Managing Tidal Change

Phase 2 Project Report

Penzhinskaya Guba, Russia

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Winston Churchill Memorial Trust
Travelling Fellowship Award 2006

in collaboration with

The Pacific Institute of Geography, Kamchatka Branch, Russia

Executive Summary

Penzhinskaya Guba experiences the highest tidal range in Russia, of a similar range to the Severn Estuary in the UK (where the author works). Together with the Bay of Fundy in Canada, which is known to have the highest tidal range in the world, this project looked at three estuaries to compare their characteristics in relation to human use and management. In particular the potential impacts of climate change, predicted sea level rise, storms and tidal surges are likely to have a significant affect on dynamic estuaries experiencing the highest tidal ranges in the world.

Penzhinskaya Guba was considered a useful contrast to the Severn Estuary and Bay of Fundy due to the very low population density and undeveloped character of the area. It provided a baseline environment from which to see the influence of an unrestrained tide, compared to the more developed shorelines of Fundy and Severn.

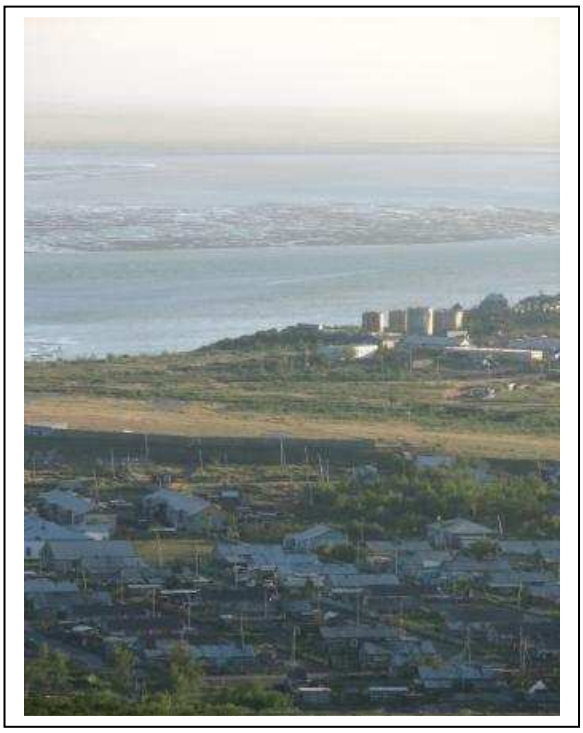
Phase 1 of the project involved one month spent in Canada and Alaska during 2006 to research the Bay of Fundy which is described in a separate report. This report from Phase 2 of the project was completed after one month spent in Kamchatka to visit Penzhinskaya Guba in 2007. It describes the aim and objectives of the research and how this remote estuary was reached. Findings from a brief assessment of the highest tides in the world are given, with site descriptions, for the three estuaries studied. The three objectives which were the focus for the research across the three sites resulted in the following main findings from the visit to Penzhinskaya Guba:

i) Public awareness of the tide
Penzhinskaya Guba has a very low population density where people's livelihoods are closely linked to the tide for transport, fishing and living - where sea breezes limit the mosquito's. This contrasts with the Severn Estuary where a very limited number of people's lives are directly influenced by the tide. Even when compared to the impact of publicity and interpretation methods used around Fundy, public awareness of the tide is higher around Penzhinskaya. There is no tourism. No clear evidence was found for a tidal bore or tidal rapids, but it could not be ruled out due to the sparse population and vast area which could not be surveyed fully during the duration of the field study.

ii) Land use management and flood risk planning
Native Koryaks settled around Penzhinskaya in small settlements, living a subsistence lifestyle on fishing and whale hunting. Around 300 years ago, the first Russian settlement began with Cossacks migrating to the area. From the 1950s people started settling in larger towns and the population increased with a Soviet Union policy to populate remote areas. Since the end of the cold war and the Soviet Union, the population is decreasing. Few traces remain of the native way of life of the Koryaks in the main settlements. However, beyond the towns and villages there is little human influence and this is still a vast area of wilderness. Viewing a coastal area with less than 0.01% of the population of the area surrounding the Severn Estuary, provided a unique opportunity to witness the influence of the tide where none of the shoreline has been reclaimed for agriculture or made static with coastal defences. This provided an insight into the historical extent of the Severn which is useful for current work on flood risk management strategies and shoreline management planning - where planners & engineers are looking for greater understanding of natural processes.

iii) Renewable energy options
Even in such a remote area, proposals for generating tidal energy have been considered. When compared to other existing and potential hydro-electric power schemes or tidal barrages, the potential provision of tidal energy from a barrage across Penzhinsksaya is significantly higher. However, serious limitations are the extreme climatic conditions and the physical distance from the supply of energy to the consumers.

The full findings from the visit to Penzhinskaya Guba are described in detail in sections relating to the three objectives outlined above. The report concludes with observations on sustainable development and management of estuaries. It highlights that for the Severn Estuary Partnership it would be useful to have a better understanding of the baseline environment and natural processes. This would inform future flood risk management, shoreline planning and support the feasibility studies for tidal power options.



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Photographs and illustrations are provided with explanation within the text of the report.

Line drawing by Sandra-Lynne Jones.

1 BACKGROUND

1.1 Introduction

The Winston Churchill Memorial Trust provides people with a unique opportunity to meet people from different countries with similar interests. Fellows gain knowledge and experience of significant value to their 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 compare the Severn Estuary in the UK, the Bay of Fundy in Canada and the Penzhinskaya Guba in Russia. The research was supported by the Severn Estuary Partnership, Cardiff University and the assistance of people in Canada, Alaska and Russia. The results of this project will be shared with people working in these locations and further afield. Following one month spent Canada and Alaska during 2006, a Phase 1 report focusing on the Bay of Fundy, was jointly authored with Maxine Westhead from the Department of Fisheries and Oceans, Canada. Following one month spent in Russia during 2007, this Phase 2 report focuses on the Penzhinskaya Guba and has been prepared in collaboration with scientists Olga Chernyagina and Vadim Kirichenko at the Pacific Institute of Geography, Kamchatka Branch in Russia.

Girls modelling Penzhinskaya mud, Manily.

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 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 3 specific objectives for the research:

i) **Public awareness and marketing**.
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**.
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 using tidal power**.
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] 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.
[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.

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 travel itinerary for the whole travelling fellowship (phase 1 & phase 2) is shown in the following table.

Table 1: Fellowship Itinerary for Phases 1 and 2

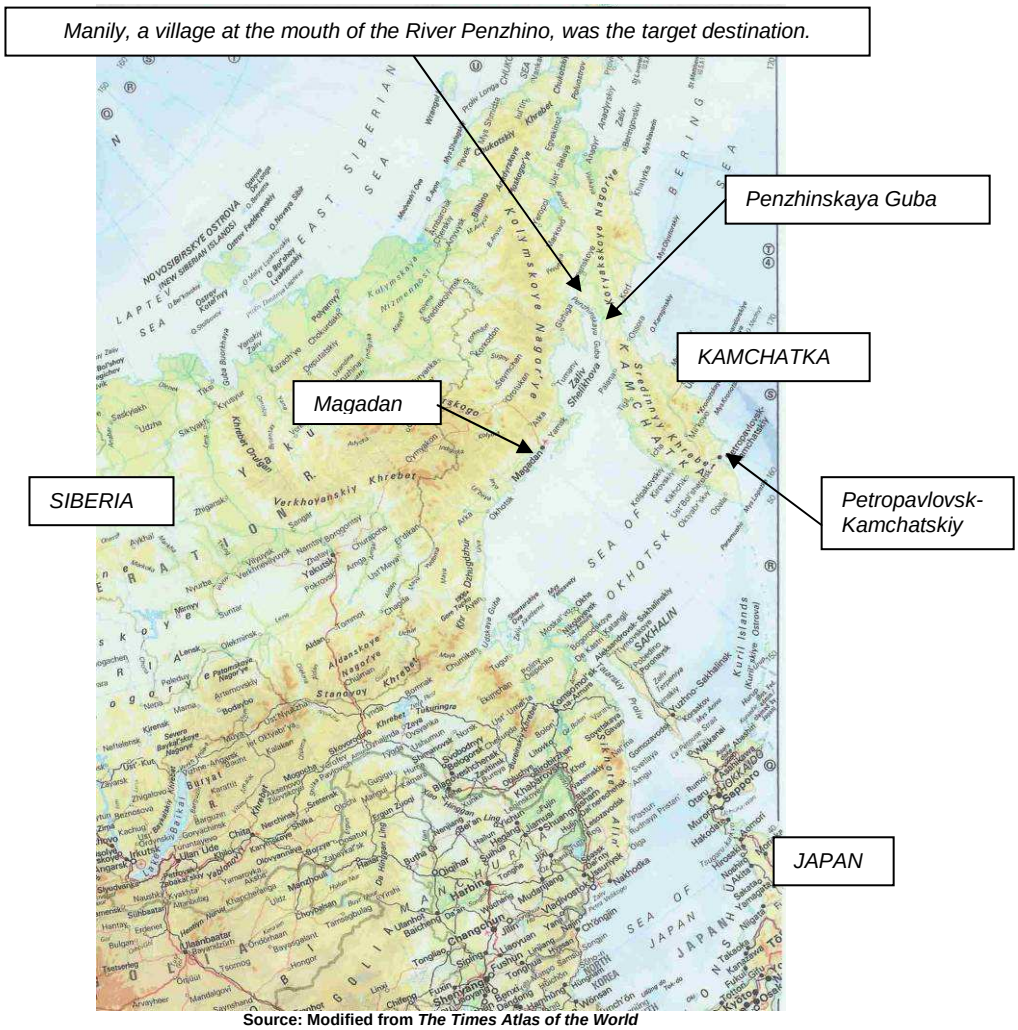
COUNTRY	CITIES & PLACES	ORGANISATIONS VISITED	DATES
PHASE 1: 2006			
Canada	***Bay of Fundy:*** *Nova Scotia & New Brunswick:* Dartmouth & Halifax - based at the Bedford Institute of Oceanography. Truro, Wolfville, Parrsboro, Moncton.	Bedford Institute of Oceanography, Dartmouth. Minas Basin Working 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 – 9th August 2006
Alaska	Fairbanks	Institute of Marine Science & International Arctic Research Centre, University of Alaska Fairbanks.	10th - 14th August 2006.
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. Kamenskoye & Manily.	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

1.5 Project Preparation and Planning

Phase 1 of the fellowship is described in a separate report '*Phase 1 Project Report: Bay of Fundy, Canada'* produced in December 2006. This report deals specifically with Phase 2 of the fellowship which was undertaken in 2007.

Research for Phase 2 of the fellowship began from the outset of the project design in Autumn 2005. Alaska was visited during Phase 1 of the project, in August 2006, to help prepare for the Phase 2 trip to Russia. Information was sought from scientists at the University of Alaska Fairbanks who had researched and modelled the tides in the Sea of Okhotsk. I had hoped their collaboration would enable me to attract UK sponsorship for a joint expedition with, for example, the UK Hydrographic Office, Met Office and/or BBC. However, the scientists areas of research had changed and their advice on how to successfully reach the Penzhinskaya Guba was to visit 'quietly' - not as part of a formal or large group. They advised that this was considered a border area of Russia, little had changed since communist times and the only foreigners (if any) that visited would be hunters.

Map 1: Location of Penzhinskaya Guba, Kamchatka, Far East Russia.



