Appendix 9:

Commercial Fisheries Studies-Phase I and Phase II

(CEF Consultants Ltd., 2008, 2009)

Commercial and Recreational Fisheries Study for Fundy Tidal Power – Phase I: Determination of No-Go Areas In Minas Channel/Minas Passage based on Use by Commercial Fisheries

Submitted to:

Minas Basin Pulp and Power Co. Ltd.
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EXECUTIVE SUMMARY

A study of commercial fishing activity in the Minas Channel/ Minas Passage area of the Bay of Fundy was conducted to determine "no-go" areas—critical areas which should be avoided by a tidal power demonstration project due to commercial fishery importance. No areas are precluded for development as tidal power sites, due to the broad geographic distribution of fisheries resources and fisheries, and the small footprint of the demonstration facility. The presence of herring and groundfish fisheries in the Southern Minas Channel, and a lobster fishery throughout the area, including Minas Passage, however, make some areas such as the northern Minas Channel and deeper parts of Minas Passage more preferable in terms of fisheries interactions. Liaison with fishers will be required, both for demonstration and commercial scale developments of tidal power facilities in the area.

1. INTRODUCTION

Fish, shellfish and invertebrates are important components of the ecosystem of the Inner Bay of Fundy as well as forming the basis for several significant commercial fisheries. The Inner Bay of Fundy supports a wide range of commercial and recreational fisheries from flatfish, gaspereau, and striped bass, to invertebrates such as soft-shell clams, baitworms and lobster. Information on fisheries and fishery species will be required as input to liaison activities with fisheries interests and the general public and for the environmental assessment of the tidal project. An initial overview of key fisheries in the vicinity of the projected tidal power sites is required to aid determining areas where the installations are unlikely to be acceptable based on fishery concerns.

Development of tidal power installations in the Minas Channel may interfere with existing commercial fishing activity as well as potentially impact fish species on which commercial fisheries depend. Typically fisheries will be excluded via fishery exclusion zones surrounding the Tidal Power Demonstration Facility (TPDF) to avoid damage to gear and tidal generating equipment when they interact. Other invertebrate fisheries such as commercial and recreational soft shell clam and baitworm could also be impacted by sedimentation resulting from a change in current regime after the installation of power equipment.

1.1 OBJECTIVE

The objective of this study is to provide information regarding commercial and recreational fishing activity in the Minas Channel and Basin that can be used to contribute to site selection for the tidal power demonstration project. This information will identify (on a preliminary basis) areas of significant commercial and recreational activity that will likely render these areas unsuitable for installation of the demonstration project.

An overview of information on the fisheries and fish species in the Inner Bay of Fundy will be the subject of Phase II of the Commercial and Recreational Fisheries Study of the environmental program for the TPDF and is not included in this report.

1.2 STUDY AREA

The study area is the section Minas Basin, Minas Channel and Minas Passage from a line running from "The Brothers" on the north shore of Minas Basin to Pereau in Kings County; and from Harbourville to Cape D'Or (Figure 1). The likely location for the tidal power demonstration project is within Minas Channel.

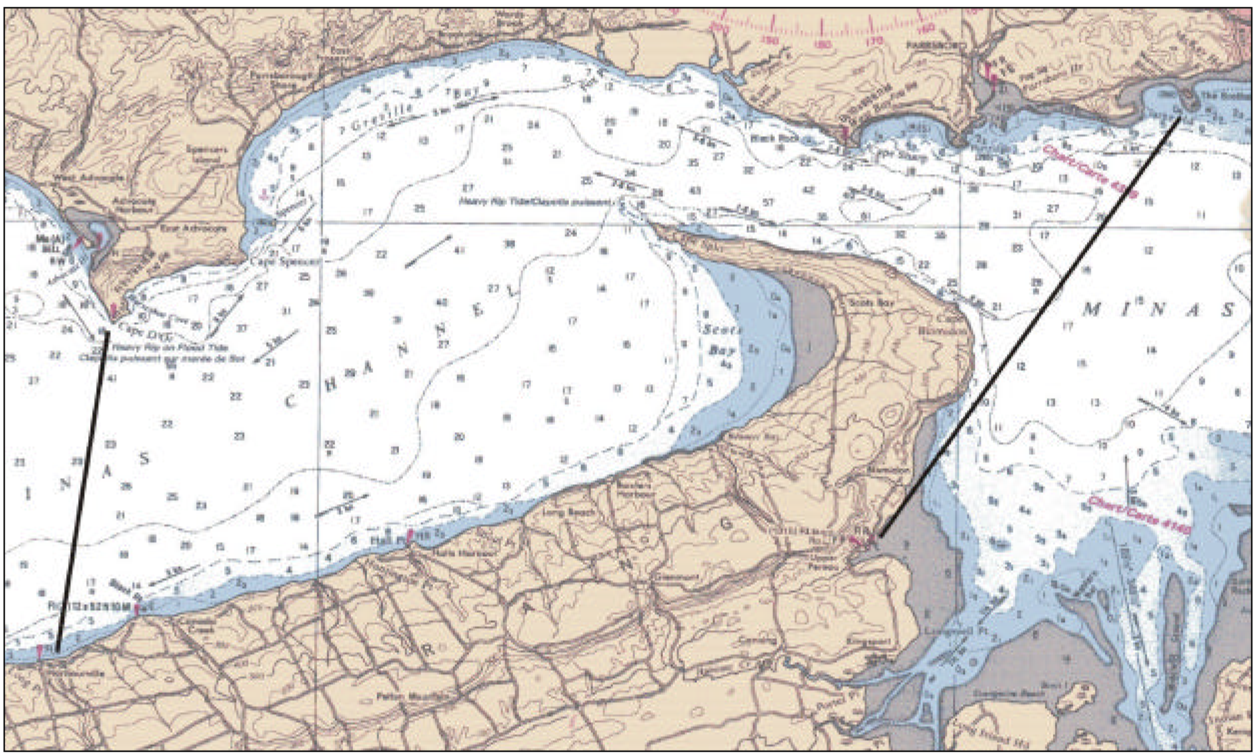

Figure 1. Study area for assessment of fishing activity.

2. COMMERCIAL AND RECREATIONAL FISHERIES

2.1 METHODS

A review of information on the commercial and recreational fisheries included interviews and personal contacts with fisheries officers, individual fishers, and representatives of key fisheries sectors, as well as a review of published and unpublished information on fisheries in the Inner Bay of Fundy. Some background information was obtained from a recent profile of the fisheries in the Minas Basin (Dyer et al. 2005); from an overview of the Minas Basin marine ecosystem (Parker et al. 2007); and from the Jacques Whitford Environment Limited (JWEL) 2008 SEA report on tidal power in the Bay of Fundy. More detailed methods are presented in the CEF Consultants report commissioned as part of this study (Appendix 1).

2.2 COMMERCIAL FISHERIES

This study profiles locations where there is demonstrated commercial fishing activity within the study area (Figure 1). Several of the main commercial fisheries occur in the Minas Channel and Minas Passage although, with exception to lobster, they are peripheral to and generally less intensive than fisheries occurring outside either boundary of the study area. All fisheries are prosecuted widely in the Bay of Fundy. Minas Channel and Minas Passage are migration/movement routes for nearly all fish species and many invertebrates such as lobster which occur within Minas Basin. However it is not considered that nearshore and estuarine commercial fisheries in Minas Basin outside the study area will be impacted by any effects of the demonstration (and subsequent commercial phase) developments on moving or migrating fish or shellfish.

In any given year, fishery use of the Minas Channel/Minas Passage varies. Catch information and location for commercial fishers, which would be useful in assessing use patterns and no-go zones, is usually reported but isn't routinely divulged by Fisheries and Oceans Canada. An indication of fish catch locations and gear in 2003 (with the exception of lobster for which catch and location reporting began in 2004) is given in the Dyer et al (2005) assessment of Inner Bay of Fundy, presented in Figure 2. Most of the activity in 2003 was outside the Minas Passage, mainly in Minas Channel and the southern Bight of Minas Basin.

Lobster is the main commercial fishery in the Minas Passage/ Minas Channel area, which is included in the inner Bay of Fundy lobster management area (LFA 35). Eleven boats routinely fish in the study area. Traps are set during the lobster season, which extends from March-July and October to December. Most fishing activity takes place along the Blomidon, Scots Bay and Parrsboro shores, and is concentrated nearshore, although traps are occasionally set in deeper, higher-current areas (Figure 2; Appendix 1) (the area of high DFO sampling sites in Figure 2 corresponds to the location of significant lobster density). High current, and floating debris moving with the currents which can entangle gear, interfere with lobster fishing. Lobster gear, which includes heavily weighted traps and lines and buoys joining them, is easily disrupted by surface vessels, including vessels in the fishery itself[1]. In any lobster fishing area, the nature of gear, which typically involves strings of lines joining the traps and buoys with long lines extending to the surface, is easily disrupted by activities of surface vessels. An important additional point from the CEF Consultants study (Appendix 1) is that within the broad nearshore area fished, the locations of the trap sets can vary from year to year based on the fishers preferences. That study suggested that because of the importance of the fishery in the study area, a consultation and liaison strategy be developed and implemented for managing interactions of the project with the lobster fishery in the area.

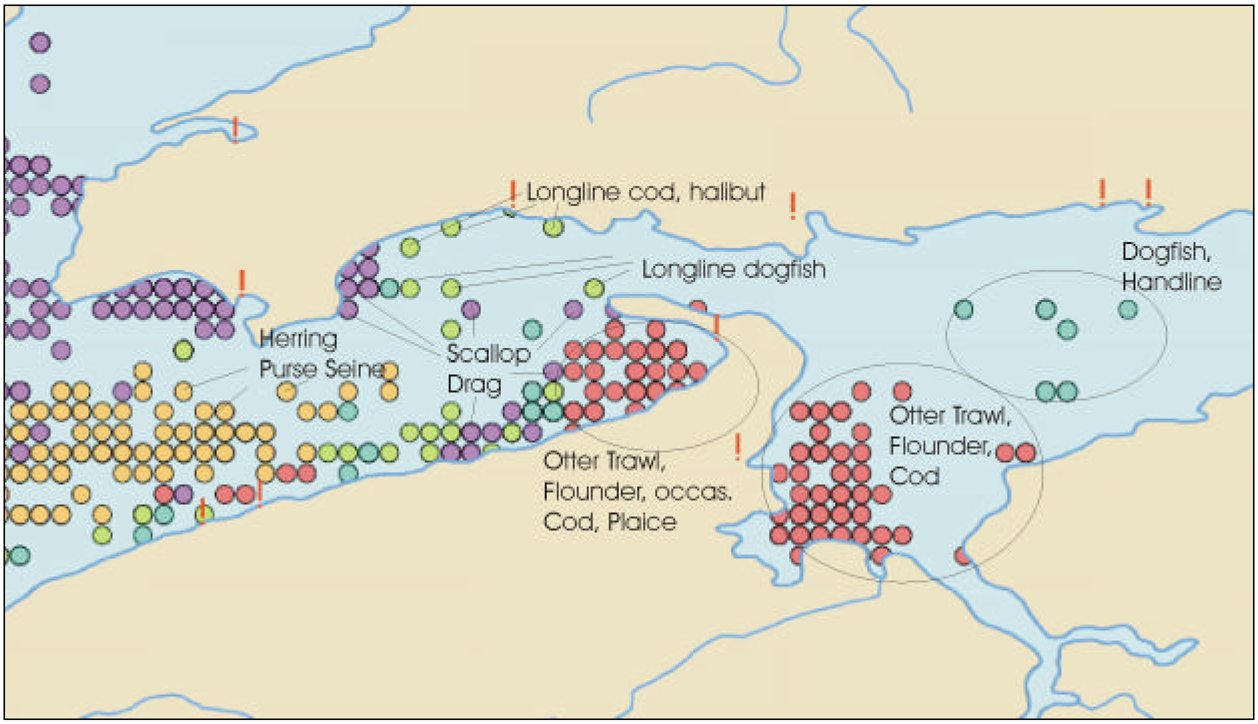

Figure 2. Locations of reported catch for landed fish excluding lobster and other shellfish, in 2003. Modified from Dyer et al. (2005). Colour of dots indicates gear type.

1 The depth sounding survey carried out by Natural Resources Canada in June 2007 to provide background bathymetry aimed in part at supporting Fundy tidal power development, caused significant damage to local lobster gear (Appendix 1).

The following fish and shellfish are caught commercially within the study area, summarized in Table 1.

