Proudman Oceanographic Laboratory

NATURAL ENVIRONMENT RESEARCH COUNCIL

Annual Report

2008–09

The Proudman Oceanographic Laboratory (POL) is a research centre wholly owned by the Natural Environment Research Council (NERC). Its main areas of research are sea-level and allied science, the physics of the shelf and slope seas, marine observation and modelling systems, and data management in POL-hosted data centres: the British Oceanographic Data Centre (BODC) and the Permanent Service for Mean Sea Level (PSMSL).

Contents

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Cover: Cuauhtémoc, the Mexican Navy training ship at Wellington Dock, Liverpool. The cadets are performing a 'formacion de honores' which they do before docking as a salute to the port of arrival. It is a honour for them to be part of this display. One of our students, Ruben Alvarado, served aboard the Cuauhtémoc and has taken part in the salute.

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Director's introduction

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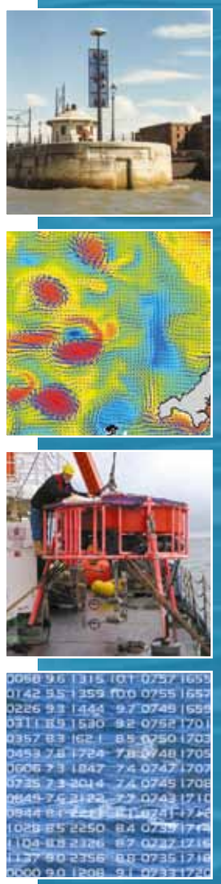

We are using the UK's shelf seas for an ever-increasing range of industrial, commercial and leisure activities. This 'user pull' is creating challenging interdisciplinary science questions. POL is able to address many of these questions using data collected from our Irish Sea Observatory with our numerical models for tides, currents, waves and sediment transport. The observatory is a collaborative venture with 16 partners including: several universities; the Met Office; Environment Agencies; the Centre for Environment, Fisheries and Aquaculture Science; Mersey Docks and Harbour Company and Sefton Council.

The shelf seas surrounding the UK also support some of the highest tides and strongest tidal currents in the world – from which electric power can be produced. Over the next few years we will direct some of our modelling expertise into studying the potential for power generation by arrays of tidal turbines and barrages. And look at the impact they are likely to have on the marine and coastal environment.

Science that supports evidence based policy is an important role of the laboratory. An excellent example of this work is the Charting Progress 2 (CP2) project. CP2 will provide a comprehensive assessment of the physical, biogeochemical and ecosystem functioning of the UK's shelf seas. Several of our scientists are collaborating with this Department for Environment, Food and Rural Affairs funded project.

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Sea level research continues to be a mainstay of the laboratory. It delighted us to mark the 75th Anniversary of the Permanent Service for Mean Sea Level by organising two scientific symposia. One was at the European Geosciences Union in Vienna and the other, as part of the British Association Festival of Science, in Liverpool.

With our *Oceans 2025*[1] partner laboratories, we hosted an extremely successful exhibition at the Tall Ships weekend in Liverpool. This was one of the keynote events celebrating the European Capital of Culture award to the city in 2008. Our exhibition showed that without doubt, the public are enthusiastic and curious about marine science and the benefits society can gain from this expanding field of research. Our laboratory has ambitious plans to increase outreach of this type as you will learn from future annual reports.

We will be increasingly turning to our shelf seas to identify 'solutions' – such as energy, carbon capture and storage – for living with climate change. The challenge will be to use our shelf seas in a sustainable way and the research expertise here in POL will help contribute towards this goal.

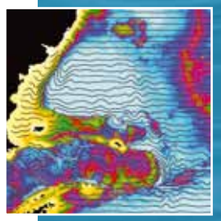
I hope you enjoy reading this year's report and will be pleased to receive your feedback and comments.

Andrew Willmott

[1] National Oceanography Centre, Southampton; Scottish Association for Marine Science; Sea Mammal Research Unit; Sir Alister Hardy Foundation for Ocean Science; Marine Biological Association

1. *We have excellence in four distinct areas: sea level science; numerical modelling of ocean margins; science, engineering and technology for in situ ocean observations; marine data management.*
2. *Prof Andrew Willmott explains tidal current power generation to two exhibition visitors.*

Science



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It is difficult to find out about the ocean beneath its surface, where satellites cannot see and sampling is only occasionally possible. POL scientists, led by Simon Williams, use continuous measurements from carefully chosen sites to better our understanding of the deep. POL technologists, led by Peter Foden, use novel instruments to make these measurements, designing new equipment to meet evolving needs.

Measuring Up

Ocean circulation, sea level and climate

Measuring the Atlantic Ocean conveyor

The Atlantic's Meridional Overturning Circulation (MOC) carries heat from the southern hemisphere to the North Atlantic region. If it stopped flowing, north-west Europe would be several degrees cooler. It is suggested that this overturning circulation may have slowed by a third since 1957. Monitoring this ocean wide circulation is a major challenge because eddies and local recirculation dominate the picture at most locations. Rory Bingham and Chris Hughes, with Ric Williams and Vassil Roussenov from the University of Liverpool, are researching the MOC. They found, in various ocean models, the MOC can be accurately monitored using only measurements down the continental slope at the western side of the ocean. Also, using 150 years (1856–2005) of tide gauge measurements, they found strong signs that coastal sea level measurements alone produce an accurate measure of the MOC. Assuming the model carries over to the real world, the results show the MOC has varied by less than a quarter since 1856, and has, if anything, slightly speeded up since 1957.

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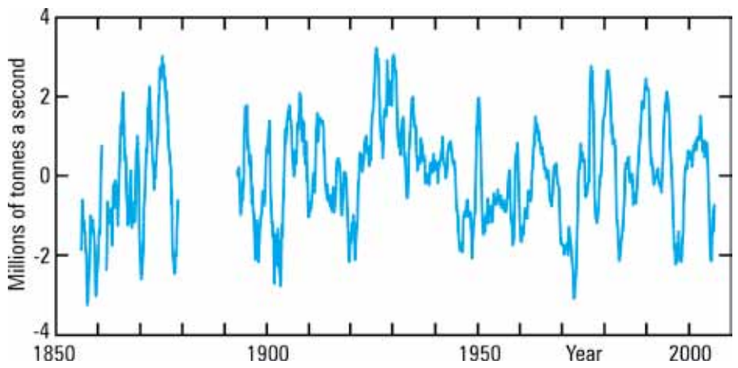

1. Meriodional overturning circulation variations inferred from 150 years of tide gauge measurements.

2. The absolute gravimeter taking measurements at Eskdalemuir, Scotland.

3. Eskdalemuir location map.

4. Trends in sea level around the UK during the 20th century.

New absolute gravity site

Simon Williams and Daniel McLaughlin have been collaborating with the British Geological Survey, the Institute of Engineering Surveying and Space Geodesy and the University of Nottingham. They successfully measured absolute gravity at the Eskdalemuir Observatory in southern Scotland and installed a permanent continuous Global Positioning System receiver. Combining these new measurements with the existing geophysical and meteorological instruments makes the observatory a unique site. Coupling this with the site's location and remoteness from anthropogenic noise, means measurements taken here will be useful in studying changing gravity resulting from the Earth's continuing response to the last ice age.

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Sea level trends around the UK

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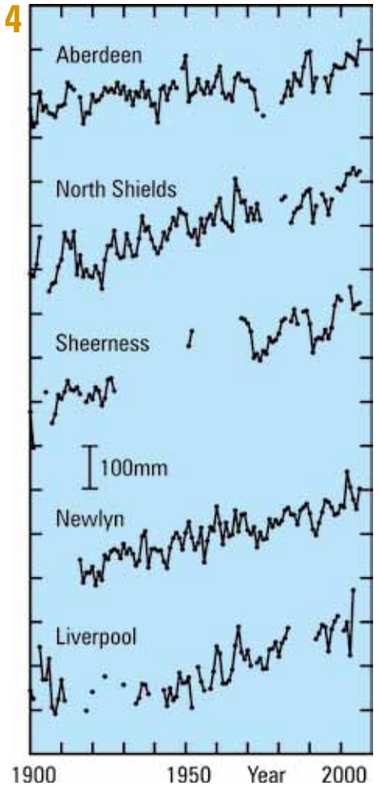

Sea level change is an important scientific topic closely linked to studies of climate change. It is of great interest to the government and public because of the possible impact of rising sea level on the coast and the associated cost of coastal protection. Philip Woodworth and Simon Williams have been working with Norman Teferle and Richard Bingley of the University of Nottingham and Ian Shennan of Durham University. Using records from the UK National Tide Gauge Network, they estimated long term sea level trends around the UK. They found the 20th century sea level rise of 1.4mm a year around our coasts can be attributed to climate change. This rate is several tenths of mm a year lower than global estimates. However, they found that UK sea level change is not described by a simple linear increase alone. It includes variations on many timescales, probably because of several atmospheric and oceanic processes. For future regional UK sea level changes, their conclusion is there is no basis for major adjustment to existing projections for the 2080s included in the 2002 UK Climate Impacts Programme.

Modelling sea ice dynamics

Miguel Morales-Maqueda and colleagues from the Université Catholique de Louvain, Belgium, have introduced new sea ice dynamics to the ocean modelling framework NEMO (Nucleus for European Modelling of the Ocean). The Met Office and several UK oceanographic laboratories use NEMO to study ocean climate problems at global and regional scales. The new dynamics improves the coupling between sea ice and ocean in the model. It gives more accurate simulations of polar oceans than previously achieved.

