shoal region. Unfortunately the stations go only as far as Minas Channel and there are no stations in Minas Passage or Minas Basin. All fishes are identified, enumerated and measured and physical oceanographic variables measured (temperature, salinity and substrate).

Based on the number of studies and the similarity of resulting fish captures, the fish occurring in the Bay of Fundy and Minas Basin are well known. Unfortunately there have been very few directed fish studies within Minas Passage except for surveys of herring larvae (Bradford and Iles 1993).

THE ENVIRONMENT

Minas Basin is a warm water, marine habitat of the inner Bay of Fundy (Bousfield and Liem 1959). Annual temperature ranges from a peak of 16-20^{o}C in summer (Aug-Sept) to 0-1^{o}C in winter (February). Winter is characterized by drifting blocks of ice which in some years cover most of Minas Basin from January to March and severely scour the substrate of the intertidal zone (Bleakney and McAllister 1973). Salinities range from 24ppm at the inner end of Cobequid Bay to 30ppm in Minas Passage (Bousfield and Liem 1959). Much of the subtidal, benthic substrate is sand and gravel with extensive intertidal zones (1-3km wide) of sand, silt and mud (Bleakney and McAllister 1973). Minas Passage and Minas Basin have low to high turbidity depending on tidal amplitude and time of year (Amos 1984). Turbidity is lowest during neap tides and in summer, highest during spring tides and in winter. Turbidity is highest in Cobequid Bay at the inner end of the Basin and least in Minas Passage. The fishes of Minas Basin and Minas Passage reflect these characteristics, consisting of marine and diadromous species with a high proportion of coastal migrant, warm water stocks from as far south as Florida (Dadswell et al. 1984a) and stocks from the Scotian Shelf (MacDonald et al. 1984) and the Gulf of Saint Lawrence (Saunders 1969).

Minas Passage is the body of water connecting the inner Bay of Fundy and Minas Channel to Minas Basin. Minas Passage has temperatures of 14-16^{o}C from June to October (Bradford 1987) and because of powerful currents the water column is isothermal from bottom to surface (Tee 1975; AECOM 2009). It is a region of complex and powerful currents caused by the extreme tides of the inner Bay of Fundy where the intertidal range is up to 17m at the inner end of Minas Basin during large spring tides (Garrett 1972). Tidal velocities up to 3-6m/s occur in Minas Passage during falling and rising tides and four large gyres have been identified around Cape Split and Cape Blomidon (Tee 1975; Greenberg 1984). Residual currents were calculated with speeds up to 0.75m/s (Tee 1975). The strong tidal velocities have scoured most of the substrate of Minas Passage to bedrock (AECOM 2009). Minas Passage is about 12 km long and the currents and gyres would be expected to hinder the progress of smaller species and life stages through the Passage but may help to speed the progress of larger species and life stages. In general, fishes make about 2 body lengths/s (bl/s) at cruising speed (Moyle and Cech 1996) and fishes smaller than about 50cm in length could be held up in Minas Passage for longer periods than their average migration rates especially if caught up in the gyres.

RESULTS AND DISCUSSION

Details are provided on a total of 77 fish species that have either been recorded in Minas Basin, Minas Channel and/or Minas Passage or can reasonably be expected to occur. Where information is available seasonal migratory timing, water column distribution and known or expected abundance are provided. It is very likely that more fish species occur in Minas Passage than are listed and their abundance could be greater than anticipated. These details will be determined as fish studies progress in the Passage.

The fishes are listed in two ways. A taxonomic listing is provided as a narrative for easy access to the species information and scientific references. The fishes are also compiled in a list which categorizes them with regard to their potential risk of interaction with the proposed turbines and incidental harm, and provides suggested capture gear for sampling, periodicity of occurrence in Minas Passage and abundance (Table 1).
The red category includes fishes that have a high probability of interaction with the turbines and/or potential for significant harm to their population. The orange category is fishes with a moderate probability of interaction with the turbine and a low to moderate risk of harm and the green, fishes with a low probability of interaction or harm. Degree of potential harm was determined by fish size and susceptibility to turbine passage impact (strike, pressure effects, shear and cavitation; Dadswell and Rulifson 1994), their habitat (pelagic or benthic), their importance to fisheries and the health of their population (endangered, threatened; etc.) The taxonomic listing is similarly color coded for cross reference to the categorized listing (Table 1). A total of 10 fishes are listed in the red category, 11 in the orange category and 57 in the green category.

Four species of fish which are known to occur in Minas Passage have been declared ‘endangered’ or ‘threatened’ by the Committee on Endangered Wildlife in Canada (COSEWIC) and/or are listed in the Canadian Species at Risk Act (SARA). Inner Bay of Fundy Atlantic salmon (SARA, endangered, Schedule 1), porbeagle shark (SARA, endangered, no schedule), striped bass (SARA, threatened, no schedule) are protected to one degree or another and may need an ‘assessment of harm’ for any potential environmental impact. Barndoor skate are listed by COSEWIC as ‘endangered’ but have not been listed by SARA. Atlantic sturgeon is listed as a ‘species of concern’ by COSEWIC but has not been given a status.

Compilation of Fishes

Class Agnatha **'Jawless fishes'**

Order: Myxiniformes **"hagfish"**

1. *Myxine glutinosa*- Atlantic hagfish. Marine, benthic. Hagfish are abundant in the outer Bay of Fundy over mud bottoms (Scott and Scott 1988). They are benthic scavengers that usually burrow into the substrate during daytime. Hagfish attack dead and dying fishes and will predate on shrimp. Sampling with baited traps can capture up to 500 hagfish during a 12 hour set in Passamaquoddy Bay (Scott and Scott 1988). Hagfish have never been observed in the inner Bay of Fundy but they possibly occur inside Minas Basin where there are subtidal mud substrates.

Order: Petromyzontiformes **"lampreys"**

2. *Petromyzon marinus* – sea lamprey. Anadromous, pelagic. Larvae are benthic in fresh water where they burrow into mud and silt of stream banks. Adults are pelagic in marine situations and are blood predators of fishes (Scott and Scott 1988). Lampreys are common in all Bay of Fundy tributaries with marine access. Sea lampreys are semelparous and spawn in freshwater streams during April-July after which the adults die. After hatching larvae remain burrowed into sand-silt bottoms of streams for up to seven years before they metamorphose into juveniles and then migrate to sea. They begin preying on fishes for blood during estuarine emigration. Maritime populations migrate to sea and live offshore on the Scotian Shelf preying on fish blood for an indeterminate period (Halliday 1991). Adults return to fresh water when mature (Scott and Scott 1988). They are known from the Shubenacadie, Gaspereau and Kennetcook Rivers in Minas Basin (Scott and Scott 1988). They probably also occur in all other Minas Basin streams with anadromous fish populations.

Juveniles migrating offshore should be common within Minas Passage during spring (April-June) attached to adult and juvenile gaspereau, shad and salmon. Abundance should be in the 10's of thousands. Adults migrating inshore to spawn should be found in Minas Passage during April-June. Lampreys are difficult to capture when in mid-water, marine situations because of their eel like form which allows them to escape from most sampling gear (Halliday 1991). Adult abundance during inward migration through Minas Passage would probably be in the range of 1000-10,000/yr. Adult sea lampreys will be susceptible to turbine strike because of their body size, pelagic habitat and attachment to other fishes.

Class Chondrichthyes **'Cartilaginous fishes'**

Order: Squaliformes **"sharks"**

Many of the sharks have large body size (1-10m) which increases their chance of blade strike during turbine passage. Although most are never common or abundant in Minas Passage they are mostly predators and scavengers, which means there is a good probability they will be attracted to the turbine sites if there are dead or wounded fish present (Moyle and Cech 1996).. Such behavior will further increase their chances of turbine impact.

3. *Odantaspis taurus* – sand tiger shark. Marine, benthic. Sand tigers are a rare species in Canada. Two specimens have been observed in the outer Bay of Fundy (Scott and Scott 1988) and two were captured during summer (August) inside Minas Basin (Dadswell and Rulifson 1994). They may be more common in Minas Basin than observations suggest since the sandy bottom habitat preferred by sand tigers is widely available inside Minas Basin and summer water temperatures are warm (Bousfield and Liem 1959).

Records indicate this species would be rare in Minas Passage and would only be encountered incidentally during summer. Abundance expected in Minas Passage would probably be in the range of 1-10/year.

4. *Alopias vulpinus* – thresher shark. Marine, pelagic. Thresher shark have been captured in the Bay of Fundy (Scott and Scott 1988) and may occur annually in the inner Bay. Perley (1852) described three captured in drift gill net catches in Shepody Bay and fishers have described them from weir catches in Minas Basin (Leim and Scott 1966). Other authors have questioned these records (Templeman 1963) but the physical characteristics of threshers are very particular (the extremely long upper tail lobe) and records by fishers are probably valid. A very good description of a 'thresher' tail a meter in length taken from a shark caught in Minas Basin is given in Perley (1852). Specimens captured in the outer Bay of Fundy were large (3-5 m; Scott and Scott 1988) and large individuals have been taken off Yarmouth in shark derbies during recent years (Dadswell, pers. obs.). Large sharks that were tagged have been documented to travel long distances rapidly (up to 5000 km; Casey and Kohler 1990) and virtually any species of large shark could be expected in the inner Bay of Fundy during summer.

Threshers feed on herring, alsoids and squid all of which are abundant forage items in Minas Basin during summer (Dadswell et al. 1984a; Bradford and Iles 1992). Threshers should be expected in Minas Passage during June to September but only in small numbers (1-10/yr?). They would be attracted to turbine sites because of vibrations from wounded fishes.

5. *Carcharodon carharias* – great white shark. Marine, pelagic. Piers (1934), Templeman (1963) and Scott and Scott (1988) have documented nine white sharks from the Bay of Fundy which were caught in the outer Bay from July to November. Case (1968) documented a 5.2 meter specimen caught in a drift gill net off Noel Head

in Minas Basin on August 15, 1966. A photograph of this specimen is in his publication. There is also an unconfirmed report of a great white taken from a weir off Advocate in Minas Channel during the summer of 1977 (Dadswell et al. 1984a).

Large great white sharks captured in the Bay of Fundy had fed on harbour porpoise and harbour seals. Great white stomachs are also often filled with whale blubber (thought to be from dead whales; Carey et al. 1982) but they are also known to attack living whales in packs. Since porpoises, seal and whales are abundant in all parts of the Bay of Fundy during summer great whites should be expected in Minas Passage especially during August. Abundance will be very low, probably not more than 1-5/yr and possibily not every year.