Table 1. Commercial fisheries in Minas Channel and Minas Passage

Fishery	Gear/Sector	Timing	Assessment	Comment
Fish				
Groundfish	Bottom Trawls; Weirs	Spring-Fall	Not much activity in study area but most caught by trawl outside Minas Passage (along Cape Split and along south half of Minas Channel). Occasional bycatch in weirs.	Study area is only occasionally used and not a major component of commercial activity
Winter Flounder	Bottom trawl	Spring-Fall	Widely in Scots Bay area and again in Harbourville area; widely in southern Bight of Minas Basin and occasionally along Cape Split in Minas Passage.	Study area is only occasionally used and not a major component of activity
Haddock	Bottom Trawl	Spring-Fall	Historically spawning area and good catches in Scots Bay area through Harbourville and in Minas Basin, but due to overfishing, only occasionally caught now.	Study area is only occasionally used and not a major component of activity
Halibut	Longline	Spring-Fall	Occasionally caught as bycatch of longline fishery in nearshore areas of Minas Channel, and occasionally in Minas Basin	Not a major fishery and not prosecuted in Minas Channel area.
Cod	Bottom Trawl	Spring-Fall	Commonly caught as bycatch in southern bight of Minas Basin and along the shore of Minas Channel	Not a major directed species in Inner Bay.
Atlantic Herring	Purse Seines, Weirs	May-June, Septemb er	Several important Spring- and Fall-spawning areas through the study area, including important Scots Bay area. Purse seine fleet may extend into the Passage. Weir fishery in Partridge Island area (Parrsboro).	Purse seine fishery from larger vessels exploits adult spawning concentrations in Scots Bay. Main Concentrations in outer Minas Channel.
Shark	Longline	August-October	Longline fishery for dogfish shark occurs from Ile Haute through Minas Passage	The fishery is widespread in the Minas Channel and is less intense in the Passage. It is prosecuted by fishermen out of Halls Harbour and

Fishery	Gear/Sector	Timing	Assessment	Comment
				Harbourville in Minas Channel.
Shellfish				
Lobster	Trap Fishery	March-July; Oct. – Dec.	Trap fishery extends throughout study area. Predominant deployment of traps in shallower water on the margin of Minas Passage and Channel, where currents are reduced.	Lobster concentrated in the rockier areas, often where faster current predominates, mainly west of Minas Channel near Advocate Harbour (Parker et al. 2007).
Sea Scallop	Trawl Fishery	Jan-March; Aug-Sept	Scallop beds in Scots Bay and around Ile Haute (JWEL 2008)	Major beds further out the Minas Channel but those in Minas Passage area not the most significant.
Softshell clams	Clam digging	May – Oct.	Commercial beds historically outside study area, main ones nearby from Five Islands to Bass River. Shore from Scots bay down Cape Split not suitable or accessible for clam harvest.	Some recreational digging may occur in the salt marsh/estuary in the Black Rock, Black River area, but not likely to be impacted by project.
Baitworms	Digging	June-Nov	Significant number of worm licences in Parrsboro area, presumably fishing range of flats in area.	Stock widely distributed in Minas Basin and the study area is not one of the main fishing areas.
Marine Plants	Shoreline and immediate sub-tidal harvest	Year-round	Some harvest in Minas Channel area (Advocate, south shore between Scots Bay and Harbourville).	No resource harvesting in study area.

Brush weirs, mostly for herring, are found in the Partridge Island/Parrsboro Area (1 active in 2005)(Dyer et al 1005), Moose River (1 inactive), Above Five Islands (2 active), Lower Economy (4 active) and Upper Economy (1 Active, 1 inactive)(Dyer et al 2005). Two weirs for flounder are at Economy and Five Islands. Groundfish are bycatch in these weirs.

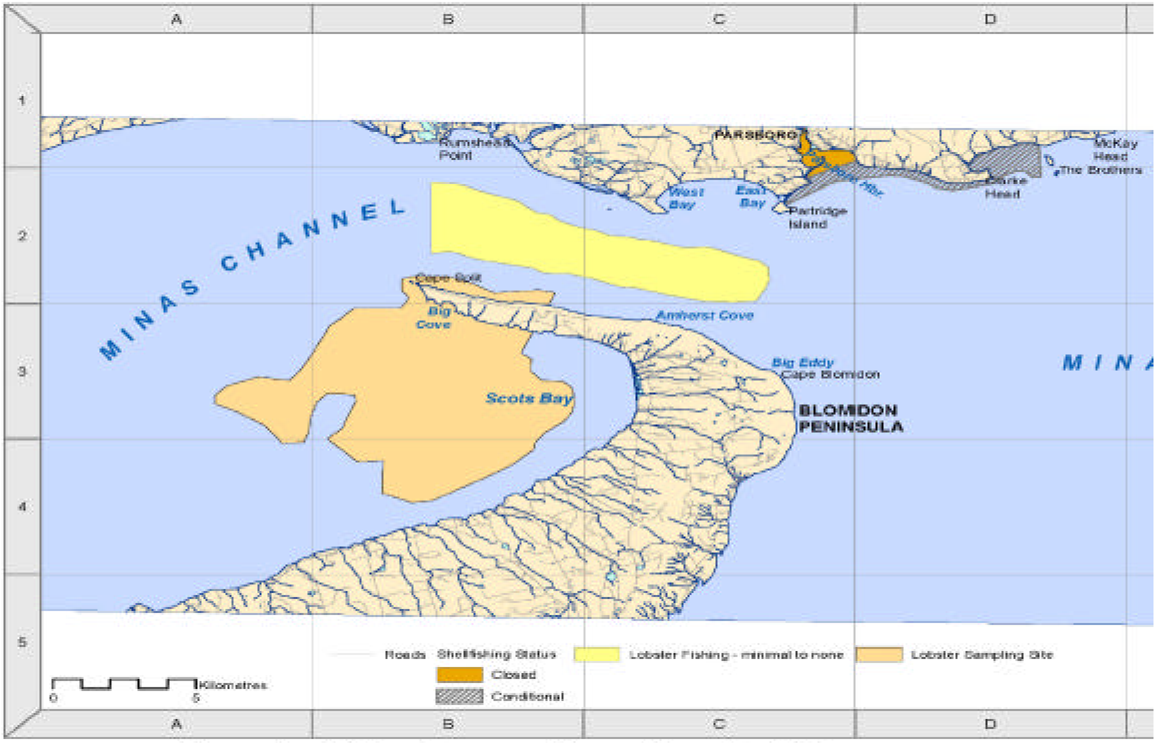

Figure 1: Fishing Areas and Areas Closed to Fishing

Figure 3. Areas of lobster fishing activity in Minas Passage/ Minas Channel area. Yellow area indicates low intensity of fishing activity. Lobster fishing activity occurs in remaining parts of Minas Channel and Passage but no concentrations occur.

2.3 Recreational Fisheries

Local recreational fisheries occur along or near the shore for various inshore species such as striped bass, winter flounder, pelagic species such as mackerel and herring, and digging for softshell clams occurs on mudflats almost exclusively on the Parrsboro Shore. Parrsboro Harbour and the shore from Parrsboro (Partridge Island) to The Brothers is occasionally closed to shellfish harvesting due to bacterial contamination. Overall, these fisheries will not be directly impacted by project activities.

2.4 Aboriginal Fisheries

Annapolis First Nation (Cambridge, Kings Co.) have two lobster licenses for the inner Bay, based out of Digby and Harbourville, which would cover the study area. They also have a communal food fishery for miscellaneous species from Margaretsville to Cape Split, which includes clams, herring and mackerel (Dyer et al 2005). The Millbrook First Nation fish five lobster licences, four out of Digby, and fish in the Digby area (Dyer et al.. 2005). Folly First Nation (located outside Dorchester, N.B., has two boats located in Parrsboro that fish in the area)(Dyer et al. 2005).

3. ASSESSMENT OF NO-GO ZONES

Avoidance of an area for development of a Demonstration Tidal Power facility, would be necessary in the event of: 1) any unique or important feature of the local environment, either biologically (e.g. species at risk, major spawning area); or 2) socio-economically (e.g. irreplaceable fishery resource, historical/archaeological site). From general knowledge, and background information assembled on the Inner Bay of Fundy for the Tidal Power Strategic Environmental Assessment and previous studies, there are no populations of organisms or resource species which uniquely occupy areas within the study area--most resource species are widespread. Commercial fishing activity is largely limited to a lobster fishery (excepting deep, high current areas in the Minas Passage), which is widespread in the Inner Bay of Fundy, and to fisheries for pelagic fish (e.g. herring, dogfish) and groundfish (e.g. winter flounder, cod, haddock) in the Minas Channel and particularly along the Scots Bay-Harbourville shore. A groundfish fishery is localized in the Southern Bight of the Minas Basin. With these constraints, development of the tidal power demonstration project anywhere in Minas Passage and the central and northern parts of Minas Channel would not be constrained by biological features and commercial fisheries. Commercial scale development would occupy larger areas of the seabed, and potentially would infringe more on existing commercial fisheries, although it is unlikely that more than a small percentage of an area occupied by a particular fishery would be involved, and therefore developments could be mitigated with the involvement of the fishers. Thus commercial developments could likely take place in most parts of the study area, providing there is suitable involvement and consultation.

4. CONCLUSIONS

No areas are precluded for development as tidal power sites, due to the broad geographic distribution of fisheries resources and fisheries, and the small footprint of the demonstration facility. The lobster fishery in Minas Passage is the most important commercial fishery with which there will be potential interactions with the tidal power demonstration project. Liaison with fishers will be required, both for demonstration and commercial scale developments of tidal power facilities in the area. The presence of herring and groundfish fisheries in the Southern Minas Channel, and a lobster fishery throughout the area, including Minas Passage, also make some areas such as the northern Minas Channel and deeper parts of Minas Passage more preferable in terms of fisheries interactions for possible locations for demonstration and commercial scale tidal power projects.

5. REFERENCES

Dyer, C., S. Wehrell and G. Daborn. 2005. Fisheries Management Issues in the Upper Bay of Fundy. Acadia Centre for Estuarine Research (ACER) Publication No. 80.

Jacques Whitford Environment Limited. 2008. Background Report for the Fundy Tidal Energy Strategic Environmental Assessment. Report to the Offshore Energy Environmental Research Association. JWEL Project No. 1028476.

Parker, M. M. Westhead, and A. Service. 2007. Ecosystem Overview Report for the Minas Basin, Nova Scotia. Oceans and Coastal Management Report 2007-05.

APPENDIX 1 – CEF CONSULTANTS REPORT, APRIL 2008.

1 INTRODUCTION

1.1 Background

Minas Basin Pulp & Power Co. Ltd. is investigating the potential for generation of electrical power within the Minas Channel of the Bay of Fundy using non-barrage type tidal power generators. A first step in this process is to collect physical and environmental background information on the area to determine possible locations for testing power generating equipment. Part of the assessment is to identify potential sites where equipment can be installed with minimal interference with resources or resource users.

This report represents an initial study of potential 'no-go' areas where installation of a test facility could interfere with fishing activity. Information has been collected by extraction of information from the Internet, published information, including the Estuarine Resources Inventory published by MRMS in 1979, and interviews with fisheries officers, fishers, First Nations and other relevant stakeholders.

The purpose of the consultation was to determine no-go areas for testing sites based upon the local knowledge of people who use the Minas Channel for fisheries related purposes. Groups and individuals were faxed or emailed an information notice and asked to describe areas they considered inappropriate for testing sites. Responses were received verbally through grid numbers and landmark descriptions, and graphically with descriptions drawn on the map. These responses were then translated into generalized areas depicted on a map of the Study Area (Figure 1).

2 ENVIRONMENTAL SETTING

2.1 Physiography

Minas Basin, the southern branch of the upper Bay of Fundy, is a semi-enclosed remnant of a 200 million-year-old rift valley, once located near the Equator. In Micmac legend the Basin was originally the beaver pond of the man-god Glooscap, who lived on Cape Blomidon at the base of Cape Split. Four counties, with a combined population of 180,000, surround it. Truro, with 12,000 people, is the largest urban centre, and there are only five other towns with more than a thousand residents. Most of the population is dispersed in villages and rural communities.

Minas Basin is comprised of four distinct regions: Minas Channel at the mouth; central Minas Basin; a southward bulge called the Southern Bight; and Cobequid Bay, forming the innermost extremity. Sometimes, only the latter three areas are considered Minas Basin proper; but here we include the Minas Channel, the arrowhead's shaft, as an integral part (7).

The spine of the Channel is a 50 kilometre long, S-shaped, 100-metre deep trench that snakes around Cape Split and links the Basin to the Bay of Fundy. At its westernmost end, flanked by Cape Chignecto to the north and Harbourville to the south, the Channel is 24 kilometres wide. It is narrowest, only 5 kilometres wide, at its easternmost end between Partridge Island (near Parrsboro) and Cape Blomidon. Over much of its 75,000-hectare area, the water depth averages only 25 to 50 metres at low tide, but the central trench is up to 115 metres deep (1).

Central Minas Basin, Southern Bight and Cobequid Bay together, form an obtuse triangle about 80 kilometres long and 29 kilometres wide at its broad western end. It narrows to a point in the estuary of the Salmon River near Truro, at the head of Cobequid Bay (1).

2.2 Geology and Seabed Morphology

The Inner Bay of Fundy comprises Cobequid Bay and Minas Basin (sub-Unit 913a) and Chignecto Bay (sub-Unit 913b). This Unit differs in many ways from the Outer Bay, particularly because of the effects of the high tides and the presence of more sheltered environments. Minas Basin and Cobequid Bay have extensive areas of intertidal mud flats, owing to the high tidal range, coastal erosion, and sediments brought in from several of the major rivers of Nova Scotia – the Salmon, Shubenacadie, Kennetcook, Avon, and Cornwallis rivers which flow into Cobequid Bay or Minas Basin, and the Petitcodiac River of New Brunswick which flows into Chignecto Bay. The coastlines of these basins have extensive salt marshes or dykelands. Beyond the mud flats in the subtidal zone, the bottom is variable in character, consisting in places of exposed bedrock, sand, and gravel and mud. The strong tidal currents create sea-bottom sand waves several metres in height and hundreds of metres in length.

In the intertidal zone of the Minas Basin a complex series of sand waves, megaripples, and sand bars reflect the locally strong tidal flows. These occur at Economy Point, Five Islands, and the Avon River estuary, and over wide areas subtidally (1).

Minas Basin also contains about 1,330 hectares of low salt marsh that is regularly flooded by the tide, almost 80% of which is concentrated around the Southern Bight.

2.3 Sediments

Glacially derived sediments comprise much of the seabed of the Inner Bay, but sediment derived from coastal erosion is important in some cases and accounts for local differences in bottom sediments, especially between Minas Basin and Chignecto Bay. Sediments in Minas Basin are principally sands and gravels, but intertidal and sheltered environments have muddy bottoms. The sand comes from the wave erosion of sandstone cliffs along the shoreline and from glacial outwash deposits. Chignecto Bay has extensive mud flats and the bottom is muddy, derived largely from shales on the nearby coasts (1).

2.4 Oceanography

The tidal force is predominant and, because of resonance, establishes a macro-tidal environment. Tidal mixing tends to minimize seasonal variations in temperature and salinity. Ice occurs in the upper reaches from December to April.