More tropical hurricanes

The Gulf Stream and El Niño Southern Oscillation are increasing the temperature sensitivity of Atlantic tropical cyclones. The impact of global warming on hurricanes is of timely and widespread practical interest and remains controversial. Hurricanes may be increasing because of global warming, but the observational evidence is challenging to interpret. Here, for the first time, Svetlana Jevrejeva with Prof John Moore (Arctic Centre, University of Lapland) and Dr Aslak Grinsted (Centre for Ice and Climate, University of Copenhagen), applied advanced cross-wavelet statistical methods to 135-year long observational records. The results revealed time-evolving links between Atlantic tropical cyclones (which are representative of hurricanes) and ocean temperature. They found rising sea-surface temperatures cause more Atlantic tropical cyclones. Given the rising temperatures and variability in the Gulf Stream, numbers of tropical cyclones, and hence hurricanes, will continue to rise.

Science

Within the Shelf and Coastal Processes theme a combination of models and observations provide the tools for new understanding of various processes of importance to society. Progress has been made on elucidating the links between physics and biology which will lead to better predictability of the productivity of shelf seas and ultimately their role in the carbon cycle. In the nearshore zone there are new results on sediment transport, coastal change and coastal flooding.

In the Mix

Shelf and coastal processes

Morphodynamics of the Dee Estuary

The Dee Estuary in NW England is a macrotidal (tidal range exceeding 4m at spring tides) coastal plain estuary. It has a history of management from Roman times to the present day, including canalization and reclamation of part of the inner estuary. Rowena Moore, Judith Wolf and Alexjandro Souza, with Prof Stephen Flint from the University of Liverpool studied the processes of present-day morphological change in the estuary. The team used computer models and LIDAR data to examine the effects of tidal asymmetry. They found the shallower intertidal areas (sand and mud banks) were the most tidally asymmetric, showing flood dominance. The main navigation channels showed some ebb dominance but with tides relatively undistorted. The overall flood dominance is likely to induce a net sediment import into the estuary. This explains historical morphological changes of large scale accretion (increase by natural growth) over the last two centuries. It also explains recent morphological changes as seen from the LIDAR surveys, showing mainly net accretion from 2003–06. Hypsometrical analysis (measuring land elevation above sea level) suggests the estuary may be approaching equilibrium. The flood dominance and sedimentation rate may therefore decrease in the future. Research and modelling show that in an infilling estuary, an increase in the area and elevation of tidal flats can eventually shift the estuary towards ebb dominance. But, for the Dee Estuary, the ratio of large tidal amplitude to water depth suggests the tidal flats would have to be very extensive indeed for this to occur.

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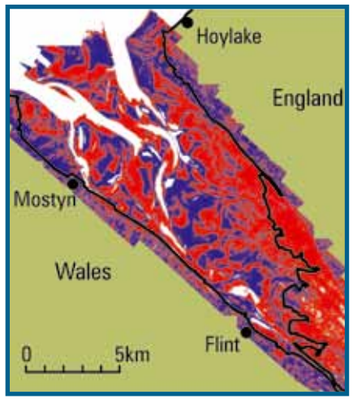

1. *Bathymetric changes from LIDAR surveys of 2003–06. The black line, indicating the coast, is the mean high water mark. Blue areas show erosion and red, deposition.*
2. *A summer satellite image of sea surface chlorophyll. High concentrations (red) indicate large numbers of phytoplankton. The white dashed line shows the edge of the continental shelf (water depth of 200m). A band of phytoplankton along almost the entire shelf edge corresponds to where the internal wave mixes nutrients up towards the sea surface.*

Physics and fish at the Continental Shelf Edge

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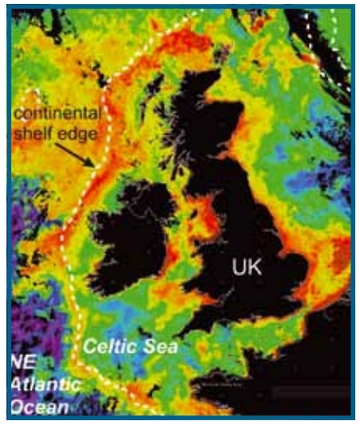


During a collaborative research cruise with Bangor University and the University of Southampton, Jonathan Sharples and colleagues made an interesting discovery. They made a new link between the physics of the shelf edge and the success of important commercial fisheries. Tides cause a large wave to form on the thermocline below the sea surface. As this wave hits the edge of the continental shelf it breaks, causing turbulence and mixing nutrients from the deep water to the sea surface. This local supply of nutrients leads to growth of large phytoplankton (single-celled marine plants) which are food for fish larvae. Satellite images of sea surface chlorophyll show phytoplankton distribution along a large section of the continental shelf edge. This population of large-celled phytoplankton supports important stocks of mackerel, horse mackerel (scad) and hake. Analysis of fishing vessel positions shows this band of chlorophyll to be one of the most fished parts of our shelf seas.

Ensemble surge forecasting

Kevin Horsburgh and Jane Williams worked with the Met Office and HR Wallingford in a project aimed at showing the benefits of coastal flood forecasting using probability – the likelihood of it happening. A key result was a surge ensemble forecasting system. A traditional forecast produces a single estimate of how each surge will evolve. The ensemble modelling approach produces several forecasts. Each forecast uses slightly different starting states, boundary conditions and model physics. Sampling the range of forecast results quantifies the uncertainty in the forecast. Kevin and Jane developed an ensemble-based surge forecasting system validated over the period 2006–08. Processing surge model results provides various useful products valuable to forecasters – graphs of the average and ensemble spread; the probability of exceeding local flood thresholds, for example. The results show the ensemble has improved the accuracy of forecasts to about six days. This work proved storm surge ensemble forecasting gives better, more quantitative management of flood risk. The ensemble also produces a more accurate central estimate of water level beyond the first day of the forecast. The Met Office has now adopted the system for operational coastal flood forecasting.

Accelerating dense water flow down...

After winter cooling or fast evaporation, water in a shallow shelf sea may be denser than in the adjacent deep ocean. Then, it flows down the slope from shelf to ocean. The ocean-to-shelf density increase and steepness of the bottom slope acts as 'forcing', so the water finds its own level where the ocean has the same density. If the forcing is weak, the flow is in a steady thin bottom layer down the slope. John Huthnance has developed theory for stronger forcing. Here; the flow changes character in several stages. First, the steady bottom-layer flow becomes thicker, until for a certain strength of forcing it fills the whole depth of water. For yet stronger forcing, the flow cannot be steady; it accelerates down the slope in a thin bottom layer; this accelerating layer itself becomes thicker for even stronger forcing. The theory suggests that for very strong forcing the whole water column accelerates. This work describes conditions for starting the flow of the ocean's densest waters from polar shelf seas to the deep ocean. It was initiated in a project 'Cascading' funded in part by INTAS (W. Europe collaboration with former Soviet states).

Measuring suspended sediment

Being able to measure the transport of sediments in coastal and shelf seas is important for coastal erosion and flood protection assessment studies. Acoustic measuring techniques are unique and valuable. They provide non-intrusive measurements, with centimetre resolution, at interwave and turbulent timescales of 0.1–0.25 seconds. This makes them an ideal tool in suspended sediment process studies. Ben Moate and Pete Thorne evaluated and verified a method for finding out the acoustic scattering properties of suspended sediments with broad size distributions.
They compared predictions with measurements taken in controlled laboratory experiments. Previously, the method was not proven for irregularly shaped particles such as natural marine sediments. Theirs are the first measurements that assess the impact that size distribution, breadth and distribution type, have on the scattering properties. Knowledge of these properties is essential for estimating suspended sediment concentration and size using acoustic instruments. They have also examined the impact that errors in the breadth of size distribution have on the acoustic estimates. This work has focused on removing one possible source of uncertainties in acoustic measurements of sediment transport parameters at sea, though is also applicable to other acoustic scattering fields.

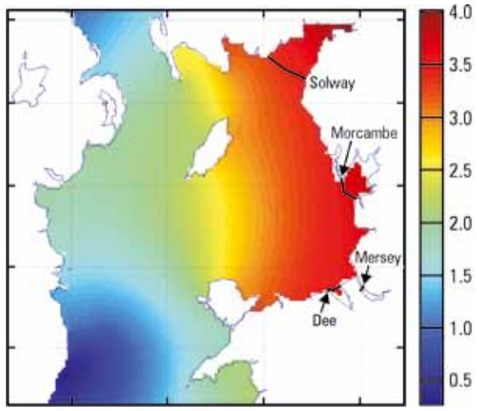
Science

We research several areas of marine renewable energy – mainly tidal power (range and stream) and offshore wind energy. In 2004, we provided tide and current data for the tidal energy maps in the DTI (now BERR) Atlas of UK Marine Renewable Energy Resources. We also have the ability for mapping wave energy availability using our work on modelling the wave climate around the UK.

MARINE resources

Science for sustainable marine resources

Tidal power and the environment



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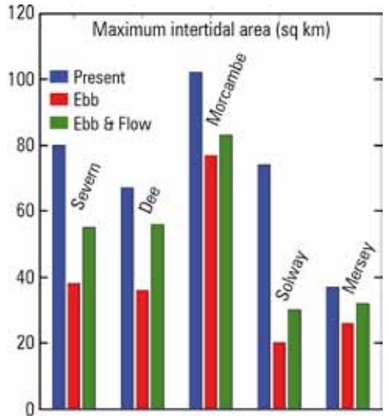
Judith Wolf, Jason Holt and Ian Walkington have been working with the Maritime Environmental & Water Systems (MEWS) Group at University of Liverpool. They have just completed a two-year study funded by the Northwest Regional Development Agency's Joule Centre. Using computer modelling, they evaluated the scope for reliable electricity generation from a combination of estuary barrages/lagoons and tidal-stream generators. They found renewable energy produced in the North-west would be comparable and complementary to possible Severn Estuary generation. It could provide 50% of the North-west's own energy requirements, that's 5% of the present UK electricity needs. The team invested a substantial effort in setting up a large computer model of the west of the UK. They used it to find out the possible changes in tidal regime resulting from various barrage and free-stream turbine schemes. It included an assessment of local and far-field impacts of barrage construction in west coast estuaries (Solway Firth, Morecambe Bay, Dee, Mersey and Severn). The results show that using two-way generation, an increased number of turbines and 'tuning' pumping and delay times minimises the loss of intertidal habitat.