6. *Cetorhinus maximus* – basking shark. Marine, pelagic. Basking sharks are common in the Bay of Fundy during summer. Perley (1852); Templeman (1963) and Scott and Scott (1988) report 12 documented occurrences from the outer Bay. Specimens often wash ashore off Saint John Harbour on either side of the Bay after being struck by ships. One, living, basking shark was observed by a wind surfer inside Minas Basin off Evangeline Beach during September 1987 and a dead specimen was found off Alma in Chignecto Bay during early October 2008 (Dadswell, pers. comm.).

Basking sharks are one of the largest fishes in the ocean and attain lengths of over 10m (Scott and Scott 1988). They filter feed on planktonic organisms, especially shrimp and they are known to dive to depths of 300m at night to feed (Tobey 1977). These sharks then rise to the surface during daylight to 'bask' on the surface where they are struck and often killed by ships. They should be expected at depth or at the surface in Minas Passage during July to October. They will probably occur annually in the Passage but numbers will be low (1-5/yr).

7. *Isurus oxyrinchus* – shortfin mako shark. Marine, pelagic. Apparently common in the outer Bay of Fundy during summer but has never been reported in the inner Bay (Scott and Scott 1988). Numerous specimens have been captured recently during shark fishing derbies and landed in Yarmouth (Dadswell, pers. obs.). Mature specimens are 2-3m in length. Probably may not occur in Minas Passage

8. *Lamna nasus* – Porbeagle shark. Marine, pelagic. Porbeagle is the most common shark species in the inner and outer Bay of Fundy other than dogfish shark. Until recently there was a commercial fishery for porbeagle in the outer Bay during summer. Catches averaged about 10MT/yr (Campana et al. 2002). Recently, however, porbeagle was declared endangered (CSAS 2005; Campana 2007) and the fishery was closed.

Porbeagle sharks are common in Chignecto Bay and Minas Basin during summer. Dadswell et al. (1984a) reported two captured at night with drift gill nets off Grindstone Point in Chignecto Bay on August 5 and September 3, 1980. One was captured at night with drift gill nets in Minas Passage off Blomidon during July, 1984 (Dadswell pers. obs.). These three specimens were all females from 2.1-2.2m in length (Dadswell et al. 1984a). Another, 318kg female was captured in a herring net off Halls Harbour in Minas Channel on July 15, 1986 (Anon 1986).

Porbeagle is a fast swimming, epipelagic shark that feeds on salmon, herring. alosids and squid (Scott and Scott 1988; Joyce et al. 2002). Porbeagles probably follow the abundant herring and alosid runs that occur in the inner Bay during summer (Dadswell et al. 1984a). They can be expected in Minas Passage from July to September. Estimated annual abundance is probably in the range of 10-100 individuals. They will occur near the surface at night and in deeper water during day.

9. *Mustelus canis* – smooth dogfish. Marine, pelagic. Smooth dogfish are uncommon in the Bay of Fundy (Scott and Scott 1988) and has been reported only in the outer Bay during summer. They could occur in Minas Passage during summer mixed with spiny dogfish.

10. *Somniosus microcephalus* – Greenland shark. Marine, pelagic and benthic. Greenland sharks are extremely rare south of the Gulf of St. Lawrence. A few specimens have been taken in the outer Bay of Fundy during winter (Templeman 1963).

Greenland shark are large but sluggish. They feed on fishes especially salmon, as well as seals and carrion. They are common in the arctic and could be more common than known during winter in the Bay of Fundy (Scott and Scott 1988). There is a lack of fish studies in the Bay of Fundy during winter and this fish may be present. Greenland shark could be found in Minas Passage during winter but probably never more than sporadically.

11. *Squalus acanthias* – spiny dogfish shark. Marine, pelagic and benthic. Dogfish shark are extremely abundant in the inner Bay of Fundy during summer and occur in the outer Bay all year (Scott 1988; Wehrell 2005; Campana et al. 2008). Commercial catches of 600-700 MT, which would be approximately 30,000-50,000 adults, are landed from Minas Basin annually (Dyer et al. 2005). Dogfish are taken by drags, hand line (Dyer et al. 2005) and drift gill net (Dadswell et al. 1984a).

The dogfish sharks found in Minas Basin during summer are mostly female (95%) and mean size averages about 85cm (Moore 1996; Wehrell 2005). Dogfish feed on wide variety of marine organisms from jellyfish to other fishes, each other and carrion. They can be expected to occur at all depths in the inner Bay, mainly on bottom during day and at the surface at night but they usually rise to the surface at slack tide regardless of time of day (Dadswell, pers. obs.). They are one of the most common larger fishes in Minas Basin, Minas Passage and Minas Channel during May to October (Dadswell et al. 1984a; Scott 1988; Wehrell 2005).

The dogfish that occur in Minas Basin during summer are probably representatives of a number of stocks. Dogfish tagged inside Minas Basin during June to August were recaptured within a few months as far south as Rhode Island, USA and offshore as far as the edge of the Scotian Shelf (Moore 1996).

Dogfish will be migrating through Minas Passage during April to October in large numbers. Inward movement will occur during April-July and outward movement from July to October. Based on an estimated fisheries mortality for the Bay of Fundy (Campana et al. 2008) and the annual landings in Minas Basin (Dyer et al. 2005) approximately 1-2 million dogfish occupy the Basin each summer and must move in and out through Minas Passage. Dogfish are often scavengers and would be attracted to turbine sites by the presence of dead fish.

Order: Rajiformes ‘skates and **rays**”

All ‘skates and rays’, except the Atlantic torpedo, are strictly benthic fishes to the point where they commonly bury themselves in the substrate during day and emerge at night (Scott and Scott 1988). They are almost always found over sand, silt and mud bottoms. All species feed on benthic invertebrates except the Atlantic torpedo which is a fish predator. Most of the species listed below can be expected in Minas Passage during spring to fall but probably pass through rapidly because of the absence of their preferred substrate (AECOM 2009). The skate population in Minas Basin is unknown but based on trawl catches it must be quite large (Wehrell 2005).

12. *Torpedo nobiliana* – Atlantic torpedo. Marine pelagic and benthic. Torpedo rays are a rare species on the Canadian Atlantic coast and are known only from the outer Bay of Fundy during summer (Scott and Scott 1988; Dadswell, pers. obs.). It attacks fish prey and stuns them with electricity pulses. It may possibly occur in Minas Passage during mid-summer.

13. *Raja erinacea* – little skate. Marine, benthic. The little skate is known from the entire Bay of Fundy and occurs from the lower intertidal zone to offshore. This species is very common in Minas Basin during summer (Wehrell 2005) and will be found in Minas Passage.

14. *Raja senta* – smooth skate. Marine, benthic. The smooth skate occurs in deepwater (30-60m) off the outer Bay of Fundy all year (MacDonald et al. 1984). Deepwater habitat is absent in Minas Basin except in Minas Passage where the substrate would provide little habitat for this species. It may occur in Minas Channel, perhaps during winter.

15. *Raja radiata* – thorny skate. Marine, benthic. The thorny skate is common in the entire Bay off Fundy year around (Scott 1988). It is common in Minas Basin during summer (Wehrell 2005). It will occur over hard bottom (Scott and Scott 1988) and may be more common in Minas Passage than the other skates. Scott (1988) recorded it from Minas Channel.

16. *Raja ocellata* – winter skate. Marine, benthic. Winter skates are very common in the entire Bay of Fundy all year and are found from the lower intertidal zone to offshore (Scott 1988). This skate is the most common in Minas Basin during summer and is probably also present during winter (Bousfield and Leim 1959; Wehrell 2005). Winter skate should be expected in Minas Passage but residency is probably short term.

17. *Raja laevis* – barndoor skate. Marine, benthic. Barndoor skates occur year round in the Bay of Fundy (Liem and Scott 1966). It occurs in Minas Basin during most of the year (Bleakney and McAllister 1973) but is not abundant. The barndoor is a large skate and besides invertebrates also preys on fishes (Scott and Scott 1988). Probably occurs in Minas Passage during movements to and from the Bay of Fundy.

The barndoor skate has been declared endangered by COSEWIC but at this date is not listed for protection by SARA.

Class: Osteichthyes **'Bony fishes'**

Order: Acipenseriformes **"sturgeons"**

18. *Acipenser oxyrinchus* - Atlantic sturgeon. Anadromous, benthic. The Atlantic sturgeon is the fifth most common fish captured by trawls in Minas Basin during summer (Wehrell 2005). The aggregation in Minas Basin during summer numbers about 10,000 individuals/yr and consists of mainly juveniles of 1-2m in length (Wehrell et al. 2008; Wehrell, pers. comm.). Adult Atlantic sturgeons are known to reach 4.6m in length (Scott and Scott 1988). Tag returns from sturgeon marked inside and outside Minas Basin and preliminary DNA analysis (Wirgin pers. comm.) indicate the sturgeons are from numerous stocks along the Atlantic coast.

Atlantic sturgeons first appear along the north shore of Minas Basin during April/May and migrate through the Basin to the Southern Bight during July/August then exit by Minas Passage during September (Wehrell et al. 2008). An unknown portion of this aggregation as well as young juveniles and adults may over winter in freshwater tributaries of Minas Basin (Dadswell pers. obs.). At present the commercial fishery for Atlantic sturgeon in the Bay of Fundy is closed except in the Saint John River. Formerly in Minas Basin weir catches were harvested.

Atlantic sturgeons spawn in the Saint John, Annapolis, Saint Croix, Stewiacke/Shubenacadie rivers and formerly in the Avon River in the Bay of Fundy and Minas Basin drainages (Huntsman 1922; Dadswell 2006; Dadswell pers. obs.). Juveniles remain in estuaries for 3-5 yr. After movement to sea large juveniles and adults feed and migrate along east coast of North America from Chesapeake Bay to Labrador. Atlantic sturgeons tagged inside Minas Basin have been recaptured as far south as Cape Cod, Massachusetts and as far north as the Gaspe, Quebec. Atlantic sturgeons that were tagged outside of Minas Basin and recovered inside Minas Basin by commercial fishers or during research were from the Hudson, Connecticut and Merrimack Rivers (Wehrell, pers. comm.).

Similar to sharks, sturgeons have large body size which increases their chances of turbine blade strike. Dead sturgeons have been found each year below the tidal turbine at Annapolis Royal.