Source: Modified from *The Times Atlas of the World*

Planning for the trip to Russia began in early 2007 by making contact with people from many different countries (see Table 2 below), who had knowledge of northern Kamchatka and Far East Russia. There was very little information available on how to reach Penzhinskaya Guba, on the border between Magadan Oblast and Kamchatka Oblast (see map 1 above). Air navigation charts available in the UK helped to establish my aim of reaching a village called Manily at the head of the estuary. Initially I planned to try and reach Manily from Magadan, which is the nearest city with an airport receiving international flights. However, I was advised by a Russian-American scientist who visits Magadan each year, that flights from Magadan to Manily are not always scheduled and the cost of chartering a ship would be some $10,000 – well beyond my budget. I was also advised that the border between Magadan Oblast (region) and Kamchatka Oblast might be problematical for a foreigner. Another issue was that from January 2007, new regulations had been introduced which required all foreigners to obtain a permit as well as a visa to travel in Kamchatka or Magadan Oblast. Since more of the Penzhinskaya Guba is within the Kamchatka region, I felt that for administrative & legal purposes it maybe better to start and limit my trip to areas within Kamchatka. There was also more likely to be infrastructure for tourism in Kamchatka that may mean more options for flights to this remote area.

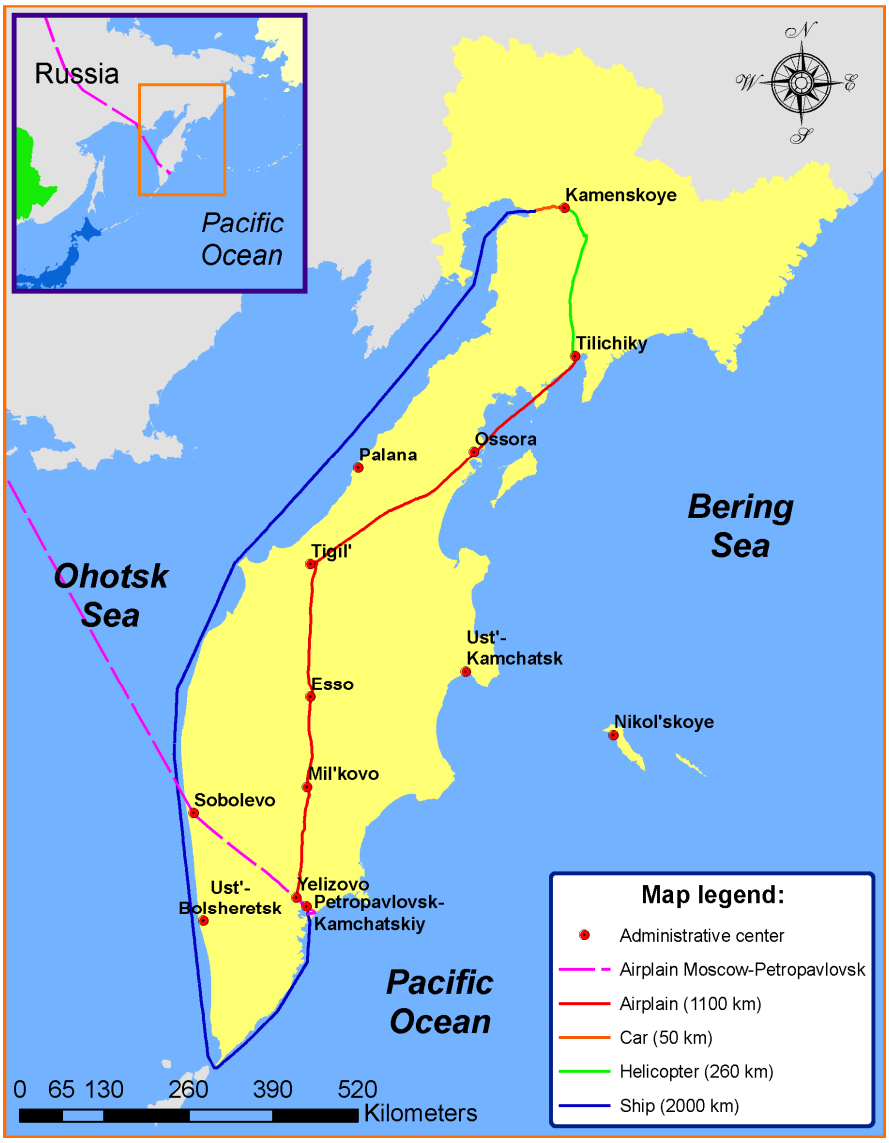
The following table lists people contacted during the project planning stage who helped provide advice and additional contacts for preparation of the trip.

Table 2: Russia, Phase 2 Contacts Pre-Trip

CONTACT NAME	ORGANISATION	LOCATION	NOTES
Professor Kowalik & Dr Igor Polyakov	**Institute of Marine Science & International Arctic Research Centre, University of Alaska Fairbanks.**	**Fairbanks, Alaska**	Researched tides in the Sea of Okhotsk including Penzhinskaya Guba (see Phase 1 report).
Vassily Spiridinov	**World Wide Fund for Nature**	**Moscow, Russia**	Head of Marine team for WWF Russia, provided contact with WWF in Kamchatka.
Fergus Beeley	**British Broadcasting Corporation (BBC)**	**Bristol, UK**	Visited Kamchatka in early 1990s. Provided contact with Eugene Potapov.
Eugene Potapov	**Philadelphia University**	**U.S.A.**	General advice on the Sea of Okhotsk region and Magadan.
Sandra-Lynne Jones	**Freelance translator**	**Bath, UK**	Friend of Eugene Potapov who lived in Kamchatka and visited Koryakia in 1992. Provided contact with Emma Wilson and Olga Tutubalina.
Emma Wilson	**International Institute for Environment & Development (IEED)**	**London, UK**	Undertook research in Kamchatka & Sakhalin island. Provided contacts including Olga Chernyagina.
Dave Martin & Roman Kultaev.	**Russian Far East Program Director & Project Manager, Kamchatka Region Pacific Salmon Centre**	**Portland, USA**	Working on some projects in Kamchatka. Recommended contact with Martha Masden,
Martha Masden	**'Diligens' Explore Kamchatka Travel Agency**	**Yelisovo, Kamchatka**	Visa invitation, permit application and logistical support. Accommodation in Yelisovo.
Olga Tutubalina	**Faculty of Geography, Moscow State University**	**Moscow, Russia**	Identified website link to Penzhino website administered by Ilya Smirsa.
Ilya Smirsa	**Student**	**Kamenskoye, Russia**	Created website for Penzhino Administration – put me in contact with Igor Anatolovich.
Katharina Garnet	**McGill University**	**Germany**	Recommended contact with Alex King. Recommended Petra Rethmann - the author of "Tundra passages" – for research in the east of northern Kamchatka.
Alexander King	**Anthropologist, University of Aberdeen**	**Scotland, UK**	Travel advice, contacts and cultural context.
Laura Williams	**World Wide Fund for Nature (WWF)**	**Yelisovo, Kamchatka, Russia**	Contacts and travel advice.
Olga Chernyagina	**Pacific Institute of Geography Kamchatka Branch**	**Petropavlovsk-Kamchatskiy, Kamchatka, Russia**	Knowledge, information and logistical support.

By March 2007, planning got well underway to make the journey to Penzhinskaya Guba - via Moscow to Petropavlovsk-Kamchatskiy (the capital city of Kamchatka). Once there, the aim was to find a way of travelling north as it proved impossible to plan this from the UK (even through a local travel agent). During the time available for trip-planning (alongside a full time job!) pre-trip time was spent prioritising the visa and permit application process based on my tentative travel itinerary. It was very difficult to be certain about the route or timetable of any flights that went as far north as Kamenskoye or Manily on the River Penzhino. It became apparent that it would involve at least one or two stops at towns within Kamchatka and transport by small plane and/or helicopter. There was no readily available information on how much a ticket on a scheduled flight (plane or helicopter) would cost. The cost of chartering a plane or helicopter was beyond the reach of the grant. After requesting some additional budget from the Trust and adding personal savings into the project, I hoped the trip would be possible for less than £4000. Kamchatka is not a low-cost destination! The details of the trip, how the travel fell into place, the people met and what was discovered about tidal life around the Penzhinskaya Guba, are detailed in this report. The main and biggest achievement was to actually reach (and return on schedule from) this remote estuary where it is likely no other English (or western) person (especially a woman!) has ever been.

Map 2: Route of Travel to Penzhinskaya Guba, Far East Russia.



1.6 Putting the Itinerary to the Test!

On arrival in Petropavlovsk-Kamchatskiy, an outline itinerary was used to obtain my permit as the reality of travelling within Kamchatka meant that it was impossible to plan anything exactly. Weather and the availability of planes/helicopters and pilots are often unpredictable. Schedules exist for small planes and helicopters but they are often delayed, sometimes by days or even weeks.

Despite the busy summer season and crowded internal flights, I was fortunate to obtain a plane ticket to travel north to Korf (the airport for Tilichiky) within 5 days of arriving in Kamchatka. This was thanks to the knowledge, contacts and expertise provided by Martha Masden of Explore Kamchatka and my timing coinciding with a National Geographic team travelling from Korf to Hailino to visit Koryaki villages.

A meeting with scientists at the Pacific Institute of Geography in Petropavlovsk-Kamchatskiy, led to a hydrologist - Vadim Kirichenko (who specialises in Geographic Information System mapping) acompanying me on the trip north from Petropavlovsk-Kamchatskiy to Penzhinskaya Guba.

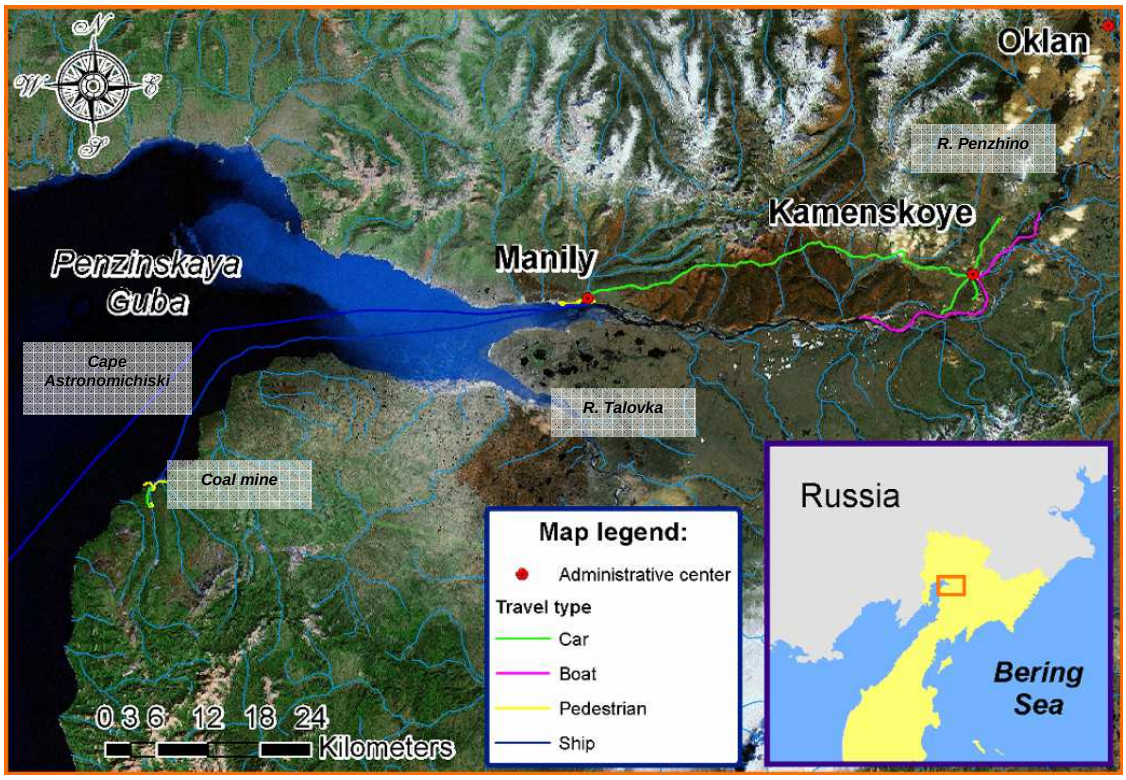
The weekly flight from Yelisovo (the airport for Petropavlovsk-Kamchatskiy) to Korf ran a day late. Fortunately, the weekly helicopter from Korf to Kamenskoye & Manily also ran a day late that week so at one point it looked as if it would be possible to travel to Penzhinskaya in one day. Unfortunately the connecting helicopter from Korf departed 15 minutes before we arrived by plane! This meant a 6-day wait

in Tilichiki (the nearest town to Korf airport) until the next scheduled flight. Several days were spent in Korf airport (just the other side of the lagoon) in case an additional (emergency) flight was able to take us further north any earlier.

