



Severn Estuary and Climate Change: State of the Science

SECCRAG meeting, Wednesday 6th May, 2009

Brunel Boardroom, Empire Museum, Bristol

EXECUTIVE SUMMARY

The Severn Estuary Climate Change Research Advisory Group convened a meeting in Bristol under the IMCORE project to assess the current state of the science on the Severn Estuary, relevant to the issue of climate change impact assessment and adaptation.

The meeting built upon previous efforts which have identified the need for improved collaboration between scientists, policy-makers and practitioners on a range of issues, including:

- Monitoring of baseline indicators for future climate change
- Signposting of existing & future research
- Bridging between strategic & tactical research
- Increased accessibility of & trust in existing research (and collaboration between research and policymakers).

An informal overview of the state of the knowledge on the estuary was provided by delegates for a range of sectors:

- Marine Renewables
- Meteorology and Climate
- Physical Environment
- Fisheries
- Water Quality
- Built Environment
- Cultural Heritage and Archaeology

There are significant gaps in understanding and the database for the Severn is out of date or completely absent on some crucial topics. However, there is an adequate understanding of long term, historical change on the estuary, and the impacts of climate change are perceptible in some fields, such as changing species distributions.

A citations database and review of planning initiatives around the estuary are being developed as part of the IMCORE initiative to support this assessment.

Summarising the state of the science, the workshop identified opportunities to deal with gaps in understanding, and identify options for adaptation. The main proposals relate to improved coordination of data and research, and better management of science.

The delegates mapped a way forward for achieving this, and agreed to continue improving the understanding of the science base through a series of forthcoming workshops under the IMCORE project during 2009-10.

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Attendance:

Chris Spencer, UWE (CS)
Gethin While, Glamorgan University (GW)
Guy Schumann, Bristol University (GS)
Hance Smith, Cardiff University (HS)
Jonathan Mullard, Severn Estuary Partnership (JM)
Ken Tatem, Environment Agency (South West) (KT)
Nick Rodgers, Cardiff University (NR)
Peter Henderson, PISCES Conservation Ltd and University of Oxford (PH)
Peter Jones, RSPB (PJ)
Rhoda Ballinger, Cardiff University (RCB)
Richard Brunning, Somerset Council (RB)
Roger Falconer, Cardiff University (RF)
Roger Wade, Environment Agency Wales (RW)
Ros Smith, Bristol University (RS)
Tim Stojanovic, Cardiff University (TS)
Wendy Dodds, Cardiff University (WD)

Apologies:

Mike Phillips, Swansea Metropolitan University
Vanessa Straker, English Heritage
Steven Stanbridge, Environment Agency
Anne Hayes, Bristol Port Company
Richard Cowell, Cardiff University

Acronyms

BGS	British Geological Survey
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
COMPASS	Coastal Marine Perception Application for Scientific Scholarship
COREPOINT	Coastal Research and Policy Integration
DEFRA	Department for Environment, Fisheries and Rural Affairs
EA	Environment Agency
EDINA	Edinburgh University, National Academic Data Centre
EH	English Heritage
EIA	Environmental Impact Assessment
ESRC	Economic and Social Research Council
EU	European Union
GOSW	Government Office South West
IMCORE	Innovative Management of Europe's Changing Coast
INTERREG	EU Interregional Funding
IPCC	Intergovernmental Panel on Climate Change
LIDAR	Light Detection and Ranging, Remote Sensing Tool
NAO	North Atlantic Oscillation
NERC	Natural Environment Research Council
RCZA	Rapid Coastal Zone Assessment
RSPB	Royal Society for the Protection of Birds
RTPI	Royal Town Planning Institute
SEA	Strategic Environmental Assessment
SECCRAG	Severn Estuary Climate Change Research Advisory Group
SELRG	Severn Estuary Levels Research Group
SEP	Severn Estuary Partnership
SMP2	Shoreline Management Plan (Round 2)
TAN	Technical Advisory Note (Planning)
UKCIP	UK Climate Change Impacts Programme
UKCP	UK Climate Predictions
UWE	University of the West of England
WAG	Welsh Assembly Government

WORKSHOP OBJECTIVES

The main purpose of the workshop was to review the current state of the science on the estuary, relevant to the issue of climate change impact assessment and adaptation.

The meeting is one of a series of three, sponsored under the IMCORE EU Interreg 4B project <http://www.imcore.eu/> in collaboration with the Severn Estuary Partnership. Building on the Interreg IIIb COREPOINT project, these workshops will enable the further progression of a *Severn Estuary Climate Change Advisory Group* which has been convened to bring scientists and policymakers together around the estuary.

By convening a relatively small group of 20 delegates the workshop aimed to encourage structured discussion of the key issues surrounding (a) how an assessment can be made of climate change impacts and options for adaptation on the Severn Estuary and (b) communication between scientists and policymakers and practitioners.

INTRODUCTION TO THE IMCORE PROJECT

RCB introduced the IMCORE Interreg IVb IMCORE North West European project. Promoting a transnational, innovative & sustainable approach to climate change adaptation along the coasts of North West Europe, this project will run until 31/10/2011. Project partners include Cardiff University, Glamorgan University, Severn Estuary Partnership, University of Aberdeen, Sefton Borough Council, University College Cork, Cork County Council and Donegal County Council. It has five major work strands including: identifying drivers for climate change, developing adaptive management strategies and future scenarios building. More detailed information is available at: <http://www.imcore.eu/>

On the Severn Estuary, the IMCORE project is aiming to facilitate better informed climate change adaptation. Specific work areas on the Severn concern the following five areas:

1. Improving the science/evidence base
 - o Through the Severn Estuary Climate Change Research Advisory Group (SECCRAG)
2. Planning review & stocktake
 - o Climate change considerations / synergies in the planning system
3. Futures research
 - o Investigating 'coastal futures' for the Estuary
4. Education and awareness on coastal climate change
 - o Education schools pack
5. Climate change adaptation assessment
 - o Based on 1, 2 and 3

WD presented an overview of the Planning Review and Stocktake being conducted by Cardiff University as part of the IMCORE project. This work is auditing and reviewing existing and emerging climate change-related policy making by planning bodies around the Severn Estuary, and the supporting evidence base. This assessment will examine cohesion around the estuary on the issues of climate change mitigation and adaptation.

