Managing Tidal Change

Phase 1 Project Report

Bay of Fundy, Canada

Natasha Barker
Winston Churchill Memorial Trust
Travelling Fellowship Award 2006

in collaboration with

Maxine Westhead
Dept of Fisheries & Oceans, Canada

Executive Summary

The Bay of Fundy in Canada is widely known to experience the highest tidal range in the world. The Severn Estuary in the UK is known to experience the 2nd highest tides in the world after the Bay of Fundy. The author's work for the Severn Estuary Partnership motivated this research project to compare approaches to current issues affecting the future use and management of estuaries. In particular the potential impacts of climate change, predicted sea level rise, storms and tidal surges are likely to have a significant affect on estuaries experiencing the highest tides in the world.

The location of estuaries with high tidal ranges puts the Severn Estuary into context with other high tidal range sites. A very remote estuary in Far East Russia called the Penzhinskaya Guba was identified as a third estuary for study. It was considered a useful contrast to the Bay of Fundy and Severn Estuary due to the very low population density and undeveloped character of the area. It provided a baseline environment from which to compare the influence of an unrestrained tide with the more developed shorelines of Fundy and Severn.

This report from Phase 1 of the project was completed after one month spent in Canada & Alaska. It describes the aim and objectives of the research and travel itinerary for the project. Site descriptions for the three estuaries in the project are provided. The three objectives identified as the focus for the research across the three sites, resulted in the following main findings from the visit to the Bay of Fundy:

i) Public awareness and marketing the tide for tourism
Public awareness of the tide around the Bay of Fundy is very evident through marketing and branding of *Fundy* and *tide*-related names in retail, financial and visitor services. Advanced use of interpretation to promote the Bay of Fundy attracts many visitors and international tourists. The publicity and interpretation methods used for Fundy could offer significant scope for improving awareness of the value of the Severn Estuary.

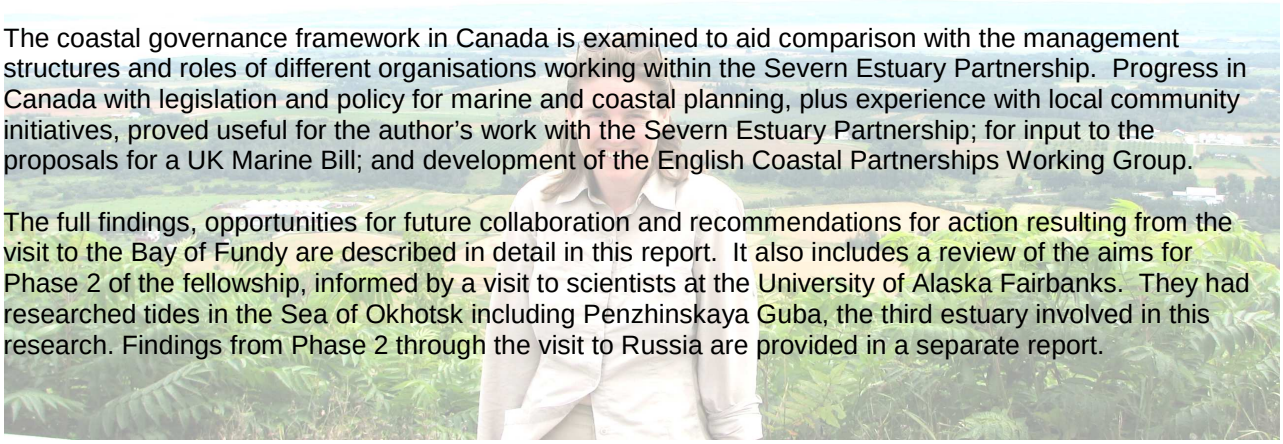
ii) Land use management and flood risk planning
A similar history of land reclamation has led to flood defences around 60-80% of the shoreline of both Fundy and the Severn. However, there are contrasts between flood defence and coastal protection structures. Highly engineered defences around the Severn offer less flexibility for future adaptation to sea level rise than earth embankments with wide natural habitat buffer zones typical around the Fundy shoreline. Techniques for managed re-alignment of the shoreline around the Severn could be informed by learning from the natural processes around the Fundy shoreline. Planning responses to future development pressure around Fundy could be informed by the experiences from the Severn.

iii) Renewable energy options
Annapolis Royal Tidal Power plant provided an example of an operative tidal power plant based on tidal range technology. It was a pilot scheme for larger tidal barrage proposals in the upper Bay of Fundy during the 1980s. Proposals for harnessing tidal power from Fundy are now focusing on tidal stream technology. This contrasts significantly to feasibility studies for the Severn which are now re-considering the Severn Barrage, alongside other options to harness the tidal range. Tidal causeways in the Bay of Fundy have caused significant and unpredictable siltation, flooding and erosion impacts on the river systems. This has resulted in a higher perception of the risks associated with tidal barrages.

The difference in population, with less than 10% around Fundy compared to the Severn, is an important characteristic that influences people's response to recognising, living with and harnessing the tide.

The coastal governance framework in Canada is examined to aid comparison with the management structures and roles of different organisations working within the Severn Estuary Partnership. Progress in Canada with legislation and policy for marine and coastal planning, plus experience with local community initiatives, proved useful for the author's work with the Severn Estuary Partnership; for input to the proposals for a UK Marine Bill; and development of the English Coastal Partnerships Working Group.

The full findings, opportunities for future collaboration and recommendations for action resulting from the visit to the Bay of Fundy are described in detail in this report. It also includes a review of the aims for Phase 2 of the fellowship, informed by a visit to scientists at the University of Alaska Fairbanks. They had researched tides in the Sea of Okhotsk including Penzhinskaya Guba, the third estuary involved in this research. Findings from Phase 2 through the visit to Russia are provided in a separate report.



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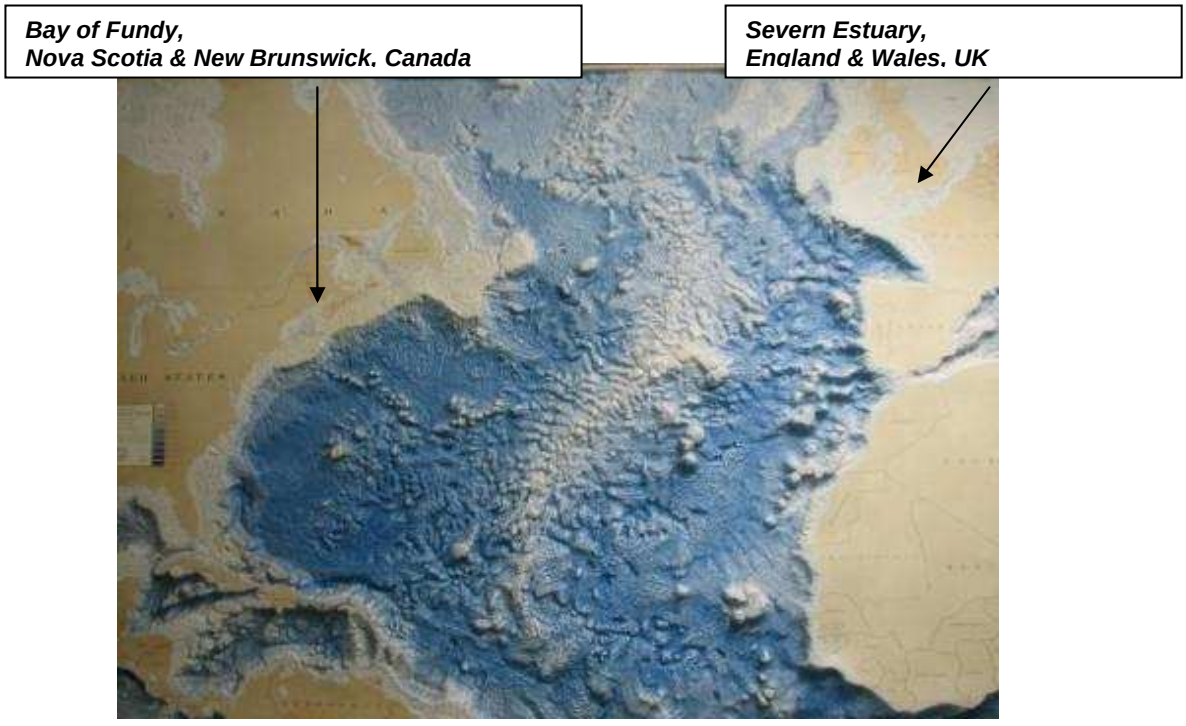


Map 1: Location of the Bay of Fundy and Severn Estuary in relation to the Atlantic Ocean.
Source: 3D wallchart map of the Atlantic Ocean at Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada.

1 BACKGROUND

1.1 Introduction

The Winston Churchill Memorial Trust provides Fellows with a unique opportunity to meet people from different countries with similar interests. Fellows gain knowledge and experience of significant value to the country, the community, their occupation and personal development. The Trust view the Fellowship Award as an 'opportunity of a liftetime,' providing the resources to enable travel to and between countries of relevance to the Fellows work.

Natasha Barker from the Severn Estuary Partnership based at Cardiff University in Wales, UK has worked as an Estuary Partnership Officer since 1998. This work has involved leading and participating in aspects of EU funded projects relating to integrated coastal zone management and river catchment management. In 2006, Natasha established the English Coastal Partnerships Working Group, which informed development of Integrated Coastal Zone Management Strategies for England & Wales and the UK's Marine Bill. Natasha previously worked as an Environmental Scientist for a consulting engineering firm and was involved in developing the Black Sea Environment Programme in the early 1990s. Her interest in the newly independent states continues through consultancy work on a range of projects in Ukraine, Georgia and Russia relating to public awareness and sustainable coastal management.

This fellowship award enabled Natasha to explore differences between the Severn Estuary in the UK, the Bay of Fundy in Canada and the Penzhinskaya Guba in Russia. Undertaking the fellowship was made possible through the support of the Severn Estuary Partnership, Cardiff University and the assistance of many people in Canada for phase 1 of the project. The results of this work will be shared with people working in both locations. This report is jointly authored with Maxine Westhead from the Department of Fisheries and Oceans, Canada, who was instrumental in providing access to people and information.

1.2 Aim

The overall aim of this project was to investigate man and nature's response to tidal change on estuaries with the highest tidal ranges in the world. The potential impacts of climate change; predicted sea level rise, storms and tidal surges may have the greatest affect on these areas. It is considered that the challenges for coastal management, and interaction between people and the environment are seen to be most evident and challenging in these dynamic high tidal coastal areas.

Current approaches to coastal management around the Severn Estuary, spanning England & Wales in the in UK (14m tides[1]) - where the author works - were assessed alongside two other coastlines experiencing some of the highest tidal ranges in the world; the Bay of Fundy, spanning Nova Scotia & New Brunswick in Canada (16m tides[1]); and the Penzhinskaya Guba, spanning Kamchatka and Magadan regions in the Sea of Okhotsk, Russia (13m tides[1]). The 3 sites for investigation contain some of the highest tidal ranges in the world.

The rationale for using these 3 sites for investigation was based on their high tidal ranges and the following specific aims:

a) **Phase 1: Canada and Alaska** - compare existing approaches to coastal management between the UK and Canada, through sharing experience between the Severn Estuary and the Bay of Fundy. As part of the phase 1 trip, preparations for Phase 2 were explored with scientists in Alaska who had researched tides in the Sea of Okhotsk.

b) **Phase 2: Russia** - consider the interaction between people and the tides, by comparing the extremes of the Severn Estuary, a highly developed area, with the Penzhinskaya Guba, a very remote and almost entirely undeveloped area. (The Bay of Fundy lies somewhere between these two extremes.) The Penzhinskaya Guba presents an opportunity to experience a 'control' site where there is very little influence of human development on the shoreline.

Information from the 3 coastal areas would be used to compare the physical character, geographical

[1] Approximate highest tidal ranges. The highest recorded tidal range in the world is 16.27m measured at Burntcoat Head in the Minas Basin in the Bay of Fundy, Canada. The maximum recorded tidal range in the Severn Estuary is 14.7m at Avonmouth near Bristol, England. A 13.9m tide has been reported for Penzhinskaya Guba.

knowledge and management approaches to address 3 current issues, as described in the objectives below.

1.3 Objectives

The overall objective of the project was to compare approaches to managing tidal change and establish links with organisations managing and/or researching the influence of the tide. Current issues relating to management of the Severn Estuary led to three specific objectives for the research:

i) **Public awareness and marketing: 'Recognising the Tide'**.
Assess the level of community awareness of high tidal ranges. Explore existing and potential opportunities for promoting public awareness of the coastal environment (and climate change impacts) through marketing and tourism initiatives. Gather examples of interpretation methods and public involvement in tide-related activities (e.g. tidal bores). Compare management approaches to habitat protection for migrating birds, human impacts and response.

ii) **Land use management in response to flood risk**: '**Living and Working with the Tide'**
Assess the extent of coastal protection and flood defence measures and future options. Due to climate change there is increasing pressure on inter-tidal habitats with sea level rise and the risk of habitat and species loss due to coastal squeeze[2]. Compare habitat and landscape change in environments with high and low population densities. How adaptive are approaches to shoreline management and development plans?

iii) **Opportunities for renewable energy**: **'Harnessing the Tide'**
Due to climate change, there is increasing political attention towards opportunities for renewable energy. Identify past, present and proposed options for harnessing tidal energy. Tidal power plants could provide a useful source of energy, but technologies are relatively young. Make links with academic, government and commercial organisations involved in assessing the potential for renewable energy using tides.

1.4 Itinerary

The travelling fellowship was spent on field visits and linking with organisations responsible for resource management and research interested in one or more of the above issues. The overall project itinerary is provided in Table 1, followed by the detailed itinerary from visiting the Bay of Fundy in Canada (3 weeks) and Alaska (2 weeks) in preparation for Phase 2 of the project.

Cape Split in the Bay of Fundy

[2] Coastal squeeze is caused by increasing sea levels meeting coastal defences which don't allow inter-tidal habitats to migrate inland, resulting in a loss of inter-tidal area.

Table 1: Fellowship Itinerary for Phases 1 and 2

COUNTRY	CITIES & PLACES	ORGANISATIONS VISITED	DATES
PHASE 1: 2006			
Canada	***Bay of Fundy:*** *Nova Scotia & New Brunswick:* Dartmouth & Halifax - based at the Bedford Institute of Oceanography. Truro, Wolfville, Parrsboro, Moncton.	Bedford Institute of Oceanography, Dartmouth. Minas Basin Working Group, Wolfville. Bay of Fundy Tourism Partnership, Parrsboro. Nova Scotia Agriculture & Resource Stewardship, Truro. St. Mary's University Geography Dept, Halifax. Annapolis Royal tidal power station, Annapolis Royal. Clean Annapolis River Project, Annapolis Royal. Environment Canada, Dartmouth. Acadia Centre for Estuarine Research, Wolfville. Fundy National Park, New Brunswick.	20th July – 9h August 2006
Alaska	Fairbanks	Institute of Marine Science & International Arctic Research Centre, University of Alaska Fairbanks.	10th - 14th August 2006 (returned 25th August).
PHASE 2: 2007			
Russia	Moscow	World Wide Fund for Nature, Russia	5th July 2007
	Penzhinskaya Guba, *Shelikova Bay & the Sea of Okhotsk:* Yelisovo Petropavlovsk-Kamchatskiy. Korf & Tilichiki.	Pacific Institute of Geography – Kamchatka Branch. World Wide Fund for Nature – Kamchatka Branch. Kamchatka Oblast & Koryak Autonomous Okrug – regional and local authorities. Penzhino District Administration.	9th July – 9th August 2007

Map 2: The Bay of Fundy is situated on the east coast of Canada just north of the Canadian/U.S. border in the area known as the 'maritime provinces'.

Table 2: Canada & Alaska Phase 1 Itinerary

CANADA & ALASKA

DATE	LOCATION	CONTACT/ VISIT	NOTES
KEY: Meetings/ Site visits	***Field study***	***Travel***	***Other - not directly related to the project.***
Fri 20 Jul – Sun 23 Jul FLIGHT: London – Montreal & overnight stay. TRAIN Montreal – Halifax. Familiarisation.			
Mon 24 Jul 06	**Bedford Institute of Oceanography (BIO), Dept Fisheries & Oceans (DFO) Halifax**	**Maxine Westhead,** Project Leader, Bay of Fundy/Gulf of Maine, Fisheries and Oceans Canada - introduced to staff in Oceans & Coastal Divisions	CONTACT: **Tim Hall**, Head of Oceans Division. **Dave Duggan**, Head of Coastal Management Division. **Scott Coffen-Smout** (knows Wales UK) & **Glen Herbert** (knows RB & HS @ CU, went to Bangor Uni), Oceans & Habitat Branch - wkg on Scotian Shelf Plan
Tue 25	**BIO, DFO Halifax**	**Maxine Westhead**	CONTACT: **Paul McNabb** (linked contact from … to Maxine Westhead)
	BIO, DFO Halifax	**Anita Hamilton**, Stewardship Coordinator,Habitat Management Div	Habitats, remediation, fish passes, self-regulating tidal exchange technology.
Wed 26	**Truro**	**Hank Kolstee,** Supervisor, Land Protection, Agriculture Resource Stewardship, Nova Scotia (Truro).	
	Parsboro	**Terri McCulloch**	CONTACT: **Michael Fuller** (Pegasus Paragliding) & **Christa** (apt in Halifax where I stayed): (902) 254 2872 / info@pegasusparagliding.com
Thu 27	**Shubenacadie, nr Truro**	**Shubenacadie River Runners Ltd.**	CONTACT: **Brian & Kim vandeCrie**
	Halifax	**Danika van Proosdij**, Associate Professor, Dept of Geography, Saint Mary's University, Halifax	Tracks changes over time as a result of the Avon River tidal barrier
Fri 28	**Wolfville**	**Minas Bay Working Group meeting**	CONTACT: **Mike Brylinsky**, Director of Working Group (outgoing). **Anna Redkin** Director of Acadia Centre for Estuarine Research & Secretary to BoFEP & MBWG. **Justin Huston** (Coasts, Provincial Gvt). **Peter Wells**, Director of Working Group (incoming).
Sat 29	SW Nova Scotia	Halifax – Crescent Beach/Cape LaHave	Stops at Lunenburg and Bush Island Provincial Park (kayaking).
Sun 30	SW Nova Scotia	Crescent Beach/Cape LaHave - Bear River	Stops at Kejimkujik National Park (seaside adjunct); Lockeport; Clarks Harbour; and Cape St. Mary.
Mon 31	**Annapolis Royal & Digby**	**Stephen Hawboldt**, Clean Annapolis River Project & Annapolis Royal Tidal Power Plant	Tide clock purchased at: Kathy's Gifts & Collectables. 50 Water Street, Digby NB VOV 1AO. (902) 245 1253
	Newton Ville (nr Wolfville)	**Tracey Horsman (GIS), DFO, BIO & Jamie Gibson, DFO, BIO**	Overnight stay in Newton Ville, nr Wolfville
Tue 1 Aug	**Wolfville**	**Graham Daborn**, Director, Arthur Iriving Academy for the Environment, Acadia University	
	Wolfville area	**Nova Scotia Dept of Natural Resources**	**Rancy Milton**, Manager, Wildlife Resources (Wetlands & Coastal Habitats); **Sherman Boates**, Manager, Wildlife Resources Biodiversity (shorebirds & species @ risk), **Reg Newell**, Stewardship Coordinator, Eastern Habitat Joint Venture. Nova Scotia Provincial Gvt
Wed 2	**Dartmouth**	**Larry Hildebrand**, Environment Canada	
	BIO, DFO Halifax	**Charlie O'Reilly**, DFO, BIO	Tidal prediction & survey inc. Ungava Bay expedition research.
Thu 3	**BIO, DFO Halifax**	Maxine Westhead	
Fri 4	**BIO, DFO Halifax**		Met **Harry Thurston**, author of many books on the Bay of Fundy including *Tidal Life* which is widely available.
Sat 5	Halifax - Tiverton, NS	**Grand Pre marsh reclamation and interpretation site**	North American Right Wales (25)
Sun 6	Tiverton - Alma, NB	**Digby; St Martins, Fundy Trail Parkway; Fundy National Park**	CONTACT: **Tracey Kohlruss**, Visitor Services, Fundy National Park (506 887 6009) tracey.kohlruss@pc.gc.ca. Peter Etheridge, Director of NP?
Mon 7	Alma - Advocate Harbour, NS	**Cape Enrage, Hopewell Rocks, Moncton, Fort Lawrence**	CONTACT: **Tim Milligan**, BIO Dartmouth - survey work at Moncton (4263273)
Tues 8	**Advocate Harbour- Halifax**	**Parrsboro – Terri McCulloch**	
Wed 9 FLIGHT: Halifax - Montreal + Montreal – Vancouver			
Thur 10 FLIGHT: Vancouver - Anchorage - Fairbanks, Alaska			
Fri 11 – Sun 13	Fairbanks	Familiarisation	
Mon 14	**University of Alaska Fairbanks**	**Professor Zygmunt Kowalik**, Institure of Marine Science.	Researching ocean dynamics inc modelling tsunamis
	University of Alaska Fairbanks	**Dr Igor Polyakov**, Frontier Research System for Global Change, International Arctic Research Centre.	Researching causes of global warming
Tue 15 TRAIN: Fairbanks – Anchorage			
Wed 16 – Fri 18	Whittier	Blackstone Glacier	Holiday: sea Kayaking
Sat 19 – Fri 24	Valdez	Columbia Glacier & Glacier Ilsland	Holiday: sea kayaking & camping
Fri 25 Aug FLIGHT: Anchorage - Vancouver – London			

Map 3: The Bay of Fundy – Chignecto Bay & Minas Basin

2 FINDINGS

2.1 Highest Tides

The **Severn Estuary** is often said to experience the second highest tides in the world, after the Bay of Fundy in Canada. A 14.7m tidal range is the maximum recorded at Avonmouth near Bristol.