After a 6 day wait in Korf & Tilichiky, the scheduled weekly helicopter to Kamenskoye and Manily flew on Thursday 19th July to Kamenskoye, located 60km upstream of Manily on the River Penzhino. Eleven days after arriving in Kamchatka I reached the River Penzhino. A few days were spent in Kamenskoye to meet the local administration staff, who had provided an official invitation for my permit and to register with the police. It was also a good location from which to see the extent of the catchment before the river became tidal, approximately 10km downstream from Kamenskoye (see Map 3).

After a few days spent in Kamenskoye, an opportunity was found to travel to Manily by river on a local barge. This started well, but an hour after departure about 20km downstream, the barge grounded on a sand bank and seemed well and truly stuck. The high tide of the day came and went. The barge engines gave up after several attempts to plough our way through the sand bank. The captain and crew decided to wait it out after failed attempts at digging the sand bar. With low river flows and neap tides the prospect of a long wait overnight, seemed likely. After five hours my satellite phone was put to good use to make contact with the family we'd stayed with in Kamenskoye. Staff from the local administration, who I'd met at the fish-camp upstream of Kamenskoye, took three of us from the barge with a small motorboat. One hour back upstream found us returning to Kamenskoye for a quick meal and a hastily arranged jeep to take us by road to Manily.

Map 3: Locations Visited Around Penzhinskaya Guba.



On Sunday evening, 22nd July 2007 I arrived in Manily two weeks after landing in Kamchatka. Five days were spent based in Manily. This included walks along the shoreline from the village and an overnight trip by barge to the coal mine in Penzhinskaya Guba, as shown on the map above. Time was also spent talking to local people and meeting those who lived and worked most closely with the tides – the Port Director, barge operators, hunters and fishermen.

Whilst staying in Manily, the cargo ship *Krashinenikov* arrived on its once per year delivery from Petropavlovsk-Kamchatskiy (a stroke of luck?!). An opportunity was sought to return on the *Krashinenikov* to Petropavlovsk-Kamchatskiy as the timing seemed suitable. It would also save money and not

necessarily take any longer than flying (due to the unpredictable nature of flight schedules, availability of fuel and weather). After a half-hour vetting process (involving a drunk man pleading my case) the Captain of the *Krashinenikov* agreed to take Vadim & I (reluctantly as women are bad luck at sea) as one of a few passengers.

Five days were spent on board the *Krashinenikov* from Manily to Petropavlovsk-Kamchatskiy, sailing through the Penzhinskaya Guba, Shelikova Bay and Sea of Okhotsk. This completed a round-trip in 3 weeks.

A detailed itinerary of the completed Phase 2 visit to Russia, is shown in the following Table 3. It also indicates who was met during the trip and notes on the subject of our discussions.

Table 3: Russia, Phase 2 Itinerary, Contacts and Meeting Notes

RUSSIA - Itinerary & Contacts

DATE	LOCATION	CONTACT NAME & ORGANISATION	NOTES
KEY: Meetings/ Site visits	*Field study*	*Travel*	***Other - not directly related to the project.***
Thu 5th July	**Moscow**	**Vassily Spiridinov (Marine Branch) World Wide Fund for Nature**	Advice and contacts
Fri 6th July	**Moscow**		Site-seeing
Sat 7th July FLIGHT: Moscow 1400 - Petropavlovsk Kamchatskiy 1000 Sunday			
Sun 8th July	**Yelisovo**	**Martha Masden, Diligens - Explore Kamchatka (Travel Agency)**	Arranged visa invitation, permit & registration in Petropavlovsk-Kamchatskiy. Provided B&B accommodation, contacts and logistical support.
Mon 9th July	**Yelisovo**	**Laura Williams, Director, World Wide Fund for Nature (WWF) Kamchatka/Bering Sea Ecoregional Office**	Provided contacts and advice.
	Petropavlovsk-Kamchatskiy	**Dr Robert Mosieev & Olga Chernyagina, Pacific Institute of Geography, Kamchatka Branch**	Met with Yigor (translator). Explored common ground over salt marshes, tidal estuarine ecology and coastal management.
	Yelisovo (WWF office)	**Boris Lezhni, Koryakski Duma (met in WWF office)**	Provided local information and travel advice.
Tue 10th July	**Petropavlovsk**		Purchasing flight ticket to Tilichiki & telephone calls to potential contacts.
	Yelisovo	Olga Romanenko, Ecological & Environmental Consultant	Met at Martha's B&B. Working on Kuril Islands project.
Wed 11th July	**Yelisovo**	**Yuri Gerasimov, Ornithologist**	Met in Yelisovo with Yigor (translator).
Thu 12th July	**Yelisovo**	**Vadim Kirichenko, Hydrologist, Pacific Institute of Geography, Kamchatka Branch**	Accompanied on trip from P-K to Penzhinskaya Guba and back (3 weeks).
	Paratunka hot springs	Rodney Russ, Heritage Expeditions	Offered to put me in contact with international ornithologists, including those living near the Severn Estuary.
Fri 13th July FLIGHT - small plane 'Koryak Air': Yelisovo 1430 - Tilichiki 1800			
Sat 14th July	**Tilichiki**	**Valeriy** (local contact provided by Igor Anatolovich)	Walked approx 3km along coast to the south, around village and met local people. National Geographic team departed.
Sun 15th July	**Tilichiki**		Walked approx 8km along coast to the north.
Mon 16th July	**Tilichiki & Korf**	**Zamanov Izmayudin Ziyodinovich**	Waiting at the airport for a helicopter. Met local policeman from Manily.
Tue 17th July	**Tilichiki & Korf**		Waiting at the airport for a helicopter.
Wed 18th July	**Tilichiki**	**Vadim Gennadivich Martinov, Director, Koryakski Reserve**	Waiting for helicopter, meeting local people and Director of nearby reserve.
Thu 19th July FLIGHT - Helicopter 'Koryaksi Air': Korf 2030 - Kamenskoye 2200			
Fri 20th July	**Kamenskoye**		River Penzhino - walk up and downstream of Kamenskoye.
	Kamenskoye	**Igor Anatolovich, Penzhino Administration & Boris Lezhni, Head of Koryakski Duma**	Discussions about River Penzhino, Penzhinskaya Guba, local communities and the Severn Estuary.
	Kamenskoye	**V.C. Cobenini, Director of the Museum**	

	Kamenskoye	**Vassily & Galina Dimitrievich**	Provided accommodation in their home for 3 nights, local information, road transport locally and arranged trip on barge to Manily.
	River Penzhino fishcamp, 10km upstream of Kamenskoye	**Mosyi Kamen, Sergiy Moiseev and others, local fishermen**	Discussions about River Penzhino, Penzhinskaya Guba and Severn Estuary tides and fishing.
Sat 21st July	**Kamenskoye surrounds**		By road west of Kamenskoye - radio communications station on hill and east of Kamenskoye.
Sun 22nd July	**BARGE: Kamenskoye 1100 - River Penzhino until 1800.** Stuck on sand-bar approx. 20km downstream - returned to Kamenskoye by small boat. **JEEP: Kamenskoye 2000 - Manily 2130**		
Mon 23rd July	**Manily**	**Oleg Alexeivich Isaev, Director of Manily School** (from Ukraine) **& staff**	Information about Manily, Penzhinskaya Guba, local community and Geography.
	Manily	**Nikolay Giorgovich Smirnov, Director of Manily Port (from Petropavlovsk-Kamchatskiy)**	Provided tide tables for Cape Astronomicheski (-1hr from Manily), viewed hydrographic charts and discussed navigation, tides and tidal bores. Arranged possibility of trip on coal barge.
	Manily	**Galina, Manily School Museum and History teacher**	
Tue 24th July	**Manily**		Meeting and talking with local people. Walk along coast around Manily.
Wed 25th July	**BARGE: Manily 0730 - Coal Mine 1130.**		
	Penzhinskaya Guba coastline	**Met Feodor, Captain of the barge and staff at the coal mine.**	Walking approx. 4km along the coast east and west of the coal mine.
Thu 26th July	**BARGE: Coal Mine 0400 - Manily 0930**		
	Manily	**Fishing & Hunting Inspector**	Discussions about fishing permits. Kamchatka Institute of Fisheries sometimes sends a boat for monitoring (mainly salmon).
Fri 27th July	**Manily & Penzhinskaya Guba**		Walked approx. 5km along the coast west of Manily
Sat 28th July	**SHIP 'Krashinenikov' Nikolay Ivanovich (Captain). Manily 0900d - Penzhinskaya Guba & Shelikova Bay. Good v**iews of coastline, calm sea.		
Sun 29th July	**SHIP 'Krashinenikov': Sea of Okhotsk.** Fog		
Mon 30th July	**SHIP 'Krashinenikov': Sea of Okhotsk.** Fog & choppy sea.		
Tue 31st July	**SHIP 'Krashinenikov': Sea of Okhotsk.** Cloudy but calming sea.		
Wed 1st Aug	**SHIP 'Krashinenikov': Pacific Ocean**. Good views of coastline.		
Thu 2nd Aug	**- Arrived Petropavlovsk-Kamchatskiy 0200 - Yelisovo** (by taxi)		
Fri 3rd August	**FLIGHT - Helicopter 'Aeroflot' Yelisovo 1300 - Nailichovo National Park 1400**		
Fri 3rd August – Mon 6th Aug	Nailichovo National Park	Victor Michailovich Okrugin, Instutite of Vulcanology & Seismology, Academy of Sciences of the Russian Far East Division. Geographers, Geologists & Biologists from Moscow.	General interest - potential collaboration with Cardiff University School of Earth, Ocean & Planetary Sciences. Rest, relaxation, visits to hot springs and writing-up.
Tue 7th Aug	**FLIGHT - Helicopter 'Aeroflot' Nailichovo 1300 Yelisovo 1400**		
Wed 8th Aug	**Petropavlovsk-Kamchatskiy**	**Olga Chernyagina & Vadim Kirichenko, Pacific Institute of Geography, Kamchatka Branch**	De-brief and agreement for further collaboration.
		Roman Kultaev & Dave Martin, Russian Far East Program Director, Pacific Salmon Centre, Portland, USA	Studying salmon rivers in Kamchatka for similar reasons i.e. to assess the character of a pristine ecosystem.
	Yelisovo	**Laura Williams, World Wide Fund for Nature (WWF) Kamchatka Regional Office**	
Thu 9th Aug	**FLIGHTS - International 'Aeroflot': Yelisovo 1300 - Moscow 1300. Moscow 2000 - London 2030**		

Contact details for other people and organisations required for the logistics of the trip are not detailed in this report but are available. These include, for example, flight ticket agencies, airports, accommodation and local fixers.