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Review of the state of UK seas

Safeguarding our Seas, published in May 2002, sets out the Government's vision for clean, safe, healthy, productive and biologically diverse oceans and seas. Charting Progress, published in 2005, shows the extent to which the seas round the UK continental shelf meet the vision. Charting Progress highlights gaps in knowledge and understanding of the seas and in arrangements for gathering and co-ordinating information.

With wide UK collaboration, descriptions and trends of the state of UK waters have been assembled. The marine variables described are sea temperature, salinity, pH (for acidity), sea level, waves, circulation and suspended sediment. The Met Office has contributed a chapter on weather and climate. Collation of this information was carried out through the UK Marine Monitoring and Assessment Strategy. It will feed into a second integrated assessment of the state of the marine environment – Charting Progress 2 – required under the Marine Strategy Framework Directive. Charting Progress 2 is due for publication in 2010.

Collaborators are: John Huthnance and many others (POL and BODC); Tim Smyth and others (Plymouth Marine Laboratory; Denise Smythe-Wright and others (National Oceanography Centre, Southampton); Mark Inall (Scottish Association for Marine Science). Collaboration also from: Agri-Food and Biosciences Institute; Isle of Man Government; Centre for Environment, Fisheries & Aquaculture Science; Fisheries Research Services and the Met Office.

1. *Tidal amplitude M_2+S_2 and barrage locations.*
2. *Present maximum intertidal area (sq km) and under two possible turbine scenarios.*
3. *The projected change in primary production in the Humboldt Current region around the coast of South America, showing the difference between pre-industrial conditions and one possible future scenario ($gCm^{-2}yr^{-1}$).*

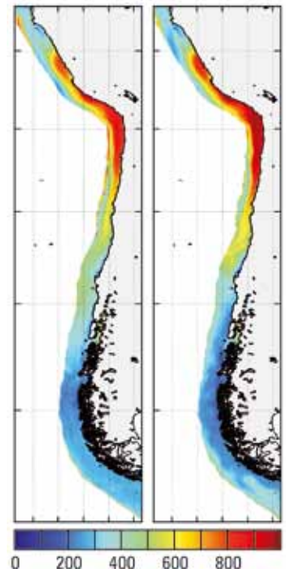
Effect of the changing climate on waves on the NW European continental shelf

To examine the effects of climate change on waves for a medium high CO_2 emissions future, Judith Wolf and James Leake used Met Office/Hadley Centre winds to drive a 12km grid wave model of the NW European continental shelf. The results show a slight increase in seasonal mean and extreme waves to the SW of the UK. There is a reduction to the north of the UK and little change in the North Sea. There are large uncertainties, especially with projected extreme values. Judith and James examined these by comparing the natural variability over decadal time-scales with the difference between two 30-year time slices representing the present day and future climate. They identified statistically significant trends in annual maximum wave height reducing by 0.3cm a year (projected from now to 2100) to the north of Scotland.

The effects of climate change on the world's fisheries

James Harle and Jason Holt have developed a model system for the QUEST-Fish project. It allows regional models of any of the world's coastal or shelf seas to be setup and run, simulating the physics and ecosystem at the bottom of the food chain. Early results show the ability of this system. Using output (forcing) from global climate models in their system, James and Jason are able to study the effects of global changes on regional primary production (plant growth). By using different forcing scenarios, they can explore various possible futures. The results from these simulations will feed into fisheries and economic models investigating socio-economic implications of these changes.

QUEST-Fish examines how climate change would affect the potential production for global fisheries in the future, compared with past and present. It excludes exploitation because of the uncertainty of likely future regulations.



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Science

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Technology is fundamental to our ability to make observations. 'Novel observations of the universe by new platforms and instruments fuel great leaps forward in understanding' (Marcia McNutt, Monterey Bay Aquarium Research Institute). Our work here targets (i) systems for instrument control at, and data telemetry from, remote locations: coasts and the deep sea, (ii) measurement systems for in-water microstructure, turbulence and detailed particle dynamics.

MARINE technology

Measurement systems and telemetry

Long-term deep-ocean lander

1

Long time series of three or more years are valuable for assessing trends and variability in ocean circulation. They are of greater value if we can receive data periodically, with instruments keeping their datum by remaining on the seabed. Peter Foden, Steve Mack, Geoff Hargreaves and Jeff Pugh are developing MYRTLEX – Multi-Year Return Tidal Level Equipment. This is a prototype deep-ocean lander that can remain on the seabed for up to ten years. In October 2008, as part of an Oceans 2025 trials cruise on *RRS Discovery*, MYRTLEX was deployed off Fuerteventura in the Canaries. Acoustic and satellite telemetry tests successfully recovered data from a depth of 1690m.

HY-BIS*, a remotely operated vehicle also on trial, photographed MYRTLEX on the seabed. These are the first-ever images of a POL deep-ocean lander in position. Then, following a release failure, HY-BIS inspected and successfully recovered MYRTLEX from its second deployment – highlighting how important trial cruises are.

In December 2008, a data capsule with three years of bottom pressure data was recovered from MYRTLE at depth of 2793m in the Southern Ocean off Elephant Island.

2

1. MYRTLEX prototype photographed by HY-BIS at a depth of 1690m.*
**HY-BIS (Hydraulic Benthic Interactive Sampler) is a deep-ocean vehicle developed by the National Oceanographic Centre, Southampton.*

2. MYRTLE data capsule recovered from a depth of 2793m in the Southern Ocean.

Telemetry for remote sea level and tsunami monitoring

The Indian Ocean tsunami in December 2004 showed the need for a low cost, real-time sea level monitoring system, used globally and independent of local services or infrastructure. With the aim of satisfying this, we are collaborating with Inmarsat, GFZ Potsdam and the University of Hawaii Sea Level Center. Inmarsat make the Broadband Global Area Network (BGAN) satellite communications system. First testing of a prototype sea-level monitor at Liverpool and Ascension Island in the South Atlantic, with further testing at two sites in Sri Lanka proved successful.

Knowledge transfer discussions with OTT Messtechnik of Germany led to a newly designed OTT data logger incorporating BGAN telemetry. A prototype is due for testing in 2009. A paper describing the development was widely distributed at Oceanology International '08. The paper, 'Real time sea level data transmission from tide gauges for tsunami monitoring and long term sea level rise observations' won the Denny Medal for POL authors Simon Holgate, Peter Foden, Jeff Pugh and Philip Woodworth. The Denny Medal, awarded since 1892 by the Institute of Marine Engineering, Science and Technology, is for the best Journal of Operational Oceanography paper of the year.

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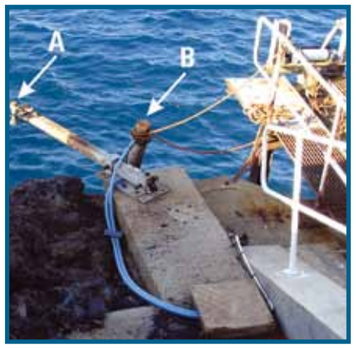

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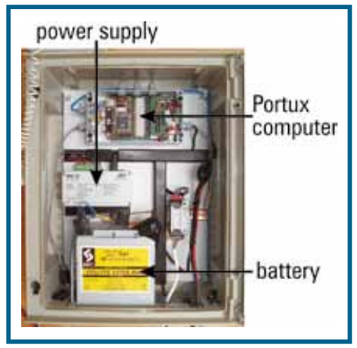


3. Tide gauge installation at Ascension Island showing radar gauge (A) and stilling well (B) housing pressure sensors.

4. The BGAN tide gauge electronics cabinet.

5

5. Peter Foden installs the BGAN terminal at Ascension Island.

Wave energy and sediment movement

The Wave Hub, off the coast of Cornwall, will provide an electrical 'socket' on the seabed connected to the National Grid by an underwater cable. It will support and encourage developers of wave energy devices by allowing them to test their arrays over several years in true offshore conditions. It will assess if the technologies will perform effectively producing the expected amounts of power.

The 'Wave Hub Impacts on Seabed and Shoreline Processes' project will examine the affect of the devices used on the Wave Hub. As part of this impact assessment, the University of Plymouth provided funds for Mike Smithson and Dave Jones to refurbish our Sediment Transport and Boundary Layer Equipment. STABLE makes detailed measurements of currents near the seabed and their affect on sediment movement. Initially, a six-week deployment will start in June 2009.

6. Emlyn Jones (left) attaches an instrumented clamp to the towed cable while Mike Smithson (right) stands by to pass him another one.

7. Mike Burke prepares STABLE for deployment.

7

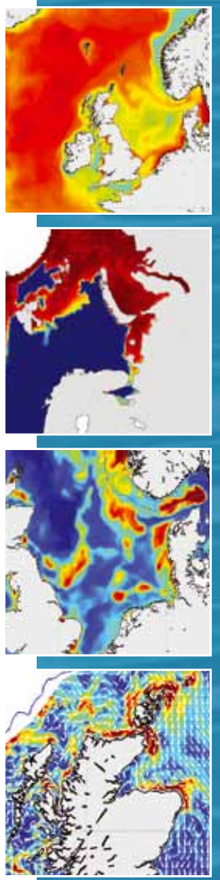
Towed temperature-chlorophyll chain

Phytoplankton, a primary source of food for fish, grows in spring when our shelf seas stratify. It occurs in patches, often a kilometre or less across, in a layer 2–5m thick, typically at a depth of 30m (+/- 20m). We want to collect information from this layer to understand the structure and movement of the phytoplankton patches. In our 2007–08 report we described developing an instrument chain designed to do this.