Atlantic sturgeon feed on benthic invertebrates and small fishes (sand lance; Scott and Scott 1988) in the subtidal and over the Minas Basin tide flats at high tide (Armitage and Gingras 2003). They appear to congregate in discrete 'sturgeon holes' at low tide that are well known and usually avoided by trawl fishers (Dadswell pers. obs.). Sturgeon are primarily benthic fish but for unknown reasons they rise to the surface and make spectacular jumps during high tide (Dadswell pers. obs.)

Atlantic sturgeon will be common to abundant in Minas Passage moving inward during May-June and outward during August-September and will occur throughout the water column. Up to 10,000 individuals can be expected to pass through Minas Passage twice a year and the abundance will increase in the near future as sturgeon conservation efforts in Canada and the USA take effect (Dadswell 2006).

19. *Acipenser brevirostrum* – shortnose sturgeon. Anadromous, benthic. The shortnose sturgeon is only found in the Saint John River estuary region of the Bay of Fundy (Scott and Scott 1988). The shortnose is a small species of sturgeon that only reaches a maximum length of 1.4m (Dadswell 1979). It feeds primarily on various species of molluscs in fresh water and low salinity regions of warm estuaries.

During 30 years of fisheries work in Minas Basin using virtually every means of fish capture gear available a shortnose sturgeon has never been seen (Dadswell pers. obs.). Shortnose sturgeons are not expected to occur in Minas Passage.

Order: Anguilliformes **"eels"**

20. *Anguilla rostrata* – American eel. Catadromous, benthic. American eel are common to abundant in all tributaries of the Bay of Fundy, in estuaries and along marine shorelines. Larvae arrive in Bay of Fundy after drifting north in the Gulf Stream from spawning grounds in the Sargasso Sea (Scott and Scott 1988). Mainly females migrate upstream in rivers while males live in estuaries and along the sea shore (Jessop 1996). Eels are predatory, feeding on all invertebrates and fishes they can ingest. Females return to the sea after 7-10 years of growth to maturity and with the mature males migrate to the Sargasso Sea to spawn. After spawning the adults die.

American eel support commercial fisheries at all life stages (as glass eels entering freshwater, as yellow eels during growth in freshwater and as silver eels while migrating back to the sea; Jessop 1996)). Eel are an important, local fishery in the Minas Basin tributaries (Dyer et al. 2005). Eel populations around the North Atlantic are in severe decline and are being considered for listing (SARA/COSEWIC)

Glass eels (6-10cm long) will be abundant in Minas Passage during April and May. Silver eels (80-100cm long) will migrate offshore through Minas Passage during August to October. The abundance of glass eels occurring in Minas Passage annually will probably be in the millions (Jessop 1996). Silver eels migrating seaward will probably number in the range of 10,000-20,000. Eels are scavengers and would be attracted to a turbine site by dead fish.

Order: Clupeiformes **"herrings"**

The clupeids lack a lateral line and instead have evolved a highly specialized gas bladder that functions to enhance sound reception (Hoss and Blaxter 1979). The system includes two, thin-walled, forward projecting tubes from the gas bladder that interface with the otic bulla of the hind brain. Rapid hydrostatic pressure flux during turbine passage causes expansion in the gas bladder and tubes leading to hemorrhaging of the hind brain and often death. All clupeids are susceptible to high turbine passage impact (Stokesbury and Dadswell1991; Dadswell and Rulifson 1994).

Clupeids also school into dense 'bait balls' when under attack by pelagic fishes or cetaceans as a predator defense mechanism (porpoise; Moyle and Cech 1996). If a school of herring or alosids during the 'bait ball' condition made turbine passage many would be struck because of the dense packing of the school.

21. *Alosa aestivalus* - blueback herring. Anadromous, pelagic, planktivorous. The blueback herring, 'gaspereau' or 'river herring' are common to abundant in every tributary of the Bay of Fundy with spawning habitat (rapids) and access (no water fall at head of tide; Dadswell 1985). They spawn in fresh water in spring (May-June) after which adults return to the sea (Scott and Scott 1988). Juveniles migrate to sea during August to October at an average length of 10cm (Stokesbury and Dadswell 1989). Growth to maturity requires 4-5 years at sea where the North American Atlantic stocks migrate north and south annually.

Blueback herring are extremely abundant in the pelagic zone of Minas Basin during summer. Mid-water trawl catches up to 345/hr of 'gaspereau' were made off Economy Point during late June 1983 (Bradford 1987). Stone (1985) found adult blueback herring were most abundant in Minas Basin gill net catches during July and in weirs during August and September. The summer aggregation in Minas Basin is derived from east coast stocks from as far south as Virginia (Rulifson et al. 1987; Dadswell and Rulifson 1994).

Blueback herring and alewifes (gaspereau) support a fishery in the Gaspereau and Shubenacadie Rivers (Dyer et al 2005) and in the intertidal weirs of Minas Basin (Dadswell et al. 1984a). Adults and juveniles are taken in the intertidal weirs from April to December but the major movement through Minas Passage is probably into Minas Basin from March to July and exiting the Basin from July to November. The timing, spatial distribution and intensity of this movement require research but the abundance of this population will be in the 10's of millions.

22. *Alosa pseudoharengus* – alewife. Anadromous, pelagic, planktivorous. Like blueback herring, alewife (together known as 'gaspereau' in the Maritimes) are common to abundant in every tributary of the Bay of Fundy with spawning habitat (lakes and slow riverine areas) and access (no water fall at tide head). They spawn in fresh water in spring after which the adults return to sea (Scott and Scott 1988). Juveniles migrate to sea during August to October at an average length of 10 cm (Stokesbury and Dadswell 1989). Growth to maturity takes 4-5 years at sea where stocks migrate north and south along the Atlantic coast annually (Neves 1981).

Alewife are extremely abundant in the pelagic zone of Minas Basin during summer where mid-water trawl catches of 'gaspereau were up to 345/hr (Bradford 1987) and drift gillnet catches are up to 55/100m/30min (Dadswell et al. 1984a; Stone 1985). Like blueback herring the summer aggregation in Minas Basin is derived from many Atlantic coast stocks (Rulifson et al. 1987; Dadswell and Rulifson 1994).

Alewife support commercial fisheries in the Gaspereau and Shubenacadie Rivers (Dyer et al. 2005) and from intertidal weirs of Minas Basin (Dadswell et al. 1984). The commercial catch in the Gaspereau ranged from 64-200MT/yr and the Shubenacadie, 50-

363MT/yr during the period 1965-2000. The spawning population of alewife in the Gaspereau River ranges from 200,000-1 million adults annually (Gibson and Myers 2003). Alewife is captured in rivers from April to June and in intertidal weirs from April to December.

The majority of alewife movement through Minas Passage is probably inward during March to July and outward from August to November. Like blueback herring the timing, spatial distribution and intensity of this movement requires research but again the abundance will be in the 10's of millions of individuals from 0+ to 6+yrs.

23. *Alosa sapidissima* – American shad. Anadromous, pelagic, planktivorous. American shad are common to abundant in all Bay of Fundy tributaries with spawning habitat (deep, rapid flow riverine sections) and access from the sea (no head of tide waterfall; Liem and Scott 1966). They spawn in rivers in spring (May-June) after which adults return to sea. Juveniles depart fresh water after 3-4 months of growth (Aug – Oct). Adults and juveniles migrate along the Atlantic coast from Florida in winter to the Bay of Fundy, the Gulf of St. Lawrence and Labrador in summer. During a 5 year study in Minas Basin and during which 8000 external tags were applied to shad, there were approximately 400 tag returns from as far south as Florida and as far north as Labrador (Dadswell et al. 1987)

Large commercial fisheries exist in the Saint John, Shubenacadie and formerly the Petitcodiac and Avon Rivers in the Bay of Fundy (Leim and Scott 1966; Dadswell et al. 1984a). The shad fishery in the Shubenacadie varied from 10-60MT between 1991 and 2001 (Dyer 2005). The population in the Annapolis River is closed to commercial fishing but has 100,000 – 150,000 spawning adults annually (Melvin et al. 1985). After spawning these fish are captured in the inner Bay of Fundy (Melvin et al. 1986). Shad are taken by drift gill net and intertidal weirs in Minas Basin during May-August (Dadswell et al. 1984b).

Shad of all ages are extremely abundant in the inner Bay of Fundy during summer (May- October: Dadswell et al. 1983) where the population consists of migrating stocks from all rivers on the Atlantic seaboard from Labrador to Florida (Dadswell et al. 1987). The coastal migratory population enters the Bay of Fundy along the Nova Scotia shore and follows the residual current pattern through the Bay departing on the New Brunswick shore. Shad become increasing dense as they move into the embayments (Minas Basin, Cumberland Basin) at the inner end of the Bay of Fundy where the run effectively doubles back on itself. Population estimates for American shad in Minas Basin during 1982 indicated approximately 3 million adults were in the Basin during the 12 week period from June 1 to August 30 (Dadswell et al. 1984b).

Shad migrate inward through Minas Passage to Minas Basin from April-July and outward to the Bay of Fundy during July-October. The total population (0+ juveniles to adults) migrating through Minas Passage annually is probably in the range of 10 million fish. Migration speed of feeding shad in the Bay of Fundy was estimated at 3.0-3.5 km/d (Dadswell et al. 1987). Shad of 40-50cm in length should make the crossing through Minas Passage in about 4-5 days. Smaller shad will probably take longer.

24. *Brevoortia tyrannus* – Atlantic menhaden. Amphidromous, pelagic. The menhaden feeds on phytoplankton and detritus. Juvenile menhaden are found in large

Bay of Fundy estuaries (Annapolis and Saint John Rivers; Stokesbury and Stokesbury 1993). Adults spawn in Minas Basin near Economy Point (Dadswell, unpub. data) and some over winter in Kennebecasis Bay in the Saint John River estuary (Scott and Scott 1988). The population that spawns in Minas Basin is possibly the only spawning occurrence in Canada. Occasionally, southern stocks from Chesapeake Bay penetrate into the Bay of Fundy during warm summers.

The stock that occurs in Minas Basin is small and seldom more than 10-20 individuals are found in intertidal weirs during late summer (August; Dadswell, pers. obs.). This species is not fished commercially in Canada.

Adults would traverse Minas Passage inward to spawn in Minas Basin during May-June. Adults and juveniles would depart Minas Basin via Minas Passage in late summer. Population size moving through Minas Passsage probably consists of a few hundred adults and 10 thousand+ juveniles.