Vadim & Natasha - days were spent waiting for a helicopter from Korf.

Aeroflot helicopter landing at the roadside near Kamenskoye.

Arriving in Kamenskoye – the helicopter landed on the roadside just above the village. Pictured left, Igor Anatolovich from Penzhino Administration and right, Natasha Barker.

A big welcome from the children of Kamenskoye.

2 FINDINGS

2.1 Highest Tides

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

High tidal range visible at Lydney Harbour on the Severn Estuary in 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 tidal ranges has been identified in the **Penzhinskaya Guba** (Bay) in the Sea of Okhotsk in Kamchatka, Far East Russia. Tide tables indicate the irregular diurnal nature of the tides frequently reaching 12-13m and *Kowalik, Z. 2004* from the Institute of Alaska, Fairbanks, documents a 13.9m tidal range making this the highest tidal range site in Russia (Isachev, 2006). As with the tides in the Bay of Fundy and Severn Estuary, amplification of the tide occurs from Shelikova Bay at the mouth to the head of this funnel-shaped estuary. In a similar form to the Bay of Fundy, the head of the Penzhinskaya Guba is split into two narrow bays between the mouth of the River Penzhino and River Talovka.

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.

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 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. In addition to the Severn Estuary and Bay of Fundy area, they are known to occur in other parts of the world, including on 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 has recorded the 2nd highest tidal range in the world, on occasions in excess of 14.5m and with average tides of approximately 12m. It is Britain's second largest estuary with an area of 557km^2 including an intertidal area of 100km^2. It spans England and Wales from 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 is one of the largest and most important 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 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, in 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 South. 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 roughly 50 km long and ranges from 5km – 24km wide.

The world's highest recorded tides were measured in the Minas Basin at Burntcoat Head, at 16.27 m. The average tides are around 12 m but may reach 17m on a storm surge.

The primary cause of the immense tides is resonance within the Bay of Fundy-Gulf of Maine system. It is effectively bounded at the outer end by the edge of the continental shelf 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.

About 180,000 people sparsely populate the watershed and coastline of the Minas Basin. Truro is the largest of the urban centres with a population of 12,000.

The Bay of Fundy

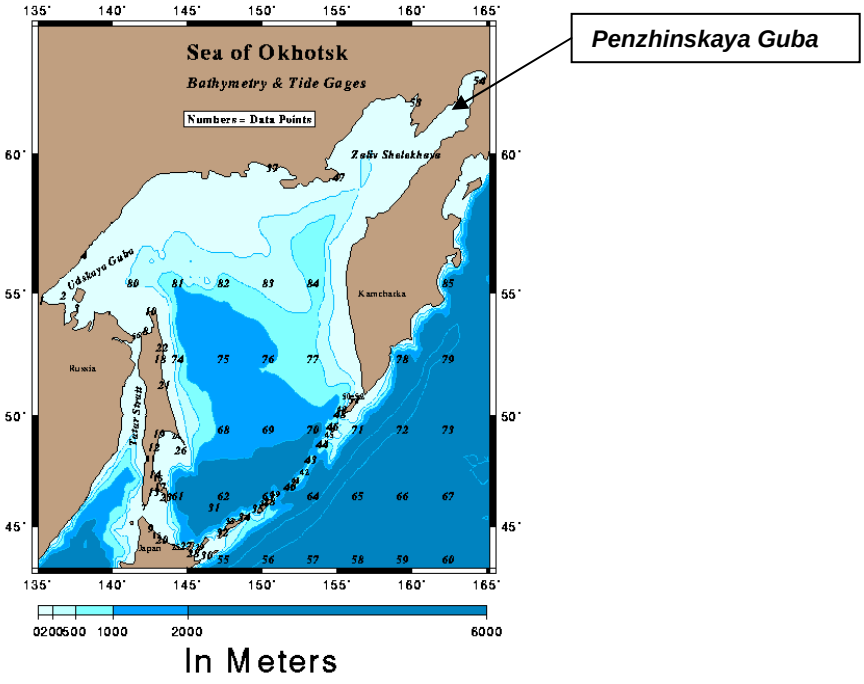
2.2.3 Penzhinskaya Guba, Kamchatka & Magadan regions, Russia

Some of the highest tides in the world have been recorded in the Sea of Okhotsk in far north-east Russia. The extent of Penzhinskaya Guba from Shelikova Bay to the head of the estuary is some 400km long and 100km wide.

As with 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. In a similar form to the Bay of Fundy, the head of the Penzhinskaya Guba is split into two narrow bays between the mouth of the River Penzhino and River Talovka (see Map 3). 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 observed it had 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 ^{0}c, 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



Professor Zygmunt Kowalik, in the Institute of Marine Science at the University of Alaska Fairbanks (UAF), has undertaken research on the Sea of Okhotsk. During Phase 1 of the fellowship the author had the opportunity to meet him in Alaska to discuss plans for the visit to Penzhinskaya the following year. Through the discussion, the following points were noted for future reference:

- Penzhinskaya Guba displays the highest diurnal tides in the global ocean;
- The diurnal tides, typically with one maxima per 24hr period (compared to the Severn Estuary with two maxima) are sometimes influenced by semi-diurnal tides and are therefore irregular;
- Bernshtein (1996) illustrated how the 18.6 year tidal cycle was significant for the generating potential of tidal power plants;
- currents are very difficult to predict, unlike tides, but tend to be stronger when the moon is closer; currents are sometimes known as 'old tides'.

Observations on the character of tides in the Penzhinskaya Guba, based on one week spent in Kamenskoye and Manily include the following:

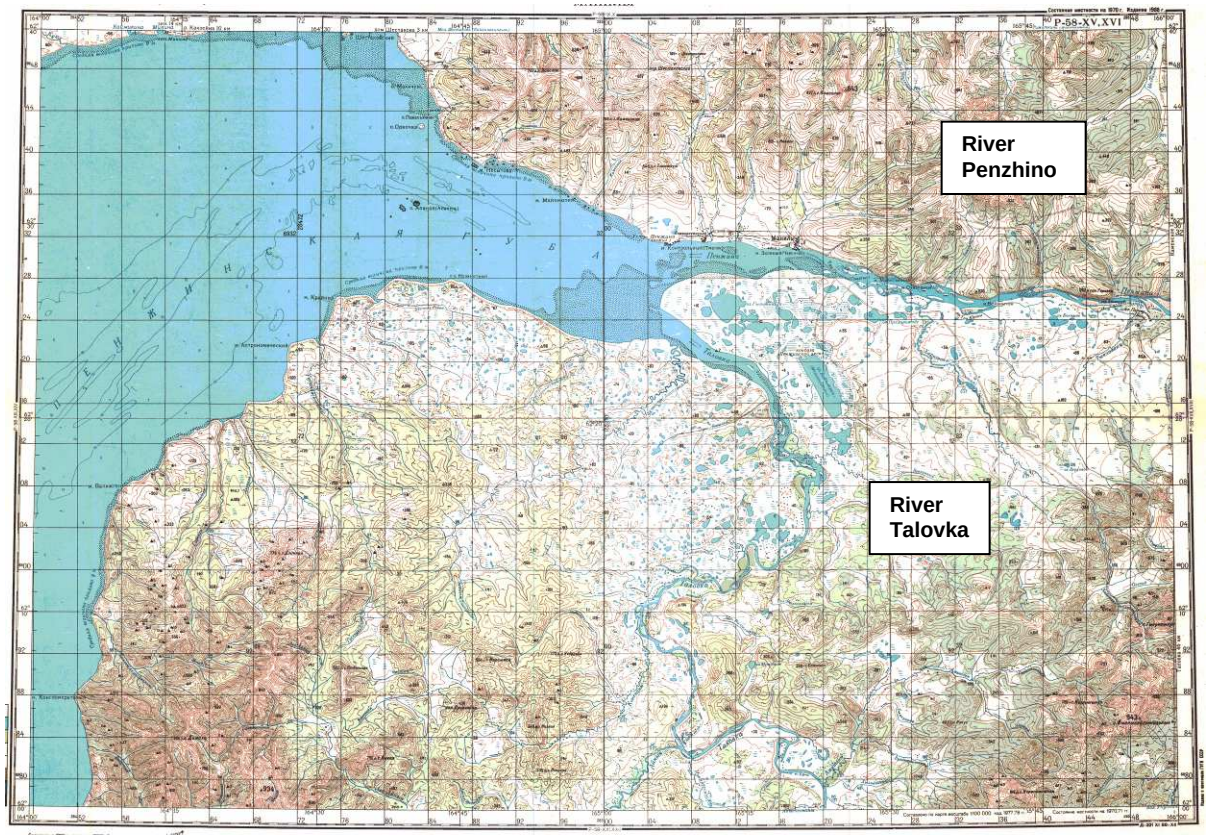
- Tidal influence from the Sea of Okhotsk extends into the Penzhinskaya Guba and up the River Penzhino 50km upstream of Manily, 13-16km downstream from Kamenskoye.
- The tidal range appears similar to the Severn Estuary in UK but the pattern of tides is different due to the irregular diurnal pattern in Penzhinskaya Guba (see graphs on page 24).
- The climatic extremes in the Penzhino area, from -50^{0}c in mid-winter up to +40^{0}c in the summer, mean that the shoreline is subjected to faster rates of erosion/accretion. Ice can form up to 4m thick.
- The natural environment is in a pristine state compared to the Severn Estuary and Bay of Fundy. Indicators of the health of the ecosystem include references made by local people and scientists to over one million migratory birds (Yuri Gerasimov *pers.comm.*) and 500 beluga whales.
- The vast landscape of mudflats, salt-marsh and cliff shoreline are little explored with a low and decreasing population contained in a few settlements.
- Russian settlement has dominated native culture, particularly over the last 50 years, with now little evidence of Koryak traditions apart from well presented local museums in Kamenskoye library and Manily school.
- People live closer to the tides; depending upon them for fishing, fuel and transport. The way of life has similar characteristics to subsistence living around the Severn Estuary hundreds of years

ago. This was illustrated by, for example, the use of lathe nets for fishing from the shoreline and seine netting from small boats.

Ships and barges navigate around Penzhinskaya Guba and are largely dependent upon the tide. Their movements are limited to high tide times, landing on the shoreline to unload on a falling tide and departing on a rising tide. This was witnessed through a trip by barge from Kamenskoye towards Manily, and a trip on a coal barge from Manily to the coal mine on the south-east coastline of Penzhinskaya Guba. There are few navigation aids and the only apparent infrastructure for ships is a re-fuelling depot just west of Manily. With no docks larger ships anchor up to 30km offshore. The dynamic coastal processes, particularly during winter when the river and estuary are frozen for up to 8 months of the year, have been deemed too destructive for piers and harbours.

The question of whether a tidal bore wave ever forms, raised a lot of interest and lively discussion, but ultimately appeared not to be known by local fishermen, barge operators or hunters to exist on the River Penzhino. Fewer people have knowledge of the River Talovka and there is a possibility of a tidal bore in other tributaries feeding into the Penzhinskaya Guba.

Map 5: Russian Map of the Upper Penzhinskaya Guba (1:200,000 topographic)



Scenes from around Penzhinskaya Guba

2.2.4 Physical Characteristics of the Sites

The Penzhinskaya Guba has a similar form, on a smaller scale, to the Bay of Fundy - with two major rivers forming in the upper part of the Bay. The overall character of all three sites studied, is the east -west flow of the major rivers to estuary and bay. The table below compares the main physical characteristics of the Severn Estuary with the Penzhinskaya Guba.