Low tide at Lydney Harbour in the Severn Estuary, South Wales.

The **Bay of Fundy** is widely known to experience the highest tides in the world, with the highest recorded tidal range of 16.27m measured at Burntcoat Head in the Minas Basin and tides reaching 17m on storm surges. The high tides have been attributed to the funnel shape of the Bay and the fact that the natural period of the Gulf of Maine-Bay of Fundy system exacerbates the tide height (the 'bath-water' effect). However, research conducted by the Canadian Dept of Fisheries & Oceans demonstrated that the tidal Range in the Bay of Fundy is approximately equal to that of **Ungava Bay** in Canada (O'Reilly et.al, in Environment Canada (2005b).

Low tide at Scotts Bay in the Bay of Fundy, Nova Scotia.

One of the world's highest tides exists in the **Penzhinskaya Guba** (Bay) in the Sea of Okhotsk in Far East Russia. A 13.9m tidal range is reported (Kowalik, Z. 2004) by the Institute of Alaska, Fairbanks – making the tidal range similar to the Severn Estuary in UK.

Other high tides are experienced in the White Sea in Russia, the Cook Inlet in the Gulf of Alaska, the Persian Gulf, the Java Sea, the west coast of New Guinea and off northern Australia and Antarctica. Within Europe, St. Malo on the La Rance river in France, claims some of the highest tides in Europe with an average range of over 12m. The methods used to measure the tides and selection criteria for determining the 'largest tidal range' is probably not consistent across the sites. The figures quoted are therefore subject to interpretation and the subject of some debate. As stated by O'Reilly et.al (Environment Canada, 2005b):

Further resolution will require very expensive field surveys and, regardless of findings, the truth may never by totally 'accepted'

Charles T. O'Reilly, Canadian Hydrographic Service, 2005

Box 1: Definition of Tidal Range *(Source: http://en.wikipedia.org/wiki/Tidal_range)*

The **tidal range** is the vertical difference between the highest high tide and the lowest low tide. In other words, it is the difference in height between high and low tides. The most extreme tidal range will occur around the time of the full or new moons, when gravity of both the Sun and Moon are pulling the same way (new moon), or exact opposite way (full). This type of tide is known as a spring tide. During neap tides, when the Moon and Sun's vectors make a right angle at the Earth, the difference between high and low tides is smaller. The typical tidal range in the open ocean is about 0.6 meters (2 feet). As you get closer to the coast, however, this range gets much greater. Coastal tidal ranges vary globally and can differ anywhere from 1.8 meters to 3 meters (6–10 feet). The world's biggest tidal differential occurs in the Bay of Fundy in Eastern Canada, where the sea level changes by up to 17 meters (55 feet) during the day. Ungava Bay in Northern Quebec, north eastern Canada, is believed by some experts to have higher tidal ranges than the Bay of Fundy (about 17 metres or 56 ft), but it is free of pack ice for only about four months every year, whereas the Bay of Fundy rarely freezes. What is generally regarded as the next highest tidal range occurs in the Bristol Channel in the UK, where sea levels change by some 15 meters (49 feet). The smallest tidal ranges occur in the Mediterranean, Baltic, and Caribbean Seas.

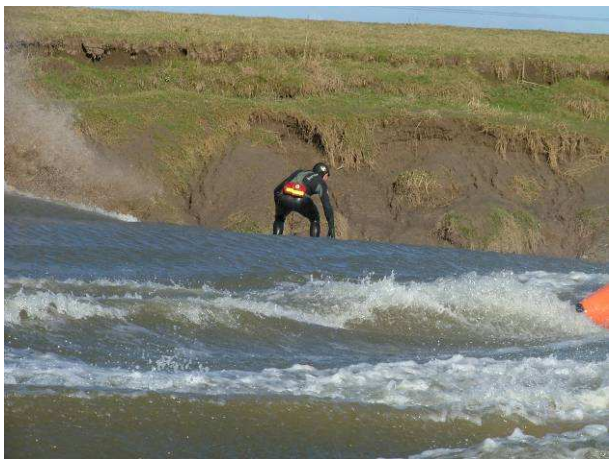
The existence of **tidal bores** in the Severn Estuary and in the Bay of Fundy is one phenomenon of the tides that was considered worthy of further investigation; particularly in relation to objective i) public awareness and marketing tidal sites for tourism. Tidal bores are caused by the speed of the incoming tide relative to the downstream flow of the river (see Box 2). In addition to tidal bores and rapids in the Severn Estuary and Bay of Fundy, they are also known to occur in other parts of the world, such as the River Amazon in South America and the River Quiantang in China.

Box 2: Definition of a Tidal Bore *(Source: http://en.wikipedia.org/wiki/Tidal_bore)*

A **tidal bore** (or just **bore**, or **eagre**) is a tidal phenomenon in which the leading edge of the incoming tide forms a wave (or waves) of water that travel up a river or narrow bay against the direction of the current. As such, it is a true *tidal wave* (not to be confused with a tsunami).

Bores occur in relatively few locations worldwide, usually in areas with a large tidal range (typically more than 20 feet between high and low water), and where incoming tides are funnelled into a shallow, narrowing river via a broad bay. The funnel-like shape not only increases the height of the tide, but it can also decrease the duration of the flood tide down to a point where the flood appears as a sudden increase in the water level.

Bores take on various forms, ranging from a single breaking wavefront—effectively a shock wave—to 'undular bores' comprising a smooth wavefront followed by a train of solitary waves (solitons). Larger bores can be particularly dangerous for shipping, but also present opportunities for river surfing.



Tidal bore waves on the Severn Estuary.

2.2 Site Descriptions

2.2.1 Severn Estuary, England & Wales, UK

The Severn Estuary (*Mor Hafren* in Welsh) lies between England and Wales in south-west Britain. The river Severn catchment spans a large part of Wales and the south-west Midlands region of England. The estuary lies between South Wales and South West England, extending into the Bristol Channel and beyond into the Atlantic Ocean south of Ireland.

The Severn Estuary is Britain's second largest estuary with an area of 557km^2 including an intertidal area of 100km^2. It extends from the tidal limit near the city of Gloucester in England to the urban areas of Newport & Cardiff in Wales and Weston-Super-Mare and Minehead in South-West England. When its seaward extension is included, the inter-tidal habitat of mudflats, sand banks, rocky platforms and saltmarsh are one of the largest and most important areas in Britain, occupying an area of around 2000 km^2. The population density is quite high, particularly in and around the urban centres of Cardiff-Newport, Gloucester and Bristol. It is estimated that over 3 million people live within 10km of the Severn Estuary.

The Severn Estuary has recorded the 2nd highest tidal range in the world of 14.7m. The Severn Bore, a tidal wave which may reach 2m in height, occurs in the lower reaches of the River Severn during high tides. The world record for the longest surf-ride, of 7.6 miles, was made on the Severn Bore in March 2006. The extremely high tidal range and funnel shape of the coast make the Severn Estuary unique in Britain and rare on a wider European scale.

Sites around the Severn Estuary reveal the large extent of the tide.
Natasha, Severn Estuary Partnership Officer, looking at marshes near the 2nd Severn Crossing.

2.2.2 Bay of Fundy, Nova Scotia & New Brunswick, Canada

The Bay of Fundy is part of the Gulf of Maine which lies between south-eastern Canada and north-eastern U.S.A. The Bay is 270km long; a narrow funnel-shaped body of water that lies between Nova Scotia and New Brunswick, on the East Coast of Canada. The head of the bay, or the Inner Bay of Fundy, is divided into Chignecto Bay to the north and Minas Basin to the east. They are ecologically similar, having extremely high tidal ranges that expose large expanses of mud flat.

> *'A system with a biological pump at both ends'*
> *Graham Daborn, Acadia University, Wolfville, Nova Scotia, Canada*

As the Minas Basin is a semi-enclosed body of water, it is classified as an estuary (Pritchard, 1955). The Basin is approximately 80 km long and 30 km wide at the widest point. The Minas Channel is approximately 50km long and ranges from 5km to 24km wide. The world's highest recorded tides were measured in the Minas Basin at Burntcoat Head, at 16.27 m.

The primary cause of the immense tides is resonance within the Bay of Fundy-Gulf of Maine system. It is bounded at the outer end by submerged banks with a 40:1 (approx) increase in depth. The highest tides occur in the north-eastern upper end of the Bay, as they do in the Severn Estuary, because the earth's rotation drives any motion anti-clockwise in the northern hemisphere. The extreme high tides also result from the Bay of Fundy's funnel-shaped geography.

Red sandstone cliffs and salt marsh dominate the shoreline. During extreme low water, the area of the exposed intertidal zone is approximately 400 km^2, or more than one-third of the total area of the Basin. No other coastal marine area in the world of comparable size has such a large proportion of bottom exposed to the air at low tide [Bousfield, 1959 #223].

The Bay's tides cause tidal bores, rapids and whirlpools. Tidal bore waves form where the incoming tide moves upstream against the outgoing flow of the rivers St. Croix, Meander, Shubenacadie and Salmon.

Saint John is the largest population centre around the Bay of Fundy, situated in the province of New Brunswick. In Nova Scotia province, about 180,000 people sparsely populate the watershed and coastline of the Minas Basin and Truro is the largest urban centre with a population of 12,000.

Minas Basin, Bay of Fundy, viewed from the north shore between Parrsboro and Truro.
Maxine Westhead, Dept Fisheries & Oceans Canada, rafting the tidal rapids of the Shubenacadie river.

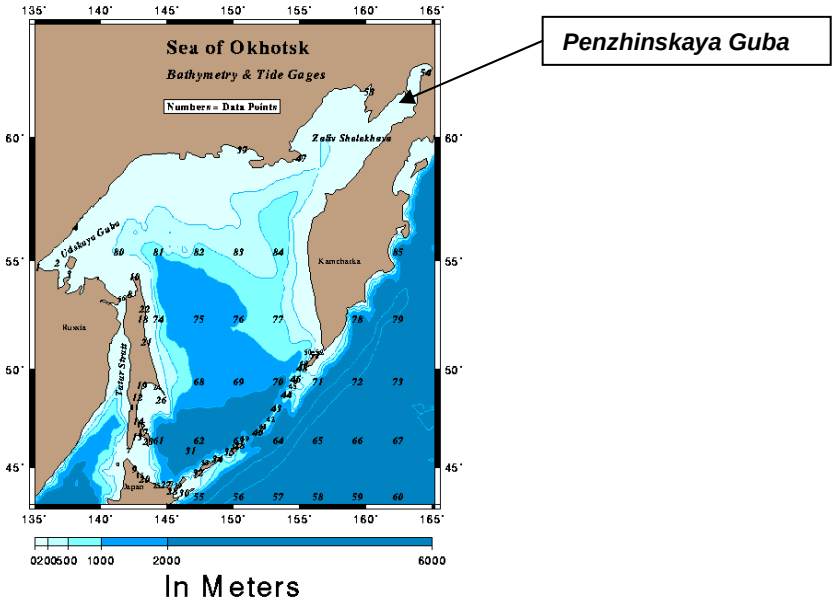
In simple terms, the Severn Estuary is similar in size and scale to one of the two arms of the Bay of Fundy: Chignecto Bay or the Minas Basin. Since the highest recorded tidal range in the world is located in the Minas Basin, this was the main focus for comparison with the Severn Estuary. The table below compares the main physical characteristics of the Severn Estuary with the Bay of Fundy.

Table 3: Physical Characteristics of the Severn Estuary and Bay of Fundy

Characteristic	Severn Estuary, UK	Bay of Fundy, Canada
Size of estuary/bay and intertidal exposure	557km^2 (intertidal area 100km^2)	Approx 1200 km^2 (intertidal area 400 km^2)
Largest dimensions (approximate)	Bristol Channel – 170km long, 70km wide Estuary - 50km long, 15km wide	Bay – approx 270km long, 80km wide Minas Basin - 80km long, 30km wide
Highest tidal range	14.7m at Avonmouth	16.27m at Burntcoat Head (Minas Basin)
Average high tidal range	Approx 12m	Approx 14 m
Tidal bore	Front wave up to 2m height followed by fast moving grade 2 white water	Numerous periods of 2-3m waves with grade 3-4 tidal rapid sections
Landscape & Geology	Dominantly low-lying land backed by gently sloping hills (Cotswolds, Forest of Dean Brecon Beacons)	Low-lying land and red sandstone cliffs surrounded by gently sloping hills.
Population	Approx 3 million	Approx 300,000 (180,000 Minas Basin)
Land use	Urban, industry, agriculture, wetlands, tourism, major cities, transport infrastructure and power stations.	Agriculture, wetlands, infrastructure, tourism, towns and scattered settlements.

2.2.3 Penzhinskaya Guba, Kamchatka & Magadan Regions, Russia

Some of the highest tides in the world have been recorded in the Sea of Okhotsk in far north-east Russia (Kowalik, 2004, Isachev, 2006). As with the tides in the Bay of Fundy and Severn Estuary, amplification of the tide occurs from the mouth to the head of the Bay in the Penzhinskaya Guba area of the north-eastern part of the Sea of Okhotsk. One of the largest tidal ranges of 13.9m has been recorded and investigated here, by scientists at the Institute of Marine Science at the University of Fairbanks in Alaska, U.S.A. Bernshtein (1996) identified the Penzhinskaya Guba as holding the record height for the coastline of Russia at 13.4m. He identified its significant potential to supply tidal power to USA, Canada and/or Siberia, Japan, China and Korea – despite severe climatic conditions with temperatures down to -50, average temperatures of -6.5 ^{0}c, some 220 days of winter, and an irregular diurnal tide. However, in terms of its physical size and tidal range, it appears to have some similarities to the Severn Estuary.



Map 4: Location of Penzhinskaya Guba and the Sea of Okhotsk.

2.3 Coastal Governance in Canada

2.3.1 Canada's Federal Context for Coastal Management

In 1997 Canada introduced an *Oceans Act* which made Canada the first country in the world to have comprehensive oceans management legislation. The Act led to the development of a national *Oceans Strategy.* Key to its implementation is the creation of Integrated Management Plans for coastal and marine waters. One of the earliest plans currently under development is the Eastern Scotian Shelf Integrated Management (ESSIM) Plan which involves Nova Scotia. The Oceans Act assigned the **Department for Fisheries & Oceans** (DFO) the lead role for integrated planning and management of all ocean activities. Some 23 federal government departments and agencies, plus provincial interests who have some form of jurisdiction over the oceans or its resources, are focused to meet the goals of the Strategy in a collaborative effort with industry and the public (Chao et. al.).

- ***Oceans Strategy & Action Plan***

Canada's *Ocean Strategy* (2002) is the Government's policy statement for the management of estuarine, coastal and marine ecosystems. The Strategy supports programs aimed at understanding and protecting the marine environment, supporting sustainable economic opportunities and providing international leadership. Under this Strategy, the federal government will develop, support and promote activities to establish institutional governance mechanisms to enhance co-ordinated, collaborative oceans management across the federal government and with other levels of government – using new and existing mechanisms such as committees, management boards and information sharing. The Strategy also seeks to implement a program of integrated management planning – establishing decision-making structures and bringing together citizens to engage in decisions that affect them, promoting stewardship and public awareness.

Coastal Communities – extract from the Oceans Strategy

Canadians have expressed a desire to be more engaged in ocean management. The Strategy offers Canadians the opportunity for greater and more direct involvement in policy and management decisions that affect their lives. Coastal communities will be actively involved in the development, promotion and implementation of sustainable oceans activities, as Integrated Management planning will offer this kind of direct opportunity. In this way, there is a more viable planning process, associated actions are relevant to the area and there is 'on the ground' expertise and capacity for implementation, monitoring and compliance promotion.

- **Integrated Management Planning under the *Oceans Act***

Amongst the activities identified in the *Strategy*, the federal government is committed to promoting integrated management planning for all of Canada's coastal and marine waters. This includes supporting the planning process for *Large Ocean Management Areas* and supporting coastal and watershed planning initiatives. Alongside this, the federal government indicates support towards stewardship and public awareness activities. Canada's *Oceans Action Plan* (2005-07) was an initial step to take implementation of the Strategy one step further.

Integrated Management initiatives are underway on all three of Canada's coasts, including for the Atlantic Ocean, the *Eastern Scotian Shelf Integrated Management* (ESSIM) initiative (off SE Nova Scotia). The **ESSIM Forum** has been established to provide a networked structure for engaging and linking federal and provincial government departments, boards and agencies, First Nations, oceans industry and resource user groups, community associations, non-governmental organisations and academia in the ESSIM process.