6

Dave Jones designed and built a special clamp to hold a fluorometer (measures chlorophyll) and temperature sensor. The clamp attaches to a cable with a simple twisting motion. Thirty of these instrumented clamps attach to a cable towed behind a ship. Deployment (and recovery) is easy and rapid, taking about ten minutes. Used for the first time in the Celtic Sea during July 2008, the instrumented cable was deployed from *RRS James Cook*. Six deployments, each for 25 hours, five on station and one towed at 3.5 knots proved a great success.

Science



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Numerical models are a vital tool for developing our understanding of the Earth system, but must be able to effectively represent the marine environment from the global ocean to coastal/shelf seas, linking hydrodynamics and ecosystem processes with the accuracy to provide reliable present day and climatic predictions. The work described here will help deliver the state-of-the-art models needed for the next decade of UK marine science.

The Numbers game

Next generation ocean prediction systems

Potential climate change impacts on European Seas

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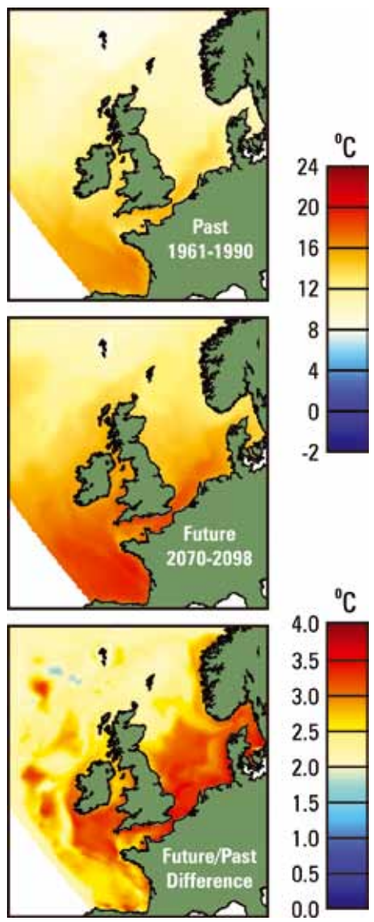

As part of a continuing collaboration with the Met Office Hadley Centre, Jason Holt and Sarah Wakelin conducted a series of model experiments. They researched how climate change might impact the temperature and salinity of the North-West European continental shelf. Using forcing data from the Hadley Centre Regional climate model, they studied the difference in average conditions between 1961–90 and 2078–99. The results show projected warming in shelf seas – in particular near coastal regions – is substantially faster than the open ocean. But the increase in stratification (vertical changes in density) is less marked on the shelf. Also shown, is a freshening of these seas into the next century. Jason and Sarah's results, produced for UK Climate Projections, mark the start of an extensive investigation where they will explore the reliability of such projections and what the range of possible conditions might be.

1. Projected change in sea surface temperature between the recent past 1961–1990 (top) and the end of this century, 2070–2099 (middle). The bottom figure shows the difference between the two predictions.

Irish Sea optics assimilation

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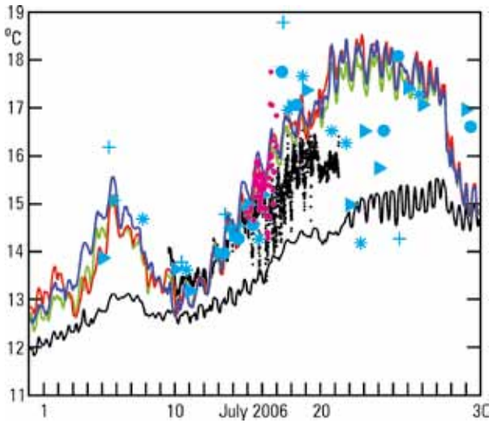


An accurate representation of ocean water clarity is important for correctly computing its capacity to absorb heat. In opaque waters, light and its associated thermal energy cannot penetrate as far into the sea as in clear water. So, if a computer model representation of the ocean water is too opaque this leads to a surface intensification of thermal energy resulting in raised calculated sea surface temperatures.

The GeoEye's OrbView-2 satellite uses a SeaWiFS instrument to gather the optical properties of the ocean. The instrument records characteristics such as chlorophyll concentration and water clarity. Jeff Polton used SeaWiFS data – processed by Plymouth Marine Laboratory – from eight daily satellite passes for the period 1998–2007. The data are for dissolved organic matter, detritus and phytoplankton absorption and reflected light. Jeff applied these variable optical properties to the POL Coastal Ocean Modelling System giving complete spatial and temporal coverage. He found that including this improved optics scheme gives significantly better results for upper ocean temperatures.

2. Surface water temperature at a location in the western Irish Sea. The black line shows the original model. Coloured lines show model results using satellite data to control the 'murkiness' of the water improving the agreement with measurements – mooring (red and black points) and satellite (blue points).

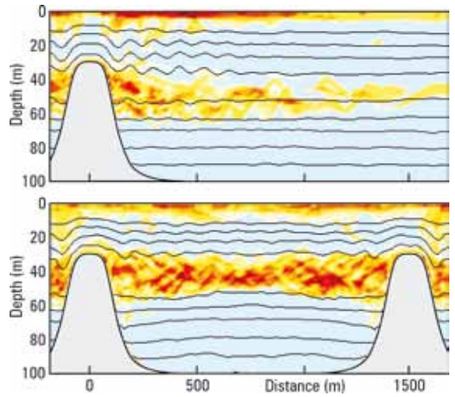
3. Model results shown as cross sections through single (top) and multiple (bottom) sills. Turbulence intensity (yellow to red) shows the increase in internal wave interaction between multiple sills.

4. Change in the primary production (total plant growth over the year) arising from a 50% reduction in riverine nutrient loads.

Internal waves over complex bottom topography

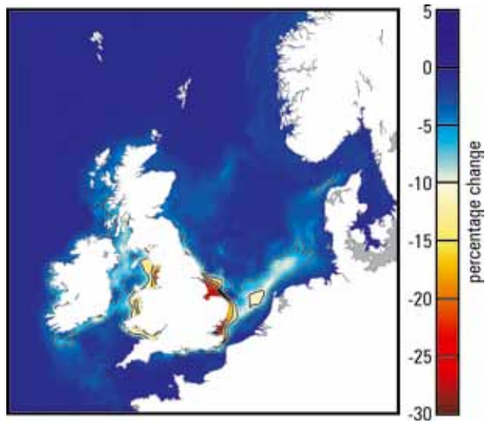
It is difficult to quantify the fundamental role ocean floor topography plays in ocean circulation. In the coastal ocean, researchers use sill regions at the entrance to a fjord as a 'test bed' to examine the role of bottom topography. A sill is an area of shallow water, with deeper water to each side and as an isolated bottom feature is an ideal study case. Recently, observations and modelling have shown strong internal tidal waves and mixing in multiple sill regions. This suggests that trapping of waves between topography is important. Using a fine gird (meters) model, Jiuxing Xing and Alan Davies have shown that multiple sills lead to internal tidal wave interaction between the sills. The associated energy trapping has important consequences for local turbulence, mixing and flow. So, in a more general sense, can internal waves reflect and focus over rough topography such as seamounts at the shelf edge or in the deep ocean? And, how would this impact on ocean circulation? Alan and Xing are now working to find the answers.

3



Consequences of nutrient reduction in the North Sea

4



Algal growth can affect regions of the North Sea, potentially disturbing the ecosystem balance and reducing water quality. Sarah Wakelin used POLCOMS-ERSEM* to study the impacts of reduced nutrient levels in river outflows on North Sea ecosystems. The model, covering north-east Atlantic, is forced by flow rate and nutrient load data for 49 rivers – including all major rivers flowing into the North Sea and the Irish Sea. A reference run used river nutrient levels for 2002. Two further model runs used nutrient data for reductions in nitrogen and phosphorus of 50% and 70% from their levels in1985. Results for the 50%-reduction run showed a decrease in the primary production of 5-10% in the southern North Sea and up to 30% in UK coastal waters, compared with the reference run. The 70%-reduction run gave 10–15% and 40% respectively.

*POLCOMS-ERSEM is the POL Coastal Ocean Modelling System-European Seas Regional Ecosystem, coupled hydrodynamic-ecosystem model.

Science

www.pol.ac.uk

Coastal Observatory

Ocean observing systems

Our Coastal Observatory – currently focusing on Liverpool Bay – seeks to record and understand how the coastal ocean responds to change, particularly climate change. Soon, with UK and Irish research organisations and agencies, it will contribute to a wider observatory. The larger collaborative observatory will encompass the rest of the Irish Sea and beyond.

Observational campaign

The Coastal Observatory is made up of measurement systems and computer modelling. Web tools provide display and delivery of data – much of which is in real-time. There are five primary measurement platforms each with complementary time and space characteristics:

1) Fixed-point time series – most significant are two mooring sites measuring ocean currents, waves, temperature and salinity; a weather station on Hilbre Island and a network of tide gauges.

2) Spatial surveys of water column properties made throughout the year – typically every six weeks using the *RV Prince Madog*.

3) The *Liverpool Viking* instrumented commercial ferry – makes a daily round trip between Liverpool and Dublin providing sea surface measurements.

4) HF radar measurements of surface currents, waves and winds over a wide spatial area up to 1600 square kilometres.

5) Weekly composite satellite images of sea surface temperature, suspended particulate matter and chlorophyll – from the NERC Earth Observation Data Acquisition and Analysis Service.

Since starting in August 2002, the measurements now span over six years. There have been 59 research cruises aboard the *RV Prince Madog*. As part of our ever developing suite of instrumentation, in 2008 the observatory took delivery of an ocean glider. This will allow water properties to be measured over 100s of kilometres for up to 30 days duration. It will broaden our focus beyond Liverpool Bay to the rest of the Irish Sea and Western European shelf.