SEVERN ESTUARY CLIMATE CHANGE RESEARCH ADVISORY GROUP

RCB reported on previous SECCRAG workshops held in 2007, funded under the INTERREG COREPOINT IIIB project.

Previous SECCRAG workshop identified the following key research priorities:

- Downscaling of climate change assessments
- Assessing state of the estuary
- Social & economic assessment of impacts
- Mapping assets at risk
- Implications for coastal risk management
- Identification of research inputs for estuary-wide, local authority and other plans.

With the following issues identified for the Severn Estuary:

- Monitoring of baseline indicators for future climate change
- Signposting of existing & future research
- Bridging between strategic & tactical research
- Increased accessibility of & trust in existing research (& research community).

For further information, reference should be made to the COREPOINT [SECCRAG workshop reports](#) (2007) and to the summaries of the COREPOINT SECCRAG process presented at the Coastnet Conference '[A very visible truth, climate change at the coast](#)' and the [Severn Estuary Forum](#) (2008)

Session 1: CLIMATE CHANGE AND THE SEVERN ESTUARY: REVIEW OF THE CITATIONS DATABASE

Aim / Content of Session:

This session sought to gain feedback from participants concerning the Citations Database. The first point made was that most of the references do not actually relate to climate change assessments, but rather the baseline information which is needed to make these kinds of assessment. TS presented Version 4 (May 2009) which currently stands at over 950 citations. The floor was opened for feedback, including suggestions on possible improvements, suitability of the format of the database (e.g. EndNote software), the index / keyword system currently used and the management of the database in the future.

Feedback from the group concerning the database, included:

- Objectives of database need to be refreshed due to its current breadth
 - e.g. is it to inform policy making, or is it to be tailored to support focused scientific investigations
 - if aimed at local government, the size and time required would be off-putting for policy makers who ideally would prefer abstracts or even better, a simple prioritisation of issues (e.g. 6 key issues)
- Academic bias / historic focus
- There needs to be translation of content:-
 - Right format for audiences
 - Right organisation of topics
- It was noted that there is a strong perception that the Severn has been extensively researched BUT when compared to other estuaries/areas such as the Humber and Liverpool Bay, it is not the case with respect to both monitoring and understanding
 - There is a good case to compare of state of science of Severn Vs. another estuary such as the Humber (potential ESRC/NERC proposal)
- Data gaps on the Severn include:
 - Sediment / morphology /water quality /hydrology (RF)
- Examination of chronology of the citations contained in the database would be valuable e.g. "History of the science of the Severn Estuary".

Session 2: REVIEW OF STATE OF THE SCIENCE

Aim / Content of Session:

This session sought to develop understanding of climate change on the estuary. To achieve this, presentations were given by representatives from key topic areas delivering perspectives on the current state of science on the estuary within their respective fields. Each presentation, approx 5-10 minutes in length, addressed, where possible, the following questions:

- 1. What are the key messages coming through?**
- 2. What evidence is there of climate change trends?**
- 3. Does the science / research cover key questions required for climate change assessments?**
- 4. What are the uncertainties or contentious issues on the science?**

Or

What needs to be done to provide an assessment?

The following presentations were given during this session:

Marine Renewables, Roger Falconer, Cardiff University

Meteorology and Climate, Nick Rodgers, Cardiff University

Physical Environment, Chris Spencer, UWE and Guy Schmann, University of Bristol

Fisheries, Peter Henderson, PISCES Conservation Ltd. and University of Oxford

Water Quality, Roger Wade, Environment Agency

Built Environment, Rhoda Ballinger, Cardiff University

Cultural Heritage and Archaeology, Richard Brunning, Somerset Council

Individual presentations were followed by informal short group discussions, allowing feedback from the floor to identify synergies with other disciplines, additional professional perspectives and key considerations. Brief summaries of the presentations follow:

MARINE RENEWABLES, Roger Falconer, Cardiff University

Key Messages coming through:

Climate Change.

Climate change is being taken seriously amongst public and professionals on a day to day basis.

Sea Level Rise Scenarios for the next IPCC assessment report are likely to be revised upward.

The consensus is that whatever we do about mitigation, we have already altered the biogeophysical system. There is a growing awareness of the importance of rainforests within this system. In some parts of the world, the damage caused by increasing storminess and hurricanes are a major concern.

Renewable Energy Solutions in the Severn Estuary.

A major consideration in the development of UK renewable energy is the 2020 target 15% of energy generation from renewable sources. However, a more long term focus on mitigation using 2050 as a horizon, might lead to the maximisation of different factors. On the Severn Estuary this could lead to more favourable consideration of the Minehead-Aberthaw Tidal Energy Scheme with its potential for two way energy generation which would have less impact on intertidal habitats, as well as greater energy production.

As far as offshore lagoon solutions for tidal energy in the Estuary, there is a need for greater research and understanding about proposed schemes. Recent calculations have suggested that these would provide <25% of the 14TW energy proposed from a tidal barrage.

What evidence is there of climate change?

- Changes in rainfall patterns across Wales
- Changes in shoreline erosion
- Changes in storm activity
- Changes in bird numbers along the Severn
- Changes in fish species

Uncertainties

Major questions surround the assessment of climate change impacts on the estuary, include:

- Changing rainfall- how this will vary in patterns and intensity? There are likely to be big local variations. There are knock on effects downstream. This needs to be assessed holistically on a catchment scale, treating the whole water cycle rather than just considering the estuary or river.
- Sea level rise
- Storminess at sea and storm surges
- Shoreline erosion and estuary morphology
- Flood elevation, inundation extent
- Interaction of hydraulics / hydrology with ecology
- Changes in bird numbers and fish migrations, linked to changes in habitat and climate.
- Water quality implications of changing biological, geomorphological or chemical processes

Recent research by Cardiff University has looked at how increased storminess might have a knock on effect on re-suspension of sediments, and how this will combine with land-based sources of P and N to give increased nutrient loads in the estuary. The research focused on T90 values. However, the modelling of microbiological processes is a field in need of greater research. (This modelling is in its infancy compared to hydraulic modelling, with a constant being used for the decay rates of faecal coliforms).