- **Marine Protected Areas (MPAs) and the Legal Framework for Coastal & Marine Designation**

The *Oceans Act* provides the Minister of Fisheries and Oceans with the obligation to develop a National Strategy for Oceans Management, including the co-ordination of a federal marine protected area (MPA) program. It is administered and implemented by the 3 federal depts: **Parks Canada** (PC), **Environment Canada** (EC) and **Fisheries and Oceans Canada** (DFO). Over the past 5-7 years, 3 coastal and 2 ocean MPAs have been designated and more are in the pipeline. Designations for

protection of the marine and coastal environment are also possible through other federal tools: through Environment Canada and the *Canada Wildlife Act; Migratory Birds Convention Act;* and the *Species at Risk Act*. Through Parks Canada, national Marine Conservation Areas can be established under the *Canada National Marine Conservation Areas Act*, National Parks can have a marine component under the *Canada National Parks Act,* and marine/coastal species can be protected under the *Species at Risk Act.* (Government of Canada, 2005a). The **Canadian Wildlife Service** is part of Environment Canada and manages wildlife matters that are the responsibility of the federal government.

- **Policy & Operational Framework for Integrated Management of Estuarine, Coastal & Marine Waters**

Under the *Oceans Act* a framework for integrated management is set out in the policy & operational framework. It proposes that an *Integrated Management Body* could be composed of both governmental and non-governmental representatives with interests in a given ocean space, with the ultimate objective of establishing integrated management plans for all of Canada's coastal, estuarine and marine waters. Federal government responsibilities will be co-ordinated in partnership with provincial/territorial/regional authorities, industry, non-governmental organisations and the science community. *Coastal Management Areas* will nest in with the *Large Ocean Management Areas*.

> ***Coastal Management Areas (CMAs)***
> *Coastal Management Areas will enable communities to play a stronger role in issues affecting their future by matching local capabilities and development priorities to the opportunities and carrying capacities of the local ecosystem.*

Many of the management issues to be addressed fall within the provincial/territorial or municipal jurisdiction, therefore the role of DFO is identified as facilitator and provider of expertise and access to information. In some cases the Department may lead the development of the Integrated Management Plan, depending on the issues to be resolved and the willingness and capacity of local interest to lead the process. A typical model for an Integrated Management Body, together with stages for developing the Plan, is illustrated in Canada's Policy & Operational Framework for Integrated Management.

2.3.2 Environment Canada & the *Atlantic Coastal Action Programme* (ACAP)

Environment Canada has played a leading role in the local delivery of coastal management, particularly through the Atlantic Coastal Action Programme (ACAP) initiative. It is a unique community-based program initiated by Environment Canada in 1991 to help restore and sustain watersheds and adjacent coastal areas. The ACAP 'family' is currently made up of 16 organisations in the 4 Atlantic provinces. Each of the 16 not-for-profit organisations operate independently, but are linked under the umbrella of ACAP to 'represent a force stronger than the sum of the individual parts' (Environment Canada, 2003).

The projects focus on knowledge generation, capacity building, direct action and the advancement of science. They build on the local capacity and knowledge required for communities to make informed decisions and address complex issues related to the environment. ACAP projects result in a variety of partnerships formed between communities, governments, non-government organisations, academia and industry. The partnerships are said to consistently demonstrate the value of a community-based approach and produce results on an ecosystem basis (e.g. on a catchment scale).

ACAP also runs a Science Linkages Initiative that creates links between ACAP organisations and scientists from Environment Canada. Together, the partners develop proposals, conduct scientific work and report on results. From 1997 to 2003, over 60 Environment Canada scientists transferred their knowledge of scientific methods and practices to ACAP organisations. Over $1M was invested to fund 95 projects, with the total value of the projects being much higher – about $4.5M.

The partnership funding brought in by the ACAP initiatives often far exceeds the investment made by government. ACAP organisations often help to deliver government programs and initiatives and it has been found through the initiative that having communities deliver ACAP programmes costs much less than if the programmes were delivered in a traditional way with government offices and employees. From 1997-2001 the impact (Gross Domestic Product) of ACAP initiatives was $22 million in direct and spin-off economic activity, which far exceeded Environment Canada's $6 million investment in ACAP for that

period. In addition, total expenditures related to the administration of ACAP projects generated $4.4 million in federal and $3.6 million in provincial tax revenue.

Four of the ACAP initiatives are located around the outer areas of the Bay of Fundy: St Croix Estuary Project Inc; Eastern Charlotte Waterways Inc; ACAP Saint John Inc; and the Clean Annapolis River Project. The Clean Annapolis River Project was visited due to its proximity to and local knowledge of the Annapolis Royal tidal power plant (see Section 2.6.5).

The ACAP initiatives demonstrate leadership in community empowerment and a holistic approach to protecting the environment. Many have initiated partnerships, raised additional funds, purchased land/property, organised clean-ups, undertaken monitoring programmes and facilitated long term planning as well as promoted community involvement and stewardship.

> ***'ACAP' philosophy*** *as expressed by*
> *Stephen Hawboldt, Executive Director of the Clean Annapolis River Project*
>
> Some issues, such as sustainability, are so complex with many facets that no single organisation can have the capacity and/or the mandate to address them. Multi-stakeholder processes are highly efficient and effective ways to address sustainability issues as they bring together all of the relevant actors to the table in an open, transparent and inclusive forum. By working together, the sum of the parts is greater than the whole. Each partner gives a little and gains a great deal.

Further information about ACAP is available at www.atl.ec.gc.ca/community/

Similarities could be drawn between the community-based ACAP programme in Canada and the voluntary work of Coastal Partnerships in the UK, as discussed further in Section 3.2.

2.3.3 Provincial & Municipal Government Context for Coastal Management

Whilst the federal (national) government has broad responsibilities for the stewardship and management of Canada's oceans and resources, the provinces (regions) have primary responsibility for provincial lands, the shoreline and specific seabed areas. The municipalities (districts) have responsibility for many of the land-based activities affecting the marine environment.

The Bay of Fundy lies between the two provinces of Nova Scotia to the east and New Brunswick to the west.

- **Nova Scotia**

Nova Scotia, as a provincial government, has many departments. The following are most involved with the coastal/marine environment:

- Agriculture
- Fisheries and Aquaculture
- Energy
- Environment & Labour
- Natural Resources
- Tourism, Culture and Heritage

Nova Scotia has recently expanded their team to increase their expertise in coastal management and planning, based within the Fisheries and Aquaculture department.

The new inter-departmental **Provincial Oceans Network** was recently established to determine the provincial government's position on and strategy for coastal management. The Federal Government is keen for provinces to take a stronger role in delivering integrated management in coastal areas. Their existing planning remit is only to High Water mark, but the provinces have other responsibilities/ownership into territorial waters. There are, however, uncertainties and irregularities in jurisdictions and the regulation of intertidal activities.

Municipalities in Nova Scotia are currently collaborating through monthly meetings over renewable energy, due to increasing interest. Their discussions include consideration of options for tidal power generation from the Bay of Fundy.

- **New Brunswick**

A *Coastal Areas Protection Policy for New Brunswick* has been developed by the Sustainable Planning Branch of New Brunswick's Department of the Environment and Local Government. This sets out the high value of the coast for fisheries, tourism and habitats and illustrates how increased knowledge, greater pressures for development and climate change requires new policies for protection.

The objectives of the policy are related to the threats from storm surges, coastal erosion and contamination, and to maintain public safety, healthy coastal ecosystems, fisheries and ecotourism. It establishes protection zones in three zones (core, buffer, transition) with guidance on the kind of development activity acceptable in each zone. Activities are identified which require a formal environmental review. Activities prohibited in all zones include the construction of groynes, infilling, dredging (except with a permit), beach quarrying and causeway construction if a bridge would be technically feasible.

The New Brunswick coast is a contrast of developed areas such as Saint John and Moncton, highly organised ecotourism such as along the Fundy Trail (car route) and unspoilt wilderness coastline.

2.3.4 The Bay of Fundy Ecosystem Partnership & Minas Basin Working Group

As for the Severn Estuary in the UK, there is no statutory framework or other formal system to manage the estuarine ecosystem of the Bay of Fundy as a whole - though this is evolving in Canada through the ESSIM plan (see Section 2.3.1) - and there is an evolving legal structure for marine spatial planning in the UK through the Marine Bill. In both cases, there are currently many and varied institutions managing resources on a sectoral basis with supporting legislation. There are, however, voluntary initiatives in the Bay of Fundy, with similarities to the Severn Estuary Partnership, which have evolved (over a similar timescale since the early-mid 1990s) to encourage the exchange of information and collaboration.

- **Bay of Fundy Ecosystem Partnership (BoFEP)**

The *Bay of Fundy Ecosystem Partnership* (BoFEP) was established by a group of scientists and government officers interested in the future of the Bay, with the first workshop held in 1996. Interest in the potential for tidal power schemes in the late 1970s and throughout the 1980s was a significant factor in focusing people's interests and motivating research & monitoring. The BoFEP initiative is now well recognised with a website, regular newsletter, working groups and a biennial conference. At the current time there is no co-ordinating officer, but an annual budget allocation of $50,000 from Environment Canada which is used to contract services. The initiative has predominantly been hosted by the Centre for Estuarine Research at Acadia University in Wolfville, Nova Scotia. During July 2006, several of the people who were instrumental to the establishment of BoFEP were interviewed (Graham Daborn, Peter Wells and Larry Hildebrand) as part of this research.

Box 3: Organisational Structure and Membership of the Bay of Fundy Ecosystem Partnership

Members of the 2006/2007 BoFEP **Steering Committee** include:

- Hugh Akagi, member-at-large
- Michael Butler, Atlantic Coastal Zone Information Steering Committee
- Maria-Ines Buzeta, Fisheries and Oceans Canada
- Graham Daborn (former Chair), Arthur Irving Academy for the Environment
- Al Hanson, Canadian Wildlife Service
- Steve Hawbolt, Clean Annapolis River Project
- Russell Henry, New Brunswick Department of Fisheries
- Pat Hinch, Nova Scotia Department of the Environment
- Marianne Janowicz, New Brunswick Department of the Environment
- Barry Jones, **Chair**, Consultant
- Claudette LeBlanc, Atlantic Coastal Zone Information Steering Committee
- Jon Percy, Sea Pen Communications
- Gerhard Pohle, Huntsman Marine Science Centre
- Danika Proosdij, St. Mary's University
- Anna Redden, Acadia Centre for Estuarine Research
- Mark TeKamp, Nova Scotia Department of Fisheries and Aquaculture
- Peter Wells, Environment Canada (emeritus)
- Maxine Westhead, Fisheries and Oceans Canada

BoFEP **Working Groups**

The bulk of the actual "work" of BoFEP is carried out through the Working Groups. There are 18 active and proposed Working Groups (WGs) under the BoFEP umbrella. The more active groups include the Minas Basin WG, the Biosphere Reserve WG, Fundy Informatics Group, Corophium and Mudflat Ecology WG, and the Salt Marsh and Restricted Tidal Systems WG. Proposed WGs include Resource Development, Marine Energy, Coastal Development, and Integrated Coastal Zone Management. A full list of WGs can be found at http://www.bofep.org/working.htm. Anyone who attends a workshop is recognised as a 'member' of the partnership.

Box 4: Outputs from the Bay of Fundy Ecosystem Partnership

Biennial Workshops: BoFEP holds a Bay of Fundy Science Workshop every other year, at various locations throughout the Bay of Fundy area. An average of 150 participants gather to discuss scientific issues along with management challenges, socio-economic issues, and other interests. The first workshop was held in 1996, with the 7th workshop taking place in October 2006.

Workshop Proceedings: Detailed workshop proceedings are produced after every workshop, providing the community with a comprehensive record including abstracts, full papers, and major discussion points at plenary sessions.

Fact Sheets: BoFEP has produced 27 'fact sheets' that describe the present scientific understanding of many of the environmental issues confronting the Bay. They summarize available information in an impartial and non-technical manner that is suited for a general audience, and range from 4-12 pages. A complete listing can be found at http://www.bofep.org/fundy_issues.htm.

Fundy Tidings Newsletter: A quarterly electronic newsletter sent to any interested person or organization which includes items such as funding opportunities, recent graduate theses, website updates, upcoming events, and more. Archives found at http://www.bofep.org/tidings.htm.

An important role of BoFEP is its cross-boundary link with the Gulf of Maine in U.S.A. The ecosystem links between the Bay of Fundy and the Gulf of Maine are well recognised, particularly with respect to migratory fish such as Atlantic Salmon and Herring. The Gulf of Maine Council on the Marine Environment (a 15 year old Canada/US partnership) and BoFEP have strengthened their collaboration in recent years. Priority areas of work include tidal barriers, conservation of biodiversity, and public education.

An application for the Bay of Fundy as a UNESCO Bioshpere Reserve has been under development in recent years and is well progressed for the Chignecto Bay & New Brunswick areas. Inclusion of Nova Scotia in the application was hindered by a campaign against the proposal from communities in the rural Cape Chignecto area.

- **Minas Basin Working Group (MBWG)**

The Minas Basin Working Group is one of several working groups of BoFEP that meets on a fairly regular basis, usually at the Centre for Estuarine Research at Acadia University, Wolfville. It is made up of representatives from the following organisations.

Box 5: Membership of the Minas Bay Working Group

There are some 50 members of the working group, which is based on interest or attendance at meetings. The following members of the group attended a meeting in July 2006:

- Peter Wells, Consultant (retired from Environment Canada) – Chair from July 2006
- Mike Brylinsky, Centre for Estuarine Research, Acadia University, Wolfville (former Chair)
- Hank Kolstee, Nova Scotia Dept of Agriculture (dykes)
- Justin Houston, Nova Scotia Dept of Fisheries and Aquaculture (coastal management)
- Larry Hildebrand, Environment Canada (coastal management)
- Maxine Westhead, Fisheries and Oceans Canada (integrated management)
- Reg Newell, NS Department of Natural Resources (habitat protection)
- Patricia Hinch, NS Department of Environment and Labour (coastal management)

A full list of members is shown on the website:
http://www.bofep.org/wg.htm#Minas%20Basin%20Project

The Minas Bay Working Group became a Working Group of the Bay of Fundy Ecosystem Partnership in 2000. It began to establish its own identity and to formally articulate and expand its purpose, mission, and objectives.

The Working Group mission, similar to that of the Gulf of Maine Council (GOMC), is to maintain and enhance environmental quality in the Minas Basin and its watershed, and to allow for sustainable resource use by existing and future generations. Its objectives are: to engage the public in identifying issues and

actions pertaining to the sustainability of the Basin's resources and its coastal communities (i.e. encourage active community participation in all aspects of the working group's activities);

- to facilitate partnerships, collaboration and new funding opportunities among researchers, policy makers, resource managers and community groups pertaining to any aspect of the sustainable use and management of the Minas Basin.
- to work towards a multi-stakeholder supported management plan for the Minas Basin, taking into account its natural resources (living and non-living), the needs for conservation and protection, and Canada's long-term commitment to sustainable development;
- to facilitate coordination of efforts to identify critical habitats and living resources of the Minas Basin (i.e. encourage conservation of the Basin's biodiversity);
- to identify habitats and species issues for future scientific investigation and research;
- to enhance access to and interpretation of information on Minas Basin and its natural resources;

Membership of the Minas Basin Working Group remains open to all who agree with the principles of BoFEP and have an interest in the sustainable management of the Minas Basin. The Working Group has produced the following outputs.

Box 6: Outputs from the Minas Bay Working Group

Research Reports
Environmental and resource management in Minas Basin, Bay of Fundy

Projects
Minas Basin Watershed Profile. [PDF format]. *Bay of Fundy Ecosystem Partnership Technical Report #2. (156 pages)* Compendium of socio-economic, demographic, land-use, resource use and other information from the region

Community Forums

- A Draft Summary of the State of the Minas Basin Forum. Mark TeKamp.

On October 28th 2003, a forum on the State of the Minas Basin (SOMB) was held in Wolfville, Nova Scotia. The purpose of this meeting was to bring together a diverse group of resource users, scientists, managers, and individuals with knowledge of the local environmental characteristics to discuss the health and quality of the Minas Basin watershed.

- Planning for Action in the Minas Basin watershed.

Bay of Fundy Ecosystem Partnership Technical Report #1.
Synthesis report from the Minas Basin Community Forums organized by the Minas Basin working Group.

- Working with Minas Basin Watershed Community Groups

Summary Report. Lisa McCuaig. February 2004.
In 2003, the Minas Basin Working Group hosted a number of community forums in the Minas Basin watershed area. The Working Group implemented a work plan to address the issues that were identified at these community forums. Subsequently, the Working Group hired a coordinator to work with community groups to develop action plans for the Minas Basin Watershed. This is a report summarizing the results of this initiative.

A full list of BoFEP publications, including those for the Minas Bay are available at http://www.bofep.org/publications.htm.

The work of the MBWG was of particular interest to this project due to the nature of the highest tides in this area, with several river catchments feeding into the Minas Basin – the major ones being the Rivers Avon, Shubenacadie, Cornwallis and Salmon. This makes it particularly comparable with the Severn Estuary which has 5 major rivers feeding into it.

The MBWG does not at the time of writing employ a co-ordinator, though it has in the past and recognises that this is a useful way of progressing the group's objectives. Annual work programmes have been produced but are lacking full implementation with limited staff resources. A small allocation ($1000) from the $50,000 annual budget of BoFEP is available to the group. A full time coordinator was hired for approximately 6 months in 2003-2004, however the funding was opportunistic and could not be continued.

Members of the group have led some very interactive and successful community forums which have enabled issues to be identified and actions proposed.

During the July 2006 MBWG meeting (at which I was present) there was interesting discussion on the following points:

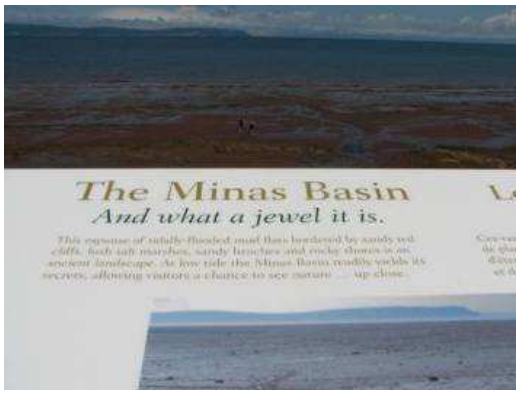
- Role of MBWG in leading research / carrying out practical delivery projects – it was decided to motivate a few local voluntary monitoring groups;
- How to carry forward the work programme (without a co-ordinator);
- Role of the MBWG in the renewable energy debate, evolving policy and when/how to stimulate public involvement & awareness – it was decided that the group could convene a public forum on this at some point in the future.

Many similarities were seen between the context for coastal management work in Canada compared to the UK at this time. This enabled valuable comparisons to be made between the role of BoFEP, the MBWG and the Severn Estuary Partnership.