The Inner Bay of Fundy is estuarine in character and generally has greater temperature extremes than in the main part of the Bay of Fundy, because of the pronounced warming of water as it moves over the mud flat, restricted circulation, and high turbidity. The Basin's water is warmer in summer and colder in winter. In late summer it may reach 14ºC in the Minas Channel and central Basin and 21ºC in upper Cobequid Bay. On hot, calm days, the shallow water flowing over the sun-baked intertidal mudflats may reach 26ºC. In midwinter, the water temperature hovers around the freezing point. The salinity ranges from about 31 parts per thousand in the Channel to 28 parts per thousand in upper Cobequid Bay (7).

Suspended sediment levels in the Inner Bay of Fundy are high and significantly higher in Chignecto Bay than in Minas Basin. In the Bay of Fundy a Sechhi disk disappears at six to ten metres, while in the Minas Channel it is invisible after three or four metres. In the central Minas Basin the Secchi depth varies with the tide, from about two metres at mid-tide to four metres at slack water. Closer to shore in the Southern Bight, the disk disappears in just a few centimetres.

Phytoplankton productivity may be limited because suspended sediments make the water opaque (1). Half of the primary (plant) production comes from mudflat diatoms, with the remainder almost equally split between the phytoplankton and salt marshes.

2.5 Plankton

Over a hundred species of zooplankton have been found in Minas Basin. Contrary to expectations, zooplankton production is nearly as high as in other less turbid waters. There are fewer herbivorous zooplankton dependent on phytoplankton, but more omnivorous species that eat detritus or the bacterial film on silt particles. The abundance and distribution of zooplankton is patchy and constantly changes during the course of a tidal cycle. The assemblage in the Southern Bight is dominated by small estuarine copepods. Detritus-eating Mysid shrimp, hovering in swarms above the muddy bottom, are an important food for shad, alewives and other fish.

2.6 Marine Plants

Seaweeds are not generally abundant and occur in isolated patches where suitable hard bottom is present. *Fucus* species and *Ascophyllum nodosum* occur in the upper intertidal, and seaweeds of various kinds occur below extreme low water. A significant bed of the kelp *Laminaria saccharina* containing various seaweeds, including the dulse *Palmaria palmata* and coralline algae *Corallina officinalis*, has been found between Cape Blomidon and Medford Beach in western Minas Basin, and a dulse bed occurs near Parrsboro (1).

Phytoplankton populations are not generally as productive as in other Inner Shelf areas because light levels are reduced by high sediment loads in the Minas and Cumberland basins. The majority of plant production comes from microscopic algae growing on the surface of mud flats and from salt marsh grasses (1).

2.7 Birds

Various seabirds occur, including gulls and cormorants, as well as various birds of prey (Ospreys and Bald Eagles) that use the coastal bluffs and nearby inland areas for nesting. Shorebirds in large numbers visit the mud flats on their passage north in spring and then return late in summer from Arctic breeding areas.

2.8 Fish and Shellfish

The Minas Basin is home to a variety of fish, some of which were once exceptionally abundant. At least 50 species have been found in the region. The channels winding through the salt marshes are important nursery areas for some of them. Some animals that live and breed in the Basin appear locally endemic. These include species of jellyfish, crabs, barnacles, planktonic copepods, snails and bivalves. The nearest populations are in the southern Gulf of Maine or the warm, brackish water of the southern Gulf of St. Lawrence.

The burrowing amphipod *Corophium volutator* crowds the mudflats of the Southern Bight, with up to 60,000 rice-sized animals per square metre. The clam *Macoma baltica* is more abundant in southern Cobequid Bay than anywhere else in the upper Bay of Fundy. The larger soft-shell clam, *Mya arenaria*, is most abundant along the northern coast of the Basin. Several species of burrowing polychaete worms are numerous in some areas. Common rock barnacles are abundant where there are rocky outcroppings, as are the whelks that prey on them. Mud snails, *Ilyanassa obsoletus*, are numerous and conspicuous on many mudflats. Most of these bottom-dwelling animals are detritus feeders, scavengers or predators. Animals that filter phytoplankton and suspended organic matter from the water, such as blue mussels and oysters, are conspicuously absent, presumably because the turbid water would quickly clog their filters. Echinoderms, such as starfish and sea urchins, which prefer clearer water, are also scarce.

The Minas Basin is the gateway to a vast breeding & incubation area. Lobster migrate through the Minas Passage to lay eggs and propagate their species. The Passage acts like a ‘door to the nursery’ for the lobster in this area.

The Inner Bay of Fundy supports large populations of various coastal fish species. Some migrate into the bay for feeding and reproduction, and others are resident in the area throughout the year.

Most of the American Shad from east coast waters spend the summer in the basins of the Inner Bay of Fundy. More than 40 species of fish can be considered regular residents, some of the more common being Atlantic Herring, alewife, Blueback Herring, American Shad, smelt, Atlantic Tomcod, Atlantic Silverside, Windowpane, Smooth and Winter Flounder, Striped Bass, Atlantic Salmon, and American Eel. Waters are productive despite high turbidity and reduced phytoplankton production, because of the high abundance of zooplankton, which feed on detritus from salt-marsh grasses in suspension in the water. The mud flats are home to invertebrates, including numerous species of polychaete worms; softshell clams; intertidal snails; and crustaceans, including the tube-dwelling amphipod *Corophium volutator* (a small shrimp which is food for migratory shorebirds). Several species of flatfish, which live in the deeper water, come into the tidal flats and streams to reproduce and feed. Inshore concentrations of Atlantic Halibut at one time occurred in Minas Basin.

3 TYPES OF FISHERIES

Traditional local fisheries in Minas Basin include lobster, shad, softshell clams, and bait worms (e.g., bloodworms). Other commercial species fished in some areas include scallops, herring, cod, haddock, and flatfish. High tidal fluctuations, strong tidal currents, sedimentation, and frequent poor weather, limit small-scale fishermen in their harvesting activities. However, such fisheries are still one of the principal elements of local community economies. In recent years, larger vessels from the deeper, more open waters of the Bay have followed and harvested fish stocks as they migrate into the Upper Bay. Local recreational marine fisheries for dulse, clams, striped bass and flounder also occur seasonally (2).

The mudflats of the Southern Bight have a finer consistency and are better suited to a variety of burrowing polychaete worms. Some of these, particularly the bloodworm, *Glycera dibrachiata*, are the target of a commercial baitworm harvest. New fisheries, such as rockweed, sea urchin, sea cucumber, periwinkle, and krill fisheries, are emerging.

3.1 Digging

The digging and processing of the soft-shell clam has been a lucrative fishery in the Basin over the years. It is also one of the least capital-intensive, requiring only an “hack” (a long-tined rake for turning over the sediments), buckets and a cart for transporting the paraphernalia and catch over the tidal flats. Commercial clamming began early in the 1940s, with a peak production of 946 tonnes in 1946.

In the early 1980s, Minas Basin accounted for almost a third of Nova Scotia's clam production. In 1982, one hundred and ten full-time, licensed clammers, many part-timers and three processing plants produced over 680 tonnes of clams, worth at least half a million dollars. It has been estimated that only about one and a half percent of the Basin's extensive tidal flats, or about 445 hectares, have the ideal mix of sand and mud for prime clam habitat. The most productive clam flats are located along the northern shore of the Basin, particularly between Five Islands and Bass River.

3.2 Weirs

The high tidal range is ideally suited to the weir fishery, which for generations was the most popular harvest method. The crescent-shaped weirs, constructed of brush or twine netting suspended on stakes driven into the mudflats, were designed and positioned to trap fish on the receding tide. An observer in the 1850s reported that there was, on average, one weir every mile along the north shore of the Basin.

The American shad was once the dominant fishery in the Basin. Prior to 1900, thousands of barrels of salt shad were exported each year. Weir catches ranged as high as 100,000 fish on a single tide. Prior to the 1950s Atlantic salmon were the second most important species fished with weirs.

In Five Islands and Economy, weir posts are 9 – 10 ft. in length, with 3 ft driven into the floor of the bay at low tide, leaving 6 – 7 ft exposed. Up to 900 poles can be used. The "bosom" of the weir is usually higher than those at the ends of the wings. These weirs can be ¼ mile in length consisting of 2 wings and a trap. The trap is perhaps 7 x 7 sq.ft. at most. Wire birch and are often woven along the tops of the weir and softwood brush along the bottom. They are located up to one mile off shore.

Weirs are set in April and removed before winter to avoid damage by ice. Fish run in the spring and early summer: herring first (May, early June) then mackerel and shad. The weir is not fished in the warmer weeks of summer (later July and August). Before winter, the nets are completely removed to avoid damage by ice cakes.

3.3 Traps

The lobsters are concentrated in the deeper areas of the Minas Channel, where strong currents sweep the gravelly bottom free of silt. Only very large, heavy traps weighed down with hundreds of pounds of concrete can be set in such currents, requiring the use of larger boats than are normally used for lobstering.

3.4 Mobile Gear

Local trawlers fished for winter flounder in the Basin for many years. The vessels' small size and low horsepower prevented them fishing at all stages of the tide and thus limited their catches. This imposed a natural control on harvesting and ensured a sustainable fishery. However, in the late 1980s, larger trawlers from the lower Bay, having fished out flounder stocks there, moved into Minas Basin. These could work continuously at all stages of the tide, day and night and with much larger, heavier trawls. Within a very short time they decimated the flounder stock and numbers have never fully recovered, leaving a much-reduced fishery. The fifteen or so local vessels still operating in the Basin now harvest a mix of species, such as groundfish and lobster in different seasons.

4 CONSULTATION

Table 1 outlines the consultations carried out between April 18 to 28, 2008 in relation to this study. Contacts were identified from previous public meetings carried out in relation this project, native groups and selected DFO representatives. Results from these contacts are discussed in the following sections.

Table 1: People Contacted Concerning Fishing Activity in Minas Passage

Name	Affiliation	Contact Method	Response
Martin Kaye	Bay of Fundy Marine Resource Centre	Fax, phone	none
Arthur Bull	Bay of Fundy Inshore Fishermen's Association	Fax, phone	none
Croyden Wood Jr.	Local fisher	Phone, fax	none
Glen Travis	Local fisher/ Upper Bay of Fundy Fish Draggers	Phone, fax	Discussion
Roger Hunka	Native Council of Nova Scotia	Phone, e-mail	none
Vincent Smith	Fisheries Officer	Phone, e-mail	Discussion, email image
Anita Hamilton	DFO Habitat Branch	Phone	Discussion, materials
Ted Currie	DFO Major Projects	Phone, e-mail	Discussion
David Robichaud	DFO Population Ecology	E-mail	E-mail image

4.1 DFO Representatives

The Department of Fisheries and Oceans has the responsibility for management of fish resources and fishing activity. Representatives from various DFO sections and the fisheries officer responsible for the Minas Passage area were contacted. The area fisheries officer generally described the Blomidon, Scots Bay and Parsboro shorelines as having weaker currents and therefore a greater concentration of lobster traps. Near the centre of the Minas Channel currents tend to be strongest making lobster fishing more difficult and less common. Floating material and debris, which accumulates in the Minas Passage, can pose challenges to fishing gear that would also apply to testing equipment.

Other DFO representatives provided information on lobster sampling locations, the ecology and relevant studies of the Minas Passage and how we might consider the fishery over longer periods of time (8, 9). The greatest density of lobster fishing as identified by DFO is around Cape Split and Scots Bay. This is based on information collected by DFO observers on commercial fishing boats, and from fishermen's log books submitted to DFO. It is an indication of where the fishery has been directed over the past ten years but as the response from the fisheries officer validates, it is only a fraction of all fishing activity in the Minas Channel. Other locations are distributed more sparsely off of Parsboro Harbour.

Of particular importance was the response that we should consider that lobster traps are not dropped in the same place each year. It was recommended that testing equipment sites be decided with some consideration to potential future no-go areas by generalizing the best lobster fishing areas.

4.2 Fishermen

The following is largely excerpted from a brief prepared by the Heavy Current Fishers Association as part of the Strategic Environmental Assessment of Bay of Fundy tidal power in 2007, which is included as Appendix B.

Many fishers working the Minas Channel have done so for most of their lives, practicing a trade learned from previous generations and passed down through families. The area is a difficult one to fish in with the heavy tidal currents and rip tides that require careful navigation. Although close to 100 boats from District 35 could work the waters in question – only 11 of them do.
Fishing in Minas Basin generates nearly $10 million per year in the local economy. Fishing may occur during any time of the year, although specific seasons limit most fisheries.

It was noted by fishers that the Coast Guard vessel *Matthew* was in the Minas Channel for approximately three weeks in June 2007, doing seismic mapping of the sea floor. During this process the vessel ran over fishing lines, destroyed traps and interfered with the fishing operations of the area without contacting any of the fishers in any manner. Each fisher lost some 15 to 20 traps from this venture as well as other equipment that was destroyed. A repeat incident, regardless of how it occurs, would contribute to increased strain on relations between users of the Minas Channel (6).

The Heavy Currents Fisheries Association (HCFA) is a leader among fishers in the Minas Passage. Representatives have met with their local municipal governments, the Environment & Labour Minister, the Natural Resources Minister, Nova Scotia Department of Environment staff, and Nova Scotia Power Environmental Operations and Approvals representatives.

The HCFA wants to be involved with developing Procedures & Protocols for fishing operations in the vicinity of any in-stream tidal power generators or testing equipment. The fishers have 5 traps each that are allowed for "scientific" purposes by DFO. The HCFA would like to utilize these in the studies, placing them around the generators – before, during and after each in-stream turbine's testing period – to see what effect the various generators might have on the lobster catch. The members of the HCFA have considerable knowledge of the area such as tidal currents, sea floor terrain, migratory paths and area catches, and are willing to share the information. However, the fishers expect to have a working relationship with interested groups and be engaged in solutions and research.