Engineering uncertainties

These relate to the operational efficiency of a range of tidal power options, or groups of options. There are related questions linked to efficiency of tidal stream energy devices. There have been major improvements in the technology since earlier proposals, so there remains much to be explored concerning optimum design configurations.

- Operation and efficiency of tidal stream turbines
 - Operation and response of tidal lagoons
 - Opportunities of tidal stream and wave energy devices
-

- Fish mortality rates with barrages, lagoons, turbines...

GROUP DISCUSSION

(RW) –supported most of the above points. Added:

The Environment Agency are currently setting up a research project over the next 2 months to look at impacts of climate change on the estuary. Some key questions to be considered include:

- Changes in migratory bird patterns (linked with bird numbers around the estuary)
- Changes fish migration due to temperature changes.

Whatever the changes in patterns, it remains highly likely that the estuary will continue to be important as a habitat.

Concerning the question of renewables, there is a dearth of evidenced-based and data led information on the impacts of tidal energy. Relating to water quality- many of the key papers date from research done in 1970s and 1980s. Some useful work has been done more recently but only on local or site scale. Furthermore, the original specifications for tidal energy developments were concerned to maximise energy output, and the turbine technology concerned has moved on since 1980s proposals. This requires reconsideration.

(PJ) Contrasted two approaches to decision-making: the government intends that assessments should proceed on the basis of 'evidence-based policy' but the political and cultural realities mean that we are more often working to 'policy-based evidence'. PJ noted the urgent requirement of policy makers for evidence that will assist them in dealing with the current policy issues they are facing. Policy responses are being formed, and many bodies are taking up public policy positions on issues such as climate change. Policy staff work with the evidence that they can glean together, and are in need of mechanisms that can assist them to get a good handle on the state of the science.

METEOROLOGY and CLIMATE, Nick Rodgers, Cardiff University

Key Messages coming through:

The last major paper on storminess referenced by the citations database dates to the 1981 storm surge. There are therefore more papers and datasets concerning climate which need to be captured in for the Severn Estuary Citations Database. A long term data record is required specifically for the Severn Estuary. There may be adjuncts which can be used from other places to help generate a good understanding of the processes occurring. The Marine Climate Change Impacts Partnership's [Ecological Linkages Assessment](#) (2009) provides useful and improved summaries, and gives support to assessments. This document has been reviewed by paleo-oceanographers and climate experts within the School of Earth and Oceans, Cardiff University and gives an overview of current state of the science within the UK. UK Climate Change Projections (UKCP09) will be launched by Ministers later in the year (within this parliamentary session).

What needs to be done to provide an assessment?

In terms of climate, a key question concerns the prevalence of Easterly winds in spring, and data on storm tracks. These have knock on implications for flood risk which requires an assessment of

storm intensity and directions to calculate the likelihood of overtopping sea defences. In general, an assessment of change on the estuary requires better baseline information and monitoring, to complement relatively limited network of existing weather stations at data bouys around the estuary, which are taking oceanographic and climate measurements for a range of national agencies and laboratories.

GROUP DISCUSSION

(TS) on the social side, there are implications of climate change for activities such as tourism and recreation around the estuary, with warmer summers possibly leading to increased trips to the coast, and implications for resorts such as Penarth and Weston.

PHYSICAL ENVIRONMENT, Chris Spencer, UWE

Key Messages coming through:

Long term sea level changes at a large scale are relatively well understood for the estuary. Changes in the relatively recent past (*i.e.* 2000 BP) are less well understood, with respect to both the evolution of landforms and sea level rise. For example, there are big gaps in data and knowledge about changes in sedimentology on the estuary and how landforms will react to these. In assessing climate change impacts in response to sea level change, there is a need to draw on the multiple site based studies and synthesise and scale up this evidence to the estuary level.

Citations database:

The current SECCRAG citations database provides a good baseline of research on the estuary and shows the detailed site studies which have taken place around the estuary on sedimentology and hydrodynamics. There is an opportunity to further draw together broad scale research such hydrographic surveys which have been conducted on the estuary.

What needs to be done to provide an assessment?

- There is a requirement to synthesise present research to understand how coastal landforms have reacted in the past, and use this knowledge of behaviour to project changes for the future.
- This requires a clear understanding of how sea level has been a driver of change in the past in order to project likely future changes.
- The major human modifications of the estuary will have to be factored into this understanding of how the estuary will change.

GROUP DISCUSSION

(RB) The development around the coastline, including the constraints caused the sea walls, is an important factor in the modern day evolution of the estuary. There remains uncertainty about the relative importance of anthropogenic/natural drivers.

PHYSICAL ENVIRONMENT, Guy Schumann, Bristol University

The Hydrology research group at Bristol (drawing on a current GWR research fellowship) is presently conducting a probabilistic assessment of sea level rise, incorporating consideration of global sea ice melt. The UKCIP07 assessment predictions are based on increased storminess, but do not calculate sea level rise due to ice melt. UKCIP09 will give an ensemble of model simulations, more probabilistic in nature- so perhaps show potential futures and levels of uncertainty better. The monetary losses associated and economic impacts associated with sea level rise are an area of research that is potentially difficult to establish but warrant further research consideration/effort. Ros Smith is developing models which consider past storm surges and flood risk on the estuary. The Hydrology Group will be using the same calibrated hydrodynamic model to simulate flood risk under future sea level rise scenarios.