25. *Clupea harengus* – Atlantic herring. Marine, pelagic, plantivorous. Herring are common to extremely abundant in all parts of the Bay of Fundy. Adults are marine, benthic spawners and stocks congregate on Lurcher Shoal off Yarmouth during October, in Scots Bay during August, and in Minas Basin during May to spawn (Bradford and Iles 1993). Larvae and juveniles (brit) form dense schools in the inner Bay of Fundy. Bradford and Iles (1993) found larval densities were highest inside Minas Basin (5-35/10m^2). Abundance of herring larvae in Minas Passage during July were about 50% of the catches inside Minas Basin (Bradford 1987). One-half hour midwater trawl tows in Minas Channel caught 1000-10,000 brit during August and brit were abundant in other parts of the inner Bay of Fundy surveyed during February (Koeller 1979). Larger juveniles aggregate in Minas Basin during early summer ('June herring'; Perley 1852; Dadswell et al. 1984a; Bradford 1987). Adult herring schools occur at all depths in the water column but mainly near bottom during day and near surface at night. They form dense 'bait balls' when attacked by harbour porpoise pods (Dadswell pers. obs.).

Herring in Minas Basin, Minas Passage and Minas Channel are caught using intertidal weirs, intertidal gill nets and by purse seining (Bradford 1987). The spawning stock biomass of the spring spawning group in Minas Basin is estimated to be 500MT and yields annual catches of about 50MT (Bradford and Iles 1993). The spawning stock biomass of the summer spawning group in Scots Bay-Minas Channel is estimated at approximately 75,000 MT with an annual yield of about 15,000MT (Dyer et al. 2005). Atlantic herring support the largest fishery by biomass in the Bay of Fundy (CSAS 2007). The annual TAC is set at 20% of the estimated total adult biomass of 500,000MT.

Herring of most life stages (larvae, juveniles and adults) are common to extremely abundant in Minas Passage during the entire year (Koeller 1879; Bradford and Iles 1993). Larvae are abundant during spring, summer and fall and brit are common during winter. Large juveniles and adults are abundant moving inward and outward through Minas Passage during March – June (Minas stock adult spawners, 'June' herring juveniles). Adult spawners from the Scots Bay spawning stock are abundant in Minas Channel during July-September and large schools probably penetrate Minas Passage during this period. Abundance of all stages of herring in Minas Passage could be in the range of 10-100's of millions during periods of passive (larvae) and active (juvenile, adult) movement. Larvae and juveniles are capable of maintaining themselves in discrete areas near their spawning sites where productivity is high (Iles and Sinclair 1982). Based on observed abundances of larvae and juveniles three of these regions are inside Minas Basin near Economy Point, in Minas Passage and in Minas Channel (Koeller 1979; Bradford and Iles 1993)

Order: **Salmoniformes "salmon, trout and smelt"**

26. *Salvelinus fontinalis* – brook trout. Anadromous, benthic. Populations of brook trout occur in virtually every tributary of the Bay of Fundy from small brooks to large rivers (Scott and Scott 1988). Juveniles remain in fresh water but adults enter marine waters from April to September then return to over winter in freshwater. Brook trout support the most popular recreational fishery in Nova Scotia (McMillan ; pers.comm.).

Although brook trout are common to all tributaries of Minas Basin, Minas Passage and Minas Channel they are very seldom found during sampling in Minas Basin (Dadswell et al. 1984a, Dadswell pers. obs.). During weir surveys in Minas Basin since 1982, brook trout have never been encountered even when the weirs are situated within a kilometer or two of known brook trout streams (Walton River; Harrington River). Likewise, brook trout are never encountered during gill net sampling or angling in marine waters (Broome, pers.comm.). Brook trout probably occur only in the mouths of fresh water tributaries of Minas Passage and are probably in estuarine waters only from April to August.

27. *Salmo salar* – Atlantic salmon. Anadromous, pelagic. There were approximately 59 Bay of Fundy tributaries which had stocks of Atlantic salmon but at least 7 of these now extinct because of dams or causeways (Amiro 2003). Inner Bay of Fundy stocks were declared endangered by COSEWIC in 2003 and are now listed under Schedule l by SARA (no allowable take; CSAS 2004). Minas Basin had salmon runs in most tributaries including the Shubenacadie-Stewiacke, Salmon, Gaspereau, Cornwallis and Avon and all tributaries along the north shore from Truro to Parrsboro. Many of these streams now lack populations because of causeways (Avon) or because of the inner Bay of Fundy wide collapse of stocks (Gibson et al. 2003b).

Atlantic salmon spawn in fall in fresh water streams and most adults from iBoF rivers return to sea by December (Amiro et al. 2003). Juveniles (parr) remain in fresh water for 1-3 years then migrate to sea during May-June as smolts. Adults remain at sea for 1-2 years migrating in the North Atlantic in regions with water temperatures of 4-10C (Scott and Scott 1988). Adults home to natal iBoF rivers from July to November. Salmon runs in most Minas Basin rivers consisted of 1SW adults (50-60cm in length) and returning kelts (multiple spawners; Huntsman 1954; Amiro et al. 2003).

Formerly Minas Basin had both commercial and recreational salmon fisheries. The commercial fishery was closed in 1982 (Dadswell et al 1984a) and the sports fishery in 1992 (Amiro et al. 2003). Salmon were taken by the commercial fishery in Minas Basin by drift gill nets and intertidal weirs (Huntsman 1958). Catches from 1900-1982 varied between 1-4MT/yr (Dadswell et al. 1984a). The angling fishery occurred in most Basin tributaries. Formerly, angling catches in the Shubenacadie-Stewiacke River basin were from 500-1000/yr (Morantz 1978) but catches in other tributaries seldom exceeded

100/yr (Amiro et al. 2003). The estimated population of returning adults to Minas Basin tributaries was around 40,000 as recently as 1989 but only 250 were counted in 1999 (Amiro 1999). Similarly, parr densities have declined in all tributaries (Gibson et al. 2003b). The smolt run size in the Gaspereau River during 2009 was estimated to be about 5600 but only 1100 were wild smolt, the rest were hatchery stocked fish (Quinn 2010).

Atlantic salmon smolts can be expected migrating seaward through Minas Passage during May to July. Atlantic salmon adults will occur in Minas Passage from June to December. Although most adults will be from Minas Basin tributaries some are migrants from other Bay of Fundy stocks, the USA (Connecticut and Penobscot Rivers) and the Gulf of Saint Lawrence (Miramichi River; Saunders 1969: Meister 1984). Pre-spawning adults will be migrating inward during June to November. Kelts (post-spawning salmon) will be moving seaward during Nov.-Dec.

Smolt migration speeds at sea average 6-26km/d (Lacroix and McCurdy 1996) and most smolts would be expected to clear Minas Passage in one to two days unless countered by gyre currents (Lacroix 2008). Adult salmon make from 20-50 km/day when migrating at sea (Meister 1984; Hansen et al. 1993) and movement through Minas Passage should be rapid.

Numbers of migrating smolts will probably be in the range of 10,000 to 20,000 annually (wild and hatchery fish) unless the iBoF salmon stocks rebound. Numbers of migrating adults at present population levels will probably be less than 500 individuals inward and perhaps half of this outward as kelts. If, however, iBoF salmon stocks rebound in the future 20,000 to 40,000 adults could make the passage each year and the number of smolts could increase up to a million annually.

28. *Salmo trutta* – brown trout. Anadromous, benthic-pelagic. Brown trout were introduced from Europe during the late 1800's and early 1900's and have become well established in Minas Basin rivers especially the Cornwallis and Shubenacadie (Leim and Scott 1966). Their life history is similar to Atlantic salmon except brown trout remain at sea only from May to September and do not move far from their natal river. Brown trout are seen more often in intertidal weirs in Minas Basin than brook trout and are sometimes captured in drift gill nets (Dadswell et al. 1984a).

There are few rivers with brown trout near Minas Passage and this species should only occur sporadically offshore in the Passage. If present it would be from May to September.

29. *Oncorhynchus kisutch* – coho salmon. Anadromous, pelagic. Coho salmon were introduced to Maritime Rivers from western Canada during the early 1900's but most populations have since died out (Scott and Scott 1988). Coho were common in the Bay of Fundy during the 1980's when large numbers were being stocked in New Hampshire, USA and adults migrated north to the Bay of Fundy (Martin and Dadswell 1983). The New Hampshire stocking was terminated in the 1990's. There was a spawning population in the Cornwallis River which resulted from these New Hampshire introductions or other hatchery escapee's (Martin and Dadswell 1983).

Coho life history is somewhat similar to Atlantic salmon except they migrate to sea at a younger age and smaller size (after one year in the river). No adults have been recorded in Minas Basin since the late 1980's and the population in the Cornwallis River may be extirpated. They will probably not be encountered in Minas Passage.

30. *Oncorhynchus gairdneri* – rainbow trout. Anadromous, pelagic. Rainbow trout were introduced to the Maritimes from western Canada in the late 1800's and introductions continue into the present since rainbow trout in aquaculture operations often escape (Scott and Scott 1988). Their life history is similar to brown trout. Rainbows migrate into the sea in spring, feed in salt water during summer and return to fresh water during fall for over wintering.. The species is not common in iBoF tributaries but occurs in some. A few should be expected sporadically in Minas Channel.

31. *Osmerus mordax* – rainbow smelt. Anadromous, pelagic. Rainbow smelt are extremely abundant and ubiquitous in all regions of the inner Bay of Fundy (Dadswell et al 1984a). Spawning stocks occur in all rivers and brooks with access from the sea and spring arrivals are close to the same time each year. Two examples are: spawning smelt appear in the Gaspereau River on the south side of Minas Basin during late April and in the Portapique River on the north side during the second week of May (Dadswell pers. obs.). Spring arrival of spawning populations is exploited by recreational fishers but there is no directed commercial fishery in Minas Basin. After the eggs hatch in fresh water the larvae drift into the sea and there are dense concentrations of pelagic larvae in the Minas Basin from May to August (Roberts 1987; Bradford 1987). Adults occur pelagically in the water column and along shorelines (Dadswell et al. 1984a). Smelt are voracious feeders and eat virtually anything smaller than them (Scott and Scott 1988).

Surveys for smelt have never been carried out in Minas Passage but they should be expected to be abundant especially near shore. They are expected to occur in Minas Passage all year but may be more abundant during winter when the cold water in Minas Basin may cause them to migrate seaward.