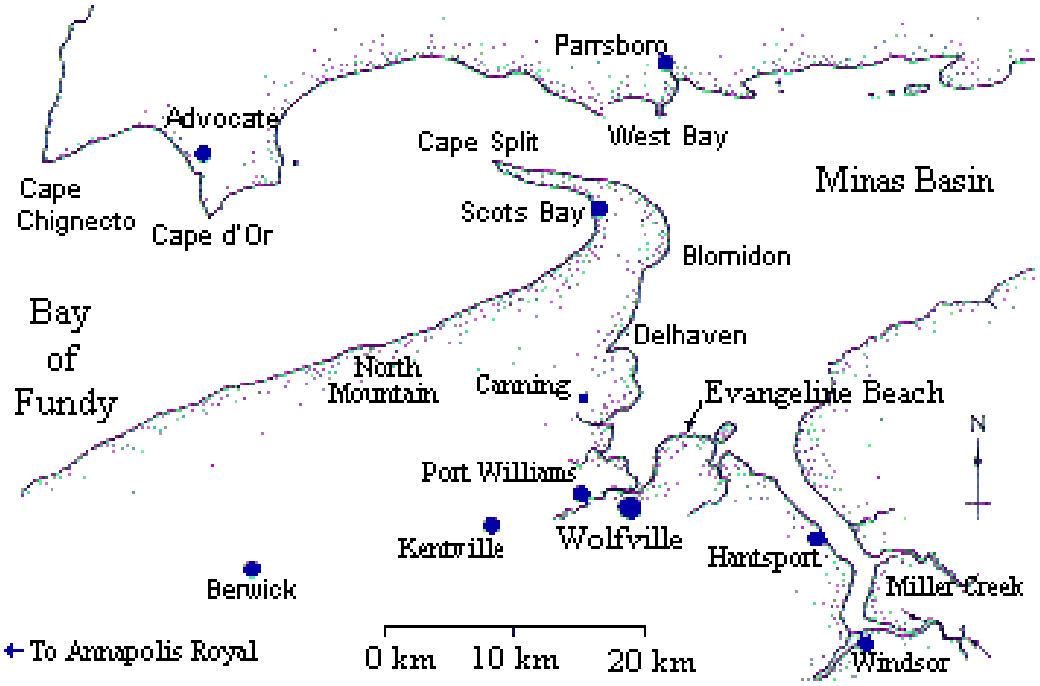
Minas Bay Working Group, July 2006.

- **Bay of Fundy Ecosystem Partnership, Minas Bay Working Group & Severn Estuary Partnership**

The aims, issues and activities of the Minas Basin Working Group are very similar to the Severn Estuary Partnerships' Management Group i.e. a group of individuals dedicated to furthering the future use & management of the area. The main difference is that the MBWG appears to be more grounded in science and monitoring the condition of the Bay, with higher involvement of academics in the working group. There appears to be a good level of public engagement from community forums and workshops, but with no co-ordination officer employed by the group. By comparison the SEP has obtained funds from a wide range of local authorities to provide a core service, employ a co-ordinator to facilitate implementation of the Strategy for the Severn Estuary (2001), whilst raising public awareness of the Severn Estuary through the Joint Advisory Committee meetings, occasional working groups and the recently established (2006) Severn Estuary Forum. The services and projects championed by the Severn Estuary Partnership are similar to the activities of the Bay of Fundy Ecosystem Partnership and Minas Bay Working Group.



Interpretation at Grand Pre in the Minas Basin.



Map 5: Minas Basin in the Bay of Fundy

Tide Clocks are hand-made locally in Annapolis Royal, Nova Scotia.

2.4 Public Awareness & Marketing the Tide for Tourism: *'Recognising the Tide'*

Objective i) Public awareness and marketing the tide for tourism
Assess the level of community awareness of high tidal ranges. Explore existing and potential opportunities for promoting public awareness of the coastal environment (and climate change impacts) through marketing and tourism initiatives. Gather examples of interpretation methods and public involvement in tide-related activities (e.g. tidal bores). Compare management approaches to habitat protection for migrating birds, human impacts and response.

2.4.1 First Impressions

On arrival in Canada, taking the train from Montreal to Halifax on my 1st day, I was engaged in conversation with a family from Moncton who talked about the impacts that a road causeway had caused on the Pedicodiac river. A few days later, travelling from Halifax to the Bedford Institute in Dartmouth for my 1st visit, the taxi driver informed me that many people around the Bay of Fundy have *tide clocks*. Awareness of the Bay of Fundy and its high tides, were apparent in casual meetings with people from the outset of this visit to Canada.

2.4.2 Public Awareness

It has been suggested (e.g. Hildebrand, 2006) that the level of awareness of coastal issues is typically weaker in urbanised coastal areas compared to rural. Around the less developed shorelines of Fundy (compared to the large urban conurbations around the Severn), we would therefore expect to see people more connected to tidal life through fishing, farming, logging, ship-building (formerly) and increasingly, ecotourism. Since only 1 million people live in Nova Scotia (approximately the same size as England) and approximately 3 million people live just around the Severn Estuary, there maybe some correlation between public awareness and population. The population of the entire Minas Basin watershed is only about 162,000 (18% of the Nova Scotian population) which is some 6% of the equivalent area around the Severn Estuary – which is more urbanised. This project didn't involve any formal survey, but based on first-hand contact with people, public awareness of the high tidal range in the Bay of Fundy appeared to be greater than recognised by people who live around the Severn Estuary. The livelihood of people around the Severn has become less rural with the expansion of major urban centres including Bristol, Cardiff and Gloucester and more industrialised with port developments at Avonmouth, Cardiff and Newport.

> *'Our history is embedded with the tides. The tides provided a unique opportunity for the ship building industry with a natural dry dock provided twice a day'.*
>
> *Terri McCulloch, Bay of Fundy Tourism Partnership*

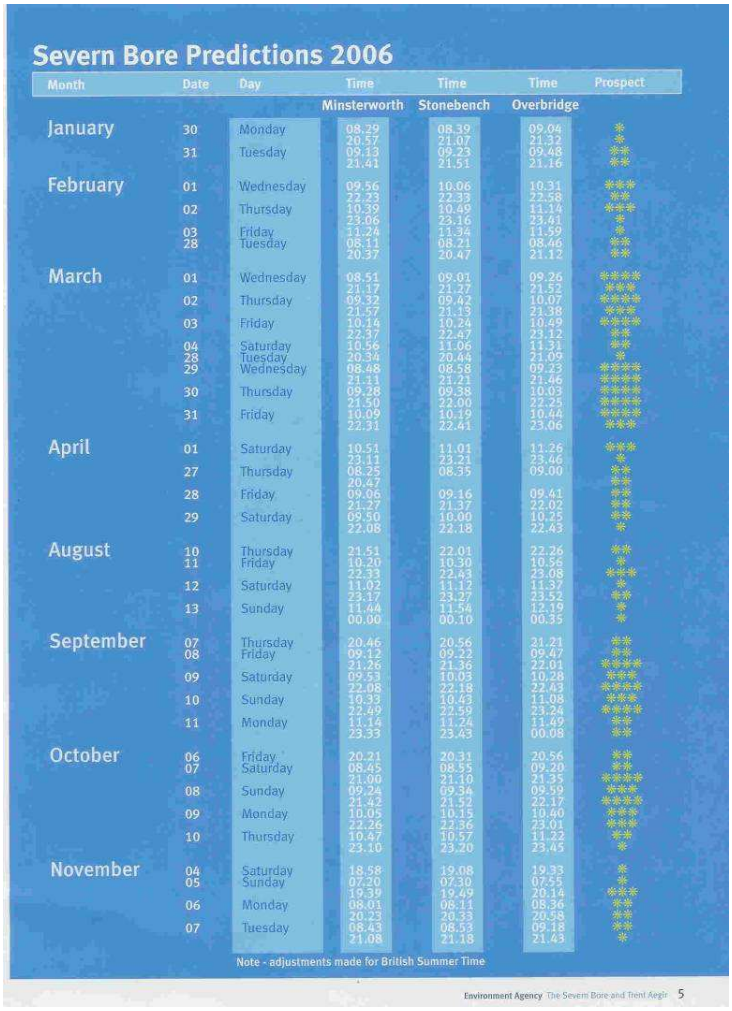
Promotional literature on the Bay of Fundy is readily available and widely disseminated. Visitor Information Centres (VICs) are well placed and frequent, stocking comprehensive brochures & leaflets on Fundy-related activities and interest features. VIC staff appeared to be very familiar with the 'highest tides in the world' and many visitors would learn this from using a VIC.

There are a wide range of descriptive books and brochures available which are specific to Fundy and the tides. Harry Thurston's book *Tidal Life* and the brochure *Bay of Fundy* by M Brylinsky of Acadia University are both popular and widely available. Thurston has written extensively about tidal life and has been actively involved in community initiatives to promote awareness of the Bay of Fundy and related issues. His work has contributed to a higher level of public awareness of the tidal patterns and habitats around the Bay.

2.4.3 Tidal Bores

The regular (almost daily) occurrence of tidal bores in several rivers and creeks around Fundy – Rivers Shubenacadie, Nappan, Petitcodiac, and others - is likely to have influenced public awareness of the power and size of the tide. By comparison, the Severn Estuary tidal bores are smaller and less frequent, but can be seen more frequently than publicised by the UK's Environment Agency (see below). The tidal bores predicted at 3 star and above attract the most number of watersport enthusiasts and visitors.

> *…the last hurrah of the flood tide.*
>
> *Harry Thurston in 'Tidal Life'*



Severn Bore Predictions 2006

Month	Date	Day	Time Minsterworth	Time Stonebench	Time Overbridge	Prospect
January	30	Monday	08.29 20.57	08.39 21.07	09.04 21.32	* *
	31	Tuesday	09.13 21.41	09.23 21.51	09.48 21.16	** **
February	01	Wednesday	09.56 22.23	10.06 22.33	10.31 22.58	*** **
	02	Thursday	10.39 23.06	10.49 23.16	11.14 23.41	*** *
	03	Friday	11.24	11.34	11.59	*
	28	Tuesday	08.11 20.37	08.21 20.47	08.46 21.12	** **
March	01	Wednesday	08.51 21.17	09.01 21.27	09.26 21.52	**** ***
	02	Thursday	09.32 21.57	09.42 21.13	10.07 21.38	**** ***
	03	Friday	10.14 22.37	10.24 22.47	10.49 23.12	**** **
	04	Saturday	10.56	11.06	11.31	**
	28	Tuesday	20.34	20.44	21.09	*
	29	Wednesday	08.48 21.11	08.58 21.21	09.23 21.46	**** ****
	30	Thursday	09.28 21.50	09.38 22.00	10.03 22.25	**** ****
	31	Friday	10.09 22.31	10.19 22.41	10.44 23.06	**** ***
April	01	Saturday	10.51 23.11	11.01 23.21	11.26 23.46	*** *
	27	Thursday	08.25 20.47	08.35	09.00	** **
	28	Friday	09.06 21.27	09.16 21.37	09.41 22.02	** **
	29	Saturday	09.50 22.08	10.00 22.18	10.25 22.43	** *
August	10	Thursday	21.51	22.01	22.26	**
	11	Friday	10.20 22.33	10.30 22.43	10.56 23.08	* ***
	12	Saturday	11.02 23.17	11.12 23.27	11.37 23.52	* **
	13	Sunday	11.44 00.00	11.54 00.10	12.19 00.35	* *
September	07	Thursday	20.46	20.56	21.21	**
	08	Friday	09.12 21.26	09.22 21.36	09.47 22.01	** ****
	09	Saturday	09.53 22.08	10.03 22.18	10.28 22.43	*** ****
	10	Sunday	10.33 22.49	10.43 22.59	11.08 23.24	*** ****
	11	Monday	11.14 23.33	11.24 23.43	11.49 00.08	** **
October	06	Friday	20.21	20.31	20.56	**
	07	Saturday	08.45 21.00	08.55 21.10	09.20 21.35	** ****
	08	Sunday	09.24 21.42	09.34 21.52	09.59 22.17	*** ****
	09	Monday	10.05 22.26	10.15 22.36	10.40 23.01	**** ***
	10	Thursday	10.47 23.10	10.57 23.20	11.22 23.45	*** *
November	04	Saturday	18.58	19.08	19.33	*
	05	Sunday	07.20 19.39	07.30 19.49	07.55 20.14	* ***
	06	Monday	08.01 20.23	08.11 20.33	08.36 20.58	** **
	07	Tuesday	08.43 21.08	08.53 21.18	09.18 21.43	** *

Note - adjustments made for British Summer Time

Environment Agency The Severn Bore and Trent Aegir 5

Severn Bore timetable for 2006.
(See http://www.severn-bore.co.uk/timetable.htm)

** = small **medium ***large ****extra large*

The Shubenacadie River has become very popular for tidal bore rafting. Three companies currently operate rafting experiences on the bore and associated rapids. On a day-long visit to directly experience the rafting, there were 11 rafts on one tide, carrying a total of approximately 70 people. At a cost of around $50-70CAD per head this is providing a good seasonal local income (mainly in the warmer months). Most days there would be one run-able tide, though occasionally two.

Tidal bore watching attracts tourists to sites across New Brunswick and Nova Scotia, particularly in the upstream towns of Moncton and Truro. Tidal bore timetables are readily accessible through VICs and on the internet (www.waterlevels.gc.ca).

> *It has been estimated that 100 billion tonnes of water flow in and out of the Bay of Fundy during one tide cycle, which is said to be equivalent to more than the combined flow of the worlds' freshwater rivers.*

The public awareness generated by the Fundy tidal bores seems higher than that of the Severn bore due to their more frequent occurrence and the tidal rapids found in the rivers leading into the Bay of Fundy. Directly experiencing the rapids generated by the tide in the Shubenacadie river showed the greater power and influence the tide seems to have compared to the Severn, even though the tidal range is just a couple of metres higher. The attraction for surfing the Severn is the front tidal bore wave, whereas in Fundy the rapids generated after the front wave and the 'reversing river' affect seen with the rush of the incoming tide are well marketed around Fundy. There is a longer viewing time and rafting trips for more people compared to the Severn where riding the front wave is practiced by local surfers and kayakers, with no commercial opportunities for rafting. However, since March 2006, the Severn holds the world's longest surf record of 7.5 miles and has received national and international publicity.

A small tidal bore on the Chiganois river inlet just west of Truro in the upper Minas Basin, 26th July 2006.

2.4.4 Bay of Fundy Tourism Partnership (BoFTP)

The Bay of Fundy Tourism Partnership was initiated in the mid 1990s as the Bay of Fundy Product Club and is based in Parrsborro, Nova Scotia. Start-up funding was provided through a collaboration between New Brunswick and Nova Scotia provincial governments and the Canadian Tourism Commission. The partnership continues to obtain funding from a variety of sources for a variety of projects, largely depending upon the initiative taken by the lead officers.

Time spent with Terri McCulloch illustrated the thorough knowledge and close connection with the community this partnership has developed. The *Bay of Fundy Recommended Experience* scheme is well established and has led to the training of staff from accommodation, activity and other tourism related services in understanding the Bay, targeting their marketing and ensuring high standards.

The Bay of Fundy Tourism Partnership works with some 50 tourism operators in different businesses, from hoteliers and restauranters to tidal bore and whale-watching companies. They offer a 5-day training course in sustainable tourism which includes training on the natural environment and value of the Bay of Fundy.

Box 7: The Bay of Fundy Tourism Partnership Objectives

The Bay of Fundy Tourism Partnership (BoFTP) develops and promotes the Bay of Fundy on Canada's east coast as an internationally-recognized, unique and remarkable nature-based tourism destination.

BoFTP advocate and deliver programs with the tourism industry in New Brunswick and Nova Scotia that support sustainability and conservation of the Bay of Fundy ecosystem.

We've built a seamless Bay of Fundy travel experience with unsurpassed standards of excellence. Through our Bay of Fundy Recommended Experiences quality program and designation, we support and encourage educational visitor experiences and a deeper understanding of the Bay of Fundy by those who live and work here.

Through an alliance of Fundy-based businesses, regional and provincial tourism organizations, and develoment agencies from New Brunswick and Nova Scotia, the Bay of Fundy Tourism Partnership strives to make the Bay of Fundy:

- One of North America's top-ten nature tourism destinations
- An integral part of Canada's national tourism brand
- Promote the implementation of sustainability initiatives for the Bay of Fundy eco-system
- Attract an annual visitation of 1 million nature tourists

For more information about the Bay of Fundy Tourism Partnership's membership program, visit the website http://www.bayoffundytourism.com/about/

Extract from the Bay of Fundy Tourism Partnerhsip's website, which contains guidance on viewing the tides, and promotes sustainable tourism and visitor information.

Hopewell Rocks in New Brunswick – a tourist destination promoted worldwide attracting 250,000 visitors per year; more than most other destinations around the Bay of Fundy.

2.4.5 Site marketing & Branding

Nova Scotia and New Brunswick take different approaches to marketing the Bay of Fundy. New Brunswick promotes a few 'honey-pot' sites which attract thousands of visitors into a more organised style of tourism. There are vast areas of unspoilt and little-visited areas contrasting with these popular attractions. Nova Scotia has a less 'branded' way of marketing the Bay, giving visitors a more dispersed experience of the area with interpretation opportunities at a variety of locations across the landscape.

Table 4: Site Marketing and Branding in Nova Scotia & New Brunswick

BAY OF FUNDY **Sites & marketing brands**	**NOVA SCOTIA**	**NEW BRUNSWICK**
An indication of the significant marketing of the 'highest tides in the world' at the Bay of Fundy is evident from a 'google' search on the internet. Other notable branding of 'Atlantic Canada' and 'the Maritimes' indicates a strong identity between tourism activity and the coast in the vicinity of the Bay of Fundy.	Fundy Shore Ecotour (well signposted throughout Nova Scoatia, linked to promoting sites & facilities).	Hopewell Rocks (large visitor attraction with full range of facilities attracting international visitors).
	Tidal Bore Rafting on R. Shubenacadie (3 active companies).	Bay of Fundy National Park (oldest national park in Canada with comprehensive entertainment programme and faciliites).
	Glooscap Trail (proposal to re-name) signposted road route around the Bay.	Reversing Falls, Saint John (urban opportunity to see the tide).
	Evangeline Beach & Grand Pre Historic Site (good interpretation panels and boardwalk at a good bird viewing area).	Fundy Trail (modern road-track with interpretation stopping points, small visitor centre and facilities).
	Tidal bore viewing in Truro (from guest houses etc).	
	Tide Interpretation Site on R. Shubenacadie (under construction).	
	Cape Split, Nova Scotia (no facilities).	