- **Citations database:**

There are gaps in data and understanding concerning issues such as sediment transport pathways. Much of the database concerning sediment transport is largely outdated, dating back to >20 years ago. There are more datasets to be mined. The SECCRAG citation database could usefully be developed into an online wiki-style database, which would allow researchers remotely up load their relevant references and findings.

FISHERIES, Peter Henderson, PISCES Conservation Ltd. and Oxford University

The citations database captures most of the significant publications concerning fisheries, but is weak on the industry sponsored ecological studies that have been conducted around the estuary (understandably, as these data are difficult to access). This type of research is sponsored by some of the major coastal industries, including: nuclear power plants (including proposals for new builds at Oldbury and Hinkley), the Bristol Port Company (for their capital dredging and port expansion schemes), and six or seven studies relevant to EIAs for Aggregate Dredging. Also private companies such as Brixham Labs who are major industrial landowners along the shoreline. Some relevant data has been collected with respect to managed retreat schemes in the Bridgewater Bay area. Altogether, access to these data are problematic and could be better organised. A related consideration is the amount of data held by consultancies who have been regularly working on the estuary, such as HR Wallingford.

Key Messages coming through:

A. Summary of Aquatic life.

The general picture is of an estuary rich in fish, with a diversity of 80+ species, (120 if rare and occasional visitors to the estuary are included). Larger crustaceans are the key invertebrates, especially *Crangon crangon* (Shrimp) which provide a big standing stock. A key aspect of the estuary is the highly mobile fauna which lives on the sea bed (the benthos is relatively poor but the epibenthos is rich, due to the fact that the estuary is a very dynamic environment). Species can be divided into those that go up river for breeding, such as Lamphrey, Shad and Salmon, and those which go further out to sea, such as Flounder and other species.

B. Key Trends

PISCES holds 30 years of monthly data on species in the estuary. This is one of the best long-term datasets in the world of its type. Long-term research has enabled the identification of three major variables influencing species behaviour

- Temperature (e.g. Shrimp retreat to upper estuary when it is cold)
- North Atlantic Oscillation (NAO)
- Salinity and river flow

What evidence is there of climate change?

C. Specific interactions

Fish- Dover Sole *Solea solea*- there has been an explosion of numbers in the last 20 years linked to changes in temperature, probably due to warmer springs which mean that the species is able to get through its reproductive period faster. The NAO affects sole growth and the presence of other species in the estuary. Salmon (considered the most culturally significant species) is in long-term decline, linked to recruitment patterns and possibly also due to higher temperatures and anthropogenic modification of rivers. Shad has become rare in the estuary, in comparison to the 19th century when it was reported to be very abundant. This may be due to changes in temperature and climate. Lamprey used to be abundant, but has also declined. Changes in temperature have been observed to change the local abundance of bass, dab, prawns and rockling in addition to sole. There is evidence of a sudden and abrupt change in fish community structure during the early 1990s. There is also a steady rise in total species richness which can be related in part to the gradual arrival of warm water tourist species.

D. Global and Local Changes

PISCES is involved in research to conduct a comparative analysis of change in the Wadden Sea, Hudson Estuary and Severn Estuary ecosystems. This will reveal the scale of change which is being experienced in marine ecosystems. For example:

1. The Common Eel is experiencing catastrophic decline worldwide caused by global change and probably linked to increased diseases and anthropogenic pressures (c.£120 can be fetched for a kilogram of eel).
2. Explosion of biomass. Species abundance may have increased by up to 50%. The theory is that with reduced pollution, productivity is stepping up. In addition, greater mixing and rise in water temperature might give rise to the release of stored organic carbon which is consumed by bacteria at the bottom of the food chain. This increase supports greater populations of throughout the food web and greater fish abundance.

Future trends related to global warming, might give rise to a more Mediterranean kind of environment which is species rich but denuded of certain current fauna.

GROUP DISCUSSION:

(RW). There is an ongoing debate about the decline of Salmon and whether they are actually in long term decline due to physical or anthropogenic factors. There is also an argument concerning the impacts of turbines on fish species from renewable energy options. This does not only concern fish kills on bigger sized fish, but also losses due greater predation from bass and seabirds on fish (as they are constrained by the fish pass) and the sub lethal stresses caused for fish by the pressure differential and using their swim bladders. It should be noted that the direct cooling systems of power stations around the estuary kill millions of fish per year.

(HS) are there also issue of the Salmon fish stock at sea and changes in marine biology in the North Atlantic

(PH) There needs to be greater sharing of data- there might be an incentive to share data between industries in order to reduce costs.

(HS) The offshore industry provides good examples of agreements to share data (e.g. oil and gas industry- all drill cores are sent to BGS). Archaeology and geology sectors provide good examples of data sharing on the estuary. For archaeology, a lot the data provision is development driven. Access to data from government departments by industry is also problematic. In a public enquiry all data should be publicly accessible, but with planning applications, access to source data it is less clear.

WATER QUALITY / POLLUTION, Roger Wade, Environment Agency Wales

Key Messages coming through:

There have been significant improvements in water quality on the estuary over the last 20 yrs in response to legislation (urban waste water treatment / EU Legislation) and better treatment of sewage and industrial discharges into the estuary

The citations database:

This contains the majority of references on the topic, but many are related to the appraisal of tidal energy and predominantly date from the 1980s. Another 50% of papers are grey literature and reports. Some of the detailed studies done by agencies are missing from the database. The most interesting observation from the citation database is the research gaps and areas where data is needed for more detailed or up-to-date assessments (i.e. post 1980s overall inputs into the estuary). The key areas covered in current research include:

- Trace Metals, in water, biota and sediments - the dominant topic for water quality research
- Organics are well covered
- Air quality has reasonable coverage
- Litter surveys are well covered, but necessarily Severn Estuary specific assessments
- There is some research on nutrients and dissolved oxygen