32. *Mallotus villosus* – capelin. Marine, pelagic, planktivorous. Capelins spawn in the sand of beaches at the high tide level during May-June (Scott and Scott 1988). They have only been captured occasionally in the Bay of Fundy (Tibbo and Humpreys 1966) but there may be one stock that spawns on beaches of the Fundy National Park (Perley 1852). Capelin probably rarely occurs in Minas Passage but schools of this subarctic fish may be present during winter.

Order: Lophi**iforhes "goosefishes**, anglers"

33. *Lophius americanus* – monkfish. Marine, benthic. Monkfish are common but not abundant throughout the Bay of Fundy and in Minas Basin (Bleakney and McAllister 1973; Scott 1988). Monkfish feed largely on fishes especially flounders and tend to follow the flounder migration to the inner Bay of Fundy in summer. It can grow up to 1m in length. This fish is a benthic, lay-in-wait predator that moves into iuntertidal at high tide and is often stranded in Minas Basin by the rapid fall of the tide (Bleakney and

McAllister 1973; Dadswell, pers. obs.). It is taken in small numbers as by-catch in the groundfish and scallop drag fisheries and in intertidal weirs in Minas Basin and Scots Bay (Simon and Comeau 1994). The population in the Bay of Fundy is stable and landings from 1990 to 2000 averaged 700MT/yr (Beanlands et al. 2000).

Monkfish will be passing into and out of Minas Basin via Minas Passage from April to October. They will be present in small numbers and will probably remain on or near the bottom.

Order: Gadiformes "codfishes'

34. *Enchelyopus cimbrius* – fourbeard rockling. Marine, benthic. Rockling are a small, cod-like fish that are common over mud and gravel bottom in the outer Bay of Fundy (MacDonald et al. 1984). They are rare inside Minas Basin and have only been observed once (Bleakney and McAllister 1973). They prefer cooler water (Scott and Scott 1988) and may be more common in Scots Bay and Minas Channel. Daborn (1984) reported their larvae were abundant in neuston samples from Minas Channel. Adults are small and seldom exceed 30cm in length.

Rockling adults should be rare in Minas Passage since the bottom consists primarily of scoured rock (EA 2009). Rockling larvae could be abundant near the surface from May-August during some years.

35. *Gadus morhua* – Atlantic cod. Marine, benthic-pelagic. Cod were once very common in the entire Bay of Fundy but stocks are now depleted (CSAS 2006). Since 1990 landings in the Bay of Fundy have fallen from 24,000MT to 3800MT in 2006. Overfishing is probably the root cause but some are suggesting an oceanographic regime change has occurred (Bundy and Fanning 2005).

Cod are found in Minas Basin and Minas Channel only during the seasonal coldwater period when temperatures are from 3-8°C (November to June; Scott 1987). Cod feed on all types of invertebrates and fishes and will follow alosid spawning runs into the low salinity water of estuaries (Dadswell, pers. obs.). Cod were formerly caught commercially in Minas Basin by long lines set in the intertidal zone (Dadswell et al. 1984a) but the fishery is now closed. It is taken in intertidal weirs occasionally (Dadswell et al. 1984a) and as by catch in the flounder trawl fishery during June (Wehrell 2005).

Cod can be expected in Minas Passage from November to July but are probably most common during March-May. It will occur on bottom and in mid water. Until the stock rebounds numbers will be low and probably fewer than a thousand will pass in and out of Minas Basin during a year

36. *Melanogrammus aeglefinus* – haddock. Marine, benthic. Haddock were once very common in Bay of Fundy during summer from Scots Bay to Lurcher Shoal while on feeding migrations from Brown's Bank and the Gulf of Maine (Perley 1852; Scott 1988). After 1965, however, haddock have become rare in the inner Bay of Fundy because of over fishing and poor recruitment (Scott 1987; Frank 1992). Before the decline of the haddock stock in 1965 landings in the inner Bay of Fundy were high but all landings in

the Bay of Fundy continue to remain low and were only 5-8MT from 1990-2005 (Dyer 2005).

Haddock only occur in the Bay of Fundy during summer where they feed over mud bottoms on small invertebrates. In winter they are offshore on the Scotian Shelf (MacDonald et al. 1984; Scott 1988). Haddock have never been recorded from Minas Basin (Huntsman 1922; Dadswell et al. 1984a) even though they were once abundant in Scots Bay (Scott 1987). Their absence from Minas Basin could be explained because of a lack of proper substrate and because they select temperatures of 4-8^{o}C (Scott and Scott 1988). Haddock are not expected to occur in Minas Passage because of higher summer temperatures and a lack of feeding substrate (AECOM 2009). .

37. *Merluccius bilinearis* – silver hake. Marine, benthic and pelagic. Silver hake are common in the Bay of Fundy during summer from outer Minas Basin to Lurcher Shoal (Simon and Comeau 1994). Silver hake are commonly caught in intertidal weirs in Scots Bay and Minas Basin but never in large numbers. During the summer of 1979 they were abundant in gill net catches in Cumberland Basin (Dadswell et al. 1984a). No directed fishery for them is exists in the Bay of Fundy because of low abundance and lack of markets in North America (Simon and Comeau 1994).

Silver hake can be expected in Minas Passage during July to September but numbers will be low, probably only a few thousand fish. They will migrate predominately in the water column.

38. *Urophycis chuss* – red hake. Marine, benthic. Red Hake is common in all regions of Bay, especially so in the outer Bay of Fundy where juveniles (0+) are commensal with sea scallops during the first fall of their life (Garmen 1983). Juveniles (1+) are common to abundant in Minas Basin intertidal weir catches during July after leaving their scallop hosts and while on migration to the lower Bay of Fundy and the Scotian Shelf (Dadswell pers.obs.). Adult red hake have never been recorded inside Minas Basin.

Juvenile red hake (20-30cm) will be abundant in Minas Passage during June-August as they migrate from their scallop hosts and pass through the inner Bay of Fundy. Movement inward to Minas Basin will be during June, outward movement, during August. There will be large numbers of juveniles migrating, probably 10's of thousands, but since they are benthic fish they will remain near bottom.

39. *Urophycis tenuis* – white hake. Marine, benthic. White hake are common throughout the Bay of Fundy especially over mud bottom of the outer bay (Scott 1987; Simon and Comeau 1994). They are taken in drags in Minas Channel (Scott 1988) White hake are tolerant of reduced salinity and there are populations in Kennebecasis Bay of the Saint John River (Scott and Scott 1988) and Minas and Cumberland Basin (Dadswell et al. 1984a).

In Minas Basin they are commonly captured in small numbers by intertidal weirs and as by catch in flounder drags (Dadswell et al 1984a; Wehrell 2005) but there is no directed fishery. Individuals observed in the inner Bay of Fundy were all juveniles.

White hake probably occur in Minas Passage from April to October during movement into and out of Minas Passage. Numbers will be few.

40. *Pollachius virens* – pollock. Marine, pelagic. Pollock are common to abundant in the outer Bay of Fundy (Scott 1988), but rare in the inner Bay except in Minas Channel where there has been a fishery since the early 1800's (Perley 1852; Dyer 2005). Juveniles from spawning in the Gulf of Maine (Trippel and Brown 1993) form large schools inshore around the Bay of Fundy over gravel and pebble beaches in spring then aggregate around wharfs in summer-fall ('harbor pollock'; Rangely and Kramer 1995). Pollack are a pelagic predator that feed almost extensively on euphasids. Their abundance and growth rates have been declining in recent years probably because of competition with resurgent baleen whale populations (Trippel and Brown 1993).

Pollack are taken commercially and recreationally using drags, long lines, gill nets and hand lines. Aggregations of adults occur in regions of dynamic flow and upwelling, around reefs and in channels (Scott 1987). The commercial fishery in the Bay of Fundy was landing 40,000MT/yr during the 1980's (Trippel and Brown 1993) but these landings had declined to 4500MT by 2004 (Dyer et al. 2005). Pollack have never been recorded inside Minas Basin but are common and were formerly abundant in Minas Channel and Minas Passage (Perley 1852; Dyer et al. 2005).

Pollack are taken by hand line in Minas Channel and Minas Passage from April to October (Barkhouse, pers. comm.). They probably move into and out of Minas Passage with the tides. Abundance is low at present (Simon and Comeau 1994) but could increase if the stock rebounds. Current numbers are probably in the thousands to 10's of thousands.

41. *Microgadus tomcod* – Atlantic tomcod. Anadromous, benthic. Tomcod are extremely abundant in turbid regions of inner Bay of Fundy, especially Cumberland Basin and Cobequid Bay (Dadswell et al. 1984a). They are also abundant along beaches in remainder of the Bay of Fundy especially during winter. They are a small fish seldom exceeding 24cm in length and 4 yrs old.

Tomcod spawn in fresh water close to tide head in December and January (hence the common name 'frost fish'; Scott and Scott 1988). There is a huge run of spawning tomcod into the Shubenacadie estuary during December that attracts large numbers of baldhead eagle to the area (Reid 1982). Pelagic larvae occur in dense concentrations in Cobequid Bay and Minas Basin during summer (Bradford 1987).

There is no fishery for tomcod in the Bay of Fundy but they are an important forage species for fish and birds (Scott and Scott 1988). They are captured in intertidal weirs in Minas Basin (Dadswell et al. 1984a) and are commonly found marooned in the intertidal zone (Bleakney and McAllister 1973).

Adult tomcod will occur along the shoreline of Minas Passage, especially in winter and pelagic juveniles will be abundant offshore in Minas Passage during January to August after which they settle and move inshore. Numbers of pelagic juveniles during this period will probably number in the 10's of millions.

42. *Macrozoarces americanus* – ocean pout. Marine, benthic. Ocean pout are common to abundant in deep water of outer Bay of Fundy and rare to common in the inner Bay (MacDonald et al. 1984; Scott 1987). Scott (1988) reported them from trawl catches in Minas Channel and Wehrell (2005) in trawl catches in Minas Basin. Bleakney and

McAllister (1973) report them stranded in the intertidal zone in Minas Basin. There is no commercial fishery for ocean pout (Scott and Scott 1988).

Ocean pout will occur in Minas Channel during summer but in low numbers. They are strictly benthic in habit.