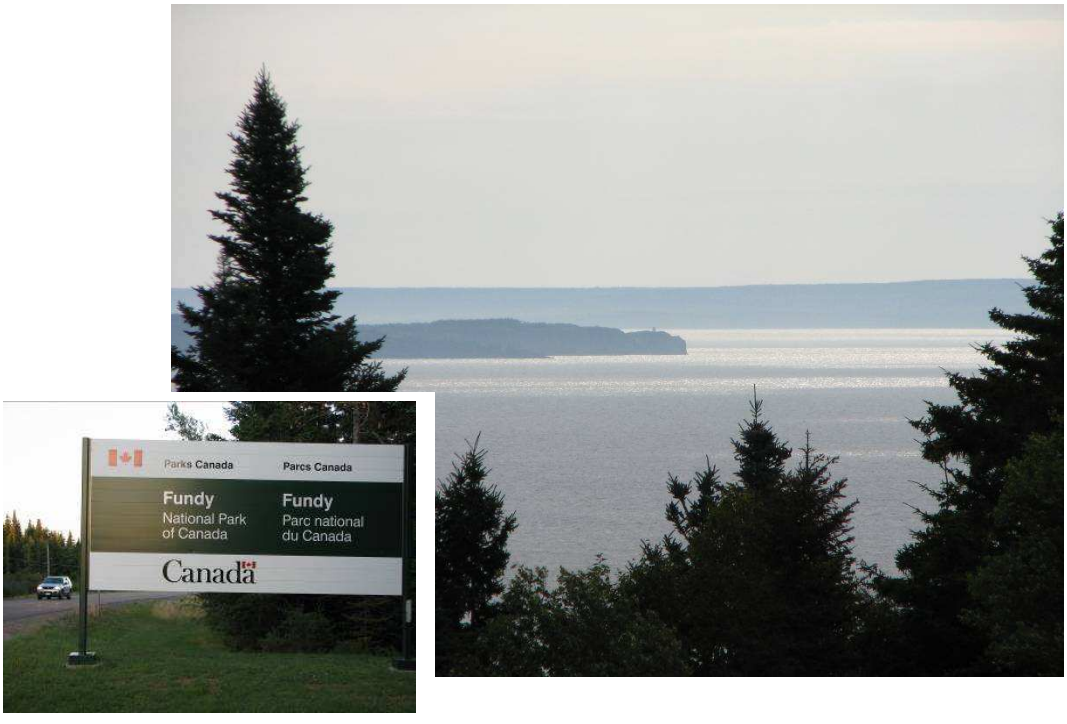
Hopewell Rocks Visitor Centre, New Brunswick.

Around the Bay of Fundy there are numerous guest houses, hotels, inns, restaurants, local companies and other initiatives which include 'Fundy' or 'tide' within their names. By comparison, there are a fewer companies that identify with the 'Severn' in their branding.

The giant tides create life-enhancing conditions

Harry Thurston, in 'Tidal Life'

Restaurants, campsites, a blueberry farm, tidal bore viewing sites, ice cream and a financial firm in Nova Scotia – public awareness of Fundy and the tide is very apparent.



Fundy was the 1st National Park designated in Canada.
It offers a huge range of environmental education opportunities for all ages.

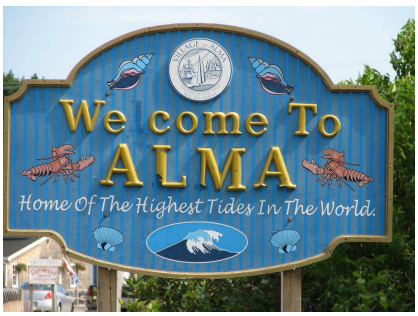
2.4.6 Environmental Interpretation – shorebirds & tides

There are several good examples around the Bay of Fundy of interpretation to raise public awareness of shorebirds. Whilst the Severn has an important winter migration season, Fundy is the summer feeding ground for a large proportion of the world's semi-palmated sandpiper - some 3 million birds visit in July-August on their migration from the Arctic to South America. Evangeline Beach and Grand Pre in Nova Scotia and St Mary's Point in New Brunswick are two good examples of popular interpretation sites, promoting balanced use for recreation to limit bird disturbance.

The level of awareness of the high tides and valuable marine environment are made prominent on the ferry across the Bay of Fundy between Digby in Nova Scotia and Saint John in New Brunswick.

Whilst public awareness of the tides and marketing the Bay of Fundy are higher in Nova Scotia and New Brunswick compared to around the Severn in England & Wales, there appears to be less awareness/concern for the potential impacts of climate change and sea level rise. The frequency of UK media coverage on climate change-related topics has probably led to more public awareness – but that does not necessarily mean people around the Severn relate the potential impacts to local increases in high tides or storm surges. The next section considers approaches to land use and flood risk planning in the context of public awareness of the tide.

Interpretation at Hopewell Rocks Visitor Center in New Brunswick, where tourists come from all over the world seeking an opportunity to 'walk on the ocean floor'.



Interpretation at Alma, gateway to Fundy National Park.

2.5 Land Use Management & Flood Risk Planning: *'Living with the Tide'*

Objective ii) Land use management in response to flood risk
Assess the extent of coastal protection and flood defence measures and future options. Due to climate change there is increasing pressure on inter-tidal habitats with sea level rise and the risk of habitat and species loss due to coastal squeeze. Compare habitat and landscape change in environments with high and low population densities. How adaptive are approaches to shoreline management and development plans?

2.5.1 Ancient Settlement

Traditional Mik'Maq communities, followed by the Acadians who first settled on the shorelines of Fundy, reclaimed marshland for agriculture and started the construction of dykes. Most of the Fundy dykes were privately maintained until 1948 when the federal and then provincial government took over their maintenance. The establishment of the Marsh Body/Committees (rather like the UK Internal Drainage Boards) have been powerful groups influencing land use around Fundy, and some 17000 ha of agricultural land are now defended by dykes.

Historic settlement from centuries ago accounts for reclaiming marshland for agriculture around the Bay of Fundy and the Severn Estuary. However, the Acadian dykes around Fundy would break in big storms or from large tides and there is still more flexibility for the earth embankments around Fundy to be modified with natural processes compared to the fixed concrete defences built around much of the Severn.

Grand Pre dyke and marshes – large signposting illustrates the value to the community of the agricultural land reclaimed by maintaining the dykes.

2.5.2 Dykes, Marshes and Coastal Protection

There are some remarkable similarities between Fundy and the Severn Estuary. Whilst on first appearances the Bay of Fundy appears much less developed than Severn, there has been widespread loss of marshlands – some 80% - with 60-70% of the shoreline backed by dykes (earth embankments). A figure often quoted for the Severn is that 80% of our shoreline is also backed by coastal defences. Both locations have experienced extensive conversion of tidal floodplains to land drained for agriculture. The main differences between Severn & Fundy are that nearly all the Fundy dykes are still earth embankments, with the occasional rock or timber reinforcement. Around the Severn a high proportion of the defences are concrete walls with rock armour toes. In addition, most of the Fundy dykes are fronted (on average) by 100m of salt marsh whereas high tide usually reaches at least the toe of the flood defence

& coastal protection structures around the Severn. The inter-tidal habitats in front of the Severn's coastal protection have mainly been eroded, with mainly mud-flats and only sporadic salt marsh communities remaining.

Hank Kolstee, Land Protection Supervisor for Nova Scotia Agriculture Resource Stewardship, described the history of marsh reclamation around the Bay of Fundy and current measures to protect agricultural land and property. The town of Truro is at risk of regular flooding. Nearby areas such as the area of agricultural land at Old Barns have been monitored carefully in recent years. A period of erosion followed by a period of accretion led the farmer to seek extension of the dyke into the estuary. After discussions with the provincial engineer/land protection supervisor, and consideration of the long term position, it has been agreed to hold the existing line of defence (not advance it) allowing the salt marsh and mud flats to act as a buffer for the existing area of reclaimed land.

Shoreline defences near Severn Beach on the Severn Estuary (left) and near Truro on the Bay of Fundy (right): similar pressures, different responses.

Examples of coastal protection work seen around Fundy included scattered rock revetment and timber revetment, where the tide reached the embankment (as shown above). Elsewhere a 'buffer zone' of saltmarsh and mudflat lies between the main tidal flow and dykes, property or infrastructure. Coastal protection works around the Bay of Fundy are often less permanent structures than the concrete defences or large embankments at high water mark around the Severn.

In a few cases, the dykes are not being maintained to their full extent around the Bay of Fundy, on the basis that the economics do not justify it. There also appears to be some perception that giving the tide space helps the overall dynamic nature of the system, thereby minimising overall costs of coastal protection. Only where it is necessary to defend property from the risk of flooding are measures being put in place.

2.5.3 Modern Legislation and Flood Risk Planning

The development of planning guidance in UK (e.g. *Planning Policy Guidance on Development in Flood Risk Areas*) and studies such as the UK Environment Agency's *Severn Tidal Flood Risk Management Strategy*, compares to the *Agricultural Marshland Conservation Act (2000)* in Canada, which recognised the development risks and need for additional planning guidance. The Fundy marshlands continue to be under pressure, for example around Wolfville with the current development of a new industrial estate in the low-lying floodplain. The incidence of flooding and flood risks to Truro and around Moncton are likely to increase public awareness of the implications of development in flood plains. However, despite additional planning guidance and insurance premiums, the pressures and occurrence of flood-plain development continues to increase, as can be seen around the Severn, for example in the Weston-super-Mare area.




Coastal protection measures around the Bay of Fundy: scattered revetment (top) and a buffer zone of salt marsh and mud flats (above) – typically 100m in front of the dykes. This contrasts with the Severn Estuary shoreline where many coastal protection structures and embankments exist along the high water mark (opposite).

Lessons are still being learnt about the value of 'working with the tide' when it comes to coastal protection in both the Severn and Fundy. Flood risk strategies for the Severn Estuary and opportunities for managed re-alignment are under consideration, such as at the Steart Peninsula, where the Environment Agency and others have been in negotiation with landowners for many years. Future approaches to maintaining coastal protection structures around the Severn are being explored through a Coastal Habitat Management Plan and 2nd phase Shoreline Management Plan. They involve consideration of alternative options such as managed re-alignment of the shoreline to reduce maintenance costs and revert some of the land back to tidal floodplain. A big difference between the two sites is the population density which affects the need for, and flexibility with, different coastal protection options.

The high profile of climate change & sea level rise issues in the UK and the involvement of the Environment Agency and local government in promoting schemes for habitat restoration & re-alignment,

may be an indicator of wider awareness of climate change impacts. There appears to be less discussion of schemes to re-align the Fundy shoreline.

The low population around the Bay of Fundy allows the open coastline to act as a 'soft' buffer zone to help protect people and property.

There are, however, areas of extensive agricultural land reclaimed from the marshes, such as around Wolfville and towards the Avon river behind Cape Blomidon. The extensive 6000ha Tantramar Marshes between Nova Scotia and New Brunswick have been significantly impacted by the development of infrastructure necessary for transport and communications networks.

The Tantramar Marshes were drained for agriculture and key infrastructure linking Nova Scotia with mainland Canada.

Comparison of approaches to land use planning and flood risk in the Severn Estuary and Bay of Fundy are limited since Fundy has a far lower population density. As a result, planning policy and flood risk management strategies appear to be more evolved for the Severn. There would therefore be valuable opportunities so share experience from managed re-alignment schemes in the UK with engineers in the Bay of Fundy.

2.6 Renewable Energy Options: *'Harnessing the Tide'*

Objective iii) Opportunities for renewable energy
Due to climate change, there is increasing political attention towards opportunities for renewable energy. Identify past, present and proposed options for harnessing tidal energy. Tidal power plants could provide a useful source of energy, but technologies are relatively young. Make links with academic, government and commercial organisations involved in assessing the potential for renewable energy using tides.

2.6.1 Tidal Energy

Increasing uncertainty over relying on hydrocarbons (coal, oil, gas etc) for energy and impacts of climate change, are leading to more interest in renewable energy options. Tidal power offers a potentially significant new source of energy. In Europe, tidal mills were operational in the 12th century and probably earlier, but there is currently very limited use of tidal power. There is increasing interest across the world in the potential for tidal energy.

The following tidal power stations have existed for some time:

- La Rance (Brittany, France) 240 MW plant (1967)
- Annapolis Royal (Nova Scotia, Canada) 18 MW plant (1983)
- Jiangxia Plant (China) 3.9 MW plant (1985)
- Kislaya Guba (White Sea, Russia) 0.4 MW plant (1968)

The Annapolis Royal Tidal Power Plant in New Brunswick, Bay of Fundy was visited and will be discussed in some detail in this section of the report.

La Rance tidal barrage, France.

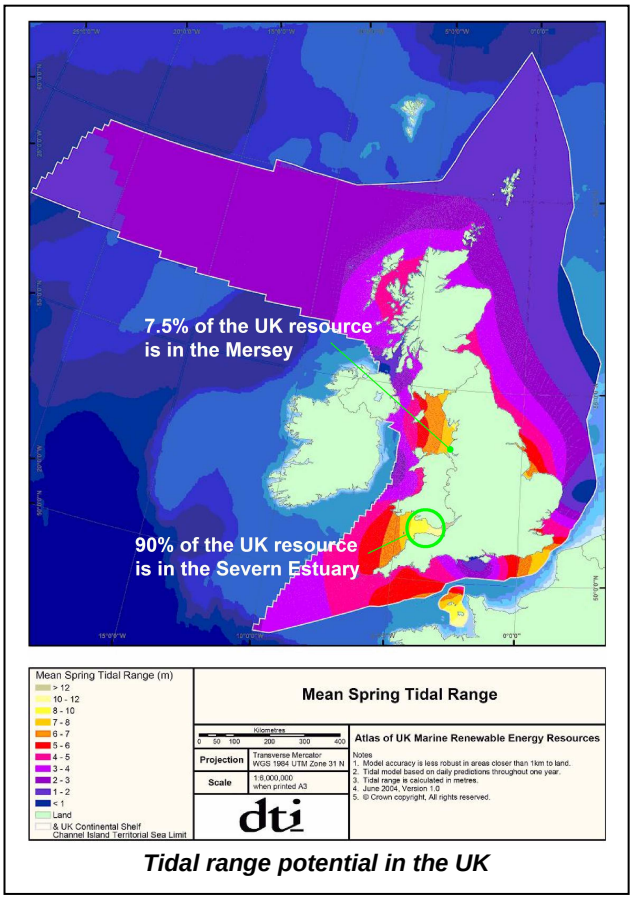
Increasingly, different tidal energy options are being researched and evaluated for their cost-effectiveness. Momentum is building in Canada to re-assess the options for the Bay of Fundy. At the same time, there is significant interest around the Severn in re-visiting the Severn Barrage proposal (of the late 1980s-early 1990s). This section should bring information into this current debate and encourage contact to be made between scientists, engineers and planners between the Bay of Fundy and Severn Estuary. The greater sharing of knowledge and understanding in these two estuaries with the world's highest tidal ranges, should enable more efficient and informed decision-making.

Visiting the Annapolis Royal tidal power plant in Nova Scotia provided useful information to help explore recently renewed interest in the Severn Barrage proposal. The Bay of Fundy and Severn Estuary are leading areas for the development of tidal energy technology.

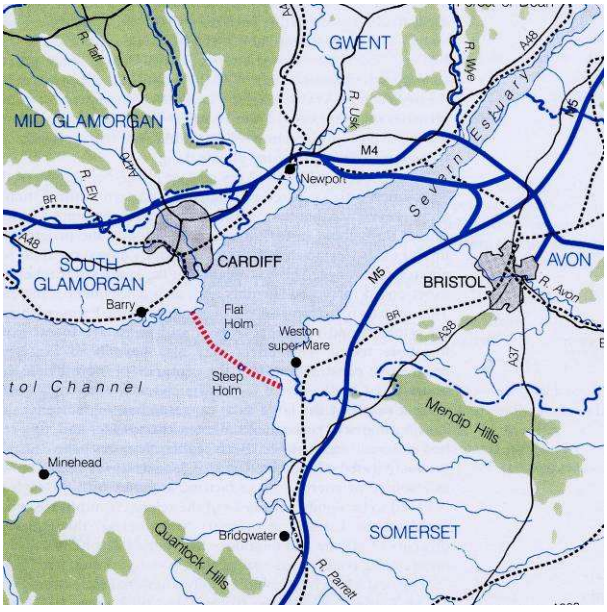
Box 3: Tidal Power Potential from the Severn Estuary *(Source: http://en.wikipedia.org/wiki/River_Severn#Tidal_Power)*

A huge tidal range and high level of surrounding industry and population have long made the Severn estuary and Bristol Channel a focus for tidal energy schemes and ideas. Plans for a Severn Barrage — running 16 km (10 miles) across the Bristol Channel from Lavernock Point near to and south west of Cardiff to Brean Down near and just south west of Weston-super-Mare in Somerset — could generate a massive 8640 MW when the tide flows, and have been discussed for several decades now.

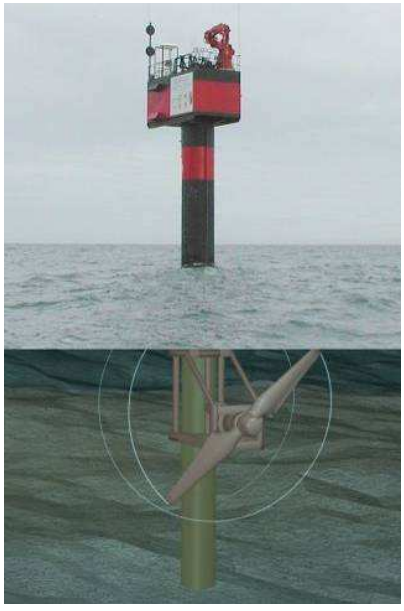
The UK Government shelved the plans in the late 1980s due largely to cost issues and local environmental concerns. However, this was before recent huge rises in the price of energy, and before Global Warming had started to be taken seriously. In April 2006 the Welsh Assembly approved the idea of utilizing the tidal power, but the RSPB has raised serious concerns about the effect on the mud flats, that have European environmental protection status, and the UK government Energy Review published later in the year did not endorse the scheme.



Tidal range potential in the UK



Potential location of a Severn Barrage scheme shown in red (approx 10 miles long).
Source: Kerr/Severn Tidal Power Group

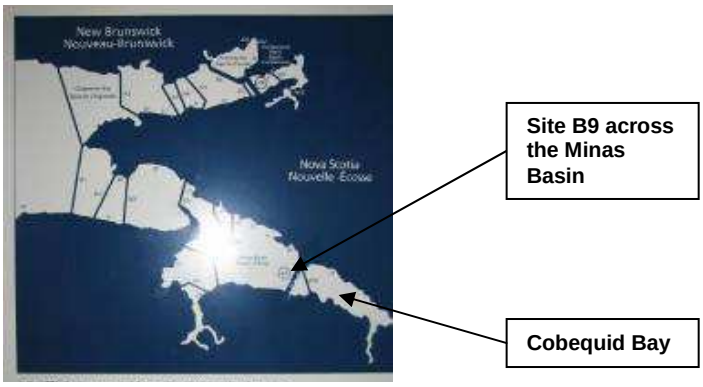


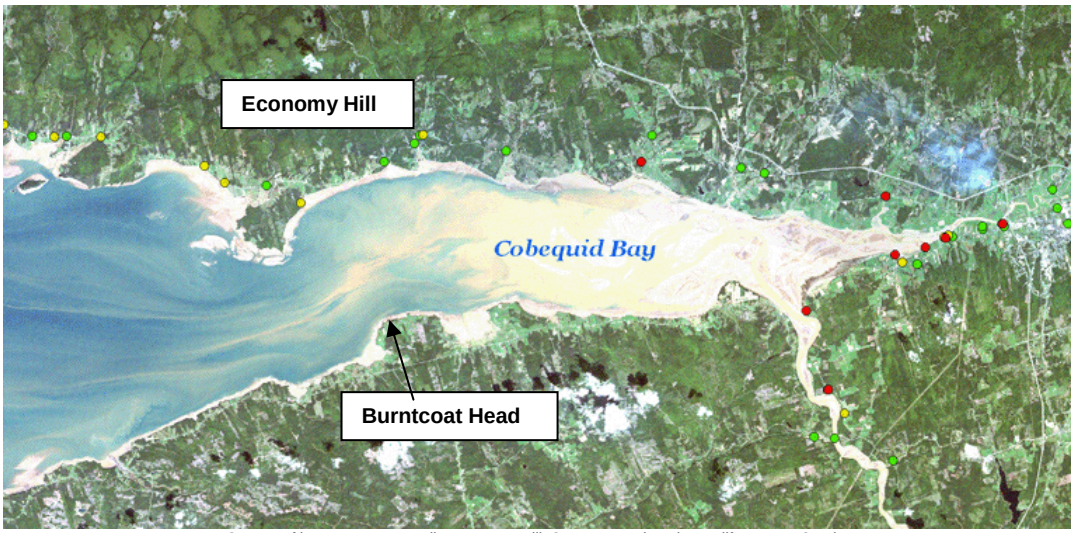
Monopile tidal stream device being trialled in the Bristol Channel, UK.
Source: Entec

A report published by the UK's Sustainable Development Commission (SDC, October 2007) gave clear recommendations to Government about the potential for renewable energy from the Severn and the value of re-considering the Severn Barrage. Government have subsequently announced that they will allocate money towards feasibility studies in the near future.