What evidence is there of climate change? What are the related uncertainties

It is likely that the main climate change impacts affecting water quality will be socio-economically driven, and human impacts will be significant as well as direct physical influences. Some of the key inputs are from coal fired power stations. Therefore a key question relates to whether Aberthaw will be active on the estuary in the future, and also whether it or replacements will operate with carbon capture mechanisms. This will have an impact on direct/indirect inputs. It is likely that two new nuclear power stations will be developed on the estuary. Major influences on water quality will be driven by changes in the catchment, especially the potential for changes in landuse related to biocrops. It is unclear if this will increase or reduce, fertilizer input. Concerning trace metals, current water quality issues and exceedance of ecological quality standards mainly relate to copper and organics. As far as Local Authority stakeholders are concerned, Bathing Water Quality is an important issue. More rainfall and greater storm run-off has the potential to lead to higher levels of bacteriological contamination. Restrictions on planning developments (discharges to the estuary) may be required due to the less disbursive environment of an estuary in

the scenario of a tidal barrage. In addition there are potential water quality issues related to anoxia, increased water temperatures and suspended sediments.

In terms of physical changes, there is a well established link between changes in toxicity and pH, for example a rise of 0.1ph is likely to increase the toxicity of ammonia, and change the amount of absorption of metals substantially. A key question concerns the relation between accelerated sea level rise and increased tidal range. Increased tidal range would be likely to lead to (1) sediment re-suspension, (2) saline intrusion (3) change in the saltwater boundary (which has knock on affect on biota and water extraction, particularly at the Gloucester/Sharpness canal). Less flow in the summer would also affect migration, there being less freshwater dilution this would affect the signal for migratory cues. Reduced flows would also give rise to an decrease in dissolved oxygen. Water temperature is also linked with levels of dissolved oxygen and in combination with other changes, could put significant stress on certain migratory fish species.

GROUP DISCUSSION

(PH) Changes in seasonal patterns of water flow, with less flow in summer, is likely to have a significant impact on fish migration, along with potential slight increases in water temperature (higher temperatures leading to less dissolved oxygen).

BUILT ENVIRONMENT, Rhoda Ballinger, Cardiff University

Key Messages coming through:

There has not been any systematic research or overview on the characteristics and trends associated with the built environment around the Severn Estuary. However, there has been a considerable amount of research, particularly consultancy-led projects on specific sectors around the estuary, notably recreation and tourism, tidal power, aggregates and landscape. These, however, have been guided by sectoral management objectives and have examined issues at a variety of scales (for example, the South West of England and South Wales, the Bristol Channel, Severn Estuary as well as site specific studies). Overall it has not been an academic priority to conduct regional research on land use change around the Severn Estuary, although there may be related references within academic, human geography text books on British land use change .

In addition to the grey literature which makes a significant contribution, there are active groups in S.W. England (Climate Change Partnership) and S.E. Wales (Strategic Planning Group) which are considering the need for adaptation and looking at the built environment both as a driver of, and receptor of, climate change impacts.

Local Development Documents provide an indication of current and future levels of development, although it should be noted that development allocations do not always translate into developed land. The 'Futures' approach being proposed as part of the Interreg IVb IMCORE project for the Severn Estuary, however, holds some interesting possibilities for considering how key trends might evolve under different climate change scenarios. Some related work has been done along other parts of UK coast such as the Humber. The latter used a Futures approach to consider linkages between landuse and water quality under different scenarios.

In terms of adaptation, the Severn Estuary Partnership Management Group recently undertook a brief overview of potential climate change issues. The findings highlighted the potential issue associated with 'planning' blight in areas adjoining the estuary, as a result of identification of perceived flood and erosion risk areas. This potentially could result in knock on problems for other, adjoining areas, perceived to be less at risk. One key element in all these considerations is that it is *communities* which are at risk not just development. Consequently, there is an urgent need to consider this as well as the form of proposed and new developments in coastal areas and the retrofitting of existing developments. In this context, it is important to consider how adaptation issues are presented and communicated to target audiences.

What needs to be done to provide an assessment?

In order to understand the current responses, there is a requirement for a stocktake of planning policies around the estuary, including high level targets for flood and coastal erosion risk management as well as engagement with planning officers. To this end, Cardiff University are undertaking a review of planning policy around the estuary and undertaking interviews with the planning community as part of the Interreg IVb IMCORE project.

There is a firm requirement to provide downscaled climate change scenarios for the Severn Estuary. For example, the Strategic Environmental Assessment of Severn Tidal Power options in the estuary only utilises general climate change scenarios.

It is important to recognise that planning and management frameworks and approaches will have to evolve as the implications and needs for adaptation become clearer. Plans must be co-ordinated and work together at a range of scales. The strategic nature of spatial plans makes them particularly important in this context, however there are questions about the level to which they encourage practical delivery of outcomes. There are also issues associated with the administrative complexity of the planning framework for the estuary and the offshore planning regime proposed under the Marine and Coastal Access Bill may further divide the estuary between England and Wales.

GROUP DISCUSSION:

(HDS): What role might insurance companies play in providing these kinds of assessments?

(RW): Insurance companies already tend to act independently and have their own flood risk assessment databases separate from the Environment Agency.

(KT) – Appropriate developments need to be undertaken using a risk based approach. Integration of SMP2 policies into local development plans.

(JM) -Marine spatial planning in the estuary may result in 2 plans for estuary (Northern & Southern). SEP & RTPI are arranging a meeting of planners from around the estuary (Autumn '09: tbc)

It was reported that WAG's 'TAN 8 Planning for Renewable Energy' is currently being revised. The group suggested that WAG's 'TAN 14 Coastal Planning' should be similarly revised. As it stands this planning guidance is not suitable for estuary wide planning issues. Also, it should be revised to bring it inline with PPS20 Coastal Planning, due shortly from DEFRA.