1. *John Kenny and Danny McLoughlin fine-tune the glider. This new instrument will allow data collection from a much larger area without needing expensive long-term ship charters.*

A platform for UK science

Each *RV Prince* Madog instrument maintenance cruise also provides a platform for university research groups. This is by direct participation and by providing samples for collaborative projects monitoring wide-ranging oceanographic properties. New partnerships significantly increased this year's range of measurements:

- University of Liverpool Department of Earth and Ocean Sciences – started routine nutrient measurements using a nutrient analyser provided by POL.
- National Oceanography Centre, Southampton – began taking ocean acidity measurements as part of a wider Defra study.
- University of Liverpool – Marie Curie Fellow, Elena Stoica, began studying the seasonal dynamics of microbacteria in Liverpool Bay using observatory cruise water samples.

2. *Scientists from CEFAS, University of Liverpool and Bangor University analyse samples aboard RV Prince Madog.*

Monitoring the health of our oceans

Guided by Dr Claire Mahaffey, the University of Liverpool's (UoL) nutrient biogeochemistry laboratory is responsible for measuring inorganic nutrient concentrations in samples collected by the Coastal Observatory. During 2008–09, they successfully set up in-house quality control protocols by employing regular use of Ocean Scientific International standards for all nutrients analysed. They also took part in an international calibration exercise led by the Meteorological Research Institute in Japan and involving more than 50 nutrient laboratories from around the world. The exercise, analysing sea water samples from the Pacific Ocean, compared results between the international laboratories.

A joint UoL and POL project 'How does pulsed stratification alter primary and secondary production? A case study in Liverpool Bay', won a three-year NERC Strategic Ocean Funding Initiative studentship. This was filled by Anouska Bailey who will take part in observatory and process study cruises during 2009 and 2010. Liverpool biogeochemists took part in five Coastal Observatory cruises during 2008. They collected samples for size fractionated chlorophyll and phytoplankton identification, chromophoric dissolved organic matter, dissolved organic phosphorus and alkaline phosphate activity.

3. *Dr Claire Mahaffey using the POL-provided nutrient analyser.*

4. *International Network of Coastal Observing Systems Workshop delegates.*

International partnerships

During the year, John Howarth, Phil Knight, Isabel Andreu-Burillo, Judith Wolf, Paul Bell and Jenny Brown presented the Coastal Observatory at meetings in Europe and the UK.

In March, POL hosted the last of three NERC-funded Coastal Observatory Workshops. The two-day workshop 'Sustaining Coastal Observatories' attracted delegates from France, Germany, Italy, Portugal, Spain, Sweden and the UK – six travelled from the US. The delegates represented 16 ocean observatories.

Data delivery

The Observatory aims to provide customised scientific information targeting stakeholder requirements. Stakeholders are the public, local authorities, port managers, academic researchers and government agencies. A steering committee links each group. During 2008, these links led to collaborations and partnerships. For example, Observatory scientists provided expert advice to a workshop 'Adopting New Technologies for Coastal Defence Monitoring', hosted by Sefton Council. And POL's high resolution Liverpool Bay model provided the Mersey Docks and Harbour Company with valuable simulations of sediment redistribution following dredging of the River Mersey.

Most Observatory data is freely available through its web pages – many data streams are available in real-time. POL and the British Oceanographic Data Centre can provide further data processing and metadata if needed.

National and international facilities

www.pol.ac.uk/ntslf

The National Tidal and Sea Level Facility (NTSLF) is the UK centre of excellence for sea level, sea level extremes, tides and storm surges. We advise policy-makers, planners and coastal engineers on the impacts of sea level rise.

The National Tidal and Sea Level Facility

www.pol.ac.uk/ntslf

Activities of the NTSLF

1

John Giles/PA News

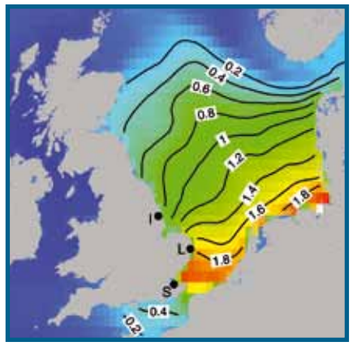
Global average sea level is forecast to rise 20–100cm by 2100. This could change the frequency and extent of coastal flooding. We need to manage the risk and develop effective forecasting systems. This demands the best understanding of the science behind sea level rise, tides, storm surges, wave processes and flooding.

With partners in top research universities, coastal engineering consultancies and the Met Office, the NTSLF provide unique expertise in sea level measurement, computer modelling of tides and storm surges, and analysis of extreme sea levels.

Working with Met Office colleagues, Jane Williams and Kevin Horsburgh deliver improved computer models for operational coastal flood forecasting. These models run four times a day, forecasting up to two days ahead. This team recently developed an ensemble prediction system. This performs several parallel simulations, giving increased forecast confidence. They also use the models to study the characteristics of storm surges in possible future climates and to assess tsunami risk in the UK and elsewhere.

The NTSLF's work of is of strategic importance to government, local authorities, the public and scientific community.

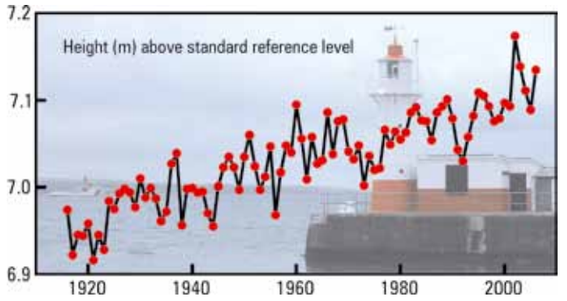
2



1. *A storm hits Blackpool.*
2. *Storm surge heights from the operational model on 9 November 2007.*

Precision measurement of sea level

3



Our understanding of future sea level rise contains a large degree of uncertainty. Most of this is because global climate forecast models poorly quantify ice melt. It is now more important than ever to keep up strong international programmes monitoring sea level throughout the world's oceans. High-quality observations give early warning of any sudden changes in sea level and act as a reality check for improving climate models.

Dave Smith, Les Bradley and Darren Gaudie manage the UK Tide Gauge Network. Long-term records from its tide gauges at 45 sites around the UK confirm the global picture of sea level over the past century – since 1915, there's been a yearly 1.8mm rise in sea level at Newlyn. This year, the team installed a new gauge at Royal Portbury dock. This will replace the one at Avonmouth sited on an ageing jetty. They also refurbished gauges at Newlyn and Portpatrick and surveyed North Shields and Newhaven for new equipment installation. They made general maintenance visits to 40 sites. The system has proven reliability with 98% data availability over the year.

Post-glacial rebound – the rise of land masses depressed by the weight of glaciers during the last ice age – complicates the accurate assessment of true sea level change. Simon Williams, Danny McLaughlin and the University of Nottingham work together to maintain a land monitoring network based on Global Positioning System technology. This network helps distinguish between true sea level variations and vertical land movement.

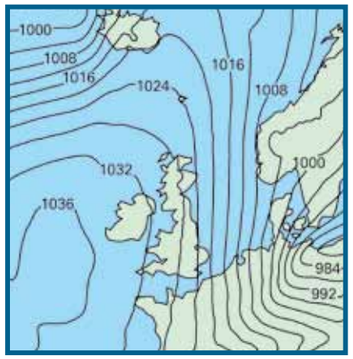
4

As part of our contribution towards international climate change research, NTSLF also monitor sea level at strategic sites in the South Atlantic and in the British Dependent Territories of Ascension and Gibraltar. This year, Geoff Hargreaves and Steve Mack upgraded tide gauge equipment at Port Stanley, Vernadsky and Rothera. Peter Foden, Dave Jones and Philip Woodworth upgraded the tide gauge at Ascension Island. Sea level data now transfers by satellite and is available to the international science community via the Global Telecommunications System and in real-time to the Sea Level Station Monitoring Facility of the Intergovernmental Oceanographic Commission.

3. *Annual sea level at Newlyn. In the background is Newlyn lighthouse and Tidal Observatory.*
4. *Portbury tide gauge instrument cabinet.*
5. *Isobars of mean sea level atmospheric pressure – from the Perturbed Physics Ensemble – near the time of the most extreme simulated surge at the Thames mouth. This matches well with the weather chart for the 1953 surge.*

Managing the risks of flooding

5



£150 billion of financial assets and about 5 million people are at risk from coastal flooding in the UK. Coastal flooding is responsible for about £1 billion of insurance losses each year. Potential changes in flood risk because of climate change and redevelopment of low-lying regions – for example, the Thames Gateway project – demand a reliable estimate of the severity and frequency of future storm surges.

Working with Met Office Hadley Centre, Kevin Horsburgh and Chris Wilson created coupled models of future climate and storm surge for UK waters. To describe the many uncertainties present in climate models, they adopted a 'perturbed parameter approach'. Here, eleven versions of the models were run, each with different settings. Regional atmospheric models then provided realistic winds used to force the surface of a storm surge model. This work gave policy makers information on storm surge climate at the end of the 21st century. The project, funded by the Environment Agency, is part of a programme to plan appropriate flood defences for the Thames Estuary over the next century.

The results of this work simulate the observed extreme water levels significantly better than any previous studies. For the first time, storms created in the regional atmospheric model are as intense as the disastrous North Sea storm of January 1953. Our results suggest that future changes in the storm-driven part of extreme water levels are unlikely to increase during the 21st century.