Order: Atheriniformes

43. *Menidia menidia* – Atlantic silversides. Marine, pelagic. Atlantic silversides are extremely abundant in estuaries and shore regions of inner Bay of Fundy and common along beaches in the outer Bay. Silversides form large schools over gravel and sand beaches (Gilmurray and Daborn 1981). They are a small species living only two years and growing to 20cm in length.

There is no commercial fishery for silversides in the Bay of Fundy but they are an important forage fish for larger predators such as striped bass. Silversides occurs along the beaches of Minas Passage (Dadswell et al. 1984a) but will probably never be encountered offshore.

Order: Cyprinidontiformes

44. *Fundulus heteroclitus* – mummichog. Marine, benthic, Mummichog occur along shorelines of Minas Basin but are most abundant in tide pools (Dadswell et al. 1984a)). They arrive in the tide pools during June and leave in October (Brown 1983). Mummichogs are another, small, prey species that are forage for larger predators especially blue herons. They seldom exceed 10cm in length and 4 years of age (Brown 1983).

Mummichog should be expected in salt marsh tide pools along the shores of Minas Passage but are unlikely to be encountered in open water except along the shore. In tide pools they can be abundant (28/m^2; Bleakney and Bailey-Meyer 1979).

Order: Gasterosteiformes **“sticklebacks”**

All sticklebacks are small fishes occurring in salt marsh or shoreline habitats (Scott and Scott 1988). They are common to abundant in beach seine hauls (Dadswell et al. 1984a) and tide pools in Minas Basin (Bleakney and Bailey-Meyer 1979). None are fished commercially. All are prey for larger fishes. Usually one of the species exceeds 20cm in length.

45. *Apeltes quadracus* – fourspine stickleback. Marine and estuarine, benthic. Fourspine stickleback are common throughout the Bay of Fundy along shorelines. They are abundant in lower salinities like the inner portions of Minas Bay (Dadswell et al. 1984a). If encountered in Minas Channel they will only occur along the shoreline or in tide pools.

46*. Gasterosteus aculeatus* – threespine stickleback. Marine and estauarine, benthic, pelagic. Threespine stickleback are the most common stickleback in most regions of the Bay of Fundy and are especially abundant along high salinity shorelines and among eel grass (Dadswell et al. 1984a). Unlike the other sticklebacks they often have completely pelagic populations that are found at the surface over deepwater (Dadswell pers. obs.).

Threespine sticklebacks will occur along the shoreline of Minas Passage and there may be a small population pelagic over the deepest part of the Passage. The pelagic group may be present all year.

47. *Gasterosteus wheatlandi* – blackspotted stickleback. Marine, benthic. Blackspotted stickleback co-occurs with threespine stickleback along high salinity shorelines (Scott and Scott 1988). It is not pelagic. It will probably be found along the shore line of Minas Passage during most of the year.

48*. Pungitius pungitius* - ninespine stickleback. Marine, benthic. Nine spine stickleback co-occurs with threespine and blackspotted sticklebacks in lagoons along high salinity shores. It is also abundant in lower salinity tidal 'lakes' (Scott and Scott 1988). It should be found along the shoreline of Minas Passage all year but will be rare.

Order: Syngnathiformes "pipefishes and sea horses"

49. *Syngnathus fuscus* – northern pipefish. Marine, pelagic. Pipefish are a warm water species found in lower salinity tidal 'lakes' around Bay of Fundy (Scott And Scott 1988). It is especially abundant in localities with eelgrass. During the late summer juveniles will drift in the water column for dispersal (Dadswell pers. obs.). It is a small species, seldom exceeding 30cm. There is no fishery.

Probably uncommon in Minas Passage except along the shore line in lagoons. Juveniles may be common in the drift of Minas Passage during August to October.

Order: Perciformes "basses, snappers, etc"

50. *Morone americana* – white perch. Estuarine and andromous, benthic and pelagic. White perch are especially abundant in lower salinity regions of estuaries particularly those with tidal barrages maintaining a lake-like situation (Annapolis, Peticodiac, Avon, Tantramar, Saint John; Scott and Scott 1988). It is rarely observed in open marine waters in Canada.

White perch will probably not be encountered in Minas Passage.

51. *Morone saxatilus* – striped bass. Andromous, pelagic along shorelines. Striped Bass are abundant in the inner Bay of Fundy, especially Minas Basin (Rulifson et al. 2008). There is a summer migration around the Bay of Fundy which consists of Canadian and USA stocks (Rulifson and Dadswell 1995). A large spawning stock occurs in the Shubenacadie River. The species is listed as threatened by SARA but has no schedule (Douglas et al. 2003). The commercial fishery is closed except as a permitted

by catch (one legal-sized bass/day) but angling is still permitted. Striped bass are captured in intertidal weirs and drift gill nets in Minas Basin and used to be taken by set gill nets around the shoreline.

Striped bass are anadromous and spawn at the head of tide during May-June. Juveniles move into estuarine waters during their first summer (Scott and Scott 1988). American and Canadian stocks are migratory along the Atlantic coast of Canada and the USA. Bass tagged in Minas Basin during summer-fall have been captured as far south as Virginia (Rulifson et al. 2008). Striped bass tagged in the USA have been recaptured at numerous localities in the Bay of Fundy (Rulifson and Dadswell 1995). If they do not migrate south, Canadian populations over winter in low salinity or freshwater localities such as Shubenacadie Lake.

Striped bass will be common in Minas Passage along the shoreline and in mid water. There will be an inward migration though Minas Passage during April to July and an outward migration during July to September. Adult abundance of the Shubenacadie population is 10,000-20,000 adults (Bradford pers. comm.) and an unknown number of USA fish enter Minas Basin each summer.

52. *Pomatomus saltatrix* – bluefish. Marine, pelagic. Bluefish are a summer visitor to the inner Bay of Fundy during periods of warm summer weather (Dadswell et al. 1984a). It can be abundant for short periods during July-August in some years and then will not be seen for 5-10 years (Scott and Scott 1988). It is taken by anglers when schools appear.

Abundance of bluefish will be low to nonexistence in most years then common to abundant for a short period during July-August in Minas Passage. It is a pelagic species and will be found offshore in the Passage.

53. *Cynoscion regalis* – weakfish. Marine, benthic. Weakfish are a very rare occasional summer visitor to the inner Bay of Fundy (Dadswell and Rulifson 1994). Few will be encountered in Minas Passage on rare occasions.

54. *Pogonias cromis* – black drum. Marine, benthic. Black drum are rare, occasional summer visitor to the inner Bay of Fundy (Scott and Scott 1988). It will be a rare visitor to Minas Passage.

55. *Ulvaria subbifurcata* – radiated shanny. Marine, benthic. Radiated shanny are common in the outer Bay of Fundy and probably in Minas Channel (MacDonald et al. 1984). It is especially abundant under rocks along cliff-like shores (Dadswell pers. obs.) and may be common in Minas Passage along the shoreline. It is a small species and seldom exceeds 20cm (Scott and Scott 1988). It will rarely be captured in any numbers except by directed sampling.

56. *Pholis gunnellus* – rock gunnel. Marine, benthic and intertidal. Rock gunnels are a ubiquitous and abundant fish throughout the Bay of Fundy (Scott and Scott 1988). It will

remain in the intertidal zone during low tide hiding under rocks and seaweed. Gunnels are a small fish rarely exceeding 20cm. It will be common in Minas Passage but will be strongly associated with the shoreline and benthic habitats.

57. *Anarhichas lupus* – wolffish. Marine, benthic. Wolffish were common in deep, coldwater regions of the Bay of Fundy (Scott 1987). They are usually found in areas with boulders and rough bottom with available den sites (Scott and Scott 1988). It has never been observed inside Minas Basin (Bleakney and McAllister 1973; Dadswell et al. 1984a). Wolffish feed on scallops and lobsters. Wolffish can grow to a large size (2m) but most caught recently are under 1m.

The wolffish fishery in the Bay of Fundy has never been large and there is no TAC set by DFO. Most landings are from by catch in the scallop fishery. Landings averaged 61MT from 1998-2001 (Anon 2002).

Wolfish may be found in Minas Passage since there are scallop beds but will be confined to the bottom. They will likely be present year round but will probably be most common in winter.

58. *Ammodytes americanus* – sand lance. Marine, benthic and pelagic. Sand lance is abundant along sand and gravel beaches of the Bay of Fundy and over deep water, sand bottoms. The species forms dense schools over intertidal zones at high tide and then penetrates the substrate to remain in the intertidal zone during low water (Scott and Scott 1988). They are a small species seldom exceeding 20cm and a forage fish for many larger predators especially Atlantic sturgeon which vacuum sand lance from under the sand.

Sand lance will probably not be common in Minas Passage because of a lack of sandy, benthic habitat but they could be locally abundant over sandy beaches.

59. *Scomber scombrus* – American mackerel. Marine, pelagic. Atlantic mackerel are common to abundant in the pelagic zone of the entire Bay of Fundy except in turbid regions (Dadswell et al. 1984a). Large weir catches are often made in Scots Bay but are rare inside Minas Basin. Mackerel are highly migratory. They winter off Long Island then move north to the Bay of Fundy and the Gulf of St. Lawrence for the summer (Scott and Scott 1988). Mackerel appear in Minas Basin during May to August. They are caught in intertidal weirs and drift gill nets. Because of low market demand the annual mackerel catch in the Bay of Fundy is not large even though mackerel are abundant. The TAC has been set at 75,000MT for a number of years but catches seldom exceed 20% of this value (CSAS 2005).

Mackerel will occur in Minas Passage during May to September and in some years may be abundant. They will be pelagic in the water column and in schools. Abundance could be in the 10's of thousands.

60. *Peprilus triacanthus* – butterfish. Marine, pelagic. Large schools of butterfish are common in the inner Bay of Fundy during summer, especially Minas Basin (Dadswell et al. 1984a). Butterfish are small (max 30cm), forage species. In most regions of the Atlantic coast there is a limited fishery for them (Scott and Scott 1988). There is no fishery in Canada.

Butterfish occur in Minas Basin from June to September (Dadswell et al 1984a). They will be common to abundant in Minas Passage and will occupy the pelagic region of the Passage. Abundance could be in the millions but is unknown.

Order: Cottiformes "sculpins"

61. *Hemitripterus americanus* – sea raven. Marine, benthic. Sea ravens are a common member of benthic fish community throughout the Bay of Fundy (MacDonald et al. 1984; Scott 1988). They are common but seldom abundant in Minas Basin during summer (Dadswell et al. 1984a). There is no fishery for this species.