2.6.2 Tidal Barrage Assessments in the Bay of Fundy

The potential for generating energy from the Fundy tides was first suggested in 1910 by W.R. Turnbull, an engineer and inventor from New Brunswick. Over the next 50 years there were sporadic and unsuccessful attempts at development. The 1960s saw increasing investigations, with the Atlantic Tidal Power Programming Board making the first examination of the tidal resource as a whole and identifying the most promising sites for tidal barrages (Conley & Daborn in *Energy Options for Atlantic Canada*, 1983).





Source of base map: Dr Danika van Proosdij, St Mary's University, Halifax, Nova Scotia.

The upper Minas Basin and approximate location of the preferred tidal barrage site B9.

In the late 1970s, improvements in technology, understanding of the resource and the increasing price of fuel, led to designs for two sites that appeared to be economically feasible. The greatest potential was shown by the Minas Basin-Cobequid Bay barrage option (site B9) as shown on the above diagram. Capacities of between 4000 and 5300 MW were estimated to give an annual energy output of about 14000 GWh, potentially up to 20000 GWh. Construction costs in 1981 were estimated at just over $6 million with production beginning after 8 years construction. It was envisaged that the B9 site would contain 128 turbines in an 8km barrage and impound more than 300km^2 of tidal water in Cobequid Bay in the upper part of the Minas Basin.

Minas Basin from Economy Hill looking towards Burntcoat Head, site of the highest recorded tides in the world and the most favoured location for a tidal barrage.

Investigations during this time illustrated significant potential impacts of a barrage, particularly in relation to changing the tidal regime. Hydrodynamic numerical modelling undertaken by the Tidal Power Review Board indicated that the construction of a barrage in the upper part of the Bay would result in:

- reduction of tidal range in the vicinity of the barrage;
- increase of tidal range in the lower Bay and Gulf of Maine (USA).

The tidal range appeared to be most sensitive to conditions in the Minas Basin. A barrage at site B9 in the Minas Basin was estimated to cause a 13cm rise in tidal amplitude in Boston, New England (USA). This was considered a difficult issue and carried political risk.

Whilst no environmental assessment was carried out at that time, a considerable amount of research was undertaken. It was realised that large gaps existed in the basic knowledge necessary to predict the environmental consequences of a tidal project. Many individuals and agencies therefore undertook research under the co-ordination of the Fundy Environmental Studies Committee to increase understanding of the basic knowledge required, so that the impacts could be better predicted. These included, for example the following upstream and downstream impacts.

Table 5: Potential Impacts of a Tidal Barrage (Conley & Daborn, 1983)

Overall affects	**Inside the barrage - upstream**	**Outside the barrage - downstream**
Fish mortality due to passage through the turbines.	Halving of tidal range inside the barrage: • flood risk reduction and erosion control • reduced drainage from surrounding land • loss of intertidal habitat; conversion to sub tidal habitat would result in loss of fish & bird feeding grounds.	Reduction in inter-tidal width and area near the barrage. Changed tidal regime in the lower Bay of Fundy-Gulf of Maine with 'shortening' of the system: consequences for coastal protection far downstream where the average tidal range of 1-1.5m could be increased by up to 15 or 20cm.
Changes in tidal currents affecting food supplies, propagation and larval distribution of commercial fisheries.	Settlement of suspended sediment – greater light penetration in the water column; uncertainties about destination of settled out suspended sediments.	Removal of energy from the system will modify the physical oceanographic system with unknown consequences on biological resources for north America, from the Arctic to the tropics.
Narrowing of estuary width (through the permeable portion of the barrage).	More stratification of fresh and saline water, leading to earlier, thicker and more prolonged ice cover.	Altering tidal current patterns leading to changes in location of mudflats and saltmarsh; questions remaining on the length of time they would take to stabilise and recover biological productivity: could affect deep up-welling of ocean currents providing feeding ground for fish, sea birds and marine mammals.

In addition to the predicted effects of the tidal barrage on estuaries, coast and seas, the following terrestrial impacts were considered:

- land and material required for construction;
- land and new infrastructure required for power transmission;
- possible changes in microclimate arising from the stratification and decreased tidal exchange, shortening the growing season in the surrounding area.

The energy demanded from the tidal resource was balanced at that time by other energy options (as reported from the 'Energy Options for Atlantic Canada' conference in Conley & Daborn, 1983). The Canadian demand for alternative energy sources had to be seen in the context of the relatively low population around the Bay of Fundy. The high costs of any barrage scheme therefore meant that the construction costs would need to be met from outside the region and energy supplied to a wider area. However, Nova Scotia at that time had good coal reserves and New Brunswick had established a nuclear power station.

2.6.3 Tidal Power Options – the current position in the Bay of Fundy

In recent years, interest has been rising again to assess options for harnessing the tidal power of the Bay of Fundy.

> After decades of seeming dormancy, engineers and others interested in exploiting the powerful tides of Fundy are coming forward again with new proposals for harnessing the flowing waters in a purportedly more environmentally benign manner. The Minas Basin seems to be of particular interest. According to a story in the Chronicle Herald on 21/11/2005 Nova Scotia (in conjunction with NB, Maine, Massachusetts, California, Washington and Alaska) is funding a study "to examine the viability of tidal current power in the waters bordering these provinces and states". The author concludes, "when this study is completed in the spring of 2006, the Bay of Fundy will be singled out as one of the sites with great potential. Pilot projects would be the logical follow-up." http://www.herald.ns.ca/Search/466072.html

Example of news item on the Bay of Fundy Ecosystem Partnership website – as in the UK, there is renewed interest in tidal power options to make the most of the high tidal range.

The Coastal Issues Committee of the Nova Scotia Ecology Action Centre has been conducting tidal barrier audits around the Bay of Fundy since 2001. As part of this project, obstructions to tidal waters and the effects on salt marshes and fish habitat were assessed and recommendations for restoration were made. The results of these audits are now available on CD as a series of reports, along with other relevant EAC publications. For information or to order a CD of these reports, email tidalbarriers@ecologyaction.ca.

Vast inter-tidal mudflats exposed in the upper Minas Basin, Nova Scotia.

There has also been research on potential sites for tidal in-stream energy conversion, for which the Minas Channel and Minas Basin were identified as favourable sites in North America for central power generation. In May 2006 the report (EPRI, 2006) from this research concluded that in-stream tidal energy conversion be evaluated as a potential energy supply source to diversify and balance the energy supply portfolio of North America. The benefits are reported as:

- utilisation of an abundant, cleaner & relatively pollution free resource;
- creation of jobs, economic development and improved energy self-sufficiency;
- relatively fewer aesthetic impacts compared to other energy options (due to almost total submergence);
- tidal energy is predictable.

Seven feasibility sites were considered, including two in the Bay of Fundy: the Minas Passage in Nova Scotia; and Head Harbour Passage in New Brunswick. The Minas Passage site was estimated to have a potential of over 1GW. It has been estimated that just 15% of the available tidal energy resource base could power about 120,000 homes based on 1.3KW/home. A review of available technology (8 devices)

was presented based on tidal power research programmes in industry, government and universities in the UK, Norway, Ireland, Italy, Sweden, Canada and the US over the last 6 years. A small number of companies (backed by private industry, venture capital and European Governments) are leading the commercialisation of technologies to generate electricity from tidal streams. This includes the Marine Current Turbines *SeaFlow* and *SeaGen* turbines which have been designed in the UK. The technologies are still young but it is not too early to prioritise options for pilot testing the technology at appropriate sites – as has been undertaken in the Bristol Channel just north of Foreland Point. Collaboration between government, utilities, power producers, NGOs, project and tidal energy device developers is now being strongly promoted for research & development purposes and consideration of a 'fast-track' route through regulations. This may help to realise marine renewable demonstration projects in the first instance.

In 2006, the municipalities within Nova Scotia established a committee on renewable energy, with particular attention being paid to possible demonstration sites for tidal (sub-sea) turbines.
The Bay of Fundy Ecosystem Partnership (see Section 2.3.4) also initiated a Working Group on Energy.

Sub-sea tidal stream turbines are now seen more favourably than the barrage options for the Bay of Fundy. Feasibility studies progressing during 2007-08 do not include further assessment of tidal barrage options due to the perceived impacts and risks. This contrasts significantly to the work of the UK's Sustainable Development Commission and Feasibility Studies for the Severn Estuary for which a large incentive is to re-visit tidal barrage options.

The Minas Basin viewed from Cape Blomidon, Nova Scotia at mid-tide.

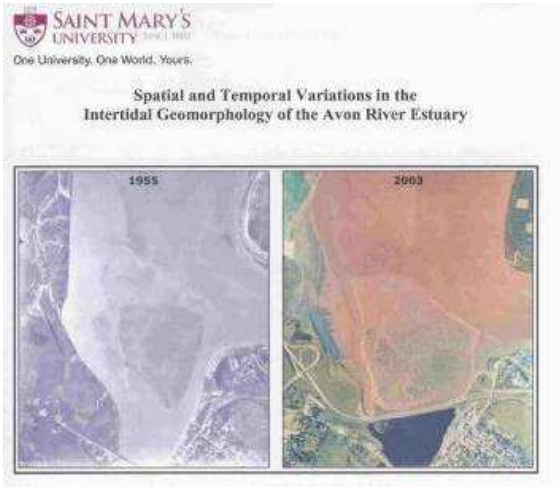
2.6.4 Tidal Barrages & Fundy Causeways

Experience from the impact of causeways on estuary dynamics around the Bay of Fundy could provide valuable insight for assessing the changes likely to be introduced by tidal barrages.

There are several locations around the Bay of Fundy where causeways have been built across the tributary rivers, instead of bridges to reduce construction costs. There has been relatively little experience of this around the Severn Estuary where bridges have been built (e.g. across the R. Usk in Newport, and across the R. Avon in Bristol). However, as a result of constructing such causeways around Fundy, an increasing level of knowledge is being developed on the effects of these small dams on the estuarine system.

- **River Avon Causeway (Windsor)**

  Rapid accumulation of mudflats followed by colonisation by salt marsh communities have been extensively studied on the River Avon downstream of a road causeway.



Before and after the Avon River Causeway: recent studies are investigating the constitution of the new salt marsh established in front of the causeway – on the downstream side.

Signposting and saltmarsh formed downstream of the causeway; waterspace upstream of the causeway.

Saltmarsh established downstream of the Avon River Causeway, near Windsor in Nova Scotia.

- **River Pedicodiac Causeway (Moncton)**

A similar scenario has been experienced on the River Pedicodiac, where a causeway was built to improve access to the town of Moncton. When the causeway was being built the engineers saw the immediate build up of silt on the downstream side. Some 15 years after construction, an extensive area of salt marsh has built up and the river has significantly narrowed. The dynamic equilibrium of the river and estuary system does not appear to be stabilising with less predictable flood risk consequences. A new bridge has recently been constructed and extensive research is underway to look at future options, including possible removal of the causeway.

The road causeway over the R. Pedicodiac at Moncton has led to significant build up of mud flats & salt marsh.

In both the R. Avon and R. Pedicodiac causeways, new large mudflats developed progressively for many years at rates so great that they did not consolidate. They remained so fluid that the typical fauna of bivalves, amphipods and polychaetes was established slowly and with difficulty. If similar effects resulted from the construction of a tidal barrage, with a long period required for re-establishment of habitats, the consequences for shorebirds and fish could be severe.

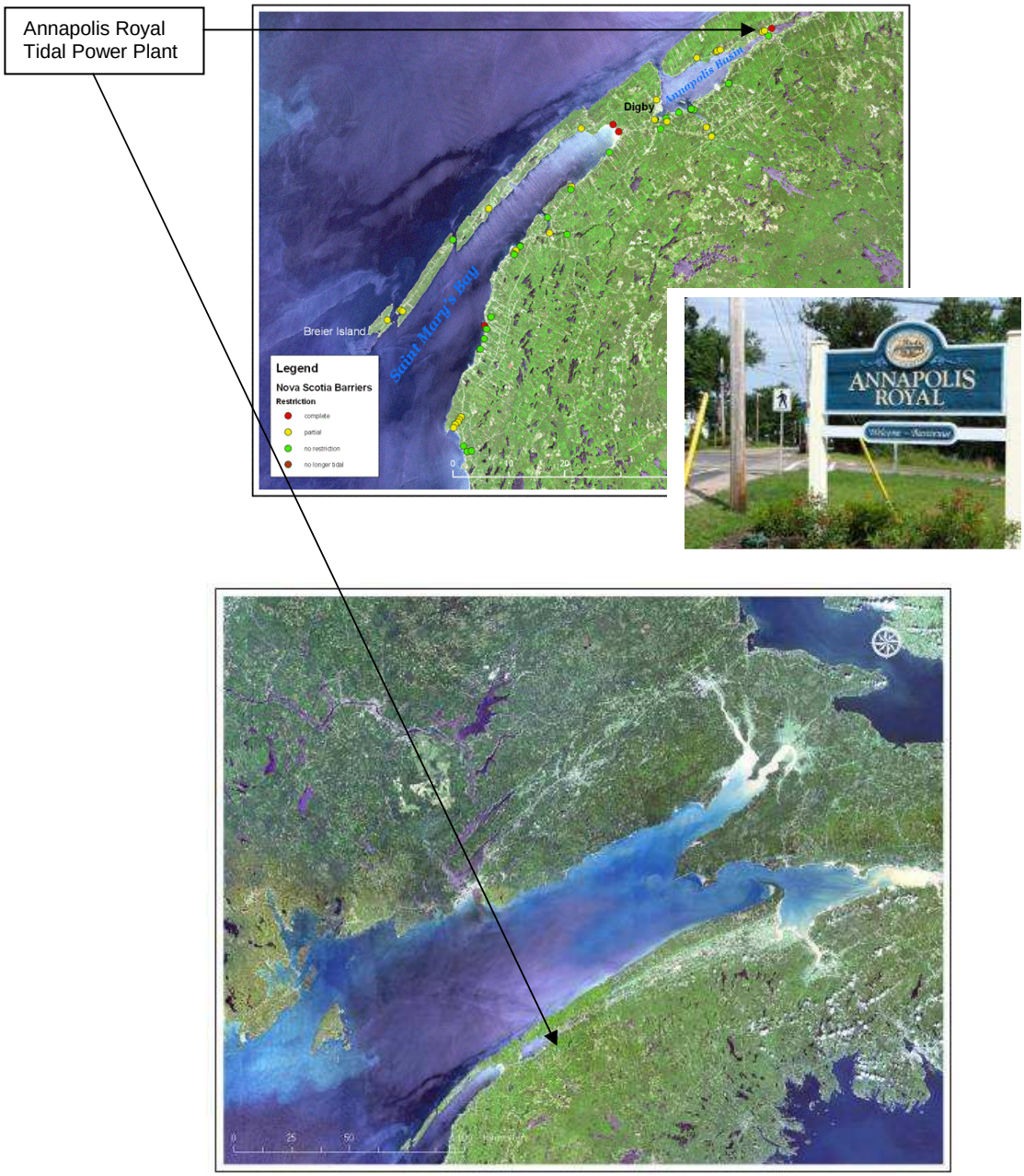
These results make it worthwhile to compare further the conditions in the Bay of Fundy with those in the Severn Estuary. Published studies are available such as:

- Environmental Impacts of Barriers on Rivers Entering the Bay of Fundy (Wells, 1999).
- Spatial and Temporal Variations in the Intertidal Geomorphology of the Avon River Estuary (Van Proosdij & Bambrick, 2006).
- Bay of Fundy Tidal Barrier Project (BoFEP, EC, GOMC & SMU) Version 1: Nova Scotia Pilot.

There are ongoing studies being conducted by the Department of Fisheries & Oceans Canada on the River Pedicodiac and St. Mary's University on the River Avon.

2.6.5 Annapolis Royal Tidal Power Station

Annapolis Royal is one of the most historic settlements in Nova Scotia. It was named Port Royal as the Acadian capital, then, following capture in 1710 by New Englanders, was renamed Annapolis Royal. Following an influx of French and British settlers, it became the capital of British Nova Scotia for 36 years before the British moved the capital to Halifax in 1749.



The Bay of Fundy
Source of basemap: Dr Danika van Proosdij, St Mary's University, Halifax, Nova Scotia.

The Annapolis Royal tidal power station became operational in 1983. It's purpose was to evaluate the performance of a single large diameter (7.6m) straight flow (*straflow*) turbine of the kind that might be used in a larger Fundy scheme. As one of 130 equivalent turbines that would be needed for a tidal barrage, it has mainly been proved to be effective. However, it should be noted that the physical environment in which this scheme operates is very different to that of the upper Bay of Fundy, where there is a higher tidal range and higher silt concentration in the water column. Nevertheless, it provides useful experience into the operation of a tidal turbine.

The Annapolis river flows into the outer Bay of Fundy. A highway, island, and flood control structure already existed at the site. Construction of the tidal power plant required 850 cubic yards of soil, 27,000 cubic yards of concrete and 2400 tons of reinforced steel. The casing for the turbine was 152ft long with a 250 ton distributor ring. The turbine itself weighed 162 tons and is 25 ft in diameter. The 18 'wigator' gates have 50 revolutions per minute and produce 20 MW of power, generating 35 million kWh of electricity per year. The turbine generates electricity for 6 hours during low tide and is connected to the Nova Scotia Power Grid System.

With the flow of 21 million m^3 of water in and out of the Bay of Fundy at each cycle of the tide, Nova Scotia Power estimated a potential power generation of 20 billion kWh, three times the consumption of Nova Scotia.

The causeway across the Annapolis with the tidal power plant; upstream (left) and downstream (right).