Taking it to the extreme

To design and build suitable defensive measures, coastal planners require accurate estimates of flood risk. An essential tool is a consistent and credible statistical method for calculating extreme sea levels. With funding from the Environment Agency, David Blackman and Kevin Horsburgh have worked with Jonathan Tawn at Lancaster University, Jeremy Benn Consulting, and Royal Haskoning. They have produced an advanced statistical method that provides reliable estimates of extreme sea level around the entire UK coastline. Their results directly apply to flood and coastal defence policy.

National and international facilities

www.bodc.ac.uk

The British Oceanographic Data Centre (BODC) is a national facility for storing and distributing data concerning the marine environment. We are part of the Intergovernmental Oceanographic Commission's network of data centres. The centre provides a resource for science, education and industry, as well as for the wider public.

The British Oceanographic Data Centre

British Oceanographic Data Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

www.bodc.ac.uk

40 years of data management

In April 1969 the Natural Environment Research Council (NERC) created the British Oceanographic Data Service (BODS). Its purpose was to act as the UK's National Oceanographic Data Centre (NODC) and take part in the international exchange of data within the framework of the Intergovernmental Oceanographic Commission's international network of NODCs. BODC continues to fulfil this role to the present day

The past 40 years have seen many changes. These include our name, location and organisational structure, the evolving nature of data collected by the science of oceanography and the technology used. For example, at the start of the 1970's there was no solid-state memory available for instruments, even the use of magnetic tape was in its infancy. Then, data were frequently recorded by mechanical instruments to paper chart, before transcription by hand to computer. Serious mainframe computers occupied entire rooms and had less than one megabyte of memory and perhaps half a gigabyte of on-line disk capacity. In contrast, present-day surveys regularly generate terabytes of data. Even a typical mobile phone can have more than ten gigabytes of memory.

However, throughout the 40 years, our fundamental role as a national facility for preserving and sharing marine data, making it usable without reference to the originator, has remained constant.

1. For 40 years BODC has processed, archived, managed and distributed physical, chemical, biological, and geophysical marine data.

2. Mark Hebden aboard RRS Discovery, a CTD (conductivity, temperature, depth) rosette is in the foreground.

A global perspective

As a national data centre BODC has a history of managing data from multipartner international projects and was the choice to host the GEOTRACES International Data Assembly Centre (GDAC) (see www.bodc.ac.uk/geotraces/).

GEOTRACES is an international programme sponsored by the Scientific Committee on Oceanic Research. It aims to improve knowledge of biogeochemical cycles and large-scale distribution of trace elements and their isotopes in the marine environment. As well as their role as micronutrients in regulating production in the ocean, their measurement will help in understanding the transport and fate of contaminants. Ultimately, this will help improve estimates of past and future oceanic conditions.

The global field programme – sampling all ocean basins – will run for at least a decade and will involve various nations. Created in 2008, GDAC is to provide data management to promote data sharing and collaboration between research groups; and to ensure safe data storage for long-term use.

3. GEBCO website homepage – hosted and maintained by BODC.

4. RAPID-WATCH website banner.

Charting the depths

Since 1903, the aim of the General Bathymetric Chart of the Oceans (GEBCO) has been to provide the most authoritative, publicly available bathymetry for the world's oceans. Working under the auspices of the Intergovernmental Oceanographic Commission and the International Hydrographic Organization, GEBCO relies largely on voluntary contributions of an enthusiastic international team of geoscientists and hydrographers. The release of a digital version in 2003 (updated in 2008) with a grid of depths at one arc-minute resolution marked GEBCO's centenary. So far, 1034 copies are in use.

2009 saw the release of a development product with a global grid of 30 arc-second resolution. This was created by combining quality-controlled ship depth soundings with interpolation between sounding points guided by satellite-derived gravity data. The grid will be periodically updated as more regional surveys become available. Adopted by Google, this grid and the centenary grid are available for download from BODC at www.bodc.ac.uk/data/online_delivery/gebco/.

Working for the marine community

Making information and knowledge available to the marine community is a key part of BODC's role. We have pioneered a proactive approach to managing complex multidisciplinary oceanographic data. Rather than just storing information, our staff collect, calibrate, compile and check the quality of data, from major research programmes to information from individual sampling stations. Public funds pay for much of the data. BODC stores the information securely and promotes its continued use.

In 2008–09, BODC: handled 144,000 enquiries; received 189 sets of data, from 49 organisations in 16 countries; published the National Tidal and Sea Level Facility (NTSLF) annual report for 2007 (www.pol.ac.uk/ntslf/reports.html); continually updated its website which received 169,000 visits with 592,000 page views.

We answered enquiries from organisations and private individuals engaged in leading edge science, offshore industry impact studies, wealth creation and university and school students researching projects. We also answered requests for information to help central and local government meet statutory responsibilities.

Our changing climate

Climate change presents what is humankind's biggest challenge this century. Although the problem is global and long-term, the impact will neither be uniform nor confined to the distant future. Changes in the coming years and decades will vary hugely from region to region across the planet. Their impact could be large, extreme weather is a particular concern of researchers. Paradoxically, global warming may mean colder winters for north-western Europe as the ocean currents that warm the air slow down.

Building on the successful NERC funded RAPID climate change programme, RAPID-WATCH will deliver a decade-long (2004–14) time series of observations of the Atlantic Meridional Overturning Circulation (MOC).

The observations will be used with data from other sources, to discover and interpret recent changes in the MOC. They will be used to assess the risk of rapid climate change because of changes in the MOC and study the potential for predicting the MOC and its impacts on climate.

With our sister organisation, the British Atmospheric Data Centre (www.badc.ac.uk), BODC will provide data management to promote data sharing and collaboration between projects and to ensure safe storage of the data for long-term use. We will have direct involvement with project scientists – sometimes in data collection. We will help with the working up, calibration and quality control of the data; compiling the data documentation and assembling the project database for use within and beyond the project.

National and international facilities

www.bodc.ac.uk

The PSMSL was established in 1933 and operates under the auspices of the International Council for Science. It is the global databank for long term sea level change information from tide gauges and provides a wider service to the sea level community.

The Permanent Service for Mean Sea Level

www.psmsl.org

PSMSL 75th Anniversary

PSMSL organised three events during 2008 in celebration of its 75th Anniversary. The September highlight of the year, 'Liverpool, Home of Sea Level Science: Sea Level Rise and Climate Change', was a one-day session at the British Association Festival of Science in Liverpool. Two speakers travelled from the USA and Canada; Prof Richard Peltier, Director of the Centre for Global Climate Change Science, University of Toronto and Prof Gary Mitchum, University of South Florida. Gary and Richard's presentations 'How much has sea level changed recently' and 'Global sea level rise, melting ice sheets and the earth's shape' were well received. A further ten distinguished speakers from the UK presented overviews of measurements and causes of sea level change and the history of its research at Liverpool.

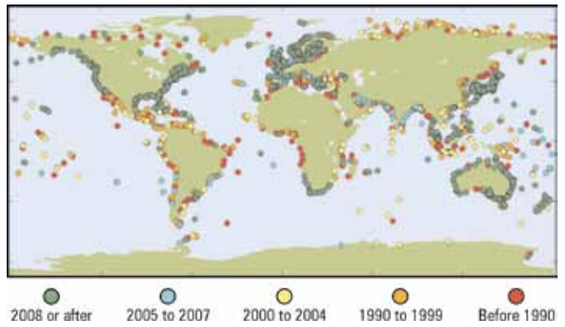
In April, PSMSL gathered experts to discuss continuing research into sea level during a special Interdivision Session at the European Geophysical Union General Assembly. And in September it sponsored the Geological Society's William Smith Meeting, 'Observations and Causes of Sea-Level Changes on Millennial to Decadal Timescales'.

1

1. Presenters at the, 'Liverpool, Home of Sea Level Science' one day session: Dr Judith Wolf, Proudman Oceanographic Laboratory; Prof Richard Peltier, University of Toronto; Dr Sarah Raper, Manchester Metropolitan University; Dr Jason Lowe, Met Office Hadley Centre; Dr Lesley Rickards, Permanent Service for Mean Sea Level; Prof Gary Mitchum, University of South Florida; Prof Philip Woodworth, Permanent Service for Mean Sea Level; Dr Richard Bingley, University of Nottingham and Prof Roland Gehrels, University of Plymouth.

The PSMSL Data Set

2



The PSMSL database contains over 58,000 station years of monthly and annual mean values of sea level from over 2000 tide gauge stations situated all over the globe. It receives data from almost 200 national authorities. On average, roughly 1500 station year entries are added to the database each year from around 700 active tide gauges. The coverage continues to be strongly biased in favour of the northern hemisphere, although the recently installed gauges in Africa are helping to redress the balance.

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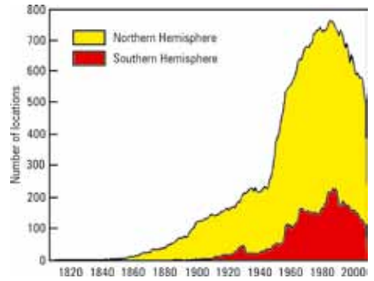


2. Tide gauge stations contributing mean sea level data to PSMSL. Coloured dots show year of most recent data.

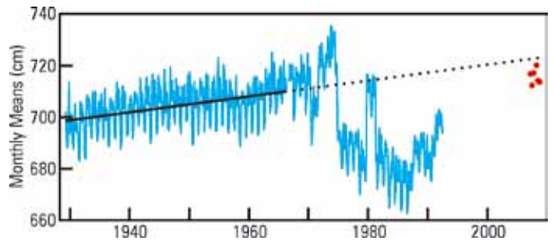
3. Comparison of the number of tide gauge stations in the northern and southern hemispheres contributing data to PSMSL.