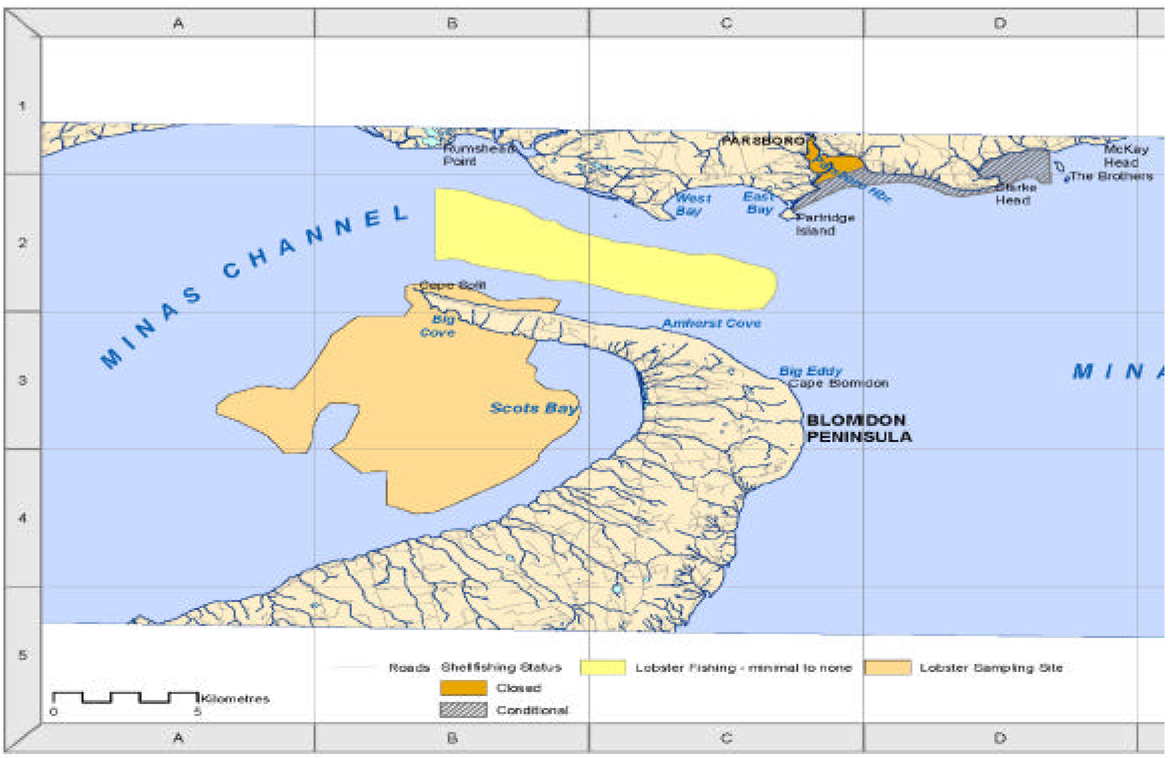

Figure 1: Fishing Areas and Areas Closed to Fishing

5 CONCLUSIONS

5.1 Consultations with the Fishing Industry

Direct discussion with fishers in the area has proven difficult. It will be critical to develop an overall consultation strategy to avoid creating misconceptions and establish an on-going working relationship.

5.2 No-Go Areas

No-go areas for possible locations for testing power generating equipment are primarily related to the lobster fishery. Figure 1 shows areas described by fishers, fisheries officer and DFO publications as the primary lobster fishing area. It is a general representation of areas which are not suitable for testing equipment.

The high currents within the yellow area shown on Figure 1 make it difficult to fish with traps during high tidal flow periods because even heavily weighted traps may not stay in position and can be easily lost and remain ghost fishing. Consequently, the least amount of lobster fishing takes place there. But it is important to note that localized areas where outcrops or boulders reduce currents may be important to specific fishers even within the yellow area depicted. These specific areas would be of particular value to fishers and they will likely continue to be reluctant to share specific locations. In addition, the installation of a tidal generator would change localized conditions and affect bottom currents in ways that would likely make some areas more suitable for trapping and others less.

On the landward side of the yellow area and eastward in the Minas Basin lobster fishing activity takes place with greater frequency. There are also areas which are closed because of bacterial contamination and conditional fishing areas in and near Parrsboro Harbour (8). The shorelines of East Bay, West Bay and beyond to Rumshead Point are dotted with potential existing and former recreational and commercial fishing sites, including flounder, dulse, and soft-shelled clams. An area where lobster catch is significant, as identified by a concentration of sampling sites of DFO, occurs around Cape Split and Scots Bay (Figure 1). Other locations are distributed more sparsely off of Parrsboro Harbour (9).

Fishers and the fisheries officer had difficulty describing no-go areas specifically due to annual variations in catch locations, the type and scale of the maps used for discussion, and the depth of local knowledge. On the part of the fishers, there was also hesitance to give information without knowing how that information would be used. They felt they could have given better, more detailed responses with familiar charts and/or a personal visit. The responses depicted on Figure 1 are therefore generalized no go areas.

5.3 Most Suitable Areas in Minas Passage

The central, high current area of Minas Passage is generally low in fishing activity, but fishing may still occur locally depending on bottom conditions and stage of tide. Potential considerations related to fishing activity and tidal power installations are two-fold:

1. An intallation may effect the lucrative lobster fishery if an installation is located in a area important to specific fisher, and these areas may change somewhat from year to year.
2. Bottom trawling may occur in the central passage area during appropriate tidal stages because the seabed is generally free of silt and could interact with a bottom mounted installation.

The yellow area depicted in Figure 1 is the most appropriate area for a test site, but additional physical data collection will be required to determine suitability for installation to equipment and localized fishing conditions. Generally available data on mobile fishing gear from the DFO Catch and Effort monitoring system is not suitable for determining specific fishing locations for mobile gear because only generalized daily positions are recorded. Further data collection and consultation will thus be required on an ongoing basis.

The high currents within the yellow area shown on Figure 1 make it difficult to fish with traps during high tidal flow periods because even heavily weighted traps may not stay in position and can be easily lost and remain ghost fishing. But it is important to note that localized areas where outcrops or boulders reduce currents may be important to specific fishers even within the yellow area depicted. These specific areas would be of particular value to fishers and they will likely continue to be reluctant to share specific locations. In addition, the installation of a tidal generator would change localized conditions and affect bottom currents in ways that would likely make some areas more suitable for trapping and others less.

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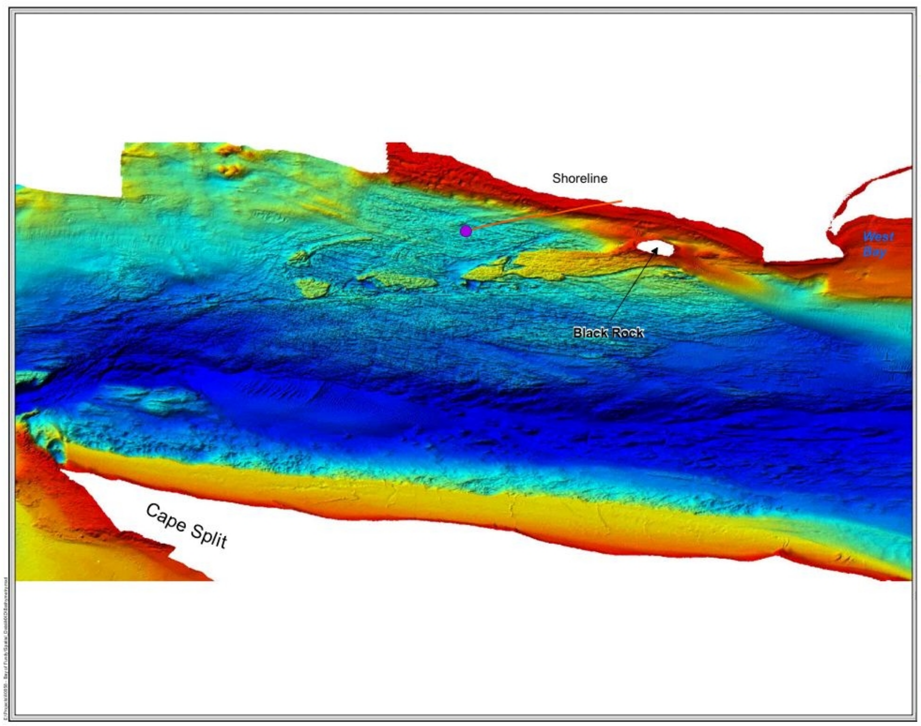
CEF Consultants Ltd.

Fisheries Landings, Value and Communities in Minas Basin

With Comments of Fish Movements



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EXECUTIVE SUMMARY

The Bay of Fundy supports a vibrant commercial fishery that is important to coastal communities around the Bay. The largest commercial fisheries are located in the Outer Bay and exploit fishes that use the Bay as a feeding ground during summer or concentrate in the region for spawning. Groundfish, including dogfish, and herring are fished throughout the Bay, including within Minas Basin. Lobster is an important commercial species in all areas. Within Minas Basin, the economic role of commercial fisheries in local communities is comparatively smaller than in the Outer Bay, but no less important at the level of the individual fisherman.

Most fisheries within the bay have long traditions, but some fisheries, such as those for dogfish, sea urchin, marine worms and some seaweeds are relatively recent. Experimental fisheries for sea cucumber have also been carried out in the outer western part of the bay (Division 4XS). Catch of some large pelagics, such as tuna and swordfish, and some sharks, such as mako and porbeagle, occur in outer parts of the bay.

Landings, value and catch and effort statistics identify catch of major species but do not define all areas important to individual fishers nor catch that may be sold or traded locally to unofficial buyers. However, available information suggests that Minas Channel, and specifically the proposed tidal test site, is an area of high tidal flow where little commercial fishing takes place. It is also a migration route used by fish, including shellfish, in their seasonal movement in and out of Minas Basin to feed or reproduce. The primary staging area prior to entry into Minas Basin through the channel appears to be south of Cape Split near Scots Bay.

Specific information on the migration patterns and vertical location in the water column of fish within Minas Basin is relatively scarce, but general patterns emerge. Most species are expected to remain in the upper water column because they have a preference for light and the high turbidity limits light penetration within Minas Basin to about 15 m (Parker et al. 2007). The large intertidal and subtidal flats of the basin support large food resources for many of these fish species, while others likely feed on eggs, larvae and juveniles of a range of species present.

Available information, including historic salmon catches and current fishing effort, suggests a staging area for many species in the Scotts Bay area prior to passage through the high currents of Minas Channel. A second staging area is likely located near the variable freshwater salt interface for those species moving upstream to spawn. Most anadromous species, with the exception of sturgeon, are most likely concentrated in the near surface water layer, while sturgeon are generally found close to bottom. Information on migration paths suggests that passage into Minas Basin, which is likely to be slower and may involve some movement in and out with the tides, is likely concentrated on the south side of Minas Channel. Migration out of Minas Basin into the Bay of Fundy is

more likely to occur on the north side and be relatively rapid, with less back and forth movement.

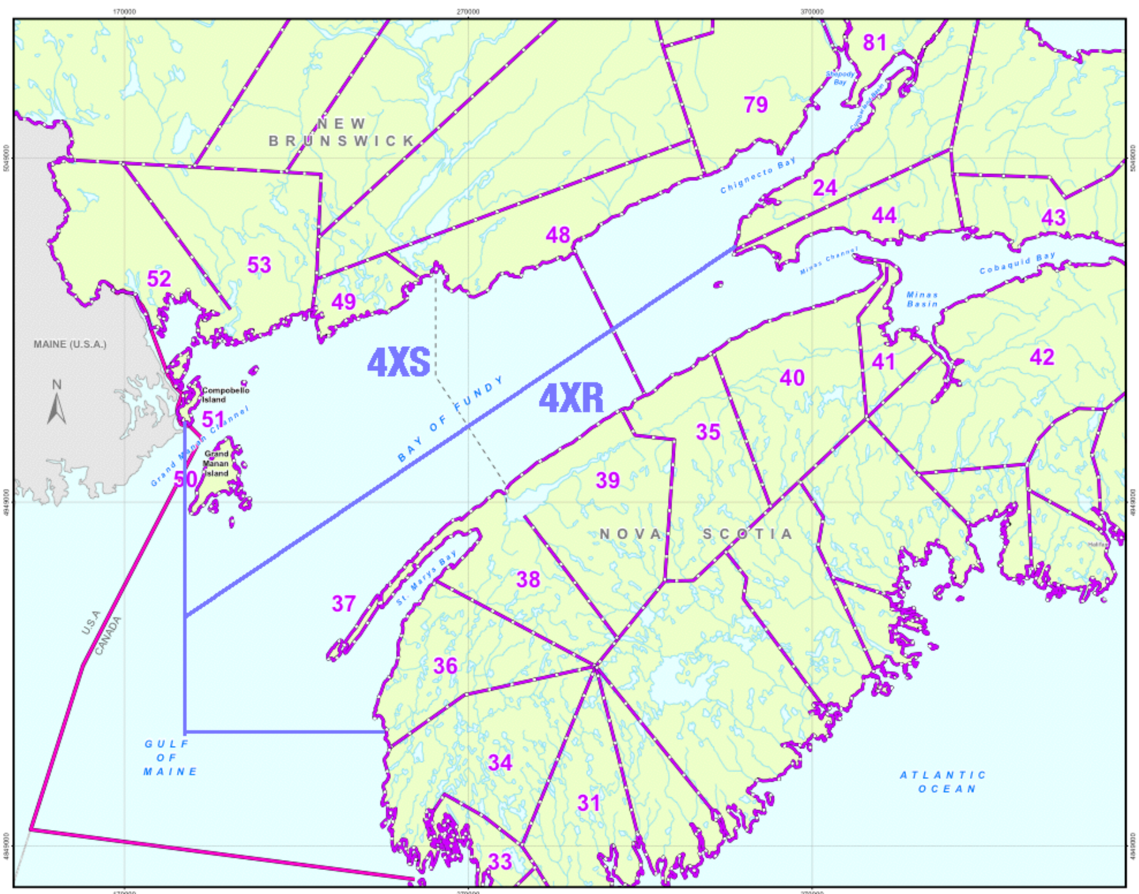
CONTENTS

TABLES

FIGURES

1 FISHERIES

The fisheries of the Bay of Fundy (DFO Unit Areas 4XR and S) were described in the recent SEA for Bay of Fundy Tidal Power (Jacques Whitford 2008). This section uses this information, augments it with recent catch, landings and value information for 2007, and provides further description of the fishing communities and socio-economic role of the fisheries in the coastal zone. In Figure 1-1 the unit areas covering the Bay of Fundy (Divisions 4XR and S) are shown in dark blue and the statistical district boundaries in purple.