Sea ravens will probably be found in Minas Passage during most of the year. They will be benthic and abundance will be low.

62. *Myoxocephalus aeneus* – grubby. Marine, benthic. Grubby are a very common, small, inshore species along hard substarte shorelines of the Bay of Fundy (Dadswell et al. 1984a). They are usually found in association with seaweed. They are benthic and a common member of the inshore community. Grubby seldom grow larger then 20cm.

Grubby will be found along the shores of Minas Passage and could be common over hard substrates in deeper water. They are strictly benthic in habit (Scott and Scott 1988).

63. *Myoxocephalus octodecemspinosus* – longhorn sculpin. Marine, benthic. Longhorn sculpin are abundant in most parts of the Bay of Fundy (Scott 1988). They are a 'large' species of sculpin reaching about 35-45cm (Scott and Scott 1988). They are commonly captured off wharf's by recreational anglers. There is no commercial fishery.

Longhorn sculpin will be common in Minas Passage but seldom abundant. They are strictly benthic in habit. They should be found year round.

64. *Myoxocephalus scorpius* – shorthorn sculpin. Marine, benthic. Shorthorn sculpin are common in most of the Bay of Fundy. This sculpin occurs onshore during winter and is mostly found over hard substrates (Scott and Scott 1988). They are not common inside Minas Basin (Dadswell et al. 1984a).

Shorthorn sculpin should be common over the hard substrate bottom of Minas Passage. They will be present all year. This species was observed in the video record taken around the turbine sites during October 2009 (Dadswell pers. obs.).

Order: Labriformes 'wrasses'

65. *Tautoga onitis* – tautog. Marine, pelagic. Tautog are a very rare summer visitor to the inner Bay of Fundy (Dadswell and Rulifson 1994). Tautog are seldom expected to occur in Minas Passage and only 1-2 individuals will be encountered if and when they do.

66. *Tautogolabrus adsperus* – cunner. Marine, pelagic. The cunner is a common resident of the outer Bay of Fundy and is especially common around wharfs (Scott and

Scott 1988). It is rarely observed in the inner Bay of Fundy and has never been recorded inside Minas Basin (Bleakney and McAllister 1973; Dadswell et al. 1984a). It should be, however, expected in Minas Passage. The Passage has considerable hard bottom substrate and probably numerous underwater cavities. Cunner use cavities during winter for hibernation (Scott and Scott 1988) and it may be common along the shores during this period.

Order: Cyclopteriformes 'lumpfishes'

67. *Cyclopterus lumpus* – lumpfish. Marine, benthic and pelagic. Lumpfish are found throughout the Bay of Fundy Bay except in the turbid inner reaches and it is known from Minas Basin (Bleakney and McAllister 1973; Wehrell 2005). It is most abundant along rocky shores and over hard, rocky bottom and could be common in Minas Passage. All Cyclopteriformes have a ventral 'sucker' that allows them to attach to the substrate or seaweeds in order to maintain position in strong currents (Scott and Scott 1988). Lumpfish caviar is the basis for a commercial fishery in Newfoundland but there is no fishery in the Bay of Fundy (Dadswell et al. 1984a)

Juveniles are pelagic among floating seaweed during summer then move inshore to seaweed beds during fall. Juvenile lumpfish are very abundant in the surface floating masses of seaweed drifting in the Bay of Fundy and have been taken from this habitat in Minas Channel (Daborn and Gregory 1983). Adult, spawning males turn red in spring and remain to guard the egg mass attached to rocks after spawning. The habitat along the shores of Minas Passage is excellent for lumpfish spawning (Scott and Scott 1988; AECOM 2009).

Lumpfish larvae and juveniles will be common in drifting masses of seaweed on the surface in Minas Passage during June to September. Abundance in some years could be high depending on survival of larvae (Daborn and Gregory 1983). Adult lumpfish may be abundant along the rocky shores of Minas Passage especially when spawning in spring since they are caught in Minas Channel and in Minas Basin (Scott 1988; Wehrell 2005).

68. *Liparus atlanticus* – Atlantic snailfish. Marine, benthic. Atlantic snailfish are common in the Bay of Fundy in localities with kelp beds to which they attach with their ventral sucker (Scott and Scott 1988). They have been caught in Minas Passage in drags that brought up kelp fronds (Dadswell pers. obs.) Snailfish are small fish and rarely exceed 10cm in length.

Atlantic snailfish will be common among kelp beds in Minas Passage year round. Their distribution will be concentrated along the shore and probably in depths less than 10m which is about the deepest the kelp distribution reaches.

69. *Liparus inquilinus* – inquiline snailfish. Marine, benthic. This small snailfish is usually found in association with sea scallops with whom they live commensally for their entire life (Able and Musick 1976). They are common wherever scallop beds occur such as around Blomidon on the south side of Minas Passage.

Inquiline snailfish will be common year round in Minas Passage wherever there are sea scallops. Snailfish larvae will probably be common near the surface in Minas Passage during late winter and spring.

Order: Pleuronectiformes "flounders"

70. *Paralichthyes oblongus* – fourspot flounder. Marine, benthic. Fourspot flounder is a southern species that is an occasional summer visitor to the Bay of Fundy but is never abundant (Scott and Scott 1988). It has been captured in Cumberland Basin but not Minas Basin (Dadswell and Rulifson 1994). It will probably occur rarely in Minas Passage and in small numbers. It is a benthic species and is likely to remain on the bottom at all times.

71. *Scophthalmus aquosus* – windowpane. Marine, benthic. Windowpane is common throughout the Bay of Fundy especially over sandy substrate (Scott 1987). They are very abundant in Minas Basin and often the most abundant fish in intertidal weir catches (Liem and Bousfield 1959). They are seldom taken commercially in Canada (Scott and Scott 1988).

Windowpane will probably not be common in Minas Passage because of the low incidence of sandy substrate (AECOM 2009). It could, however, be locally abundant along shore where there are sandy beaches since it is common in Minas Channel (Scott 1988) and abundant in Minas Basin (Wehrell 2005). It will be most abundant in summer but will probably occur all year.

72*.* *Glyptocephalus cynoglossus* – witch flounder. Marine, benthic. Witch flounder is a common resident of deep water, mud bottom locations in the Bay of Fundy (MacDonald et al 1984; Scott 1987). It is an important commercial flounder and is marketed in Canada as sole.

Witch have never been captured in Minas Basin and are rarein the inner Bay of Fundy (Scott 1988). They may occur in Minas Channel but will probably not occur in Minas Passage.

73. *Hippoglossus hippoglossus* – American halibut. Marine, benthic. Halibut are found throughout Bay of Fundy (Scott 1988) but only juveniles penetrate into Minas Basin during spring (Wehrell 2005). Large adults are common around the Advocate region of the inner Bay of Fundy and support a small commercial fishery (Simon and Comeau 1994). Juveniles and adults are taken by angling and commercially using bottom set long lines. Annual landings in the inner Bay of Fundy are about 10MT (Dyer et al. 2005).

Halibut are a predatory flatfish that pursue herring schools (Scott and Scott 1988) and large and small individuals should be expected in Minas Passage during spring. They should be expected to occur throughout the water column during bouts of foraging. Individuals probably follow herring schools into Minas Basin (Minas adult stock, 'June' herring) from March to July before warm water temperatures restrict halibut occurrence inside Minas Basin (Wehrell 2005). Abundance is probably in the range of a few hundred to a few thousand individuals.

74. *Liopsetta putnami* – smooth flounder. Estaurine, benthic. Smooth flounder are found in inshore, warm water habitats throughout the Bay of Fundy (Scott and Scott 1988). They are most abundant in the inner Bay (Minas and Cumberland Basins) but also common in Passamaquoddy and St. Mary's Bay. In Minas and Cumberland Basins smooth flounder feed over mud flats at high tide (Scully 1983; Dadswell et al. 1984a). They are not utilized as a commercial species in Canada since their total abundance is low (Scott and Scott 1988).

Smooth flounder will be found in Minas Passage but only in localized, inshore mud habitats. In these sites a few thousand individuals are likely to occur (Scully 1983).

75. *Pseudopleuronectes americanus* – winter flounder. Marine, benthic. Winter flounder are the most abundant and ubiquitous flounder in the Bay of Fundy. They are a dominant resident of most benthic fish communities in both the inner and outer Bay of Fundy (MacDonald et al. 1984; Scott 1987). Winter flounder spawn inshore in May. Juveniles are common along shorelines in fall. Growth is rapid and they reach maturity at 3 years of age (Scott and Scott 1988).

Winter flounder support important commercial and recreational fisheries in the Bay of Fundy (Simon and Comeau 1994). They are captured commercially by drags and intertidal weirs in Minas Basin. They are also taken in large amounts by drags in Scots Bay and Minas Channel (Wehrell 2005). Flounder landings in the region peaked at 200MT in 1992-93 but declined to 100MT by 2006 (Dyer et al. 2005). They are also an important angling species.

Winter flounder migrate in and out of the Bay of Fundy between summer and winter (MacDonald et al. 1984). Their abundance peaks in Minas Basin during July then declines during summer both from the effects of migration and the intense fishery (Wehrell 2005). Minas Basin represents one of the most valuable nursery areas for winter flounder in the Bay of Fundy (Scott and Scott 1988)

Winter flounder will be migrating inward through Minas Passage from April to June and outward from July to October. There has never been a population estimate of the stock in Minas Basin during summer; but since the annual landings at present are about 100MT (Dyer et al. 2005), the average size of flounder in the catch is about 500gm (Wehrell 2005) and annual fishing mortality is probably in the order of 50%, the minimum adult stock size can be estimated at about 400,000 fish. All these adult flounder as well as juveniles must pass through Minas Passage twice annually.

76. *Limanda ferruginea* – yellowtail flounder. Marine, benthic. Yellowtail flounder are taken consistently in the outer and inner Bay of Fundy in association with winter flounder but they are never abundant (MacDonald et al. 1984; Scott 1987). Wehrell (2005) observed three yellowtails taken in Minas Basin during a summer-long trawl survey when thousands of winter flounder were taken daily. Yellowtail flounder are landed as 'flounder' in the Canadian catch statistics and cannot be separated from the landings of other flounders.

A few yellowtail flounder will probably occur in Minas Passage during each summer. Numbers will be low.