Table 4: Physical Characteristics of the Severn Estuary & Penzhinskaya Guba

Characteristic	Severn Estuary, UK	Penzhinskaya Guba, Russia
Size of estuary/bay and intertidal exposure	557km^2 (intertidal area 100km^2)	Approx 28000km^2 (upper estuary intertidal area approx 600km^2).
Largest dimensions (approximate)	Bristol Channel –170km long, 70km wide Estuary – 50km long, 15km wide	Guba – 400km long, 100km wide Upper estuary 50km long, 12km wide
Highest tidal range	14.5m at Avonmouth	13.9m
Average high tidal range	Approx 12m	Approx 10m (semi-diurnal)
Tidal bore	Front wave up to 2m height followed by fast moving grade 2 white water	None known
Landscape & Geology	Dominantly low-lying land backed by gently sloping hills (Cotswolds, Forest of Dean and Brecon Beacons)	Vast expanses of wetland and low-lying land backed by hills and high mountains.
Population	Approx 3 million	Approx 3000
Land use	Urban, industry, agriculture, wetlands, tourism, major cities, transport infrastructure and power stations.	Fish camps, foraging and villages.

It is estimated that some 3 million people live around the Severn Estuary in UK; approximately 300,000 around the Bay of Fundy in Canada; and only some 3000 around the Penzhinskaya Guba in Russia. With less than 0.1% of the population, Penzhinskaya Guba offers a control site for an estuary with a tidal range similar in size to the Severn Estuary. This provided an opportunity to assess how man lives and works with the tide and/or manages tidal change at an earlier stage of human occupation and development.

Re-fuelling depot near Manily, Penzhinskaya Guba – there are no harbour, piers or docks.

2.3 Public Awareness of the Tide: *'Recognising the Tide'*

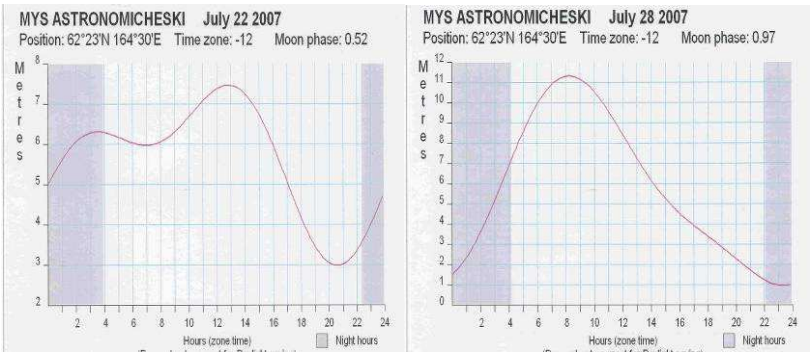
Objective i) Public awareness and marketing the tide for tourism.
Assess the level of community awareness of high tidal ranges. Explore existing and potential opportunities for promoting public awareness of the coastal environment (and climate change impacts) through marketing and tourism initiatives. 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.

2.3.1 Tidal Patterns

Tides in the Penzhinskaya Guba display the highest diurnal tides in the global ocean (Kowalik, *pers.comm*). These diurnal tides experienced in the Sea of Okhotsk are unusual and different to the semi-diurnal tides experienced in the Severn Estuary. A comparison of tide graphs illustrates this difference – with the Penzhinskaya Guba normally having one high and one low tide per day, whereas the Severn Estuary has a regular pattern of two high and two low tides per day with the tide changing direction every 6.5 - 7 hours, as opposed to very irregularly in Penzinskaya. The graphs below also show how the Penzhinskaya Guba tides are less predictable. The diurnal tide is shown for July 28 th below. Sometimes it is influenced by semi-diurnal tides causing a double high tide wave on several days each month – as illustrated on the graph for July 22nd below.

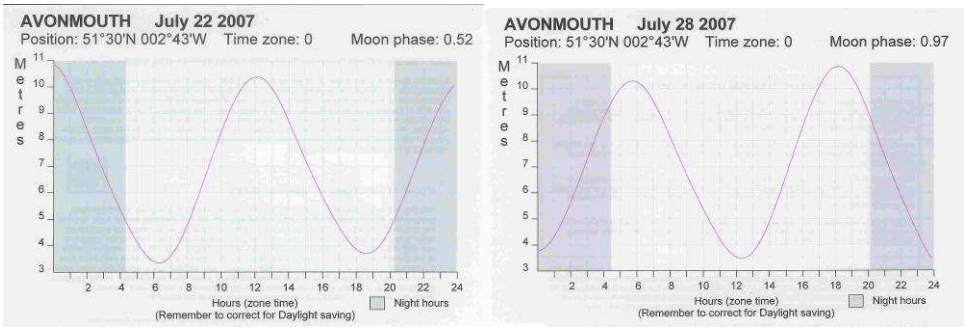
Figure 1: Tide Graphs for Penzhinskaya Guba & Severn Estuary

Mys Astronomicheski *(see Map 3, p.11)* ***is 1 hour earlier than Manily in Penzhinskaya Guba.***



Note: Semi-diurnal nature of the tide: 22nd July max height 7.5m on neap tides, compared to 11.5m tide on spring tides 1 week later.

Compare to Avonmouth in the Severn Estuary, for the same day (below).



Source: Tidecomp (www.pangolin.co.nz)

The tidal patterns for the two estuaries differ significantly, despite their similar high tidal ranges. The complex pattern of the tides would make it more difficult for people to follow the pattern of high and low tides in Penzhinskaya compared to the Severn. This was shown by barge operators in Manily being reliant on the local port official for forecasting the tides, with limited availability (control!) of the tide table.

2.3.2 A Tidal Bore?

As was seen from the research in the Bay of Fundy, the presence of tidal rapids raises public awareness of the tide. Many lively discussions took place to try and identify whether or not there was any evidence for a tidal bore wave or rapids in the Penzhinskaya Guba area. The language barrier, combined with a need to differentiate the phenomenum of a tidal bore compared to waves caused by winds or wind/wave combinations, meant that a definitive answer was challenging!

In total the author asked about 10 people and showed several of them an aerial video of the Severn Bore plus photographs of the River Shubenacadie in the Bay of Fundy. Overall, it seems that there is no real evidence for a tidal bore in the River Penzhino, where most people in the area live. If there was a regular tidal bore, the fishermen, barge operators and local people would most likely know of the phenomenum. There are much fewer people living on the River Talovka, with the main settlement of Talovka far upstream of the tidal limit. Reindeer herders in the catchment may have some knowledge of the influence of the tide in this area, but in the time available on this trip, it was not possible to meet them.

Studying the geography of the Penzhinskaya Guba in comparison to other bays and estuaries with tidal bores, it seems Penzhinskaya has the shallow funnel-shaped coastline typical of sites where the high tidal range can cause tidal bores. However, it is well known that there are very fast tidal currents in the Shelikhova Bay and the Penzhinskaya Guba, for example across the Kasherov Bank, which may be taking tidal energy out of the system before the tide reaches the mouth of the Rivers Penzhino and Talovka.

Tidal currents/mixing identified in 3 or 4 bands across the upper part of the Penzhinskaya Guba from the Krashinenikov ship, around high tide on the morning of 28th July 2007.

2.3.3 Recognising the Tide

In contrast to the Severn Estuary, where many of the 3 million people living around its shores do not need to recognise the tide as part of their lives, most people around the Penzhsinskaya Guba rely on the tide for their existence.

When asked to indicate how people relate to the tide in their lives, the Director of Manily School listed the following factors in order of priority:

i) Transport

All barges and the occasional ship navigate with the tide as there are no docks, harbours or piers. Barges will typically arrive on a falling tide and depart on a rising tide. Ships anchor and smaller barges or boats have to unload alongside. This means that people operating the barges and dealing with the shipment of cargo live around the tide times. Cargo is transported by ship from Petropavlovsk-Kamchatskiy some 2000km once/year to Manily. To give some idea of scale, we witnessed the *Krashinenikov* ship arrive with 9 vehicles and unload approximately 30 small containers over 3 days. There are also occasional (perhaps once or twice/year) cargo ships from Magadan some 1000km from Manily. Smaller amounts of cargo are delivered by helicopter to the main settlements around Penzhinskaya Guba (Kamenskoye & Manily) on a regular basis (e.g. weekly in the summer) but less frequently to other smaller villages. From the main settlements, cargo is transported by barge to other locations along the shoreline as necessary. In Manily there were approximately 8 barges that seemed to be active on a daily basis during July & August, delivering to villages upstream and along the coast of Penzhinskaya Guba.

Barges on the shoreline at Manily.

ii) Mosquitos

In summer there are many mosquitos and other flies. Their abundance depends primarily on the wind. In coastal locations there is often more wind due to weather and tidal movements. At high tide in Manily, for example, there tended to be more wind and therefore fewer mosquitos. At low tide on a still warm day mosquito's are most abundant and activity outside is severely limited. Inland, however, mosquitos are consistently much more abundant.

iii) Fish

Different fishing techniques are used along the shoreline (e.g. using lathe nets) and from small boats (e.g. seine netting). Fishermen keenly watch the state of the tide for the safest and most optimal fishing times.

iv) Whales

Native people relied heavily on whales for their meat, blubber and skins. Today, the techniques needed for whale catching have virtually been lost in history and only if the tide brings beached whale, will it be harvested by the local people. However, historically people settled on the coast for whale hunting.

The high level of dependence upon the tide for transport, fishing and mosquito avoidance, means that people are often aware of the state of the tide. Several people suggested that younger children and elderly people were particularly sensitive to the state of the tide; children often crying when there are exceptionally high tides.

Public awareness of the tide in the Penzhinskaya Guba area is therefore higher than amongst people living around the Severn Estuary or Bay of Fundy. Whereas people in the Bay of Fundy learn about the tides through sophisticated interpretation and visitor centres, people around Penzhinskaya are more aware of the tide as their livelihoods depend more upon it.

Opportunities for tourism associated with the Penzhinskaya Guba are significantly limited. Whilst this may be Russia's highest tidal range site in the world, it is extremely remote and expensive to reach. The author was almost certainly the first 'tourist' to visit the area purely to see the high tidal range!

Loading coal in Penzhinskaya Guba – the barges rest on the shoreline between high water to load.

2.4 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?

2.4.1 Native Koryaks and Russian Settlement

It is hundreds and thousands of years since people settled around the Bay of Fundy and Severn Estuary. The industrial revolution has shaped the use of the land for agriculture, industry and residential development. Settlement around the Penzhinskaya Guba is of a very different nature. Relatively recently, people from the former Soviet Union (particularly Ukraine), Russia and Far Eastern countries such as Korea, have settled in northern Kamchatka. Soviet Russia had a policy of encouraging people to settle in the remotest parts of Russia. They have come to dominate what was a land of native Koryak's.

It has been suggested (Hildebrand, 1992) that the level of awareness of coastal issues is typically weaker in urbanised coastal areas compared to rural. It would therefore follow that around Penzhinskaya, an area with very sparse population, there would be a high level of public awareness of the tide. This section therefore looks at the origins of settlement around Penzhinskaya Guba and characteristics of the population who currently live there.

There is some evidence to suggest that native Americans originated from this region of Russia (e.g. Turk, 2005). Evidence of settlements some 4000 years old has been found in Kamchatka. Native populations in Kamchatka included Evens, Chuckchi and Koryaks. Around Penzhinskaya Guba, the main native people were Koryak. There were two forms of Koryak people: *Shore Koryaks* and *Reindeer Koryaks*. Shore Koryaks settled in coastal areas, utilising resources from the sea for their living. Reindeer Koryaks settled inland and practiced subsistence living based around reindeer herds. There were 40-50 Koryak settlements at one time and 28,000 Koryakis.