Source: Adapted from JWEL (2007)

Figure 1-1: Fisheries Management Boundaries for the Bay of Fundy

The largest commercial fin fisheries are located in the Outer Bay and exploit fishes that use the Bay as a feeding ground during summer or concentrate in the region for spawning. Commercial shellfish fisheries exploit local populations mainly centered in the Bay. The Inner Bay supports smaller commercial fisheries, which tend to be fished from nearby communities, except for herring, which are fished throughout the bay by both large seiners from ports outside the inner bay or by shore-based weirs and gillnets throughout the western shore (New Brunswick) and inner bays. Inner bay fisheries comprise primarily lobster, herring and soft-shell clams, but many species in the outer bay also move in and out of the inner bays, and the inner bays may be important nursery areas for many species.

Most fisheries within the bay have long traditions, but some fisheries, such as those for dogfish, sea urchin, marine worms and some seaweeds are relatively recent. Experimental fisheries for sea cucumber have also been carried out in the outer western part of the bay (Division 4XS). Catch of some large pelagics, such as tuna and swordfish, and some sharks, such as mako and porbeagle, occur in outer parts of the bay.

1.1 Groundfishes

Approximately fourteen fish species constitute the ground or demersal fish community of the Bay of Fundy that are fished commercially. Groundfish tend to occur in the Bay during summer while migrating to and from the Scotian Shelf where spawning takes place (Mahone et al. 1984; MacDonald et al. 1984). Cod may spawn on the western side of the Outer Bay (Hunt and Neilson 1993), but more recent studies suggest that traditional spawning areas for cod, haddock and pollock in the Bay of Fundy may be no longer used (Buzetta et al. 2003).

Pollock are the most abundant semi-pelagic gadoids in the Bay. They concentrate in feeding areas with strong currents and upwelling at locations like Minas Channel, the Passamaquoddy Bay Passages and off Brier Island (Leim and Scott 1966). The Bay of Fundy pollock population is part of a trans-boundary stock that spawns in the southern Gulf of Maine during winter (Trippel and Brown 1993). Juvenile pollock, commonly called *harbor pollock,* are abundant along beaches and wharves in the summer (Rangeley and Kramer 1995).

Bottom trawling and longlining are the major gears employed in the groundfish fishery. Table 1-1 summarizes the total catch by these gears in 2007 by Unit Areas 4XR, 4Xs and 4XU, which covers catch not allocated to a specific unit area. These gears fish primarily in the outer bay but provide the best seasonal picture of the fish resources within the bay since they operate year round.

Table 1-1: Total Catch for the Bottom Trawl and Longline Fisheries in the Bay of Fundy, 2007

Unit Area	Fishing Gear	Total Catch (tonnes)
4XR	Stern Otter Trawl	1466.3
	Longline	1484.0
4XS	Stern Otter Trawl	1138.2
	Longline	70.8
4XU	Stern Otter Trawl	23.4
	Longline	622.6

Note: Division 4XU refers to catch where the unit area has not been determined and is provided as an indication of the catch not allocated to a particular unit area, which may or may not be associated with the Bay of Fundy.

Within Unit Area 4XR, which includes the eastern Bay and Minas Basin, the overall catch from otter trawlers and longliners is similar in quantity. Many of the species caught are the same, but longline catch also includes large pelagics and the majority of dogfish.

Tables 1-2 and 1-3 provide a monthly breakdown of the catch by Otter trawlers and longliners, respectively, within the eastern Bay and Minas Basin (Unit Area 4XR).

Table 1-2: Monthly Catch by Otter Trawlers by Species in Unit Area 4XR in 2007

Species	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Totals
Cod	6.19	2.52	1.44	2.20	17.68	35.12	101.87	50.52	19.88	69.36	24.73	47.15	378.66
Haddock	7.06	1.51	0.60	0.86	12.68	14.71	20.73	27.42	24.06	31.78	20.45	16.41	178.26
Redfish	5.57	10.25	4.32	0.22	6.56	16.52	10.53	2.27	4.47	12.17	4.84	4.00	81.71
Halibut	0.27	0.21	0.16	1.08	2.39	1.71	2.90	1.94	0.98	8.71	0.27	0.27	20.88
Am. plaice	0.02					2.48	13.59	9.43	0.17	0.12		0.08	25.88
Yellowtail						0.44	0.87	0.77	0.10	0.34	0.00		2.53
Wtich fl.	0.38	0.09	0.34	0.12	0.30	0.02	0.83	0.35	0.41	0.87	0.60	0.69	5.01
Winter fl.	0.42	0.32	0.24	19.49	86.24	93.96	103.01	83.71	8.61	12.18	3.27	1.34	412.78
Summer fl.							0.24						0.24
Flounder unpsp.	0.43	0.02	0.02		6.55	71.78	15.40	9.49	4.53	0.75	0.97	0.21	110.12
Skate						0.21							0.21
Dogfish							1.07						1.07
Pollock	0.87	0.59	0.51	0.20	3.04	4.03	50.49	26.48	11.82	38.58	2.24	0.94	139.79
White hake	1.08	0.30	0.43	0.19	0.27	0.64	1.98	3.14	4.39	8.39	6.25	2.63	29.69
Silver hake										1.94			1.94
Cusk			0.00			0.00		0.17	0.00	0.03	0.00	0.01	0.21
Catfish			0.00	0.01	0.11	0.32	0.04	0.18	0.10	0.03	0.02	0.00	0.81
Monkfish	0.10	0.01	0.11		0.01	0.12	0.19	0.18	0.16	0.22	0.04	0.11	1.23
Red hake	0.20									0.02			0.23
Sculpin	0.84	0.17	0.63	4.94	38.37	11.42	5.45	2.32	3.14	3.25	0.40	0.13	71.06
Groundfish Unsp.		0.00	0.01		3.07	0.42						0.04	3.54
Shark, Mako						0.14		0.13					0.27
Shark Unsp.						0.10			0.12				0.22
Total All Species													1466.34

Table 1-3: Monthly Catch by Longliners by Species in Unit Area 4XR in 2007

Species	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Totals
Cod		0.02		0.19	0.27	4.32	8.32	7.95	8.59	4.70			34.36
Haddock				0.01	0.07	0.58	1.68	2.99	5.78	5.75	0.01		16.88
Redfish									0.00				0.00
Halibut		0.15	0.56	1.64	4.43	9.61	5.13	0.54	0.95	0.17			23.18
Skate				0.04	0.02	0.01				0.16			0.23
Dogfish							187.64	596.43	375.23	188.49	21.34		1369.14
Pollock						0.15	0.11	0.01	0.48	0.03			0.78
White hake				0.36	0.02	0.24	2.04	10.92	13.50	3.17	0.01		30.26
Cusk					0.15	1.41	0.55	0.29	3.75	0.10			6.25
Catfish						0.13	0.11	0.02	0.06				0.33
Monkfish						0.01	0.02	0.05	0.10	0.00			0.18
Sculpin						0.00							0.00
Tilefish										0.05			0.05
Groundfish Unsp.									0.03				0.03
Swordfish								1.53	0.64				2.16
Albacore										0.02			0.02
Bigeye										0.00			0.00
Yellowfin										0.00			0.00
Mahi mahi										0.00			0.00
Striped bass								0.02					0.02
Mako Shark							0.09	0.01		0.00			0.10
Shark Unsp.							0.07						0.07
Fins, Unsp.						0.00							0.00
Total All Species													1484.04

Cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), and Pollock (*Pollachius virens*) are caught in both trawl and longline fisheries, whereas flounders, including Atlantic halibut (*Hippoglossus hippoglossus*), American place (*Hippoglossoides platessoides*), witch flounder (*Glyptocephalus cynoglossus*) and winter flounder (*Pseudopleuronectes americanus*), are caught primarily in the trawl fishery.

Pollock are one of few groundfish that are abundant in the Upper Bay (Jacques Whitford 2008), and accordingly pollock make up a considerably higher proportion of gillnet catch (Table 1-4).

Table 1-4: Gillnet Catch (tonnes) by Month and Species in Unit Area 4XR, 2007

Species	April	May	June	July	August	Sept.	Oct.	Totals
Cod	0.00	0.00	1.78	1.52	2.64	0.50		6.45
Haddock			0.01	0.02	0.02	0.01		0.05
Redfish				0.00	0.02	0.07		0.09
Halibut					0.01	0.01		0.02
Winter fl.	0.01			0.02				0.02
Flounder unpsp.	0.01	0.02						0.02
Dogfish			2.30	14.83	1.11			18.24
Pollock			3.13	9.67	13.06	1.09		26.95
White hake			0.17	1.17	3.99	0.62		5.95
Cusk			0.00	0.02	0.01			0.03
Catfish						0.00		0.00
Monkfish			0.03	0.04	0.02			0.09
Sculpin	0.02	0.01						0.03
Tilefish								0.00
Groundfish Unsp.								0.00
Herring							26.10	26.10
Shark, Mako				0.20				0.20
Shark Unsp.					0.28			0.28
Total All Species								84.53

Winter flounder are the most important commercial and recreational flatfish in the Bay of Fundy. They spawn inshore during spring (May) all around the Bay of Fundy, but the main stock is concentrated in St. Mary's Bay and Minas Basin in summer where they support a trawl fishery (Percy et al. 1997).

Altantic halibut are one of the most valuable groundfish and small landings of halibut are made in Statistical Districts 35, 40 and 44 along the Nova Scotia shore of the Inner Bay (Dyer et al. 2005). There is an annual migration from deep water in winter to shallow water in summer and back and an annual migration of juveniles and a few adults into the Bay of Fundy from the Scotian Shelf (Jacques Whitford 2008). Young halibut enter Minas Basin in spring where there is an angling fishery for them (Wehrell 2005).

Two species of hake are common in the Bay of Fundy; the white hake (*Urophycis tenuis*) and the silver hake (*Merluccius bilinearis*). Both are found in the Bay of Fundy, but only the white hake is captured to any extent and then only as by-catch in the groundfish fishery.

Wolffish (listed as 'catfish' in DFO statistics) have never constituted a large portion of Canadian groundfish landings, but they are caught in the Bay of Fundy. The three species of wolffish (*Anarhichas* spp.) are considered species of concern and no directed fishery occurs.

Monkfish (*Lophius americanus*) are 'anglerfish' that lie partially buried and motionless on the bottom and are well adapted to feed on flatfish. A summer migration of monkfish into the Bay of Fundy follows flounder movements. Monkfish are often stranded on the tide flats of the Upper Bay by the rapidly receding tide (Bleakney and McAllister 1973). They have become a relatively valuable commercial species in recent years and are caught predominately by trawlers.

Spiny dogfish (*Squalus acanthias*) have at times formed a large component of the commercial finfish catch within Minas Basin. Dogfish are common both on the bottom and in the water column. They are an ovoviviparous species, with the young feeding and growing off a yolk sac *in utero* before being born alive. The entire reproductive cycle takes 22 to 24 months. Sexually mature and pregnant females are distributed throughout the waters of southwest Nova Scotia and the Bay of Fundy during the summer and fall, but move offshore to deeper waters in the winter (Campana et al. 2007). Reports by fishermen and others indicate that large females are most common inshore in shallow regions such as the upper Bay of Fundy, and some fishermen report many remain throughout the winter (Campana et al. 2007).

A fishery for spingy dogfish began in 1987 and expanded during the 1990s (Percy et al. 1997). Dogfish are currently fished primarily by longliner and form the largest component of the catch for that gear. Since females are larger and more desired, the fishery is frequently carried out in the Upper Bay of Fundy (Jacques Whitford 2008).

Landings of dogfish in Minas Basin (Statistical District 40) were approximately 700 MT in both 2001 and 2002 (Dyer et al. 2005).

Gillnet catch, as presented in Table 1-4, probably provides a good indication of the seasonality and species composition of the Minas Basin finfish fishery. Note that herring are also caught by gillnets.

1.2 Pelagic Fishes

Herring (*Clupea harengus*) have traditionally been the dominant pelagic species fished commercially in the Bay of Fundy. Herring are fished by large seiners and shoreline weirs. The weir fishery is concentrated in the Outer Bay where sardine-size herring have been captured, canned and exported from Blacks Harbour for the last 120 years (Jacques Whitford 2008). The weir fishery in the Inner Bay lands sizeable catches but these are intermittent and seasonal – in 2007 only 7 tonnes were reported caught in weirs in Unit Area 4XR, which includes Minas Basin. Gillnet fisheries are concentrated along the Nova Scotia shore in the Outer Bay and in Minas Basin (Dyer et al. 2005), but catches are low compared to the mobile, purse seine fishery which lands the majority (about 98%) of the annual catches. Table 1-5 provides the monthly catch in 2007 by purse seiners in the eastern Bay of Fundy, including Minas Basin.

Table 1-5: Herring Catch (tonnes) by Purse Seiners by month in Unit Area 4XR in 2007

Jan.	May	June	July	August	Sept.	Oct.	Totals
83.00	1.00	524.35	3417.14	3935.63	222.00	105.00	8288.12

Gillnet catches (see Table 1-4) of herring only comprised 26.1 tonnes compared to the over 8000 tonnes landed by purse seiners.