The River Annapolis is home to one of the most active community initiatives in Canada. The **Clean Annapolis River Project (CARP)** is one of the Canadian Atlantic Coastal Action Programme projects supported by Environment Canada and others (see Section 2.3.2). Established in 1990, this charitable non-governmental organisation involves citizens in looking after the health of the river and watershed. Through over 100 projects the initiative has worked on water quality monitoring, coastal zone management, fish habitat restoration, environmental planning and public awareness. The work has led to environmental, economic and social improvements.

Upstream and downstream of the Annapolis Royal Tidal Power Plant in Nova Scotia.

The Minas Basin from Cape Blomidon, Nova Scotia.

2.7 Sharing Other Interests: Bay of Fundy & Severn Estuary

The context for comparing the Bay of Fundy in Canada and the Severn Estuary in the UK was outlined in Section 2.3 by illustrating the current position with coastal governance in Canada. The focus of the research for this fellowship was then described in relation to the three objectives, based on common issues between the Severn Estuary and Bay of Fundy:

i) Public awareness & marketing of the tide for tourism;
ii) Flood risk planning;
iii) Renewable energy options.

During the fellowship research, there were other areas of interest that would be worthy of further exploration, such as:

- Historical and cultural links: from ancient settlers to colonial era immigration.
- Geological comparisons: Joggins/Geological Museum in Parrsboro and the South West UK peninsula (e.g. Jurassic Coast World Heritage Site).
- Maritime public transport: the Fundy crossing from Digby to Saint John was in jeopardy at the time of writing. There is very limited cross-channel transport in the Severn Estuary & Bristol Channel.
- Wetland evolution and management.

Other areas of interest may arise as the information from this report is shared with other people and organisations.

Cape Split divides the Minas Basin (left) from the Minas Channel (right) looking south towards Scots Bay

3 OPPORTUNITIES FOR FUTURE COLLABORATION

3.1 Introduction

This section describes specific outcomes and ideas for future collaboration as a result of the research.

3.2 Coastal Governance & Integrated Coastal Zone Management

3.2.1 A New Twinning Association

Several people around the Bay of Fundy suggested the idea of establishing a twinning association with the Severn Estuary. This could provide a good umbrella for pursuing a wide range of opportunities, such as:

- Partnership structures, tools & techniques - further liaison with the Bay of Fundy Ecosystem Partnership to share approaches & experiences.
- Presentations and attendance of representatives from the Bay of Fundy at the annual Severn Estuary Forum; and from the Severn Estuary at the Bay of Fundy biennual conferences.
- Exchange of knowledge & experience between the Nova Scotia Provincial Government & Environment Agency for coastal protection; flood risk management strategies and coastal habitat management plans.
- Exchange of information on causeways/barrages & renewable energy technology & options.
- Professional development in Integrated Coastal Zone Management (ICZM) – North American & European experiences, for example through the Coastal Zone Canada series and Eurocoast/EUCC Littoral conference series.

A first step towards the idea of a twinning link has been inclusion of the 'coastal governance & ICZM' theme in this report – as this will provide the context for a wide variety of potential exchanges. Benefits from a twinning link may be in the form of funding for projects, staff secondments/exchanges or voluntary collaboration over particular areas of interest.

Specific ideas for the exchange of experience, information and/or contacts and people to date, which would support the establishment of a twinning link, include:

- Invitation to the Bay of Fundy Tourism Partnership (Terri McCulloch) from SEP to meet Tourism Agents & Operators around the Severn Estuary;
- Offers from representatives of the Bay of Fundy Ecosystem Partnership (Graham Daborn, Larry Hildebrand) to attend the Severn Estuary Forum to discuss its evolution, structure, services etc. and current issues;
- Share experience in the development and implementation of ICZM policies and practice in Canada & UK; between the Atlantic Coastal Action Plan initiative & the English Coastal Partnerships Working Group and UK Government (Defra);
- Possibility of visit/placement with SEP (Maxine Westhead).

It was agreed during the fellowship visit to Canada that we would investigate both in Canada and UK the feasibility of, and correct approach to, formal establishment of a twinning association.

3.2.2 Coastal Partnerships

Through the Atlantic Coastal Action Programme, the principles of sustainable management, the ecosystem approach and integrated coastal zone management have been supported (see Section 2.3.2). Four of the ACAP initiatives are located around the outer areas of the Bay of Fundy: St Croix Estuary Project Inc; Eastern Charlotte Waterways Inc; ACAP Saint John Inc; and the Clean Annapolis River Project. Lessons learnt from the ACAP initiatives may compare to UK based coastal & estuary partnerships due to their similar voluntary status. In particular, methods used to evaluate the financial benefits of community based initiatives may be useful in a UK context.

3.3 Public Awareness & Marketing the Tide for Tourism - *'Recognising the Tide'*

3.3.1 The *'Bay of Fundy Recommended Experience'* and BoFEP

The *Bay of Fundy Recommended Experience* is a tourism training scheme which was initiated by the Bay of Fundy Tourism Partnership (BoFEP), as described in Section 2.4.4. Terri McCulloch, who was instrumental in the design and implementation of the initiative, would be interested in visiting the Severn Estuary to compare approaches. Making a link between BoFEP's work with the Wales & SW England tourist boards, Welsh Assembly Government and South-West Regional Development Agency would enable further exploration of the benefits.

3.3.2 Tide Clocks

The use of tide clocks appears quite extensively around the Bay of Fundy. A maker of hand-crafted tide clocks was discovered in Digby, Nova Scotia. Possibilities may exist for marketing tide clocks in the UK with one maker identified in Cirencester, UK (not far from the Severn). The wider use of tide clocks around the Severn Estuary may increase public awareness of the influence and nature of tides.

3.3.3 Tidal Bore Awareness

Links already exist between some of the Bay of Fundy tidal bore operators and Severn tidal bore riders who have good video/DVD footage of tidal bores and rapids. Higher awareness of tidal bores around Fundy may influence public awareness of the tide and the natural phenomenum of the Bay of Fundy. Increasing access to information about the Severn's tide and frequency of the tidal bore wave could help promote awareness of the value of the Severn.

3.3.4 Visitor Centres & Attractions

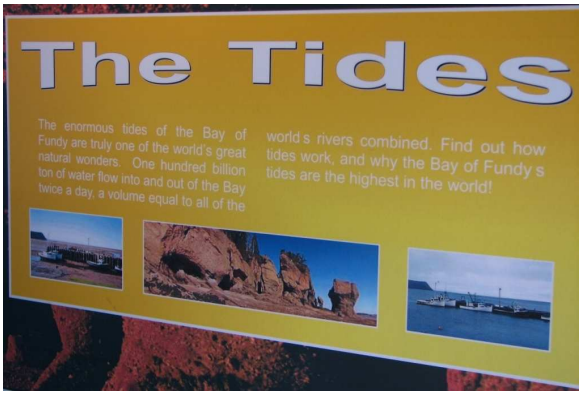
Promotion of the tide as a visitor attraction is much more significant around the Bay of Fundy in both Nova Scotia and New Brunswick compared to the Severn Estuary. Promoting awareness of the popularity of visitor attractions, such as Hopewell Rocks & Fundy National Park, with the English & Welsh tourist operators and business interests could bring new insight and opportunities to the Severn Estuary.

3.3.5 Interpretation

Many examples of interpretation panels, paths, boardwalks and viewing platforms were obtained from the visit to Fundy. These may be useful material for future Severn Estuary Partnership (SEP) interpretation work. Existing SEP communication mechanisms could be used to increase access to this information e.g. through the SEP website 'interpretation toolkit'.

3.3.6 Branding

The amount of branding associated with 'Fundy' and the 'tide' is far higher than that around the Severn. Relatively few examples of 'Severn', 'tide, or 'tidal' branding can be seen in the major cities and towns in England and Wales. More comprehensive research around the Severn would be useful to see how much branding there is and the type of businesses using branding relating to the Severn Estuary.



3.4 Land Use Management and Flood Risk Planning - *'Living with the Tide'*

3.4.1 Land Use Management

Similar patterns of land reclamation for agriculture have taken place around the Bay of Fundy and Severn Estuary. However, the level of development and continuous pressure for development is much higher around the Severn Estuary. Consequently, strategies for flood risk management and changing land use patterns to reduce flood risk are more evolved for the Severn. There maybe value in sharing some of the Environment Agency's work with the Nova Scotia Dept of Engineering, particularly to provide ideas for future planning and management in the Truro area.

3.4.2 Flood Risk & Coastal Protection

Risk management strategies are being developed in the UK, for example the *Tidal Flood Risk Management Strategy for the Severn Estuary* produced by the Environment Agency relatively recently. The Severn Estuary Coastal Group is working towards producing a second Shoreline Management Plan to inform future flood and coastal protection plans. Such information maybe useful to share with provincial government and other organisations responsible for flood and coastal protection around the Bay of Fundy.

Tide flaps and salt marshes in the upper Minas Basin.

3.5 Renewable Energy Options - *'Harnessing the Tide'*

3.5.1 Tidal Power Options

The Bay of Fundy and Severn Estuary are two sites with the highest tidal ranges in the world, and they share much common ground in the current debate over renewable energy options for the future. UK technological developments (e.g. tidal stream turbines) are being assessed in Canada for the Bay of Fundy, and pilot sites are being considered. The consenting procedure for tidal power pilot projects is also being reviewed (in Nova Scotia). Feasibility studies for tidal power options are underway in both countries. Sharing information from conferences and between organisations working on tidal power options in both locations would be very worthwhile.

3.5.2 Tidal Barrage Assessments

This project has shown the similar context for considering tidal power options and, particularly, tidal barrage options between the Bay of Fundy and Severn Estuary. At a similar time to the last in-depth studies on the Severn Estuary (1980s) there was significant investigation into the economic, environmental and technical feasibility of barrage options for the Bay of Fundy. This led to the building of a trial tidal barrage across the River Annapolis in Nova Scotia. Whilst the technology proved that the concept for tidal barrage development was feasible, the environmental conditions at the Annapolis Royal Plant are different from those further upstream in the Bay of Fundy and at the proposed locations for a barrage in the Severn Estuary where there are higher sediment concentrations in the water. Nevertheless, understanding of the Annapolis scheme is still valuable to those considering tidal barrage options across the Severn Estuary. The effect of causeways across estuaries around the Bay of Fundy is equally useful to assess geomporphological and ecological impacts.

3.5.3 Tidal Causeways

Experience from the Bay of Fundy on the response of estuaries to the construction of causeways, is potentially useful for comparison with the impact of developments around the Severn Estuary such as a tidal barrage. In particular, it would be worthwhile to share knowledge of sediment studies, the creation of new habitat and effects on flood & coastal erosion risk management.

4 RECOMMENDATIONS & ACTIONS (PHASE 1)

4.1 Introduction

The following actions are recommended to follow up the findings of Phase 1. Background to each action is contained in the corresponding numbers in Section 3 above.

4.2 Coastal Governance & Integrated Coastal Zone Management

4.2.1 A New Twinning Association

ACTION 4.2.1a) Seek to establish a twinning association between the Severn Estuary and Bay of Fundy: investigate existing twinning links in UK for towns/cities and liaise with Graham Daborn (Arcadia Institute) & Larry Hildebrand (Environment Canaca) in Canada.

ACTION 4.2.1 b): Seek SEP Management Group advice on appropriate speaker from the Bay of Fundy for the Severn Estuary Forum, June 2007 (e.g. Graham Daborn, Larry Hildebrand, Terri McCulloch).

ACTION 4.2.1c): SEP website development: the Bay of Fundy Ecosystem Partnership and Bay of Fundy Tourism Partnership have very good websites which could provide ideas for the Severn.

ACTION 4.2.1d): Produce a DVD on the Severn Estuary to stimulate interest in twinning activities. It could include general information such as footage of the Severn bore, BBC Coast production(s) and building of the Severn crossing, as well as technical reports referred to in this report.

4.2.2 Coastal Partnerships

ACTION 4.2.2: Share information with Larry Hildebrand (Environment Canada) on the work of the English Coastal Partnerships Working Group (CPWG) in relation to delivery of ICZM and lessons learnt from the Atlantic Coastal Action Programme (ACAP).

Ferry between Digby in Nova Scotia and Saint John in New Brunswick.

Agricultural land around the Minas Basin.

4.3 Public Awareness & Marketing the Tide for Tourism - *'Recognising the Tide'*

4.3.1 The *'Bay of Fundy Recommended Experience'* and BoFEP

ACTION 4.3.1 a): Identify and discuss with relevant contacts in the Wales & SW England Tourist Boards and others, opportunities to share experience with BoFEP.

ACTION 4.3.1 b): Send letter(s) of invitation to Terri McCulloch, BoFEP regarding an opportunity to visit the Severn Estuary.

4.3.2 Tide Clocks

ACTION 4.3.2: Assess opportunities to market tide clocks around the Severn Estuary.

4.3.3 Tidal Bore Awareness

ACTION 4.3.3: Seek opportunities to increase access to information about the Severn bore & promote community links with the tide e.g. through video/DVD material on the SEP website, through the *Severn Tidings* newsletter and Flood 400 initiative in 2006-07.

4.3.4 Visitor Centres & Attractions

ACTION 4.3.4a): Share information from this project with the Severn Bridges Trust who manage the Severn Bridges Visitor Centre.

ACTION 4.3.4b): Share information from this project with tourist operators and agencies in England and Wales & use example material in any future funding opportunities for tourist facilities and new visitor centres (e.g. Newport Wetlands Centre).

4.3.5 Interpretation

ACTION 4.3.5a): Add pictures of Fundy interpretation to the SEP interpretation toolkit on the website, to enable access to example material.

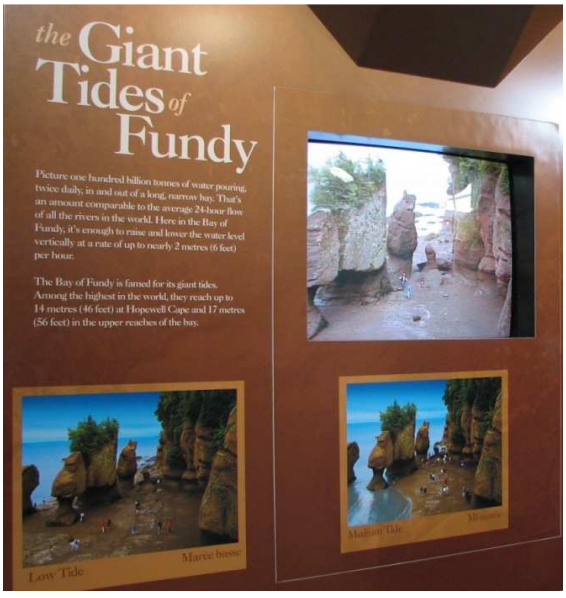
ACTION 4.3.5B): Create an SEP marketing brochure project sheet to illustrate approaches to interpretation around Fundy.

4.3.6 Branding

ACTION 4.3.6a): Collate examples of branding around the Severn Estuary (e.g. Severn Shed restaurant in Bristol; Severn to Seventh Avenue advertisement at Bristol airport).

ACTION 4.3.6b): Create an SEP marketing brochure project sheet to illustrate the range of Fundy & tide-related branding in Canada.

ACTION 4.3.6c): Consider the marketing potential and options for SEP promoting 'Severn' and 'tide' branding in SW England and South Wales.



Tides interpretation at the Hopewell Rocks Visitor Centre in New Brunswick.

4.4 Land Use Management & Flood Risk Planning – *'Living with the Tide'*

4.4.1 Land Use Management

ACTION 4.4.1a): Share information with Nova Scotia Dept of Engineering: Severn Estuary Coastal Habitat Management Plan; Steart Peninsula managed re-alignment project.

ACTION 4.4.1b): Provide information on regulated tidal exchange technology (& example from the R. Clyst) to the Bedford Institute in Dartmouth.

4.4.2 Flood & Coastal Protection

ACTION 4.4.2a): Share information with the Nova Scotia Dept of Engineering: the UK Environment Agency's Severn Estuary Flood Risk Management Strategy, Coastal Habitat Management Plan, the Severn Estuary Coastal Group work on the Shoreline Management Plan process and flood/coastal risk management policies.

ACTION 4.4.2b): Offer to share information from the Bay of Fundy's approach to coastal protection and habitat management, with the Severn Estuary Coastal Group.

Land drained for agriculture, Grand Pre, Nova Scotia.

4.5 Renewable Energy Options – *'Harnessing the Tide'*

4.5.1 Tidal Power Options

ACTION 4.5.1a): Encourage the exchange of information on tidal power options being considered between the Bay of Fundy and Severn Estuary, through:

- dissemination of this report to individuals and organisations around the Severn Estuary;
- maintaining contacts in the Bay of Fundy for outputs from conferences, new developments in tidal technologies etc;
- sharing information from the UK & Severn Estuary with people in the Bay of Fundy (e.g. Tidal Power in the UK project commissioned by the Sustainable Development Commission);

ACTION 4.5.1b): Maintain and seek contact with Nova Scotia and New Brunswick provinces regarding their approach to consenting procedures for tidal power pilot projects, selection of locations and re-consideration of barrage options (if any).

4.5.2 Tidal Barrage Assessments

ACTION 4.5.2a): Share information from the Annapolis Royal Tidal Power Station with individuals and organisations around the Severn Estuary interested in tidal barrage development – DVD, photographs and contacts.

4.5.3 Causeways

ACTION 4.5.3a): Maintain contact with researchers studying the causeways at Moncton and Windsor, for results of sediment studies, habitat evolution and planning decisions (e.g. removal of the causeway at Moncton, development of additional highway lane(s) at Windsor).

ACTION 4.5.3b): Share information from this project with individuals and organisations (e.g. engineers, local authorities, NGOs, consultants) considering options for renewable energy, particularly in relation to the Severn barrage.

Sunset across the Bay of Fundy from the Annapolis Valley, Nova Scotia, looking across to New Brunswick.

5 APPLICATION OF THE RESEARCH (PHASE 2)

5.1 Introduction

The overall aim of the fellowship is described in Section 1 of this report. Due to travel logistics, it was agreed with the Trust that the fellowship be undertaken in two phases: Phase 1 involved visiting Canada & Alaska in July-August 2006, and Phase 2 visiting Russia in July-August 2007. The visit to Alaska in August 2006 was preparatory work for Phase 2 to visit scientists who had researched tides in the Sea of Okhotsk including the Penzhinskaya Guba – the 3rd estuary in the project. This section describes the proposed dissemination of research between the Severn Estuary and Bay of Fundy completed during Phase 1, followed by findings to inform plans for Phase 2 of the research visit to Penzhinskaya Guba.

5.2 Dissemination

The research aimed to illustrate similarities and differences between the environmental characteristics of the three sites and way they are managed. The fellowship will lead to encouraging opportunities to share experience and exchange information between planners, managers, scientists and communities experiencing the highest tides in the world. New links established through the fellowship may lead to opportunities for further exchange of experience and collaboration on future projects. Further details are provided in the following table.