Between 1000 and 5000 years ago there were a series of very small settlements along the northern shore of Penzhinskaya Guba such as Chavchuyeni and Kamenshi (Historical Atlas of Kamchatka). People would have lived a subsistence lifestyle on different species of fish and harvesting whales for their blubber and skins. Grasses used to be harvested from the island called 'Dobranskoye' (Holy Island) in Penzhinskaya Guba.

Native Koryak Dress.

Russian Fisherman.

The first Russian settlement in Kamchatka were Cossacks from Magadan about 325 years ago, with 60-65 people living in a settlement called Oklan. From the 1950s people started settling in larger towns such

as Kamenskoye, Tilichiki and Palana – which are the main centres of population today – as more people settled in the region. Up until the 1990s there was a Soviet Union policy to populate remote areas of Russia and settlements such as Kamenskoye and Manily expanded as military developments took place in the Cold War. Today, the area is depopulating, with settlements such as Shestakova approximately 15km west of Manily now abandoned.

Shestakova – an abandoned village on the shores of Penzhinskaya Guba.

Today, the administrative centre for Penzhino, Kamenskoye, has a population of approximately 700. The population of Manily, at the mouth of the River Penzhino and head of the Guba is approximately 900. Many of these people are not of native origin, shown by an estimate (Valeriy Dimitivich *pers.comm.)* that only some 10 people in Kamenskoye still have the knowledge to make native dress. There are a few traces remaining of the traditional way of life of the Koryaks. Reindeer Koryaks live in the vicinity of the village Slaiootnoye upstream from Kamenskoye and in and around Talovka. Shore Koryaks may still live in small settlements around the Penzhinskaya Guba. The most unique native population of about 300 people live in Paren on the south-western coast of Penzhinskaya Guba. It is well known for the knives people make there for fishing and hunting.

Kamenskoye – administrative centre for Penzhino region

2.4.2 Land Use in the Wilderness

With a population of less than 3000 people around the Penzhinskaya Guba, there is very limited land use compared to the very developed land around the Severn Estuary supporting a population of over 3 million.

Within the settlement of Manily at the head of the estuary, there are houses (mainly wooden), streets and infrastructure associated with the electricity generating station – electricity lines, heating and hot water pipes. There is no extensive agricultural development due to the harsh winter climate with the tundra not being suitable for arable farming. There were few signs of pastoral farming with only a few cows in Manily. Gardens flourish in the few summer months with vegetables and flowers, mostly grown on plots directly outside peoples homes.

Outside the settlement, fish camps dot the shoreline amongst the marsh and sometimes on top of cliff slopes. People spend much time in the summer months fishing, gutting, cutting and drying large quantities of fish to last through the winter months. The tundra is foraged for mushrooms and berries from early August. This is also a time when bears move down to the coastline from the inland hills to forage the lowlands and fish for salmon. It is a hazardous time for local people who use dogs to help protect them from bears – there are many dogs on the streets of Manily which help to keep bears out of the village.

With such a huge expanse of land, there is no comparison to be made between the development pressures experienced around the Severn Estuary. However, as people have chosen to settle at the coast within the vast landscape around Penzhinskaya Guba, comparisons can be made to where people would have settled around the Severn Estuary in ancient times. People are attracted to the shoreline as a place to live for transport and fishing. The settlement of Manily has evolved at the mouth of the River Penzhino, rather like Truro or Moncton in the upper Bay of Fundy, or Gloucester at the upper extent of the Severn Estuary.

The land around Penzhinskaya Guba is wilderness. Apart from a handful of settlements and fish camps, there are hundreds of kilometers of untamed land. The tide is free to roam!

Vast expanse of mudflats and saltmarsh upstream of Manily where the River Penzhino meets the sea.

2.4.3 Shoreline Change

One of the major objectives for visiting Penzhinskaya Guba was to witness a dynamic estuary shoreline which is unrestrained by coastal defence and flood protection structures. Some 80% of the shoreline around the Severn Estuary has been changed due to land reclamation and the construction of earth embankements or concrete coastal defences. Similarly, 60-70% of the shoreline around the Bay of Fundy has been modified due to land reclamation and the construction of mainly earth embankments with some rock revetment.

There is no land reclamation for agriculture around the Penzhinskaya Guba and (as a result) no engineering works for flood or coastal defence. Settlements are set back from the shoreline (e.g. 100m)

so that flooding and coastal erosion is not an immediate threat to people or property. Only a few houses have been developed closer to cliffs which exhibit some signs of instability.

There is significant pressure to maintain coastal and flood defence structures around the Severn Estuary due to the high population density and high capital risk of flooding damage to property. However, a sustainable solution to increased risks of flooding due to climate change impacts is necessary if there is to be some long term solution to high levels of expenditure required to maintain defences.

Shoreline defences at Severn Beach on the Severn Estuary (left) and near Truro on the Bay of Fundy (right).

The inter-tidal habitats in front of the Severn's coastal protection have mainly been eroded, with mud-flats and only sporadic salt marsh communities. The natural shoreline of the Penzhinskaya Guba features dense marshland between cliff slopes and mudflats.

Visualising the unrestrained influence of the tide around the Penzhinskaya Guba provided an insight to how a more holistic approach could be taken to flood risk management in areas under development pressure around the Bay of Fundy and Severn Estuary. Understanding the original extent of tidal influence upon the shoreline would show how the natural ecosystem would operate, with the shoreline providing a natural buffer against tidal inundation. Identifying the original extent of tidal inundation around the Severn Estuary would help to inform future flood risk management strategies – reclaiming areas of shoreline back for the tide.

The influence of the tide on small and remote communities in Russia showed how people live much closer to the tidal cycle, providing an opportunity to see how the landscape of Britain and Canada would have looked prior to intensive settlement.

Natural shoreline with 50-200m marshland protecting people and property around Penzhinskaya Guba.

2.4.4 Reclaiming the Shoreline

Planning guidance in UK (e.g. Planning Policy Statement 25 on Development in Flood Risk Areas) and studies such as the UK Environment Agency's *Severn Tidal Flood Risk Management Strategy* recognise the need to restrict further development in the flood plain and work with natural processes to provide affordable coastal protection schemes in the future. Public awareness of the risks associated with development in flood plains is gradually increasing as we experience flash floods and damage from flood events. 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.

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. The recent preparation of a *Coastal Habitat Management Plan (CHaMP)* for the Severn will inform the 2nd round of *Shoreline Management Plans* when decisions will be made about whether to maintain, abandon or set-back existing coastal defences. The high profile of climate change & sea level rise issues in the UK is resulting in the involvement of the Environment Agency and local government in promoting schemes for habitat restoration & re-alignment.

The big challenge facing the Severn Estuary is the high population density and intensity of development which restricts opportunities to adapt to sea level rise by re-aligning the shoreline. With a lower population density and less development pressure around the Bay of Fundy, there are more opportunities to restore natural shorelines to help provide adequate protection from flooding. Penzhinskaya Guba demonstrates how wide the natural shoreline is naturally, when not constrained by flood or coastal defences.

Mouth of the River Penzhino.

2.5 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.

2.5.1 Tidal Power Potential

Due to the uncertainties of relying on hydrocarbons (coal, oil, gas etc) for energy and impacts of climate change, there is increasing interest in renewable energy across the world. Of renewable sources, tidal power is one of the major potential areas for development.

Estuaries and coastal areas experiencing the highest tides are likely to offer significant opportunities for tidal power generation (Bernshtein, 1996). Whilst the technological options are relatively young, there are some examples of existing tidal power schemes.

The following tidal power stations have existed for some time:

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

Interest in tidal barrage schemes is increasing. Other technologies for harvesting tidal energy are also being developed. The Severn Estuary and Bristol Channel are currently being used to trial a sub-sea turbine and the Bay of Fundy are looking increasingly towards alternative technologies instead of pursuing options for tidal barrages.

La Rance tidal barrage, France.

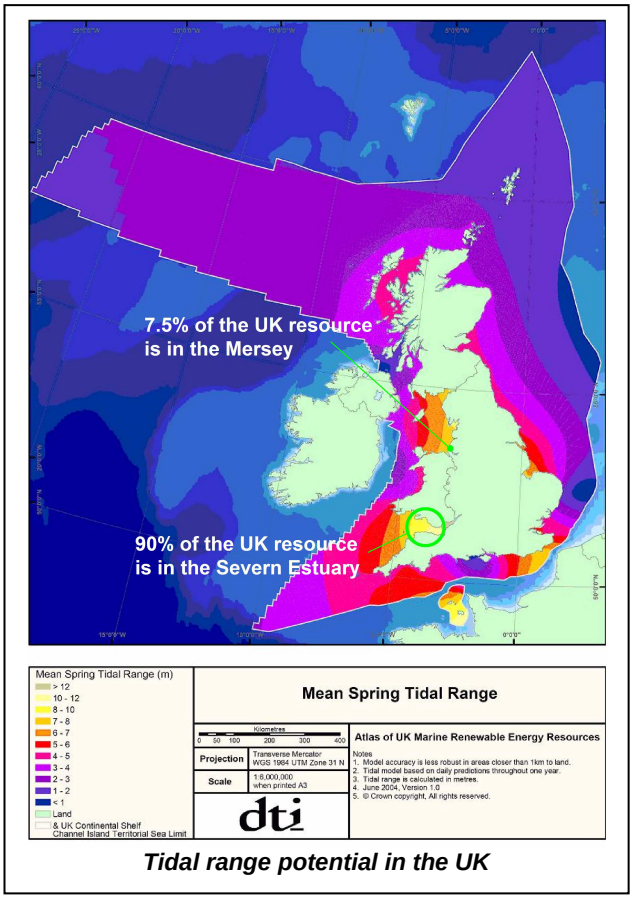
2.5.2 Severn Estuary & Bay of Fundy

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.

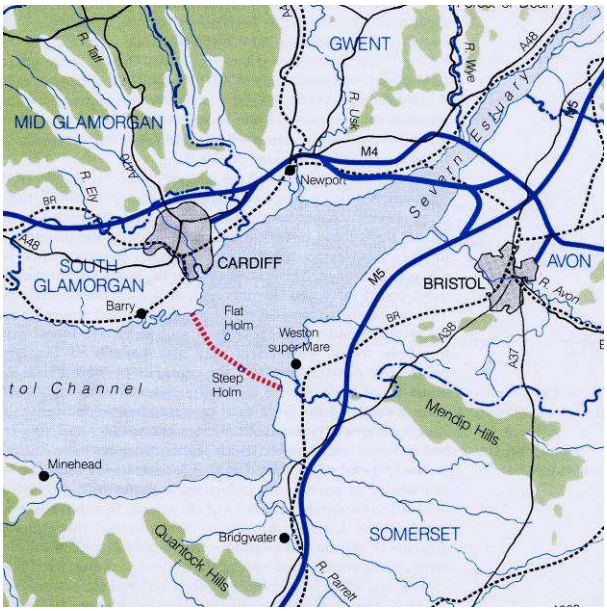
Box 3: Tidal Power Potential from the Severn Estuary *(Source: http://en.wikipedia.org/wiki/River_Severn#Tidal_Power)*

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.