Minas Basin herring are a unique population with the Bay of Fundy. Most the Bay herring are fall spawners, but Minas Basin supports a local spring spawning component, which feds intensively during gonad maturation up to and including spawning (Bradford and Iles 1992). Spawning areas tend to be at depths less than 5 m in areas of coarse substrate and algae (Stewart and Arnold 1994), with spawning from Scots Bay east through the Minas Channel to the Central Minas Basin.

Until recently, Porbeagle shark (*Lamna nasus*) were exploited by a directed, gillnet fishery in the Outer Bay of Fundy (Campana et al. 2002). In 2004, porbeagle sharks were designated as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Catch quotas for the Porbeagle have been reduced, but the population is now considered able to recover providing the human-induced mortality is kept below about 185 tonnes per year (DFO 2005). In 2008 large numbers of breeding

Porgeagle were found on Georges Bank, suggesting this is an important breeding area (Campana 2008).

Bluefin tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*) are landed in Bay of Fundy ports but very little of these catches come from the Bay of Fundy. Tuna have become a highly valued catch since air shipments to Japan began during the 1980s (Percy et al. 1997). There is a fishery for tuna on the Scotian Shelf and many of these are landed in Yarmouth (Statistical District 34). Swordfish are only captured around the edges of the Scotian Shelf mostly over great depth (Scott and Scott 1988) and some of these are landed in Fundy ports.

1.3 Diadromous Fishes

Apart from gaspereau and eel, diadromous species are primarily fished recreationally.

Atlantic salmon (*Salmo salar*) were once the premier commercial and recreational fish of the Bay of Fundy. This species spawns in freshwater streams where they bury their eggs in gravel during the late fall. The eggs hatch in April and the alevins remain in the gravel for six weeks feeding off their yolk sac and then emerge as parr. The parr remain in freshwater for one to three years before migrating to sea as smolts at a size of 13-16 cm Atlantic salmon grow and mature while migrating around the North Atlantic and then return to their natal rivers to spawn (Scott and Scott 1988). Most inner Bay of Fundy salmon are thought to remain within the Bay of Fundy and Gulf of Maine throughout their life cycle (DFO 2008a).

The commercial fishery for salmon was closed permanently in 1984 and in 2001 the Inner Bay of Fundy stocks were declared Endangered by COSEWIC (DFO 2004). The opinion of the iBoF Working Group is that in 2003 there were less than 100 wild anadromous adult breeders spread across all the rivers in the inner Bay of Fundy, with 50-75 being the most likely and 200 being an upper estimate (COSEWIC 2006). Atlantic salmon aquaculture in the outer Bay of Fundy, however, provides a major industrial base to areas such as Grand Manan Island.

Sturgeons (*Acipenser* spp.) are primarily sought as a source of caviar. Atlantic sturgeon (*Acipenser oxyrhynchus*) spawn in fresh water, but spend most of their adult life in the marine environment. Spawning adults migrate upriver in May-July in Canadian waters (NMFS 1998). In some areas, a small spawning migration also occurs in the fall. Atlantic sturgeon probably do not spawn every year, though data on spawning intervals do not exist for most populations. Spawning occurs in flowing water upstream of the salt front in large rivers. Sturgeon eggs, which are highly adhesive, are deposited on the bottom, usually on hard surfaces, such as cobble (Smith and Clugston 1997). Hatching occurs in 4 to 6 days and the yolksac is absorbed in about 10 days, after which the young assume a demersal existence. Juvenile sturgeon are thought to gradually move downstream into brackish waters, and remain resident in estuarine waters for months or years. Upon reaching a size of approximately 76-92 cm, the subadults may move to coastal waters (Murawski and Pacheco 1977) where they may undertake long range migrations.

Sturgeon are captured in drags and intertidal weirs in the Bay of Fundy and by gillnet in the rivers and estuaries (Leim and Scott 1966). Annual catches in Minas Basin can amount to 100 sturgeon a year in some weirs and daily trawler catches may reach 20-30 individuals (Jacques Whitford 2008). Since 2002 DFO has prohibited the take of sturgeon in the Maritimes in coastal weirs and as by-catch in the trawler fishery. Recent estimates suggest the population of sturgeon in the upper Bay of Fundy may be around 10,000 fish (Redden, pers. comm.).

The American eel (*Anguilla rostrata*) is a catadromous fish that lives and grows in estuarine or freshwater but returns to the ocean east of the Bahamas to spawn. Eels are fished commercially, but landings are low and may be inaccurate. A small recreational fishery with a daily bag limit of 10 exists in some areas.

American shad (*Alosa sapidissima*) are abundant in the Bay of Fundy. Fish that spawn in the Bay's rivers mix with migrants from other stocks that spawn further south along the US seaboard. Most major rivers of the Bay of Fundy support spawning populations. Spawning migrations begin in April with eggs laid above the head of tide in June and spent adults moving downstream in July. Juveniles migrate seaward during September and October at a size of 80- 110 mm and the adults return to their natal river in four to five yrs at a size of 40-50 cm (Jacques Whitford 2008).

American shad are caught both commercially and recreationally in estuaries and rivers during their migration upstream in spring to spawn. Shad are caught in weirs, traps, gillnets, scoop nets and by rod and line. The largest commercial fishery in the Nova Scotia waters of the Bay of Fundy is in the Shubenacadie River (Dyer et al. 2005). Recreational fisheries are primarily on the Annapolis and Shubenacadie Rivers (Jacques Whitford 2008).

Minas Basin has been the location of commercial shad fisheries for three centuries (Dadswell et al. 1984a). The fishery was pursued with intertidal weirs, fixed gillnets and drift gillnets. After 1990, however, restrictive management to protect the endangered Bay of Fundy Atlantic salmon were a factor in lower catches. The fixed and drift gillnet fisheries have been restricted by season length and many licenses were bought back because of the by-catch of Atlantic salmon in that particular fishery. The weir fishery has been forced to decrease weir height.

The gaspereau fishery exploits two species of river herring; the alewife (*Alosa pseudoharengus*) and the blueback herring (*Alosa aestivalis*). The proportion of these species varies between river systems, with gaspereau making up most of the fish in the

Black River system and both species comprising the run in the Avon River system (McIntyre et al. 2007). The gaspereau resource is exploited in freshwater using trap nets, scoop nets, gill nets and by angling. The major commercial fisheries around the Bay of Fundy are in the Saint John, the Shubenacadie, the Gaspereau, and rivers along southwest Nova Scotia around Yarmouth. The Black River system is the closest to the proposed tidal site and there are 18 fishermen with commercial gaspereau licenses on this river; 16 square net licenses, 1 set gillnet license, and 1 drift net license. Between about 200,000 and 400,000 fish were taken in the commercial fishery annually between 2002 and 2006. The fishing season begins on March 15^{th} and closes May 30^{th} (McIntyre et al. 2007).

There are small, recreational fisheries in many Bay of Fundy rivers. Most angled gaspereau are taken by jigging. The daily bag limit was set at 20 in 2002 and the season is from March to May.

Rainbow smelt (*Osmerus mordax*) are abundant throughout the Bay of Fundy. Smelt migrate up virtually every brook, stream and river to spawn in early spring (April to May). Bay of Fundy rainbow smelt are harvested recreationally during their spawning runs by dip netting and angling (Percy et al. 1997).

Striped bass (*Morone saxatilis*) are found throughout the Bay of Fundy but are most common in Minas Basin and Saint John, Annapolis, and Shubenacadie River estuaries. Bass spawn in the upper, tidal reaches of larger rivers and in freshwater. Juveniles remain in the estuary for their first year and then move progressively seaward (Leim and Scott 1966). Similar to shad, bass that spawn in the Bay's rivers and lakes also mix in the Bay with migrants from other stocks that spawn further south along the US seaboard (Jacques Whitford 2008).

The Shubenacadie/Stewiacke Rivers support the only current, sizeable, local spawning population of striped bass. Sport fishery data suggest that a decline in striped bass abundance occurred in the Shubenacadie River between 1950 and 1975, but that the numbers subsequently remained relatively stable (Jessop 1991). In 2002, the Shubenacadie River population totalled between 18,000 and 27,000, at least 15,000 of which were of minimum reproductive age (3 years or more) and at least 7,000 of which were 4 years and over. Although the Shubenacadie population appeared stable in 2004, the Bay of Fundy striped bass as a group were classified as threatened in 2004 (COSEWIC 2004).

Angling for striped bass in the Bay of Fundy is concentrated in the Saint John estuary, Minas Basin and tributaries, Annapolis Basin and tributaries and estuaries around Yarmouth (Leim and Scott 1966; Dyer et. al. 2005). Anglers may take only one fish/day and it must be larger than 62.5 cm.

1.4 Invertebrate Fisheries

Fifteen species of invertebrates contribute to Bay of Fundy fisheries. In recent years, invertebrate fisheries have surpassed finfish in landed value. Unlike many of the commercial fish species, the invertebrate fisheries are mostly based on populations that reside and reproduce in the Bay of Fundy.

1.4.1 Crustaceans

American lobster (*Homarus americanus*) is fished commercially in all parts of the Bay of Fundy except extremely turbid waters. The American lobster is a relatively fast growing crustacean that attains maturity at between 5 and 10 years of age (Cobb 1976), but lobster from the Bay of Fundy are slower growing than those found in other regions of the Maritimes because of the relatively cold water in most of the bay.

Lobsters are fished with baited traps using small to medium sized vessels (10 - 20 m in length) because much of the fishery is in relatively shallow water (<20 m). Fresh or frozen fish, frequently mackerel or gaspereau, is generally used for bait and much of this is caught locally. Regulatory controls include a limit on trap number/fisher (usually around 300-375), size of trap opening, minimum size limits (carapace length), and seasons. Most of the Bay of Fundy is limited to a season from late November to July with some winter restrictions. In Minas Basin (LFA 35), the season is open from October 14 to December 31 and again from the last day of February to July 31 (Variation Order 2005-115). Carapace length limits are set for different lobster districts and minimum retention size in the Bay of Fundy is 82.5 mm carapace length.

Landings increased during the 1980s and continued to increase during the 1990s (Dyer et al. 2005). Landings from the Nova Scotia shore of the Outer Bay of Fundy, which produces approximately 90% of the catch, increased 36% between 1990 and 2006, and landings along the New Brunswick shore of the Bay increased by 300%. Reported lobster landings from Minas Basin Statistical Districts 41 to 44 doubled from 110 tonnes in 2004 to approximately 220 tonnes in 2006 and 2007. Prospects look promising for continued good recruitment to the fishery (Robichaud and Pezzack 2007).

Jonah (*Cancer borealis*) and rock (*Cancer irroratus*) crab are medium-sized crustaceans that occur over rocky/gravel bottom substrates along with American lobster. They have a life history similar to lobster; Jonah crabs are the larger species, maturing at a size of 80-100 mm carapace width. Jonah and rock crabs have been landed as a by-catch of the lobster fishery since the 1960s but directed fisheries began in the Bay of Fundy starting in 1995 (Robichaud and Lawton 1996). After 10 years as an exploratory fishery, a commercial fishery began in 2004.

The fishery for Jonah crab is located in 50-300 m depths south of Grand Manan and on the Middle Ground off Yarmouth (Robichaud and Frail 2006). Rock crab is mainly caught in St. Mary's Bay, Annapolis Basin and Passamaquoddy Bay in depths less than 50 m. Both fisheries are managed with license limits (4-10 in each lobster fishing district), trap limits (100-300), seasons (outside the lobster fishing season), and size limits (Jonah crab, 130 mm carapace width; rock crab, 102 mm carapace width). The fisheries are concentrated almost exclusively on males. Crabs are landed almost entirely in the outer Bay of Fundy in Statistical Districts 37 and 38.

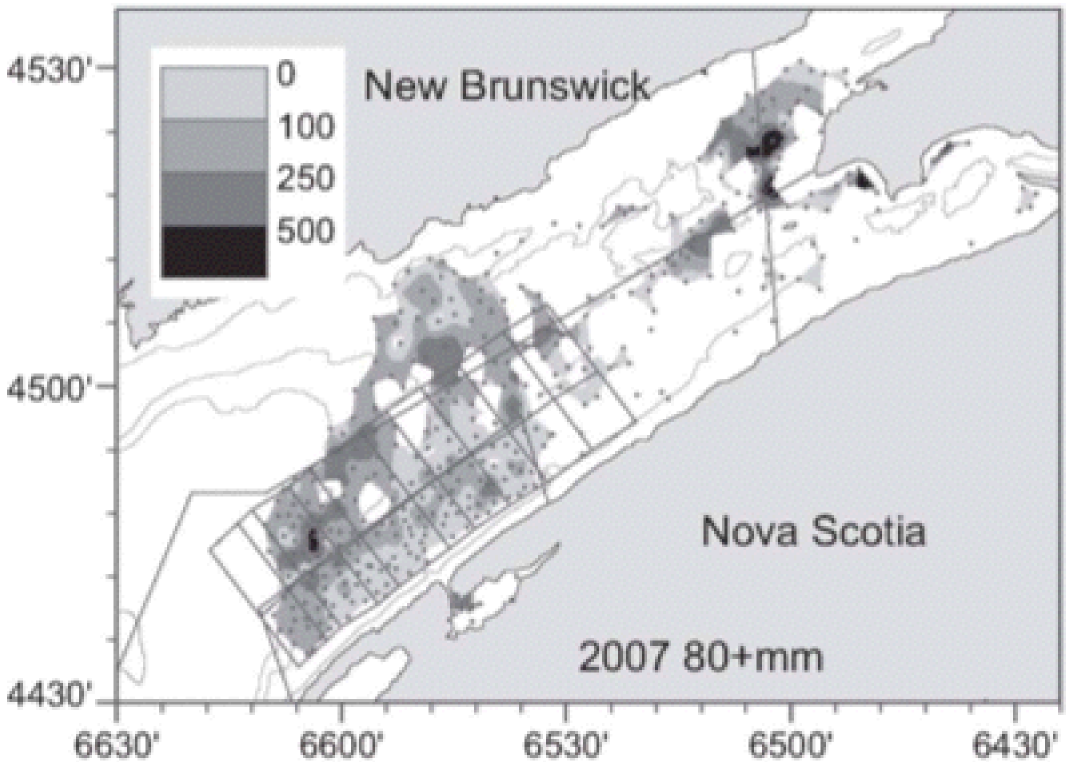
1.4.2 Molluscs

Sea scallop (*Placopecten magellanicus*) are fished commercially in all regions of the Bay of Fundy except the extremely turbid Cobequid Bay and Cumberland Basin (Jacques Whitford 2008). The largest commercial fishery occurs immediately off Digby with lesser beds in Scott's Bay, around Ile Haute and off Lurcher Shoal. Catch from the scallop dragger fleet from the eastern Bay of Fundy (Unit Area 4XR) is provided in Table 1-6 for 2007. Note that monkfish are also caught by drags.