CULTURAL HERITAGE AND ARCHAEOLOGY, Richard Brunning, Somerset County Council

Key Messages coming through:

Quite a lot of research has been done concerning the archaeology of the estuary, especially on the coastal wetlands forming the Gwent and Somerset Levels. The Severn Estuary Levels Research Committee has been established since 1985 to coordinate this research effort. Local Authorities, Developers, Archaeological Trusts and Welsh and English administrations collaborate well to advance this knowledge. The Rapid Coastal Zone Assessment (RCZA) should provide a good baseline overview of coastal heritage for the English side of the Estuary. The phase one desktop has been completed and the pilot for the stage 2 fieldwork has begun.

In Somerset, a considerable amount of work has been done on sea level change since 10 000BP. However, much of this is based on widely spaced data points, and there are big gaps in evidence. Certainly, in comparison to former ages, conditions on the estuary are very different, due to the constraining factor of sea defences established since the Roman period. This is likely to affect the future behaviour of the estuary in response to sea level rise, and the inherently unstable nature of the coast is something that comes as a surprise to some coastal residents. There is therefore a requirement for better communication of science there is a need to explain this historical perspective to communities.

What evidence is there of climate change?

Climate Change Impacts

Erosion has been an important factor in the loss of heritage assets along the coast (e.g. sites around Blue Anchor) including historic buildings, historic sea defences and ancient settlements. In the sub-tidal area, there are threats to archaeological resources such as wrecks, which are being damaged due to species invasion (more aggressive species of burrowing worms due to climate change) and also potentially to increased rates of chemical decay due to increased acidification. Other fragile remains in the intertidal zone, such as fish traps and prehistoric buildings, are also under pressure from erosion. The wooden remains of such structures are usually buried at a shallow depth and subject to point erosion. The peat layers containing archaeology are also subject to periodic substantial loss.

Whilst the intertidal archaeology is relatively well known due to its exposure, we often don't understand the changes in hydrodynamics of erosion and deposition and how this affects the resource. These losses include some of the most significant archaeological sites in the UK. The relative lack of Scheduled monuments in the inter-tidal zone is not a true reflection of the importance of the resource there.

The impacts of different adaptation measures have knock-on implications for archaeology. For example a policy of 'hold the line' will have negative impacts on the resource in front of the defence as it will increase erosion of the inter-tidal area. A recent project to undertake LIDAR mapping around the English side of the estuary should provide a baseline for measuring change and establishing long term trends. Managed realignments, such as those proposed at Steart will have a massive impact on individual heritage assets and historic landscape character. Because realignment is only possible on particular types of coastline the cumulative impact could eventually involve the potential loss of a whole type of medieval reclaimed coastal landscape. In coastal marshes and wetlands, reduced summer rainfall could cause increased peat wastage (thereby releasing CO₂ to the atmosphere) and associated destruction of nationally important waterlogged

archaeology. Furthermore, altering the economics of agriculture could have significant knock on effects (diary farming and permanent pasture are less damaging to archaeology than arable, but climate change could lead to an increase in the latter). Water shortages have implications for the continuation of waterlogged burial environments in coastal wetlands- these are a nationally important and vulnerable resource.

Uncertainties

Gaps in Understanding

Most of the potential impacts are known, but the rates of change are less well understood. This applies to coastal and inter-tidal erosion. Very little is known about the sub-tidal heritage resource in the Estuary. The baseline resource dataset created as part of the EH Rapid Coastal Zone Assessment is now at stage 2. Cadw have undertaken a similar assessment which complements the database of resources built up by Reading University, who have conducted considerable long term research and monitoring on the Gwent levels.

There are still large gaps in our understanding of the Holocene history of coastal change in the estuary. The importance of much of the sub-ittidal and inter-tidal heritage resource is not known because of a lack of investigation, especially dating.

The potential effects of sea level rise and managed realignment upon the inland freshwater hydrology are uncertain. The effects of managed realignment upon buried archaeological remains are unknown (eg. change from fresh to salt water burial environment).

Potential for Adaptation

This is difficult to assess. Managed realignment might avoid the loss of intertidal resources due to coastal squeeze, whilst the subtidal resource could potentially continue to decay. There may be some options for water storage to protect wetlands and waterlogged areas. There is a continued need to improve the database concerning the resource.

(KT) The recent series of low tide LIDAR surveys being conducted by the Plymouth Coastal Observatory (Channel Coastal Observatory) could provide some useful data.

Session 3: STATE OF THE SCIENCE SUMMARY

Aim / Content of Session:

This session sought to summarise key emerging issues from the presentations outlined above and encourage group discussion. HS highlighted issues such as the potential for improved data collection and information management, and better coordination of the science on the estuary. An overview of these is presented below. An open discussion amongst the participants followed.

State of the Science Summary, Hance Smith, Cardiff University:

1) Data and research

- Valuable projects are beginning which will provide useful information and synthesis e.g. EA research project on climate change in 2009, and the Severn Estuary Partnerships' State of the Estuary assessment
- **There is a need to develop the conceptual basis in order to provide a synthesis**
- **Socio-economic data will have a significant role in any assessments**
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- *Citations Database*
 - This is the beginning of a useful tool with wide application
 - There are a lot of gaps and some of the more comprehensive assessments date from the 1980s

2) Management of the science

- Local government have a key role in managing the estuary– what science do they need and how can they be provided with more rapid access to it?
- We need a system that will facilitate science-policy interaction
- The science must be set in its social context
- It should not be forgotten that industry and economic development has been a major source of funding for investigations of the estuary
- **Anthropogenic drivers from the watershed and potential renewable energy development will have a significant influence on the evolution of the estuary, arguably outweighing physical drivers.**
- **There is a need to integrate land and sea in assessments (The development of a marine spatial planning system for UK waters should consider this issue)**
- The Archaeological Research Committee (SELRG) provides an exemplar of disciplinary collaboration and good practice

GROUP DISCUSSION

A summary of the main delegates discussion points following HS's overview are contained below:

- The group felt that there is a need for “where we are now” assessment to be undertaken (assimilation and analysis of the science, particularly oceanographic)
- KT reported that the SMP2 for the Severn was being currently being prepared to be in line with Defra targets. Using differing assumptions on Wales / English sections of the coast. Where gaps in the knowledge have been identified, the plan will document these. The SMP will be reviewed in 6yrs time, presenting opportunities for new areas of knowledge and understanding to be integrated into the revised plan.
- The group raised concerns that there may be two marine spatial plans prepared for the estuary. JM indicated that the SEP will be meeting with WAG & GOSW to promote a coordinated approach, and indeed, one plan for the Severn.