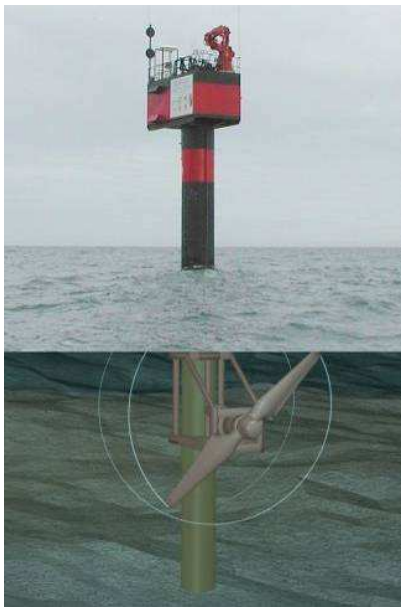
The UK Government shelved the plans in the late 1980s due largely to cost issues and local environmental concerns. However, this was before recent huge rises in the price of energy, and before Global Warming had started to be taken seriously. In April 2006 the Welsh Assembly approved the idea of utilizing 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

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). A report recently 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.

> 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 New Brunswick, 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 Annapolis Royal tidal power station became operational in 1983.

Minas Basin from Economy Hill looking towards Burntcoat Head across the Bay of Fundy. The site of the highest recorded tides in the world and the most favoured location for a tidal barrage in the 1980s.

2.5.3 Penzhinskaya Guba

The potential for tidal power generation has been recognized from Shelikova Bay and Penzhinskaya Guba in the Sea of Okhotsk (Bernshtein, 1996; Kowalik, 2004; Kowalik & Polyakov, 1998; Isachev, 2006) but the proximity of supply to demand make tidal energy less likely to be utilized (at this time) than in more developed parts of the world such as the Severn Estuary and Bay of Fundy.

Nevertheless, the Penzhinskaya Guba contains the highest recorded tidal range in Russia (13.4m) and it has been studied for its potential provision of tidal energy. Two potential tidal barrage alignments have been estimated:

i) 32km barrage at a 26m deep location; 6800 km^2 basin; 27000 MW; 72 billion kWh.
ii) 72km barrage at a 67m deep location; 20500 km^2 basin; 87000 MW; 4400 generating units with 10m diameter turbine wheels capable of producing 200 billion kWh annually.

Compared to the largest world hydro-power scheme in China (17700 MW) this scheme would be the largest ever proposed.

Potential tidal barrage routes across Penzhinskaya Guba.
Source: Greenpeace, Moscow, 2006.

The extreme climatic conditions and ice within Penzhinskaya Guba for many months of the year could make any tidal power scheme extremely challenging. Another significant issue is the physical distance from supply of energy to demand. Major consumers would be America, Japan, China or further south in the Vladivostock/Khabarovsk area of Russia, thousands of kilometres from Penzhinskaya Guba. As early as 1961, US specialists proposed a power grid project aimed at joining Russian and USA power systems across the Bering Strait. It is suggested (Isachev, 2006) that technical feasibility of wireless power transmission for long distances and the rapidly changing world energy situation should accelerate consideration of the Penzhinski tidal power plant project.

East (top) and west coasts of the narrowest part of Penzhinskaya Guba (site i) referred to above.

Tundra landscape between Kamenskoye & Manily north of the River Penzhino. Note the permafrost still visible in July.

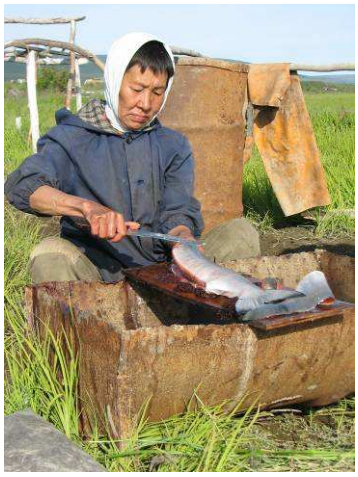
3 OBSERVATIONS FROM THE RESEARCH

3.1 Managing Tides

The study of three dynamic estuaries with different levels of human settlement and at different stages of development, have shown that the tidal shoreline is more likely to be managed where there is larger population pressure from terrestrial development. Observations from the three estuaries in this project have shown how people have tamed and controlled the tides to provide land for coastal settlement, industry, port and infrastructure development. In a remote area with low population density such as Penzhinskaya Guba, people living in a coastal settlement rely more directly on local resources from the river & sea. Life, work and transport patterns often depend upon the movement of the tides. Public awareness of the tide is higher in communities around the Penzhinskaya Guba than in communities around the Severn Estuary - where life, work and transport are far less dependent upon the tide. As society develops, there is less need to live and work closely with the tide. Consequently, public awareness of the tide appears to be higher in smaller communities and lower where there is greater population density.

However, there is significant recognition of the highest tides in the world around the Bay of Fundy, which are promoted for tourism through highly sophisticated interpretation tools. Experience and techniques used to promote understanding of tidal phenomenum in the Bay of Fundy would be useful for helping to raise awareness of the value of the Severn Estuary.

Observing three estuaries with different levels of population density have illustrated the influence settlement has had on the coast and how people live and work with tidal changes at different stages of development. The Penzhinskaya Guba provides an excellent control site to see how a natural ecological system looks when un-hindered by coastal defences and land reclamation. It provided a holistic perspective which may guide future sustainable management of more developed estuaries. When population density increases and human development intensifies, land is reclaimed for agriculture, transport infrastructure develops and society is less dependent upon the local river, estuary & sea. As populations grow and developments progress, tidal change is more managed.



People living with the tide - salmon is a major food resource for the Russian and native Koryak people who live in northern Kamchatka.

3.2 Sustainable Development or Management?

Penzhinskaya Guba has provided an insight to an 'original baseline' environment of an estuary with a 13-14m tidal range similar to the Severn Estuary. It provided some idea of the tidal extent of the Severn Estuary before the shoreline was so intensively developed.

In our western society today, there are many references to sustainable development, particularly since the World Summit on the Environment and Development in Rio de Janeiro in 1992. Sustainable development is advocated as the future way of balancing the interests of people and the environment.

Initiatives such as the Severn Estuary Partnership began in the mid 1990s to advocate sustainable development at the local level. Since the resources of the estuary are intensively used and the estuary is surrounded by dense development, there is a mechanism needed to encourage a collaborative approach to future planning and management. In pursuit of sustainability, it would seem necessary to understand a baseline environmental condition and identify an acceptable target for environmental limits and our quality of life. There is, however, no such 'agreed baseline' for managing the Severn Estuary. There are limits (in the form of consents) put on the exploitation of resources which are set and implemented by government bodies on a sectoral basis (e.g. fishing licences, industrial discharge licences and restrictions on activities within the designated nature conservation areas). However, there is a limited overall perspective or analysis of how different resource demands and estuary-based activities influence the health of the whole ecosystem. The implementation of the European Habitats & Species Directives and more recently, the Water Framework Directive are beginning to introduce standards for ecosystem health and monitor activities which may impact upon them. In addition, the Severn Estuary Partnership have recognised the value of developing a 'State of the Estuary' report and continued data collation for improving mapping of the estuary. Further investment in this direction could help to identify sustainability criteria and limits.

Around Penzhinskaya Guba, there is currently little pressure for development and therefore the quality of the environment is under little threat. However, should the need for significant development arise (for example in the event of oil exploration or a tidal power scheme) experience from the Severn Estuary and Bay of Fundy could be valuable in choosing the optimal path for long term sustainability. At the moment, the remoteness of the location means that this is a long way off! Instead, it maybe more useful for developed estuary and coastal areas with high tidal ranges, to benefit from understanding the characteristics of an undeveloped estuarine environment such as the Penzhinskaya Guba.

Knowledge of Penzhinskaya Guba provides a useful insight to a naturally functioning ecosystem and to observe the large influence of the tide across the landscape. The tide would have had a much bigger influence on the landscape around the Severn Estuary prior to shoreline reclamation and intensive development. This understanding is valuable when considering planning and development for flood defences, coastal protection structures and a more sustainable future. To ensure sustainability and ecosystem health, it may be necessary to return some of our land back to its origins, closer to the tide.

The pursuit for sustainable *development* maybe better termed sustainable *management*. An untamed tide in an estuary wilderness near Siberia, compared to a highly developed estuary in Britain, starkly illustrates how far development can remove people from an understanding of their reliance on the natural environment. Sustainable *development* implies that people can continue to develop with no end goal in sight. Perhaps a more appropriate term for the satisfactory co-existence between people and wildlife would be sustainable *management*; where human population demands are balanced with the natural environment at a level where we have achieved an acceptable long term quality of life. This, then, raises questions about what is sustainable and what is an acceptable quality of life; living in a smaller community closer to local resources (and the tide), or in a heavily populated suburban and industrialised area, where there is more freedom of movement but less connection to the natural environment (and the tide).

Development of society leads to more management of tidal change and less direct interaction between people and the tides. The challenges for sustainability are seen very clearly in coastal areas (due to high population concentrations) and particularly in dynamic high tidal environments where people and the tides have learnt to co-exist.

Cardiff Harbour Festival, August 2007.

4 APPLICATION AND DISSEMINATION

4.1 Introduction

This section describes the proposed dissemination of research completed as a result of Phase 1 & 2 of the fellowship.

4.2 Reporting

The reports listed in Table 5 below, have been produced from the fellowship. The Phase 1 and 2 reports are aimed at professional colleagues working around the Severn Estuary and all those involved in planning the trips and/or met during visits to Canada, Alaska and Russia.

Table 5: Outputs from the Fellowship

Report Title	Date	Author(s)
Managing Tidal Change Project Report for Phase 1	December 2006	Natasha Barker *in collaboration with* Maxine Westhead, Dept of Fisheries & Oceans Canada.
Managing Tidal Change Project Report for Phase 2	December 2007	Natasha Barker *in collaboration with* The Pacific Institute of Geography, Kamchatka Branch, Russia.
Managing Tidal Change Final Project Report to the Winston Churchill Memorial Trust	January 2008	Natasha Barker
Tidal Exploration – a film about Natasha Barkers' fellowship	In production.	Natasha Barker

The contents of the Phase 1 and Phase 2 reports are summarised in a final report to the Winston Churchill Memorial Trust, for a wider general audience and to be made available on their website. A short film, which is a personal account of the trip to Penzhinskaya Guba, will be shared with close colleagues and made available on request to others.

4.3 Dissemination

The research aims to illustrate differences and similarities 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.

Fish net laid out for use at high water.

Table 6: Opportunities for Collaboration and Dissemination

Purpose	Audience / Location	Activity	Specific Objective		
			i) Flood Risk	ii) Tidal Power	ii) Public Marketing
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 (SEP) *Severn Tidings* newsletter, *Severn Estuary Forum* and general media awareness around the Severn Estuary in England & Wales. See 'presentations' below.	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, Sea of Okhotsk	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 & professional development	Canada & UK	Explore Integrated Coastal Management & Governance progress. Share project reports with coastal & marine planners as detailed in Phase 1 report.			
	International (UK)	Royal Geographical Society/Institute of British Geographers Coastal & Marine Working Group session on 'Partnerships Delivering Integrated Coastal Management', September 2006 in London.			
	International (UK)	Member of the Organising Committee for the Institute of Civil Engineers International Coastal Conference, October 2007.			
	Europe	Board Member of CoastNET (UK coastal charity) and EUROCOAST 2001-2006; Council Member of EUCC-The Coastal Union 2006 onwards.			
Project dissemination.	International (Poland)	Poster on the 'Managing Tidal Change' project at the Littoral 06 conference in September 2006 in Poland.			
	Wales, UK	Institute of Civil Engineers Wales Branch, Severn Barrage conference 2007 – presentation on the role of the Severn Estuary Partnership and Bay of Fundy findings.			
	International (Russia)	Paper for the 8th International Scientific Conference 'Protection of Kamchatka's Biodiversity and Coastal Waters', November 2007.			
	International (UK)	Presentation of fellowship findings to Les Esturiales (network of European estuaries) meeting, Clevedon, UK - November 2007			
	South-West UK	Winston Churchill Memorial Trust South-West AGM, September 2007. Article for WCMT Newsletter, February 2007.			
	International (Canada)	Coastal Zone Canada 2008 poster 'Managing Tidal Change in Three Coastal Areas with the Highest Tidal Ranges, Vancouver, Canada, May 2008.			
	Bristol, UK	Presentation on Estuary Management to Soroptemists Society, Bristol, UK, July 2008			
Education	UK	Lectures on the Marine Geography degree course at Cardiff University, 2006 & 2007.			