Order: Tetradontiformes **"filefishes"**

77. Mola mola – ocean sunfish. Marine, pelagic. Ocean sunfish are a common but never abundant summer visitor to the Bay of Fundy (Scott and Scott 1988). Large specimens are captured in weirs of the outer and inner Bay during summer. Parasites from an individual caught in a weir in Scots Bay are stored in the Acadia University Museum. Ocean sunfish have a habit of 'basking' on surface lying on their side. They feed on jellyfish and attain a large size 2-4m. There is no fishery for ocean sunfish.

Ocean sunfish could occur in Minas Passage during most summers but abundance will rarely exceed 1-2 individuals. They have never been observed inside Minas Basin.

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TABLE 1 A list of fishes known to occur or could reasonably be expected in Minas Passage.
Fishes are catagorized by potential risk of interaction with proposed turbines.
Red Category: High probability of interaction with turbine and/or potential for significant incidental harm
Orange Category: moderate probability of interaction and low to moderate risk of incidental harm
Green Category: low probability of interaction and/or incidental harm

FISH SPECIES	GEAR TYPE FOR SURVEY	SEASONALITY
RED CATAGORY		
Sea lamprey	midwater trawl, off collected fishes	juveniles: May-July adults: April - June
dogfish shark	bottom trawl, bottom long line drift gill net	April to October
porbeagle shark	drift gillnet (night)	June - September
basking shark	drift gill net, observation	June - October
Atlantic sturgeon	bottom trawl, drift gillnet	April - October
blueback herring	midwater trawl, drift gill net	juveniles - all year adults March-Sept
alewife	midwater trawl, drift gillnet	juveniles - all year adults March-Sept
Atlantic herring	plankton net, midwater trawl drift gillnet	juveniles - all year adults March-Oct
Atlantic salmon	drift gillnet	juveniles May - July kelts Dec-May spawners May-Nov
pollock	midwater trawl, drift gill net angling, hand line	April - October
ORANGE CATEGORY		
barndoor skate	bottom drag	all year
American eel	plankton net, midwater trawl	glass eel, April - May

		siver eel, A Aug-Oct
Atlantic menhaden	midwater trawl, drift gill net plankton net	adults - May - June juveniles la summer
rainbow smelt	midwater trawl, drift gill net plankton net	all year
Atlantic cod	bottom drag, bottom long line shore set gill net handline	November - July
striped bass	drift gill net, angling shore set gill net	April - September
wolffish	bottom drag, bottom long line scallop drag	all year, winter?
American mackerel	midwater trawl, drift gill net angling	May - September
lumpfish	drift gill net, bottom drag plankton net	all year spring spawning
American halibut	bottom drag, bottom set long line hand line	April - July
winter flounder	bottom drag, shore seine, angling	April - October
GREEN CATEGORY Atlantic hagfish	baited traps	all year
sand tiger shark	drift gill net	July - September
thresher shark	drift gill net	June - September
great white shark	drift gill net	June - September
shortfin mako shark	drift gill net	June - September
smooth dogfish	drift gill net, bottom drag	summer

Greenland shark	drift gill net, bottom drag	December-March
Atlantic torpedo	drift gill net, bottom drag	July - September
little skate	bottom drag	all year
smooth skate	bottom drag	winter
thorny skate	bottom drag	all year
winter skate	bottom drag, shore seine	all year
shortnose sturgeon	bottom drag	probably never
brook trout	shore seine, angling	April - August
brown trout	shore seine, angling	April - August
coho salmon	drift gill net	April to September
rainbow trout	shore seine, drift gill net	April - September
monkfish	bottom drag	April - October
fourbeard rockling	bottom drag, plankton net	all year, juv May-Aug
haddock	botton drag, handline	June - September
siver hake	midwater trawl, drift gill net	June - September
red hake	bottom drag, scallop drag	June- August
white hake	bottom drag	April - October
Atlantic tomcod	bottom drag, plankton net	all year
ocean pout	bottom drag	April - October
Atlantic silversides	plankton net, shore seine	all year
mummichog	scoop net, shore seine	all year
fourspine stickleback	scoop net, shore seine	all year
threespine stickleback	scoop net, shore seine	all year

blackspotted stickleback	scoop net, shore seine	all year
ninespine stickleback	scoop net, shore seine	all year
northern pipefish	scoop net, shore seine	all year
white perch	drift gill net, midwater trawl	all year
bluefish	drift gill net, angling	July - August
weakfish	bottom, drag, drift gill net	July - August
black drum	bottom drag, drift gill net	July - August
radiated shanny	bottom drag	all year
rock gunnel	scoop net, shore seine	all year
sand lance	plankton net, midwater trawl	all year
butterfish	midwater trawl, drift gill net	June - September
sea raven	bottom drag, shore seine	all year
grubby	bottom drag, shore seine	all year
longhorn sculpin	bottom drag, shore seine	all year
shorthorn sculpin	bottom drag	all year
tautog	drift gill net, bottom drag	July-August
cunner	bottom drag, shore seine	all year
Atlantic snailfish	bottom drag, scoop net	all year
inquiline snailfish	scallop drag	all year
fourspot flounder	bottom drag	July- September?
windowpane	bottom drag, shore seine	all year
witch flounder	bottom drag	March - Novenber?
smooth flounder	bottom drag, shore seine	all year

yellowtail flounder	bottom drag	June-September
ocean sunfish	observation	July-August

FISH SPECIES	ABUNDANCE	REASONS FOR CATEGORY ASSIGNED
Sea Lamprey	common common, 100-1000/yr	pelagic in water column, large body size
dogfish shark	very abundant, millions mostly female	pelagic, large body size, commercial species risk of blade strike
porbeagle shark	rare, 10 -100/yr	pelagic, large body size, SARA listed high risk of blade strike
basking shark	very rare, 1-5/yr	pelagic, very large body size high risk blade strike
Atlantic sturgeon	abundant, 10,000+/yr	sometimes pelagic, large body size high risk of blade strike
blueback herring	extremely abundant millions -10's millions	pelagic, commercial fishery high risk of turbine pressure effect
alewife	extremely abundant millions - 10's millions	pelagic, commercial high risk of turbine pressure effect
Atlantic herring	extremely anundant 100's of millions	pelagic, large commercial fishery high risk of turbine pressure effect
Atlantic salmon	common, 10,000/yr rare, 100/ year rare- common 100-1000/yr	pelagic, SARA schedule 1 iBoF population endangered
pollock	common, 1000 -10,000	pelgic. medium body size, commercial selects high energy habitats
barndoor skate	rare	benthic, listed COSEWIC large body size
American eel	abundant, millions	pelagic. Commercial large body size

	common, 10,000 - 20,000/yr	population declining, may be listed
Atlantic menhaden	rare, 100 - 1000 common, thousands	pelagic, effected by pressure may be only Canadian population
rainbow smelt	extremely abundant millions	resident all year, pelagic larvae, recreational fishery
Atlantic cod	common, 1000 -10,000	commercial fishery, semi-pelagic population low abundance
striped bass	common, 10,000 - 20,000 adults	semi-pelagic, mostly along shoreline listed by SARA, no schedule listed threatened
wolffish	rare, hundreds/yr	commercial, being studied for listing COSEWIC
American mackerel	common 10's thousands	commercial but low demand pelagic, low abundance most years
lumpfish	juveniles abundant in surface drift seaweed, adults 100 - 1000	pelagic juveniles, potential commercial fishery for roe
American halibut	rare, 100 - 1000	very valuable commercial fishery large body size
winter flounder	abundant, ~400,000 adults	commercial fishery
Atlantic hagfish	unknown??, may not be present	no commercial fishery, benthic
sand tiger shark	very rare, 1-10/yr	southern occasional
thesher shark	very rare, seldom	southern, occasional
great white shark	very rare 1-5/ yr	southern occasional
shortfin mako shark	very rare, may not occur	southern occasional
smooth dogfish	may not occur	southern occasional

Greenland shark	may not occur	arctic - sub arctic
Atlantic torpedo	may not occur	southern occasional pelagic
little skate	common	benthic
smooth skate	very rare	benthic, not recorded inner Bay
thorny skate	common	benthic
winter skate	very common	benthic
shortnose sturgeon	never observed	benthic restricted to Saint John R. estuary
brook trout	rare in marine water	estuarine
brown trout	rare in marine water of Basin	estuarine
coho salmon	rare, probably extripated	introduced, population extripated
rainbow trout	rare, never observed	introduced, estuarine
monkfish	common 10-100/yr	benthic, often in intertidal commercial
fourbeard rockling	adults rare, larvae abundant	bentic as adults, small size
haddock	once common Scots Bay	benthic, select soft substrate select cold temperatures
silver hake	common, 1000's	mostly juveniles, no commercial fishery
red hake	common, 10's thousands	all juveniles, benthic commensal with scallops
white hake	common, 100's -1000's	juveniles, benthic
Atlantic tomcod	extremely abundant	small adult size, large population planktonic juveniles
ocean pout	very rare	strictly benthic, no fishery
Atlantic silversides	extremely abundant	inshore on beaches
mummichog	extremely abundant	inshore in tide pools along shore in winter
fourspine stickleback	common	inshore, beaches, estuarine, small adults
threespine	abundant	inshore on beaches, small adults

stickleback		
blackspotted stickleback	common	inshore on beaches, small adults
ninespine stickleback	rare	inshore, estuarine, small adults
northern pipefish	rare	inshore lagoons, small adults
white perch	rare	estuarine, small adults
bluefish	rare, 10-100/yr	southern occasional
weakfish	very rare	southern occasional
black drum	very rare 1/yr	southern occasional
radiated shanny	possibly abundant onshore	benthic, small adults
rock gunnel	abundant in intertidal	benthic, small adults
sand lance	rare	benthic, selects sand bottom habitat
butterfish	abundant? Millions	small adult size, no fishery
sea raven	common	benthic, no fishery
grubby	common	benthic, small adults, no fishery
longhorn sculpin	common	benthic, small adults, no fishery
shorthorn sculpin	common	benthic, no fishery
tautog	very rare, 1-10/yr	southern occasional
cunner	common	small adults, no fishery
Atlantic snailfish	rare? Common?	snall adults, around kelp
inquiline snailfish	common in scallop beds	small adults, commesal in scallops
fourspot flounder	rare, 1-10/yr	benthic, southern occasional
windowpane	abundant	benthic, no fishery
witch flounder	very rare	benthic, selects mud substrates
smooth flounder	common inshore	benthic, inshore only, mud sustrates

yellowtail flounder	rare, , 10-100/yr	benthic
ocean sunfish	rare, 1-5/yr	pelagic at surface, no fishery