Monitoring- related points:

- It was reported that good examples / models of best practice that should be considered for the Severn e.g. Liverpool Bay and the work of the Plymouth Coastal Observatory.
- The group referred to the Wales Coastal Monitoring Centre, with the group being uncertain as to its current operations.
It was agreed that Peter Jones, WAG, should be approached regarding the role of the centre and its current and future activities.
- There was a general agreement for the requirement for a Severn Estuary-wide, network of oceanographic and meteorological monitoring. It was suggested that there was scope for the extension of the monitoring work of Plymouth Coastal Observatory as part of this. Additionally, it was recommended that the Breaksea Spar Buoy (Trinity House), due its location in the middle of the estuary, could feasibly be utilised as a monitoring point; this would be low-cost starting point for Severn Estuary-wide monitoring efforts.

Session 4: DISCUSSION ON THE APPLICATION OF SCIENCE

Aim / Content of Session:

This session was designed to gather delegate's perspectives and encourage discussion as a group, concerning the application of the science, including the future direction of the database and the work / focus of SECCRAG. Drawing on comments from the floor and using a flip chart, TS mapped out a process for the 'Way Forward' including two further IMCORE funded workshops in 2009/10.

Way Forward

A. Provide a **Gap Analysis of current research** (including assessments made in this workshop) and circulate for comment and feedback

B. Develop a **rationale** which will justify the effort needed to **develop monitoring and ground-truthing** of climate change modelling.

C. Establish a series of **key questions from planners and managers** which require answers

D. Provide a **synthesis** of this information to be presented at the **Winter 2009 IMCORE Workshop**

E. Use the comprehensive list of questions as a basis for **prioritising climate related issues**

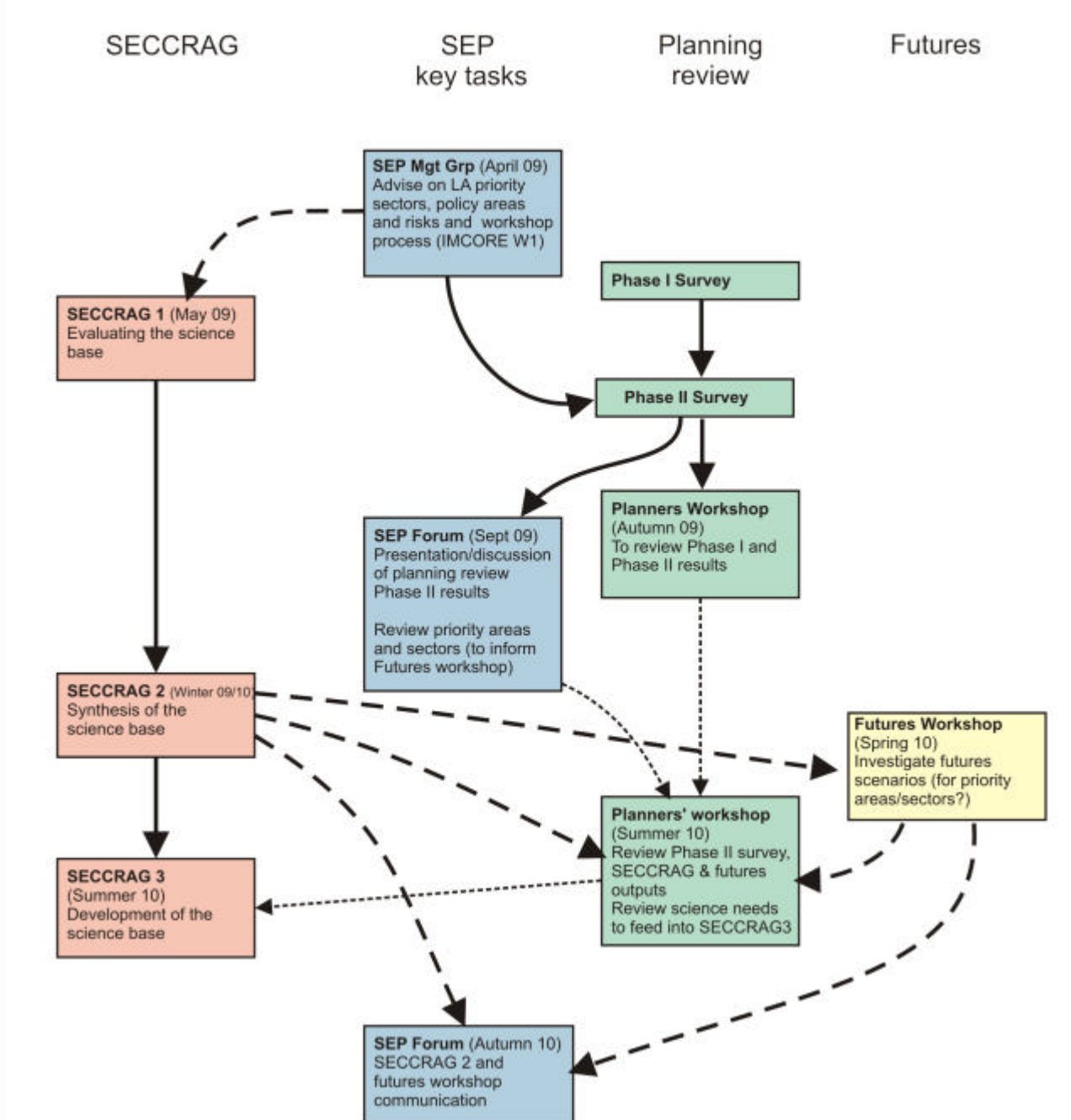
F. Consider these issues relevant to the **key drivers** (perhaps draw on the approach taken on the Humber Estuary to do this kind of work)

G. Identify key issues for which you can begin to **map and model change on the estuary**, to form the basis of a **Summer 2010 IMCORE workshop** and potentially subsequent bids by a consortium of scientists and technical officers.