Indian Ocean and Africa sea level network building

This year POL hosted three scientists and engineers as part of the Intergovernmental Oceanographic Commission's Indian Ocean Tsunami Warning System fellowship scheme and as part of Global Sea Level Observing System development in Africa. The three fellows were: Mr Naimatullah Sohoo, National Institute of Oceanography, Pakistan, Dr Parluhutan Manurung, Head of Gravity & Tide Division, BAKOSURTANAL, Indonesia and Mr Rene Ibara, Port Authority of Pointe Noire, Congo. During their visit they spent time learning about different aspects of sea level and tsunami monitoring. They gained skills in site assessment, tide gauge installation and maintenance, followed by data collection, processing, quality control and time series analysis.

The POL 2007–08 Annual Report referred to new sea level stations in the Indian Ocean and Africa for which POL provided the hardware. These include Aden (Yemen), Karachi (Pakistan) and Takoradi (Ghana). Extensive sea level measurements taken at these sites the 19th and early 20th centuries are available, but the sites had been out of action for many years. Combining the new data with historical ones, Philip Woodworth and colleagues have learned more about sea level rise in these three areas. They published their findings in the first electronic edition of the new International Hydrographic Review.

4



4. Historical monthly sea level means from Takoradi, Ghana, with recent seasonal mean values (red dots). The solid line is a fit to the historical data with an extrapolation to the present shown by the dotted line. The data after 1965 is suspect and flagged accordingly in the PSMSL data set.

The evidence for sea level accelerations

A variation in the rate of changing sea level ('acceleration' or 'nonlinear trend') is an important climate-related signal needing confirmation and explanation. Philip Woodworth, Svetlana Jevrejeva and Simon Holgate with Dr John Church and Dr Neil White (Centre for Australian Weather and Climate Research) and Prof Roland Gehrels (University of Plymouth) have studied these changing rates. They reviewed the evidence for accelerations in regional and global average sea level on timescales of several decades and longer. They compared recent findings of researchers and inspected original tide gauge records. Sea level data from Europe and North America display evidence for a positive acceleration around 1920–30 and negative acceleration around 1960. These inflections are the main contributors to reported accelerations since the late 19th century and decelerations during the mid to late 20th century. However, they found records from other parts of the world do not always show these characteristic features. Although some aspects of the sea-level time series are consistent with changes in rates of globally averaged temperature changes, volcanic eruptions and natural climate variability, modelling undertaken so far has been unable to describe these features adequately. This work stresses the need for major improvements to the sea-level data set to get greater insight into the spatial dependence of accelerations. This is especially important for those parts of the world without long tide gauge records.

Putting science to work

www.pol.ac.uk/appl

Our Applications Team are at the front line for dealing with all enquiries to POL, from large commercial companies through to members of the public. A wide range of products and services will help you get the most from POL science.

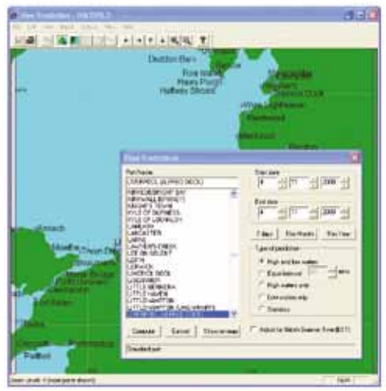
The Applications Team

www.pol.ac.uk/appl

Tides at your fingertips

Over the last ten years, the Applications Team has seen an increasing trend for business users of POL marine data to want more control over its manipulation and visualisation. To enable this, we have developed two easy to use software products which run on any Microsoft Windows based PC.

1



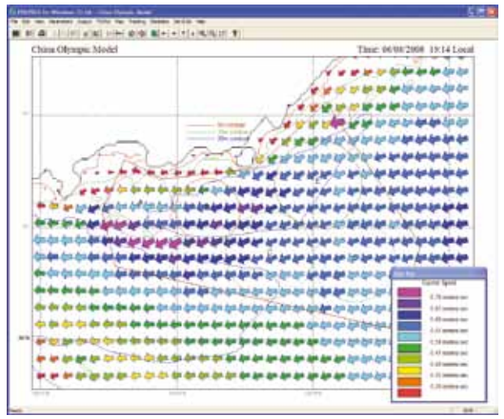
Our coastal tidal prediction software POLTIPS•3 can compute tidal heights for over 700 ports around the UK's coast, although it can, of course, do much more than a traditional style tide table. Our customers include private individuals, harbour masters, local government, press and media organisations, schools and universities to name just a few. We are the sole provider of tidal data to the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA) and the UK Coastal Monitoring and Forecasting Service (UKCMF).

Our POLPRED software produces tidal heights and currents for offshore locations – deriving its results from one of POL's hydrodynamic ocean models. The powerful visualisation tools in POLTIPS allow users to get the most out of the huge data sets that such ocean models produce. It has proved to be invaluable for those involved in offshore work such as drilling, pipeline laying, hydrographic surveying and diving in UK waters and further afield.

The core mathematical engine of POLPRED is available independently to organisations with an in-house software development capability.

Olympic gold for Team GBR

2



The Applications Team has a long history of working closely with the Royal Yachting Association (RYA) and the British Sailing Team (Team GBR) in their preparation for the Olympics. This continued in the run up to Beijing 2008. We developed a custom version of our POLPRED software based around a model of the seas around Qingdao, China, specifically set up for the RYA. It provided Team GBR with

important information on local tidal currents during the races. This 'edge' helped them to knock a few extra seconds off their race times and took them to their best medal haul ever. They topped the sailing medals chart with four gold out of a possible 11.

Marine conservation zones

National Oceanic and Atmospheric Administration

During 2008, the Department for Environment, Food and Rural Affairs funded a major project to provide access to biophysical datasets and datalayers for Marine Protected Areas. These are required for network planning and wider marine spatial planning purposes. POL is one of many organisations that fed into this project.

The Applications Team worked closely with some of POL's modellers to provide the best data possible. This resulted in extending one of the major POLCOMS models westwards to cover the entire study area. We created a detailed data set of tidal residual flow to go with a range of modelled wave parameters supplied as part of our commitment to the project.

Statistics

In 2008–09 the Applications Team:

- answered over 4,000 enquiries
- completed over 1,000 requests for data and information
- issued 60 licences for offshore data
- continued to support over 380 users of our software.

Flood warnings

The Applications Team is one of many groups at POL that work closely with the Environment Agency (EA). Since its formation in 1996 (out of the National Rivers Authority with which the team also had a long relationship) the EA has received tidal data for flood and coastal risk management and marine planning.

Probably the most well known defence against flooding managed by the EA is the Thames Barrier. A team of EA scientists decides on when to close the barrier based on various parameters. The Met Office runs a suite of numerical surge models (developed and maintained by POL) every six hours. These forecast the meteorologically induced surge up to 48 hours ahead. The surge forecast is then added to the astronomical tide provided by the Applications Team. The Duty Controller in the Barrier Control Room can then see when the water level is likely to reach a critical point and decide if it is necessary to close the barrier. This process starts up to nine hours before the arrival of the forecast peak water level, by telling the Port of London, which can then issue warnings to shipping.

1. POLTIPS•3 user-friendly interface.

2. POLPRED for Windows software showing a subset of the Qingdao model.

3. The Thames Barrier operated by the Environment Agency.

3

Putting science to work

www.pol.ac.uk/appl

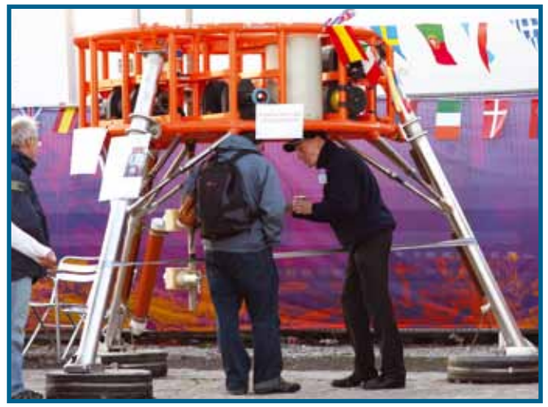
As well as the usual TV and radio interviews, newspaper articles, careers presentations to schools and talks to business and public organisations, we have had two major successes this year. Reports on these follow below.

Science and Society

Tall Ships and Liverpool, European Capital of Culture

Early in 2007, Robert Smith secured dockside exhibition space at Wellington Dock for the 2008 Tall Ships visit to Liverpool. As part of the Liverpool European Capital of Culture celebrations the magnificent Tall Ships were to birth at Albert and Wellington Docks from Friday 18 to Sunday 20 July. POL had previously taken part in the Mersey River festival, but this event was far larger and known to draw hundreds of thousands of visitors. With dockside exhibition facilities freely provided by Judith Feather – Head of Events for the Liverpool Culture Company – we invited our Oceans 2025 partners to exhibit as well. This resulted in seven of the UK's leading ocean and earth science research organisations developing a climate change related show – 'Sailing Over Changing Seas'. At the starting point of the show, inside a large marquee, a movie produced by the British Geological Survey (BGS), showed the seabed beneath the ships and the science locations on their route from Liverpool to Bergen in Norway. Topics covered at the various locations included the Liverpool Bay Coastal Observatory, the ocean's role in climate change, alien species invading our waters and ways of getting energy from the sea. On display outside the marquee were deep and shallow water instrumented platforms used to gather marine information. A tank with mini Remotely Operated Vehicles (ROVs) provided entertainment for children and adults alike.

On Friday 18, crowds braved a damp and breezy start to get a close look at the ships and exhibitions in and around Albert and Wellington Dock. Wellington Dock, a kilometre downriver from Albert Dock housed the larger of the vessels. Its opening was delayed because of late arriving ships, but once the gates opened everything ran smoothly with large numbers of people clambering on and off the ships and visiting our stand. Enthusiastic Oceans 2025 staff helped thousands of visitors learn more about the science of the seas. We received tens of thousands of visitors over the three days. The 'Sailing Over Changing Seas' stand certainly caught public imagination; it was the busiest in the area and the last to close each evening.