Table 1-6: Catch (tonnes) by Scallop Draggers in the Unit Area 4XR by Month in 2007

Species	**January**	**February**	**March**	**April**	**May**	**June**	**July**
Monkfish						0.02	0.10
Sea scallop	225.84	146.78	258.67	281.57	348.08	123.09	135.02
Species	**August**	**September**	**October**	**November**	**December**	**Totals**	
Monkfish	0.02	0.07	1.13	0.32		1.66	
Sea scallop	106.83	126.65	416.01	61.86	12.98	2243.38	

The scallop fishery in the Bay of Fundy involves 3 fleets: the All-Bay fleet, the Upper-Bay fleet and the Mid-Bay fleet. The All-Bay fleet has access to the entire Bay, the Upper-Bay fleet may not fish seaward of a line from across the Bay through Ile Haute and the Mid-Bay fleet may not fish south of a mid-Bay line running down the Bay from Advocate Head. The Bay of Fundy is divided into Scallop Production Areas (SPAs) and each Area has a quota that is divided among the various fleets, with the upper bay fleet having a Total Allowable Catch (TAC) of 80 tonnes (Smith et al. 2008). The fishery is also managed by gear restrictions including maximum drag width (5.5 m), ring size (82 mm inside diameter) and a minimum body size (80 mm SH). Figure 1-2 shows the distribution of commercial size scallops from survey tows carried out by DFO in 2007.



Source: Campana et al. (2007)

Figure 1-2: Distribution of Commercial Size Scallops from DFO Surveys in 2007

There is also a recreational, scuba diving fishery for scallop in the Bay of Fundy. The fishery is restricted by season, possession limit and minimum size. The diving season is from January 1 to April 30, maximum possession is fifty scallops and minimum size is 100 mm shell height. There are no statistics on the annual landings from this fishery.

Soft-shell clam (*Mya arenaria*) is abundant in the soft sediment intertidal flats of mud, sand, or gravel in the inner Bay of Fundy. Clams are harvested commercially and recreationally by digging the intertidal flats with a shovel or clam hack (rake). Licensed commercial diggers average 25-50 kg per tidal cycle. Recreational fishers are restricted to 100 clams/day (DFO 1996).

There are four regions in the Bay of Fundy that support commercial clam fisheries: Charlotte Co. in SW New Brunswick; the north shore of Minas Basin (notably Five Islands); Annapolis Basin; and around Yarmouth Nova Scotia. Commercial landings have been monitored for more than 100 years and exhibit cyclic peaks, which are related to both environmental and social factors, but overall landings have been declining since 1950 (Robinson 1995). The clam fishery in SD 43 along the northern shore of Minas

Basin mirrors these long-term changes (Dyer et al. 2005), and between 2004 and 2007 clam landings ranged from 18 to 76 tonnes.

A periwinkle (*Littorina littorea*) fishery is restricted to the lower Bay of Fundy and concentrated mostly around Grand Manan in New Brunswick and Digby Co. in Nova Scotia (Jacques Whitford 2008).

Two species of squid occur in the Bay of Fundy, the short-fin squid (*Illex illecebrosus*) and the long-fin squid (*Loligo pealei*). Squid are sometimes abundant in nearshore waters and caught primarily for bait, but squid have been relatively scarce in recent years.

1.4.3 Echinoderms

The green sea urchin (*Strongylocentrotus droebachiensis*) is a spiny, egg-shaped echinoderm that feeds on benthic algae and macro-algae in relatively shallow water (0-30 m). Urchins have a natural pathogen, *Paramoeba invadens,* which causes mass mortalities when water temperature stay warm for a prolonged period. Lower average sea temperatures in the Bay of Fundy have tended to limit the spread of this disease (Jacques Whitford 2008).

The Nova Scotia fishery for sea urchin extends from Digby County into Minas Channel. Landings were low on the Nova Scotia shore until 1999. The fishery operates primarily during the cold months of the year, with landings in 2007 reported from September until April (Table 1-7). Landings were primarily in Statistical Districts 37 (80 tonnes) and 38 (65 tonnes) in 2007. No landings were reported within Minas Basin Statistical Districts 41 to 44 in recent years.

Table 1-7: Diver Catch (tonnes) of Sea Urchin from Unit Area 4XR by Month for 2007

Jan.	Feb.	March	April	Sept.	Oct.	Nov.	Dec.	Totals
31.41	27.88	45.96	6.36	21.43	22.03	12.38	19.74	187.19

Orange-foot Sea Cucumber (*Cucumaria frondosa*) occurs on hard substrate bottoms of the Bay of Fundy at depths of 5-100 m. An exploratory fishery occurs only in the outer bay.

1.4.4 Marine Worms

Three species of marine worms, which burrow into the intertidal mud and sand flats, are harvested in the Bay of Fundy: bloodworm (*Glycera dibranchiata*), sandworm (*Nereis virens*), and clamworm (*Nereis sp*.).

Licenses in the Parrsboro district (44) have risen from 8 in 2002 to 61 in 2004. Total licenses for 2004 in the Upper Bay of Fundy (Statistical Districts 40-44, 24, 79 and 81) were 183 (Dyer et al. 2005).

1.4.5 Marine Plants

Seaweeds, including dulse, Irish moss and rockweed, are harvested primarily in the outer bay. Dulse does occur along the shoreline of outer Minas basin near Parrsboro (Parker et al. 2007).

Seaweeds are uncommon in the inner and upper Bay of Fundy because ice scour during winter limits the growth of intertidal seaweed.

2 FISHING COMMUNITIES

In 1986 DFO published socio-economic profiles of 112 fishing communities within the Scotia Fundy Region (Raymond 1986). Information was compiled from Statistics Canada's Census and Administrative Data Development Division, data gathered by a Department of Fisheries and Oceans survey of fishing communities, and other unpublished material collected by the Licensing Unit, Statistics Division and Economic Development Division of the Department of Fisheries and Oceans Scotia-Fundy Region. All data were for 1983 with the exception of those from the 1981 Census of Canada.

This compendium provides information on population, characteristics of the fishery, education levels, sources of employment and income. It provides a relatively unique set of data that is useful to characterize the communities historically and provides helpful comparison for current fisheries information on landings, numbers of fishing vessels and licences. A summary of background socio-economic information from this compendium is provided in Table 2-1.

Table 2-1: Numbers of Fishermen (1983) and Socio-economic Characteristics (1981) for Selected Fishing Communities in the Bay of Fundy

Community	Statistical District	Population (1981)	Number of Fishermen (1983)	Percent Working in Primary Industry	Percent of Provincial Family Income (1981)
Westport	37	356	74	35%	79%
Freeport		458	80	26%	87%
Tiverton		374	52	28%	80%
Little River		449	80	37%	102%
Sandy Cove/Centreville		549	89	31%	56%
Digby	38	2764	230	12%	89%
Victoria Beach/Hillsburn/Granville Ferry	39	2903	173	18%	92%
Port Lorne/Hampton	35	399	26	29%	62%
Margaretsville		207	14	20%	80%
Scots Bay	40	183	25	56%	74%
Gaspereau	41	677	50	18%	70%
Economy	43	472	30	15%	63%
Five Islands		473	8	18%	65%
Parrsboro	44	1799	18	8%	77%
Advocate Harbour		377	37	50%	74%
Joggins	24	592	15	8%	76%
Alma	79	329	14	0%	86%
Mispec	48	180	11		
Lorneville	49		9		
Chance Harbour/Lepreau		840	70	10%	105%
Seeleys Cove	53	162	14	9%	110%
Beaver Harbour		316	19	4%	105%
Blacks Harbour		1356	3	2%	99%

Note: Communities and Statistical Districts shaded in gray are generally within Minas Basin. Source: Raymond (1986)

In the compilation of community characteristics reported by Raymond (1986), the geographic area aggregated to represent a community or group of communities differed from community to community. In some cases the aggregation was required to allow information to be presented in a way that respected individual confidentiality with respect to catch and incomes. In others it was related to availability of information from Statistics Canada. For example, the grouping of the communities of Victoria Beach/Hillsburn and Granville Ferry produced an aggregate population larger than the community of Digby.

Regardless of the inconsistencies between community groupings, the community profiles provided by Raymond (1986) help characterize the role of fishing within various communities surrounding the Bay of Fundy.

Within the coastal communities along the Bay of Fundy, including Statistical Districts 37 to 53, fishermen make up approximately 7% of the population (Table 2-1). The proportion is somewhat lower within communities bordering Minas Basin (excluding Parrsboro) at about 5%. The proportion of the population working in primary industry, which includes fishing, is highly variable and is not highly correlated with location or size of community. The relatively prosperity (based on family income) among these communities is also highly variable and not well correlated to location or population size. Family income within the coastal communities around Minas Basin tend to be lower than the provincial average, but fall within the range of other coastal communities around the Bay of Fundy.

Table 2-2 provides the 2007 landed value from fisheries in Statistical Districts around the Bay of Fundy, from Digby Neck in Nova Scotia to St. Andrews in New Brunswick. The landed value is similar to that provided by Raymond (1986) by community when the value is adjusted for commodity value increases from 1981 to 2007[1]. The number of licences was also similar over the time period, although changes in types of licences (e.g., groundfish or lobster) changed between communities and the number of groundfish licences tended to decrease. The largest concentration of landed value occurs in the Digby and Digby Neck area.

Statistical Districts 41 to 44 cover Minas Basis, with District 44 extending as far as Cape Chignecto and including Parrsboro and Advocate Harbour. The landed value in the Statistical Districts entirely within Minas Basin (41 to 43) are considerably lower than most other Bay of Fundy districts, but similar to those within Chignecto Bay (Table 2-2). Two factors contribute to this difference in landed value. One is that the inner portions of both Minas Basin and Chignecto Bay tend to have a different species assemblages. Dadswell et al (1984) reported that the inner portions of Minas Basin and Cobequid Bay have lower salinities and the fauna reflect an estuarine-mudflat group of juvenile and adult tomcod, smelt, silversides and smooth flounder. Fauna in the other reaches reflect a oceanic-sand beach group of juvenile herring, white hake, winter flounder and adult and juvenile three-spine sticklebacks. The other difference is the extreme tidal range in the inner bay that makes it more difficult to moor fishing vessels.

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[1] The relative value of the US dollar increased from 1981 to 2007 by a factor of 2.37 based on the Consumer Price Index to 4.57 based on the Relative Share of GDP.

Table 2-2: Value ($,000) of Landings from Statistical Districts Around the Bay of Fundy, 2007

Statistical District	Value ($,000)	Location and Community Comments
37	$16,179	Digby Neck, Westport to Sandy Cove, NS
38	$12,999	Outer Eastern Bay of Fundy, Digby, NS
39	$3,903	Eastern Bay of Fundy, Annapolis Co. to Hampton, including Granville Ferry
35	$1,041	Eastern Bay of Fundy, Hampton to Kings Co. boundary, including Port Lorne
40	$2,636	Eastern Bay of Fundy, Kings Co. to Cape Split, including Scots Bay
41	$880	South Side of Minas Basin, Kings Co. to Cape Split, including the Gaspereau River
42	$91	South Side of Minas Basin, Colchester Co.
43	$579	North Shore of Minas Basin to Cumberland Co. boundary, includes Five Islands
44	$2,657	Minas Basin but extending to Cape Chignecto, including Parrsboro and Advocate Harbour
24	$629	Nova Scotia side of Chignecto Bay
81	$121	Upper Chignecto Bay, including Sackville, NB
79	$2,878	Western Side of Chignecto Bay
48	$2,377	Western Side of Bay of Fundy to Saint John, NB
49	$3,882	Outer Western Bay of Fundy, Lorneville to Chance Harbour, NB
53	$9,009	Outer Western Bay of Fundy, Seeleys Cove to Blacks Harbour, NB
52	$1,404	Outer Western Bay of Fundy, Back Bay and St. Andrews, NB

Source: DFO Statistical Tables 30 and 31 for 2007.

The landings for the statistical districts around the Bay of Fundy are presented in Table 2-3 by major species or species groups. These landings reflect the general distribution of fish within the Bay of Fundy for most shellfish species, but not necessarily for finfish, particularly herring. Groundfish tend to be landed on the Nova Scotia side of the Bay, while herring are landed on the New Brunswick side. Major groundfish landings occur as far into the Bay as District 40, in ports like Halls Harbour and Scots Bay.

Within Minas Basin (Statistical Districts 41 to 44) landings of groundfish are concentrated in Statistical District 41. A comparison of landings from 2004 to 2007 (DFO Statistical Tables 30 and 31) indicate a similar catch composition, with the addition of large numbers of dogfish in 2004 to the total groundfish catch in Districts 41(73 tonnes) and 42 (153 tonnes). Catch of gaspereau, generally a commercial species in the Gaspereau and Shubenacadie Rivers, was not specified by species in landings reports, but is assumed to have been a major portion of the unidentified species reported within Districts 41 and 42 in 2004 to 2006, but absent in 2007. Catch of shellfish, including lobster, soft-shelled clam and scallop, were relatively consistent within the Statistical Districts of Minas Basin from 2004 to 2007.