Since returning from Kamchatka, a paper has been written for the annual conference of the Pacific Institute of Geography Kamchatka Branch on the theme of 'Protection of Kamchatka's Biodiversity and Coastal Waters', November 2007. Presentations to local clubs & organisations are planned during 2008. Other talks are likely to be given for sometime following dissemination of the final reports.

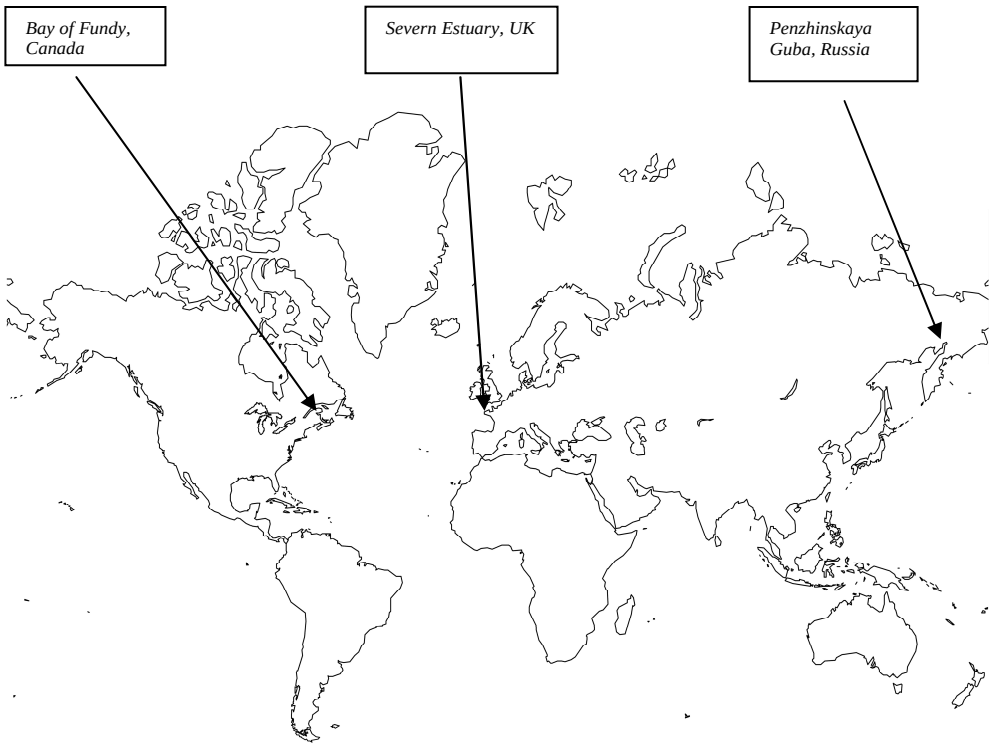
Caviar is in abundance!

4.4 Further contacts

Since returning from Kamchatka the following additional contacts have been established.

Table 7: Post-trip contacts

CONTACT NAME	ORGANISATION	LOCATION	NOTES	FOLLOW UP
Simon Winchcombe	BBC – Producer	London	Contact via Martha Masden	Sent 'top pics' and Kamchatka videos. Offered assistance with the planning of a trip to Kamchatka in 2008 for the series 'Last Man Standing'.
Ami Vitale	National Geographic – Photographer	Washington	Met in Yelisovo and travelled to Tilichiki together.	Sent all photos & videos on DVD plus Kamchatka videos. Possible inclusion of pictures in National Geographic 2008-09.
Mike Harris	Tidecomp World Tide Predictor	Bristol	Ordered tide prediction software.	Make contact with copy of report.
Stuart Judd	Coastal Ways - Programme Contact		Emailed press release and further information.	Send final reports - possible input to television series
Natalie Hoare	Geographical Journal - Features Editor	London	Emailed press release and further information.	Send final reports - possible article



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

5 CONCLUSIONS

5.1 Three Estuaries with the Highest Tides

The visit to Kamchatka concluded an exploration of two estuaries with high tidal ranges similar to the Severn Estuary in UK. Phase 1 of the Fellowship enabled the author to exchange information and meet people working in coastal management around the Bay of Fundy in Canada, which is commonly known to have the highest tidal range in the world. Phase 2 provided a unique opportunity to visit the remote undeveloped estuary of Penzhinskaya Guba, site of the highest tides in Russia and similar in its tidal range to the Severn Estuary. The trip to such a remote undeveloped estuary provided a totally different perspective on coastal management and development.

The overall objective of the project, which was to compare approaches to managing tidal change and to establish links with organisations managing and/or researching the influence of the tide – has been fulfilled. The three overall objectives of the 'Managing Tidal Change' project (see Box 4 below) have been explored and reported in separate reports: for the Bay of Fundy in a separate Phase 1 report (December 2006) and Penzhinskaya Guba in this Phase 2 report (December 2007). In addition, a final short report to the Winston Churchill Memorial Trust summarises the whole fellowship findings.

Box 4: Objectives met by the Project

Current issues relating to management of the Severn Estuary led to 3 specific objectives for the research:

i) **Public awareness and marketing**. 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**. Assess the extent of coastal protection and flood defence measures and future options. 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 using tidal power**. Identify past, present and proposed options for harnessing tidal energy. Make links with academic, government and commercial organisations involved in assessing the potential for renewable energy using tides.

The travelling fellowship was spent on field visits and linking with organisations responsible for resource management and research. Findings relating to each of the three objectives have been described in the two Phase 1 & 2 reports. The Phase 1 report concluded with a series of recommendations specific to collaboration between the Severn Estuary and Bay of Fundy, some of which have already been pursued through the Severn Estuary Partnership. This Phase 2 report concludes with more general observations about the evolution of estuaries and their sustainable management. The Pacific Institute of Geography have collated new information through this field visit and hope to undertake further research in this remote area.

5.2 Personal Perspective & Professional Benefits

The opportunity provided through the fellowship to visit such a remote and unspoilt part of the world is of much general value to a geographer. Witnessing an untamed wilderness, a land where people have little influence on the landscape and wildlife, highlights the extent to which Britain has become extremely developed. As an Estuary Officer for the past 10 years who has worked for three Estuary Partnerships in south-west Britain, the trip to Penzhinskaya Guba was an incredible opportunity to see a natural estuarine ecosystem.

Comparing three large dynamic estuaries with some of the highest tidal ranges in the world is a unique area of research which has the potential for further exploration, physically and mentally! Experiencing the contrast of an estuary in the wilderness, compared to the relatively urbanised Severn Estuary raises questions about the level of development which is acceptable to different people. Setting environmental limits and deciding what an acceptable quality of life is, are key issues raised by this research. With estuaries as the common ground, the project illustrated the contrasts between society in a Far Eastern post-Soviet wilderness world and a highly developed western capitalistic society. It was a rare privilege to obtain this perspective, particularly at a time when major new development is being considered at a national level for harnessing the renewable energy potential from the tidal range of the Severn Estuary.

At the time of writing it is not possible to predict all the benefits which will come from the fellowship. The reports will be disseminated in my professional field and may lead to further publications, exchange of information and perspectives. From a personal perspective, the visit to Penzhinskaya Guba alongside the Bay of Fundy and my ongoing work for UK estuaries, has initiated a new level of thinking about sustainable estuary management…how can we better define it, what baseline should we use, what targets should we set?

Experiencing the total wilderness of Kamchatka was like looking through a window into the history of an undeveloped estuary in the west. The experience has provided greater understanding of the development of estuaries, past, present and future…and ultimately offers a better chance of finding a sustainable balance between man and nature.

Krashinenikov ship in Penzhinskaya Guba approaching Shelikova Bay in the Sea of Okhotsk – 5 days at sea from Manily to Petropavlovsk-Kamchatskiy.

Acknowledgements

The Winston Churchill Memorial Trust provided the financial and administrative support for this 'trip of a lifetime'. Judith Barber, Air Vice Marshall Nigel Sudborough and Major General Jamie Balfour gave inspiration, encouragement and a quick response to logistical queries regarding the award. I am grateful for their flexibility in allowing me to phase my fellowship over two years, and for providing financial support to make the trip to Far East Russia viable.

Martha and Yuri

Many people were involved in guiding me towards reaching my ultimate destination of Manily at the mouth of the Penzhinskaya Guba estuary. Without any one of these people in the chain of contacts, it is likely that the trip would not have been successful. Information provided by Fergus Beeley of the BBC, and Eugene Potapov at Philadelphia University (U.S.A.) about Kamchatka and the Sea of Okhotsk, was valuable in the early stages of trip planning. Other people who helped with my trip preparation and planning are listed in Tables 2 and 3 of this report.

The success of my trip was largely due to Martha Masden of 'Dilgens' - Explore Kamchatka travel agency. Martha organised the essential documents which enabled me to travel legally within an area barely visited by westerners which raised much suspicion. She also provided contacts, logistical support and her home as a sanctuary amongst the complications and challenges of travel in Kamchatka. Laura Williams, Director of WWF in Kamchatka and Vassily Spiridinov, WWF Moscow, provided invaluable support and contacts which greatly enriched my travel experience and research.

I am grateful to Ilya Smirsa and Igor Anatolovich Sinicickyi, of Penzhino Administration in Kamenskoye, whose first email contact in February 2007 helped me believe that my travel idea was a realistic prospect. On arrival in Kamchatka, Igor Anatolveich provided an official invitation for my permit and very generous support with travel and accommodation arrangements in Tilichiki, Kamenskoye and Manily. Staff from the Penzhino administration were very giving of their time; introducing me to my first Russian 'fish-camp', taking a keen interest in questioning the tides of the world, and finally rescuing me from a barge on the River Penzhino so that I could finally get to Manily! Their generosity extended beyond even normal Russian levels of hospitality.

Olga Chernyagina and Vadim Kirichenko from the Pacific Institute of Geography shared a kindred spirit for the pursuit of knowledge. Our lively discussions on life, society, the economy and environment have enriched my understanding of Russia. Their time, energy, interest, and Vadim's maps (contained within this report) were a great addition to my research – spasibo (thank you).

The support of Cardiff University, the Seven Estuary Partnership, family and friends has been invaluable. In particular I am grateful to my parents for supporting my geographical outlook and unusual travels, and to Simon for his understanding. My friend Sandra-Lynne provided a valuable bridge between two very different worlds – Bath and Kamchatka.

Finally, thank you to Boris Lezhni from Koryakski Duma and the pilots of the Aeroflot helicopter which flew from Korf to Kamenskoye on Thursday 19th July 2007. Witnessing the vast landscape before me; the sight of a wilderness revealed from a map I had looked at in awe for 18 months; flying over the last valley and seeing the River Penzhino and Kamenskoye for the first time; realising I was going to make it to Penzhinskaya Guba - was hardly believable. It will be my 'memory of a lifetime'.

Natasha Barker, October 2007

En-route to Penzhinskaya Guba – one week spent waiting for a helicopter in Tilichiki.

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FURTHER INFORMATION

Contacts
See Tables 2, 3, and 7 and in a separate Excel file available from the author.

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

Websites

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www.severnestuary.net/sep

Penzhino
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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.

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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

Arriving at Manily on the Penzhinskaya Guba, 22nd July 2007.