At ALL stages above consider how to provide incentives that will encourage the engagement of scientists and professionals

The work of the Severn Estuary Climate Change Research Advisory group will dovetail with other meetings being hosted as part of the IMCORE project, including a Futures workshop and a workshop for planning professionals:

IMCORE WORKSHOPS & ACTIVITIES ON THE SEVERN - Draft



A number of key discussion points were raised during this session.

Actions

It was agreed that the next step for SECCGRAG would be to draw on the findings of the current workshop and database, and to conduct a gap analysis, which would then be circulated around the group. There is a real need for a synthesis of research. This will require asking the right questions, which is dependent upon good interaction between science and policymakers to formulate relevant questions. There are precedents for this approach, and it was reported that a similar exercise was conducted on the Humber Estuary¹, and JM highlighted a journal paper entitled 'Top 100 ecological questions of policy relevance.'² A major issue is the need to understand feedback linkages between social and ecological systems, and this kind of approach might form an incentive for a wide variety of scientists to become involved.

Issues concerning the utilisation of the UKCIP02 scenarios by decision makers were discussed. It was felt that these figures can often be taken at face value, with simplistic interpretations being made by decision makers. There is a need to understand whether UKCP09 data will be sufficient for assessments, or whether in certain areas more Severn specific assessments are required- what would be the implications of using too simplistic data at certain scales? There was a suggestion that certain policymakers do not know what assessments they want made, possibly due to the high pressure case work/workload on policymakers, and so are looking for scientists to provide examples of the possibilities. There was also a suggestion that certain 'policymakers' may not be aware of the significance of their role- elected members form a key part of the decision-making process but may not see themselves in this light- in other words there is the need for good communication of science to this target group.

In general, there is a strong scientific case for considering the climate change issue from the estuary perspective, not least because the uniqueness of the estuary and its extent and size. The modelling going on concerning climate change needs ground-truthing, and this is a major justification for the existence of SECCGRAG. For a number of sectors and scientific disciplines, a relatively good knowledge exists concerning the estuary, but there is no 'neat summary' of this understanding, so SECCGRAG can play a role in undertaking this too.

Engagement and Linkages

It was highlighted that there were overlapping timeframes between the work of SECCGRAG and phase 2 of the Department of Energy and Climate Change Severn Tidal Power SEA. There are opportunities for SECCGRAG to input into this. There is also a need to consider the complementarity with the work that will be required for Nuclear Energy schemes around the estuary. South West Climate Change Impacts Partnership's 'Warming to the idea' research and report outputs are applicable to the work of SECCGRAG.

¹

² Sutherland, W.J., Armstrong-Brown, S., Armsworth, P.R., Brereton, T., Brickland, J., Campbell, C.D., Chamberlain, D.E., Cooke, A.I., Dulvy, N.K., Dusic, N.R., Fitton, M., Freckleton, R.P., Godfray, H.C.J., Grout, N., Harvey, H.J., Hedley, C., Hopkins, J.J., Kift, N.B., Kirby, J., Kunin, W.E., Macdonald, D.W., Marker, B., Naura, M., Neale, A.R., Oliver, T., Osborn, D., Pullin, A.S., Shardlow, M.E.A., Showler, D.A., Smith, P.L., Smithers, R.J., Solandt, J.-L., Spencer, J., Spray, C.J., Thomas, C.D., Thompson, J., Webb, S.E., Yalden, D.W., Watkinson, A.R. **The identification of 100 ecological questions of high policy relevance in the UK.** (2006) *Journal of Applied Ecology*, 43 (4), pp. 617-627

The failure to sufficiently engage ecologists for the workshop was noted, and a review of the 54 scientists invited to the workshop was circulated to highlight potential contacts which had been identified, with a further 2-300 identified to be 'kept informed'. Delegates suggested the importance of clear lead times and the use of incentives to involve key stakeholders, including scientists from national organisations such as CEFAS, and research and consultancy sponsored by industry. Finally, in terms of engaging relevant decision-makers, SECCRAG needed to consider writing up results in a language which is accessible to Local Authority officers, and also specifically consider the approach to engage elected members.

A State of the Severn Estuary Report

JM indicated that Severn Estuary Partnership (SEP) will be supporting a review of high level strategic policies on and around the Estuary, in preference to updating the 2001 Strategy for the Severn Estuary. There is an urgent need for informed decision-making and JM reported that the SEP are therefore intending to develop a State of the Severn Estuary report, with SEP stewarding this process, and welcomed input or ideas for partnership from delegates.

Any Other Business

Guy Schumann, University of Bristol, 'Flood Risk Modelling'

GS presented a brief overview of his current research being at the University of Bristol, funded by the Great Western Research fellowship programme. This flood risk modelling work is coupling the IPCC's Fourth Assessment Report scenarios with sea ice collapse data, to develop more accurate representation of sea level rise scenarios and clearly presenting uncertainties. Other research outputs include:

- extreme scenarios e.g. storm events;
- modelling flood risk (2D)

This research is linked with other initiatives at the University of Bristol, including the work of Ros Smith who is examining past storm and flood events on the estuary. GS also indicated that he has a number of flood risk citations that can be inputted into the citations database.

Tim Stojanovic, Cardiff University, 'The COMPASS Project'

TS presented the ongoing [COMPASS](#) project, led by EDINA at Edinburgh University, as a potential technological approach to information management. Whilst traditional approaches to searching the internet involve the use of key words; COMPASS enables more intelligent web searching by using 'semantic webs'. The use of semantic webs and innovative visual presentations of search results are considered as being powerful ways of accessing vast volumes of information existing on the web.