Table 2-3: Landings (tonnes) of Major Species or Species Groups from Statistical Districts Around the Bay of Fundy, 2007

Statistical District	Groundfish	Herring	Total Finfish	Lobster	Crab	Clams	Scallop	Total Shellfish
37	1589		1681	969	33		202	1511
38	1651		1800	4251	27	16	3932	4433
39	3		5	265		43	119	438
35	53			82				86
40	1224		1228	157			145	303
41	58		58	57				58
42	0		0					
43						75		109
44	0			158			470	638
24			3	35		1	107	
81			2					8
79				181			212	418
48			0	172			67	275
49	1		1	242			261	654
53	0	22375	31499	213		29	60	589
52	7			66		80	32	304

Note: A landed weight of zero indicates a landed weight of less than 500 kg. Source: DFO Statistical Tables 30 and 31 for 2007.

2.1 First Nations and Native Fisheries

Within Nova Scotia and New Brunswick, 17 First Nation communities have access to commercial fisheries in the Bay of Fundy and its approaches. In addition to the First Nations who are adjacent to the Bay of Fundy, bands from Cape Breton Island and northwestern New Brunswick have fishery access in the Bay. All five First Nation communities in Cape Breton have fishing access to scallops and/or groundfish. A number of New Brunswick First Nations that are located inland have been provided with their commercial fishery access on Grand Manan Island or from mainland ports on the Bay of Fundy (TriNav Fisheries Consultants, 2007). In addition to First Nations, natives not considered to belong to First Nation bands have commercial fishing licences in a number of areas.

Three First Nation Bands fish regularly in the upper Bay of Fundy. The Annapolis First Nation, located in Cambridge, Kings County, fishes two LFA 35 lobster licences based out of Digby and Harbourville and one scallop licence based out of Digby. Milbrook First Nation fishes four LFA 35 lobster licences from Digby and one from Joggins or Digby, as well as two scallop licences out of Digby. Fort Folly First Nation, located outside

Dorchester, NB, has two LFA lobster licences fishing out of Parrsboro. First Nations and other natives are also allowed to fish for food and ceremonial purposes.

2.2 Recreational Fisheries

Detailed recreational fisheries catch is not available by geographic locations. Most recreational catch is reported at the county level. Sporatic recreational fishing for groundfish occurs within Minas Basin and Minas Channel, but it is not likely to occur near proposed tidal test facilities because of the high currents in the area.

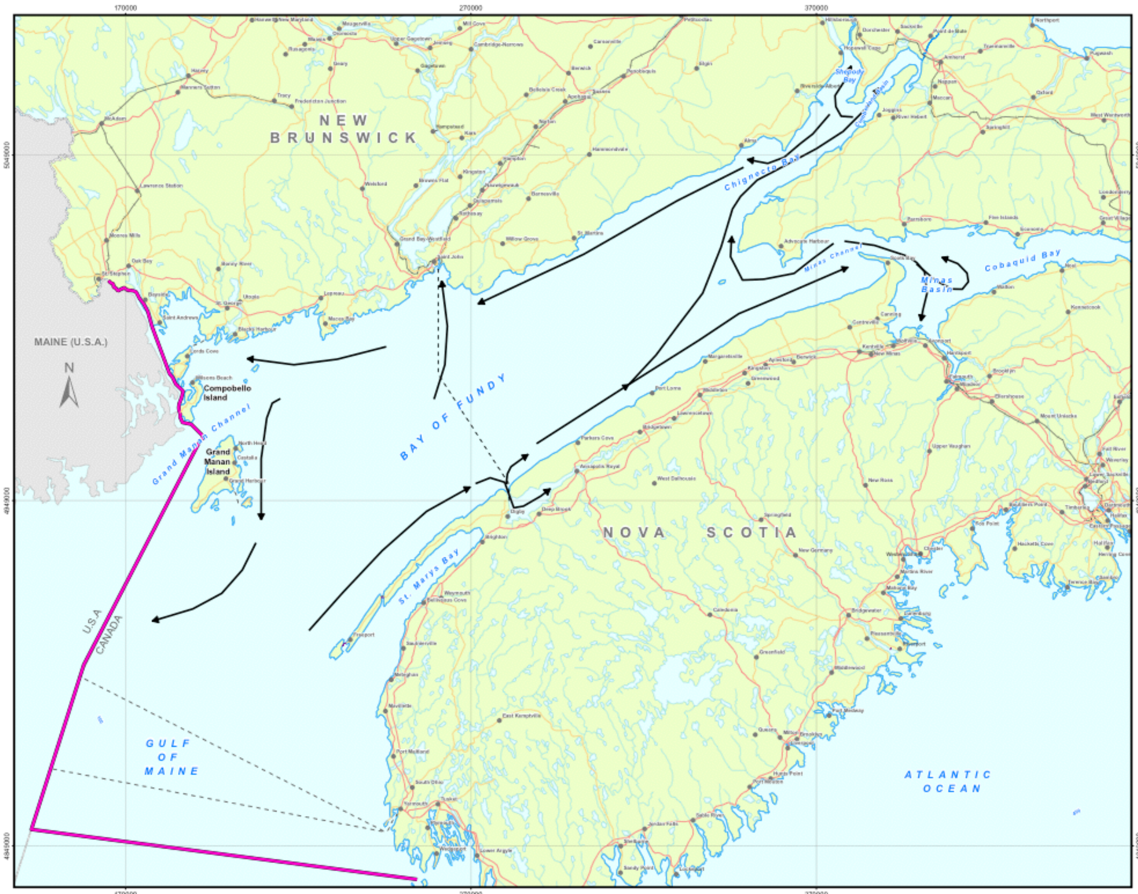
3 Fish Movements within Minas Basin

This section focuses on the migrations and movements of major species within Minas Basin. The emphasis is on the movement of adult fish present in Minas Basin either to feed or to spawn.

Information on fish movements within the Bay of Fundy are drawn primarily from Parker et al. (2007) and Jacques Whitford (2008). Additional information on estuarine migration and behaviour of species similar to those found in the Bay of Fundy is drawn primarily from Jacobson et al. (2004), which describes research on the Lower Connecticut River between 1973 and 2003.

For anadromous species, such as Atlantic salmon, shad, striped bass, gaspereau and sturgeon, the homing instinct to spawn provides strong motivation for behaviour (Hasler 1967). Water velocity is one of the primary cues in spawning migrations, but chemical characteristics of the water are thought to modify the specific response to water velocities (Stasko et al. 1973). For example, transition from salt to freshwater requires change in osmotic regulation within the fish, which usually requires the fish to stage near the transition between saltwater and fresh. Frequently a group of migrating fish may contain a mix of spawning and feeding fish, with only some of the fish entering freshwater to spawn.

The general movement of anadromous fish within the Bay of Fundy appears to follow that illustrated for shad in Figure 3-1. Fish tend to enter Minas Basin on the south and leave along the north, responding to velocity patterns established by Coriolis force. Where acoustic telemetry of fish has tracked movements in estuaries, movement is generally influenced by tide and wind conditions, with considerable movement back and forth with tidal changes (Stasko et al. 1973; Leggett 2004).



Source: Jacques Whitford (2008)

Figure 3-1: Typical Shad Migration Patterns In and Out of the Bay of Fundy

3.1 Atlantic Salmon

Of the salmon stocks within Minas Basin, only the Gaspeau River has an early run of predominantly 2 sea winter fish (Parker et al. 2007). Salmon, as well as other species may 'stage' along the Scotts Bay shore south of Cape Split before entering Minas Basin (Parker et al. 2007). A science review of potential impacts of small-scale tidal generation projects in the Bay of Fundy felt that salmon were most likely to be found in the near surface waters based on available information, but agreed that vertical distribution of salmon in the water column was not well-documented (DFO 2008b).

3.2 American Shad

Most shad found in Minas Basin in the summer spawn in US rivers to the south, but local spawning runs begin in April in most Bay of Fundy rivers; spawning occurs during June and spent adults migrate downstream in July (Jacques Whitford 2008).

Between 1967 and 1969, 230 shad were fitted with ultrasonic tags in the Lower Connecticut River. Migration upriver ranged from on average of 20 km per day immediately following tagging to 27.2 km per day for subsequently tracked shad. Corresponding rates for downriver migrations were 33 and 21.5 km per day. Migration rates were reduced in the area of the salt-freshwater inteface. Fish in the estuary tended to meander near the salt-freshwater interface, moving upstream and downstream for days. This was assumed to reflect adjustment in osmotic regulation before entering freshwater (Leggett 2004).

Studies on shad in the lower Connecticut River from 1974 to 1987 indicate that recruitment appeared to be established by the end of the larval period. Populations of striped bass, shad and blueback herring also occur in the lower Connecticut River. Analysis of data on fishing rates, environmental conditions and fish abundance led to the conclusion that reduced abundance of shad and blueback herring was likely related to predation by an increased population of striped bass, based on food habitats and size frequency of striped bass and changes in abundance of the three species (Savoy and Crecco 2004).

3.3 Striped Bass

The Shubenacadie River supports the only remaining spawning population of striped bass (*Morone saxatilis*) in the Bay of Fundy. No evidence of reproduction has been recorded in previously existing spawning populations of striped bass in the Annapolis or Saint John Rivers for about 30 years.

Striped bass were tracked using acoustic telemetry in the Miramichi River estuary during two consecutive spawning seasons in 2004 and 2005. In both years, prespawning striped bass staged in the lower and middle sections of the Miramichi River estuary downstream from the spawning area. Males and females moved in synchrony from the staging area to the spawning grounds in the Northwest Miramichi River (Douglas et al. 2009).

3.4 Sturgeon

Both Atlantic and shortnose sturgeon are found in the Bay of Fundy, but only Atlantic sturgeon are considered common within Minas Basin.

Atlantic sturgeon are found in the estuary of the Connecticut River and these fish are thought to spawn in the Hudson River and enter the Connecticut River estuary to feed. Shortnose sturgeon, however, are relatively abundant in much of the lower Connecticut system (Gephard and McMenemy 2004).

Sixty shortnose sturgeon had ultrasonic tags surgically implanted from 1988 through 2000, with 45 of these providing useful long-term (>60 days) information. Several transmitters provided information over two or more consecutive spring seasons. Sturgeon movements downriver into the estuary were rapid and directed with individual fish moving up to 30 km per day. Once in saline waters, however, movements were much slower. Adult shortnose sturgeon can tolerate both high salinities and rapid changes in salinity. In contrast to behaviour seen in other river systems, the most adult fish were found in upriver areas well above any influence of salt water during the winter months (Savoy 2004). Sturgeon in the estuary were found to feed on a wider variety and larger quantity of taxa than sturgeon collected upriver; fish in the estuary consumed almost six times the total wet weight and eight times the total volume of food (Savoy and Benway 2004).

Shortnose sturgeon appear to be a social fish, exhibiting schooling (or shoaling) behaviour particularly in areas where there are strong currents. Feeding along the bottom, their preferred diet is small crustaceans and insects in particular, soft shelled clams (COSEWIC 2005).

4 CONCLUSIONS

Most fisheries within the Bay of Fundy have long traditions, but some fisheries, such as those for dogfish, sea urchin, marine worms and some seaweeds are relatively recent. Experimental fisheries for sea cucumber have also been carried out in the outer western part of the bay (Division 4XS). Catch of some large pelagics, such as tuna and swordfish, and some sharks, such as mako and porbeagle, occur in outer parts of the bay. Overall, Minas Channel is not a major fishing area except for intermittent fishing for herring, which may occur anywhere within most of the Bay, and nearshore, primarily for lobster.

Landings, value and catch and effort statistics identify catch of major species but do not define all areas important to individual fishers nor catch that may be sold or traded locally to unofficial buyers. However, all available information suggests that Minas Channel, and specifically the proposed tidal test site, is an area of high tidal flow where little commercial fishing takes place. It is also a migration route used by fish, including shellfish, in their seasonal movement in and out of Minas Basin to feed or reproduce. The primary staging area prior to entry into Minas Basin through the channel appears to be south of Cape Split near Scots Bay.

Specific information on the migration patterns and vertical location in the water column of fish within Minas Basin is relatively scarce, but general patterns emerge. Until recently, most transmitter tags only provided information on horizontal location of fish and not vertical location within the water column. Most species are expected to remain in the upper water column because they have a preference for light and the high turbidity limits light penetration within Minas Basin to about 15 m (Parker et al. 2007). The large intertidal and subtidal flats of the basin support large food resources for many of these fish species, while others likely feed on eggs, larvae and juveniles of a range of species present.

Available information, including historic salmon catches and current fishing effort, suggests a staging area for many species in the Scotts Bay area prior to passage through the high currents of Minas Channel. A second staging area is likely located near the variable freshwater salt interface for those species moving upstream to spawn. Most anadromous species, with the exception of sturgeon, are most likely concentrated in the near surface water layer, while sturgeon are generally found close to bottom. Information on migration paths suggests that passage into Minas Basin, which is likely to be slower and may involve some movement in and out with the tides, is likely concentrated on the south side of Minas Channel. Migration out of Minas Basin into the Bay of Fundy is more likely to occur on the north side and be relatively rapid, with less back and forth movement.

4.1 Monitoring of Fish Movement

Monitoring of movement with respect to any near bottom tidal energy structure is difficult because of the high currents and high turbidity in the area. Sampling at slack tide is more feasible than at other times, but this is unlikely to be the period of major fish movement. High turbidity and low light levels make hydroacoustic or camera monitoring problematic. Longlines, used in the area and successful at catching a wide range of species of interest, appear to offer the most promise for collection of information on relative species presence at specific depths over a tidal cycle. Longlining has been used in a wide range of effects monitoring programs, but each type of sampling gear has specific sampling biases, generally requiring other sampling methods to improve reliability of the data.

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