Table 6: Opportunities for Collaboration & Dissemination

Purpose	Audience / Location	Activity	Objective			
			ii) Public Marketing	i) Flood Risk	ii) Tidal Power	Other
Share experience and understanding of the influence of dynamic tides on coastal and river management	Severn Estuary	Information disseminated through the Severn Estuary Partnership's *Severn Tidings* newsletter, *Severn Estuary Forum* and general media awareness around the Severn Estuary in England & Wales.	Major	Major	Major	
	Severn Estuary Bay of Fundy	Share information on engineering and habitat management options to alleviate coastal flood risk to people and the environment.		Major		
	Penzhinskaya Guba	Assess the influence of the tide in an un-modified environment on habitats and the landscape.		Major		
	Bay of Fundy Severn Estuary	Obtain information on tidal energy to inform government policy and improve links with the renewables industry.			Major	
	Bay of Fundy Severn Estuary	Work with tourism officers to assess approaches to marketing highest tides and tidal bores.	Major			
Contribution to a wider audience of coastal practitioners	Canada & UK	Explore Integrated Coastal Management & Governance progress				Inform English Coastal Partnerships Working Group
	International	Paper and presentation on the 'Managing Tidal Change' project at the Littoral 06 conference in September 2006 in Poland.	Moderate	Moderate	Moderate	
Professional development and awareness	International	Member of the Organising Committee for the Institute of Civil Engineers International Coastal Conference, October 2007.		Moderate		
	International	Royal Geographical Society Coastal & Marine Working Group session on 'Partnerships Delivering Integrated Coastal Management', September 2006 in London.	Minor	Minor	Minor	
	Europe	Board Member of CoastNET (UK coastal charity) and EUROCOAST	Minor	Minor	Minor	
Education	Cardiff University (UK)	Lectures on the Marine Geography degree course at Cardiff University.	Minor	Minor	Minor	
	Bristol University (UK)	Seminars on the social aspects of coastal & river engineering on Bristol University's CIWEM postgraduate diploma course.		Minor		

Dissemination of this research will be facilitated by providing copies of this report to all those met during Phase 1 of the project – as listed in Table 2 in Section 1.4 of this report. Collaboration over the recommendations and actions will then follow. An update on progress with implementing the actions will be made available from the author at any time on request.

5.3 Phase 2: Penzhinskaya Guba, Russia

5.3.1 Findings from the University of Alaska Fairbanks

The rationale for including the Penzhinskaya Guba as the 3rd estuary in the fellowship is outlined in Section 1.2 (p.8). During the early planning stages of this fellowship study, **Professor Zygmunt Kowalik** in the Institute of Marine Science at the University of Alaska Fairbanks (UAF), was identified to have undertaken research on the tides in the Sea of Okhotsk including the Penzhinskaya Guba. Useful reference material was identified through correspondence with Professor Kowalik prior to meeting him in August 2006. It was anticipated that the UAF might be interested in further research and collaboration in this area. However, since publication of papers on tides in the Sea of Okhotsk, Professor Kowalik has moved onto other areas of research (e.g. modelling the global patterns of the Asian tsunami) and was no longer undertaking research on the Sea of Okhotsk. However, we met to discuss the Penzhinskaya Guba tides and Sea of Okhotsk oceanography, and the following points were noted:

- irregular diurnal tides as found in the Penzhinskaya Guba are unusual.
- the Cook Inlet and Turnagain Arm in Alaska have a high tidal range of approximately 10m at Anchorage, but are strongly influenced by currents.
- the Coriolis force is a strong influence on currents but not on sea level – currents are very difficult to predict, unlike tides, but tend to be stronger when the moon is closer; the currents are known as 'old tides'.
- Bernshtein (1996) illustrated how the 18.6 year tidal cycle was significant for the generating potential of tidal power plants.
- Professor Kowalik's *Oceanologia* paper is available on the Oceanologia website.
- Gibrat (1996), in France, has done valuable research on tides.
- Recommended reading: Pugh – most popular book on tides; David Edgar Cartwright – Tides; Gabriel Gabon – a Canadian who wrote about tides.

Drawing on his research, knowledge of the area and some contacts, Professor Kowalik suggested the following leads for planning Phase 2 of this fellowship:

- The School of Earth & Ocean Sciences, University of Victoria, Canada – Garrett (1984) is most knowledgeable about tides and obtaining tidal power from currents. Greenburg – tidal modelling of the Bay of Fundy. Garrett & Greenburg argued about whether local tidal-power schemes could affect larger tidal/global currents due to changes in resonance.
- Hunting guides in the Sea of Okhotsk area may be best placed to offer advice on access to the Penzhinskaya Guba area. There are Alaskan companies that go to Kamchatka. Professor Kowalik maybe able to establish some contacts.
- Georgy Shevchenko, Head of Biological Oceanography, Sakhniro in Sakhalin (shevchenko@sakhniro.ru). Professor Kowalik recommended writing to him as he's been in the area for 20-25 years.
- Recommended contact: vluchin@poi.duo.ru - a friend in Vladivostock who works with him on tides, only speaks Russian, offers courses to oceanographers.
- Dept of Marine Energy Systems, Aberdeen University.
- Liverpool UK tidal observatory & interest in tidal bores – J. Proudman Laboratory.
- Recommended reference: *Geophysical Research Letters, Vol 32, L10614*. AGU The Eastern Siberian Sea as a transition zone between Pacific zone and Arctic; the author has been to the Kasherov Bank in the Sea of Okhotsk.

A morning and lunch spent with Professor Kowalik was helpful to explore the context for Phase 2 of the fellowship. There seemed to be limited scope for establishing a joint venture to research or visit Penzhinskaya Guba, but these recommended contacts provided further possibilities.

Dr Igor Polyakov is a Russian working in the International Institute of Arctic Research at the University of Alaska Fairbanks. He has co-authored papers with Professor Kowalik including research on the Sea of Okhotsk. His current interest lies in researching the causes of climate change. Through a discussion

about his work and my fellowship aims he recommended establishing contact with Dr Semiletova who works in Okhotsk.

5.3.2 Review of Aims

The remoteness of Penzhinskaya Guba estuary in NE Siberia means that the trip should be regarded as more of an expedition! As at December 2006, the following organisations have been contacted about the research:

- Hydrographic Office, Taunton, UK
- Met Office, Exeter, UK
- Institute of Marine Science and the Institute of Arctic Research, University of Alaska, Fairbanks
- World Wide Fund for Nature, Moscow, Russia.

Information obtained from people who have visited areas in the Sea of Okhotsk (BBC Natural History Unit, WWF Russia, WWF UK and linked contacts) indicate that the Penzhinskaya Guba is too far to reach by helicopter in one trip from Magadan or Petropavlovsk-Kamchatskiy. Some summers there are flights from Magadan to the mouth of the estuary but these are unscheduled. Obtaining access into the estuary by sea maybe the only feasible way to reach it. One contact estimated that the cost of this could be $10,000 and chartering a boat/ship would be extremely difficult. The sea is rough, the estuary is ice-bound for 8-10 months of the year, and the transport links are usually used only to supply timber/fuel to the local population.

Initial findings suggest intrigue but limited interest in setting up a joint expedition – there appear to be no significant drivers to fund a research expedition in this remote location. Professor Kowalik's advice was to visit the area in a 'low profile' manner so as not to raise suspicion about the purposes of visiting such a remote area of Russia. The area around and beyond Magadan has significant gold mining where thousands of people were sent and died during Stalin's era (as illustrated by the 'road of bones' featured in 'The Long Way Round' with Iwan McGregor & Charlie Borman, 2005). A British explorer walking around the world was arrested by Russian authorities in 2006 after crossing the Bering Straight from Alaska into Russia.

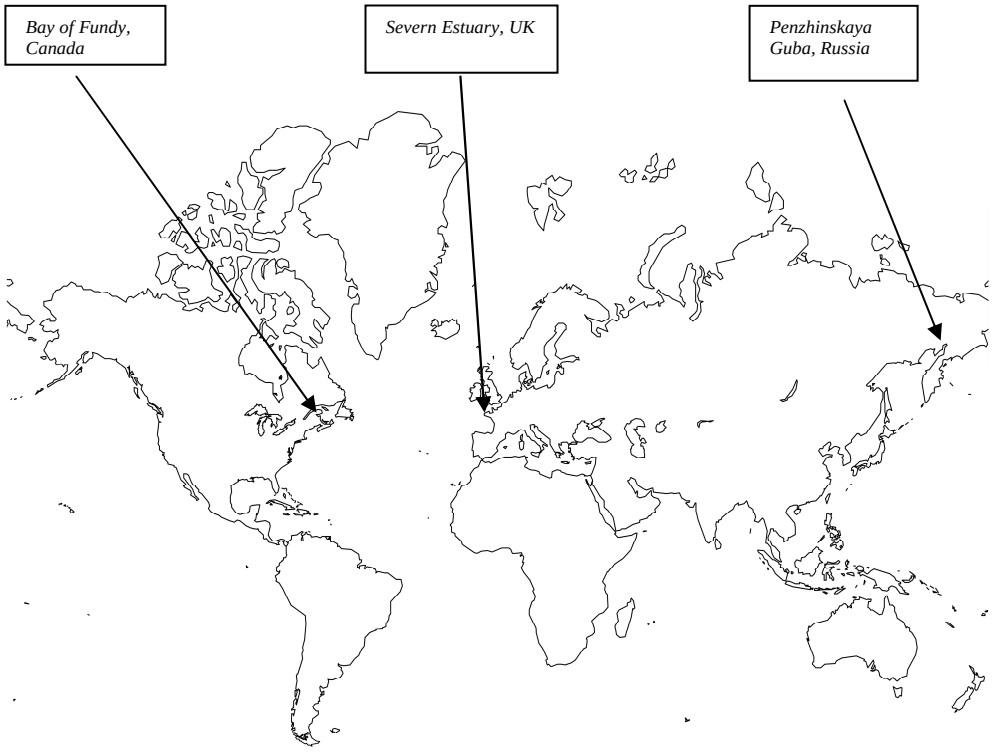
Further investigations and possibly fund raising are needed to ensure that the proposed visit to Penzhinskaya Guba would prove fruitful.

5.3.3 Other High Tide Sites

During the visit to the Bay of Fundy, researchers at the Dept of Fisheries & Oceans Canada indicated that the Bay of Fundy had been contested for the position of highest tide in the world by **Ungava Bay in northern Quebec, Canada** (*see O'Reilly et.a. in Environment Canada 2005b*). On this basis, if visiting the Penzhinskaya Guba proves unfeasible, the objective of visiting an unpopulated estuary with a high tidal range could be met through a visit to Ungava Bay. Further consideration will be given to this option pending the outcome of investigations into visiting the Penzhinskaya Guba.

For the specific purposes of the renewable energy theme of the fellowship, a visit to the **La Rance in France** to visit the tidal barrage would be useful for comparison with the Annapolis Royal plant in Nova Scotia, Canada. It would allow collation of information that would be useful for the Severn Estuary Partnership's involvement in tidal power issues.

Fundy hosts a high proportion of the remaining 350 North Atlantic Right Whale population.



Three estuaries in the world with some of the highest tidal ranges.

6 CONCLUSIONS

6.1 Bay of Fundy

Comparisons and contrasts between the Bay of Fundy and Severn Estuary were explored through a large number of meetings and by visiting a significant proportion of the Bay of Fundy coastline. The Bedford Institute of Oceanography at the Dept of Fisheries and Oceans (Canada), were very hospitable in providing office space, contacts and advice to help inform the research.

The character of the enormous Fundy tide, with huge expanses of mudflats and lowland agricultural land, has much in common with the Severn Estuary and its surrounding environment. However, there are also striking differences - from the gigantic chocolate-coloured 'white' water of the River Shubenacadie and wilderness areas of Fundy to the urban, industrialised areas such as Avonmouth and concrete coastal defences around much of the Severn Estuary. The Bay of Fundy has a much lower population density than the Severn Estuary, which has been a dominant factor when drawing comparisons between the two sites. The selection of 3 objectives linked to current issues in the Severn Estuary, proved useful to make links between the sites. The systems in place for coastal governance were also explored, and will prove useful for future coastal management work with the Severn Estuary Partnership in the UK.

There are many specific actions to follow up the fellowship visit, in addition to dissemination of this report to all those involved. Perhaps the most significant recommendation and outcome overall will be pursuing the establishment of a twinning link/association between the Bay of Fundy and Severn Estuary, which would provide a long term framework for collaboration between people in future years.

6.2 Penzhinskaya Guba

It was useful to meet scientists who have researched the remote area of Russia to inform the planning for Phase 2 of the project. Ideas and recommendations for further research were provided by Professor Zygmunt Kowalik and Dr Igor Polyakov from the Institute of Marine Science and Institute for International Arctic Research at the University of Alaska, Fairbanks. The feasibility of planning an expedition to the Penzhinskaya Guba required much further investigation.

Alternative options for Phase 2 have been highlighted during Phase 1: visiting Ungava Bay in Canada which has been shown to have an equally high tide to the Bay of Fundy, and/or the La Rance tidal barrage in France for specific information on renewable energy options.

6.3 Personal Perspective & Professional Benefits

The opportunity provided by the Winston Churchill Memorial Trust to meet colleagues with very similar interests around the Bay of Fundy has proved very rewarding. In addition to meeting 28 people connected with Fundy tidal life and collating a significant amount of information, links have already been established through this visit for others in the UK and Canada. These include officers in the Welsh Assembly Government, Environment Agency Wales and the World Wide Fund for Nature in UK. This project report will provide a strong foundation for building on the contacts established. The possibility that this could be the first step towards establishing a twinning association to build longer-term collaborative arrangements is exciting!

As described in the previous sections of this report, there are many potential opportunities for further professional collaboration between Severn Estuary partners, scientists, engineers, planners, organisations and interested individuals with people working in similar areas around the Bay of Fundy.

From a personal point of view, the fellowship has allowed me as the Severn Estuary Partnership (SEP) Officer, time to reflect on the role of SEP in a wider context. The opportunity to look at the state of coastal governance in Canada is very valuable at this time when the role of the UK's coastal partnerships is being debated (for Defra's Integrated Coastal Zone Management Strategy and drafting of a Marine Bill). The themes for investigation were well identified and all proved to provide relevant comparisons and contrasts to current management issues in the Severn Estuary. Ideas have been gained for developing SEP which will make the most of the contacts established through this fellowship.

Acknowledgements

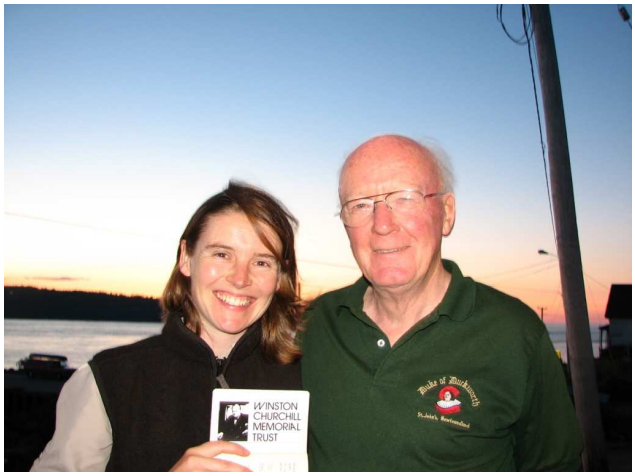
Maxine Westhead, based in the Department of Fisheries & Oceans (DFO) Canada was instrumental to the success of this research. Maxine arranged for an office base in DFO for the duration of my visit, accommodation with friends, and facilitated my contact with many of the people I was able to meet around the Bay of Fundy. Following research she had undertaken on the Severn Estuary, she took a continued interest in our exchange of knowledge and has subsequently contributed to this report.

I am grateful to the many people who gave generously of their time to share information and discuss their views on public awareness of the tide, flood risk planning and tidal energy – those people are listed in Table 2 on page 10 of this report.

Maxine Westhead – tidal rafting on the River Shubenacadie with Natasha.

Prior to full dissemination of these reports, the Severn Estuary Partnership was pleased to have the opportunity to host Larry Hildebrand from Environment Canada (visiting Cardiff University) to speak at the 2nd Severn Estuary Forum in 2007. This has stimulated direct interest and exchange of information, particularly in relation to tidal energy proposals.

Visiting and studying the Bay of Fundy in relation to my work for the Severn Estuary Partnership, has been a fascinating and rewarding experience. It has proved difficult to know where to stop this research! For the purposes of the fellowship award these reports have been finalised in March 2008. It is hoped that dissemination of the final reports from the fellowship will stimulate further exchange between people around Fundy and the Severn.



Coincidental meeting of Natasha Barker with a Winston Churchill living in Nova Scotia!

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- **Bay of Fundy Ecosystem Partnership (BoFEP)** List of and access to publications: http://www.bofep.org/publications.htm
- **Bay of Fundy Tourism Partnership (BoFTP)** Video clip of tidal change & news on 'Fundy blog'
- **Renewable Energy Options**
  Media coverage:
  http://www.theglobeandmail.com/servlet/story/RTGAM.20051020.gtfundy1020/

http://www.cbc.ca/nb/story/nb_tidepower20051018.html
http://www.cbc.ca/story/canada/national/2005/10/19/tidal-power051019.html
http://canadaeast.com/apps/pbcs.dll/article?AID=/20051021/TPMONEY04/51021002
"Nova Scotia Tidal In-Stream Energy Conversion (TISEC): Survey and Characterization of Potential Project Sites" is at: http://www.epri.com/oceanenergy/streamenergy.html#reports.
The Minas Channel and Minas Basin were identified as the only TISEC sites in North America with the potential for central power generation.
Firm hopes turbines will drive Bay of Fundy tidal power:
http://www.herald.ns.ca/Search/492121.html
Tidal power technology development and potential sites across the world:
http://www.rise.org.au/info/Tech/tidal/index.html

FURTHER INFORMATION

Contacts
See *Canada & Alaska Phase 1 itinerary* shown in Table 2, p.10 – contacts are available from the author.

Information
See REFERENCE List above.
A 'Fundy Library' is stored at the Severn Estuary Partnership office in Cardiff University (Contact: Natasha Barker on 029 20874713 / severn@cardiff.ac.uk).

Report Distribution
To all those listed in the *Canada & Alaska Phase 1 itinerary* (p.10).
Available on the following websites:

- Severn Estuary Partnership
- Bay of Fundy Ecosystem Partnership
- Winston Churchill Memorial Trust

Publicity
Publicity for the research will be pursued on completion of the Phase 1 & 2 reports during 2008.

LIST OF ACRONYMS

ACAP	Atlantic Coastal Area Action Programme
BoFEP	Bay of Fundy Ecosystem Partnership
BoFTP	Bay of Fundy Tourism Partnership
CARP	Clean Annapolis River Project
CHaMP	Coastal Habitat Management Plan
CIWEM	Chartered Institute of Water & Environmental Management
CMA	Coastal Management Areas
CoastNET	Coastal Network charity
DFO	Department of Fisheries & Oceans
EC	Environment Canada
ESSIM	Eastern Scotian Shelf Integrated Management
EU	European Union
EUCC	European Union for Coastal Conservation
EUROCOAST	Eurocoast Association
ICZM	Integrated Coastal Zone Management
PC	Parks Canada
MAP	Marine Protected Area Programme
MBWG	Minas Bay Working Group
PPG	Planning Policy Guidance
SEP	Severn Estuary Partnership
UNESCO	United Nations Environment & Science
USA	United States of America
VIC	Visitor Information Centre
WCMT	Winston Churchill Memorial Trust.

The Bay of Fundy

Source of basemap: Dr Danika van Proosdij, St Mary's University, Halifax, Nova Scotia.