Six of the participating research organisations: Proudman Oceanographic Laboratory; National Oceanography Centre, Southampton; Sir Alister Hardy Foundation for Ocean Science; Marine Biological Association; Scottish Association for Marine Science and the Sea Mammal Research Unit, form 'Oceans 2025'. This is a Natural Environment Research Council (NERC) strategic marine science programme. The programme brings together marine researchers to increase knowledge of the marine environment to better protect it for future generations. The seventh research organisation, BGS, is a NERC Research Centre.

Over a million people visited Liverpool to see the Tall Ships and associated exhibitions. Thousands watched the Parade of Sail – a fleet of 60 tall ships sailing out of the Mersey, led by the Royal Navy frigate *HMS Argyll* – from both sides of the river.

A website supporting the event is at www.sailingoverchangingseas.org and the exhibition will be at venues around the country over the next year.

1. *Bernie McConnell (Sea Mammal Research Unit) interviewed for BBC Radio Merseyside (top). POL staff explain Oceans 2025 research (below).*
2. *A crowded 'Sailing Over Changing Seas' exhibition marquee.*
3. *John Huthnance explains how a shallow water instrumented platform collects data.*
4. *Youngsters having fun picking up pennies from the'seabed' using ROVs.*
5. *A student explains to Lord Swraj Paul, Baron of Marylebone, how fresh and sea water mix in the Irish Sea.*
6. *A group of college students watch a demonstration of the eutrophication process.*

Royal Society recognises school research project

For the last three years Jonathan Sharples has worked with Childwall School in Liverpool on some small science projects funded by Royal Society Partnership Grants. This year, Jonathan and Mike McAteer (Information Communication Technology Co-ordinator at Childwall School) have again been successful in a grant application. They gained funding for a project focused on excess nutrients and coastal eutrophication in Liverpool Bay. Not only that, the Royal Society thought the project 'Nutrients down the Mersey: Are we over-fertilising the Irish Sea', so exciting they invited Childwall School to be the school show at this year's summer science exhibition.

The Royal Society's annual Summer Science Exhibition brings teams of researchers at the cutting-edge of science and technology to London. It gives scientists an opportunity to put their research and institution in the spotlight and the public a chance to find out more about new scientific advances. It is popular among secondary school students, enabling them to find out more about science and technology, engage with researchers and raise their interest in science.

In partnership with the Royal Society, the school invested in its own recording instruments. This equipment, sited in Liverpool Bay – where POL takes many measurements – provided data for analysis. The research, carried out aboard the *RV Prince Madog*, combined with the data from their recording equipment, enabled the students to measure the increase in nutrient and algae levels and the resulting drop in oxygen – eutrophication.

While working on the project, the students had detailed discussions in science lessons and lectures both at school and POL. To gain a better understanding of the project, they also visited the *RV Prince Madog* at Bangor, North Wales.

To prepare for the summer exhibition, the students were split into four groups - enterprise, media, interactive and design. They created a display with exciting colourful graphics, hands-on demonstrations, a video of their field trips and a leaflet explaining their work and findings. Overall, 50 students played an important role in creating the display. With teachers and POL researchers, eight travelled to the Royal Society in London to present their project.

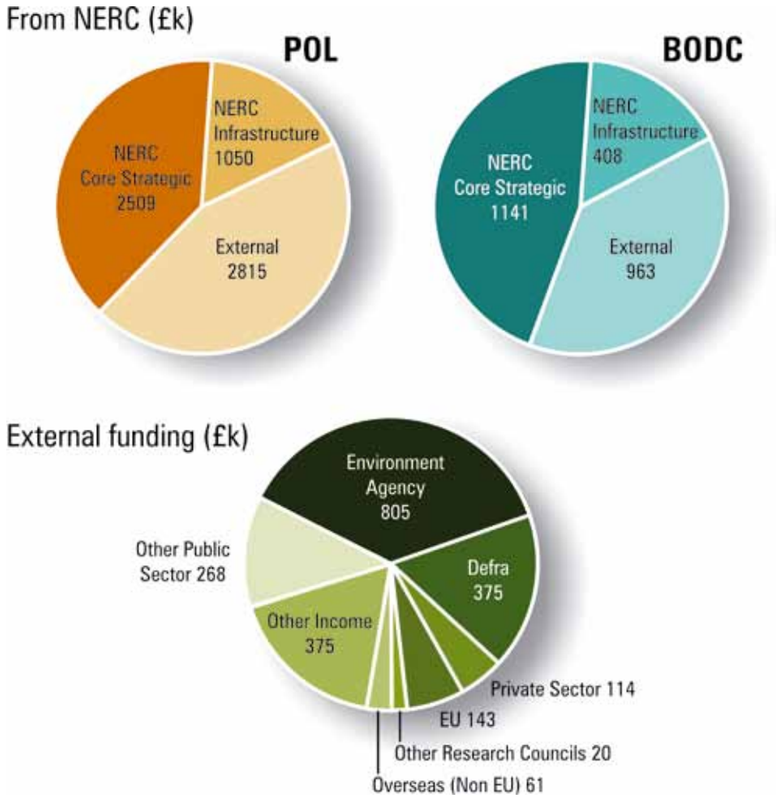
Over the four days of the exhibition, Monday 30 June to Thursday 3 July, several thousand visitors enjoyed the show. The school's stand created huge interest from the public, visiting school groups and other presenting researchers.

POL scientists taking part in the project and exhibition were; Jonathan Sharples, Matthew Palmer, Peter Jones, John Kenny, Louise Ryan, Phil Knight and Alejandro Souza, with Claire Mahaffey from the University of Liverpool. From Childwall School were teachers, Mr M McAteer and Dr L Youssef and students, Amal Abdulkadir, Ashley Ali, Usman Ali, Abbey Clark, Adam Keig, Edward Martin, Leigh Neil, Jenny Tu and Alexander Salisbury.

Putting science to work

Finance

Where we get our funding



Where we spend our funding (£K)

	Science including the NTSLF and PSMSL	British Oceanograhic Data Centre	POL Applications Team	Infrastructure	Total
Staff	2721	1563	137	1106	5527
Recurrent expenditure	1612	172	3	1572	3359
Capital expenditure	330	0	0	118	448
Indirect costs	1721	988	87	-2796	0
Total	**6384**	**2723**	**227**	**0**	**9334**

Commissioned research

Much of our work is commissioned by other organisations. Here, we list all the commissioned work we undertake in our main science themes.

Commissioned projects	
Climate, ocean circulation and sea level	
Advanced Tidal Prediction	EA
Application to the problem of 20th century sea-level rise	NERC
Attribution of ocean climate change signals in the Atlantic	NERC (RAPID)
Development of radar altimetry data processing in the oceanic coastal zone (PSMSL)	ESA
Measuring Changes in Land and Sea Levels around the coast of Great Britain	EA/University of Nottingham
National Centre for Earth Observation THEME1 (CLIMATE)	UNIVERSITY OF READING/NERC
Permanent Service for Mean Sea Level	FAGS, IOC, UNESCO and NERC
The determination of a new global GPS-derived surface velocity field	
Shelf and coastal processes	
Acoustic and optical backscatter from floculating sediments	NERC
Bank Fish	NERC
Charting Progress 2 Dynamic Seas	DEFRA
CoFEE	NERC
Development and Dissemination of Information on Coastal , Fluvial and Estuary Extremes	Private sector/EA
EPSRC Floods	University of Bristol/EPSRC
Estuarine Morphology	Defra
Field Observation and Modelling of the Sediment Triad	NERC
Flood Risk Management (FRMRC) Phase 2	University of Bristol/EPSRC
Future proofing the surge model from changes in the Met Office forcing model	EA
Geophysical Oceanography – a new tool to understand the thermal structure of dynamic oceans	University of Durham/EU
GRIDSTIX	NERC
HYDRALAB III	EU
Marine Biogeochemistry and Ecosystem Initiative in QUEST	NERC
Morphological Impacts and Coastal Risks induced by Extreme storm events (MICORE)	EU
POL INERTIAL	NERC
R and D Extremes	Private Sector
Radar algorithum	NERC
Surge Model 3DVAR Assimilation	EA
SURGE Modelling Ensemble Pilot Study	Private sector
Testing COM Viability	NERC
Thames Estuary 2100 for Phase 2 review of storm surge scenarios	EA
TRANSFER	EU
Science for sustainable marine resources	
Marine Marine Ecosystem Evolution in a Changing Environment (MEECE)	EU
Severn Barrage Tides	Private Sector
Tapping the Tidal Potential of the Eastern Irish Sea	University of Liverpool/NWDA
Next generation ocean prediction systems	
Centre for observation of Air-Sea Interactions and fluXes	NERC/Plymouth Marine Laboratory
DUST UP	NERC
Global Coastal-Ocean Modelling	NERC
Marine Environment and Security for the European Area	EU/NERC
MYOCEAN	EU
National Centre for Earth Observation THEME2 (Carbon)	UNIVERSITY OF READING/NERC
Olympics 2008	Royal Yacht Club
Sustained observation	
Changing Coastlines; data assimilation for morphodynamic prediction and predictability	University of Reading/NERC
EURO ARGO	EU
European COastal-shelf sea Operational observing and forecasting system	EU
Improved Drift Forecasting in Coastal Water	NERC
International Network of Coastal Observing Systems	NERC
Monitoring Data	CCCW
The fate of freshwater in tidally stirred shelf seas	NERC
UK tide-tide gauge network	EA
Western Atlantic Variability Experiment (WAVE)	NERC (RAPID)

Publications list 2008–09

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ISI®: Institute for Scientific Information www.isinet.com/isi/

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Other Refereed Publications

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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