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).
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Today, perhaps more than ever before, working with partners is the key to conducting successful marine research and outreach activities. During the last year many of our activities have relied on forging partnerships. With our Oceans 2025 partner laboratories and the British Geological Survey we are now planning a public outreach exhibition Sailing Over Changing Seas. This will celebrate the visit of the Tall Ships to Liverpool – one of a series of events celebrating the city’s European Capital of Culture status. With visitor numbers expected to exceed one million, we are taking this opportunity to showcase independent UK government funded marine research. The exhibition will include presentations on a diverse range of topics including marine renewable energy, rising sea level and using the oceans as a source of pharmaceutical products.

In 2008 we celebrate the 75th anniversary of the Permanent Service for Mean Sea Level (PSMSL) and are planning sea level session at the European Geosciences Union in Vienna, April 2008. A one-day symposium on Sea Level Science is also planned for the British Association Festival of Science in Liverpool, September 2008. The question of sea level rise around the UK coast, between now and the end of this century is a challenging problem that resonates with the public. The data collected by PSMSL will help scientists in their drive to answer this problem.

Philip Woodworth retired as PSMSL’s long serving Director at the end of 2007 and is now secretary of the Federation of Astronomical and Geophysical Data Analyses Services. Lesley Rickards from the British Oceanographic Data Centre, is the new Director of PSMSL. The Intergovernmental Panel on Climate

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1 National Oceanography Centre, Southampton; Scottish Association for Marine Science; Sea Mammal Research Unit; Sir Alister Hardy Foundation for Ocean Science; Marine Biological Association
Change (IPCC) presented Philip with a certificate in recognition of his contribution to the award of the Nobel Peace Prize to the IPCC.

Mark Tamisiea, one of our sea level researchers, received the American Geophysical Union’s Geodesy Section Award in recognition of major advances in Geodesy. Mark says ‘sea level studies provide the best context for making progress in many areas of geophysics.’

Creating partnerships is at the heart of our proposal to widen the scope of POL’s Coastal Observatory to cover all the Irish and Celtic Seas. We are building on the past six years experience gained by running the observatory in Liverpool Bay (the first of its type in the UK). The extended observatory will draw on the resources of institutes such as the Centre for Environment, Fisheries & Aquaculture Science, Lowestoft and the Agri-Food and Biosciences Institute in Northern Ireland, as well as POL.

Why set up such an ambitious observatory now?
Nationally, there are unprecedented demands for physical, biological, geological and chemical data from all the UK shelf seas. The Department for Environment, Food and Rural Affairs’ United Kingdom Marine Monitoring and Assessment Strategy is reviewing the health of our shelf seas; a project that POL strongly commits to and draws heavily on our observatory data. In 2009 we also expect the Marine Bill will be formally enacted, with its attendant Marine Management Organisation (MMO). In its role as a ‘one-stop’ licensing body for the use of the UK’s shelf seas, the MMO will need a wide range of marine data which the extended coastal observatory will be well placed to meet. The European Marine and Maritime Strategy needs member states to show by 2020 that they are well on the way to ensuring that all of our shelf seas receive ‘good environmental status’. To this end, data from European marine observatories will form part of that evidence base.

Continuing the partnership theme, POL and the Bedford Institute of Oceanography in Canada, are jointly recording the North Atlantic overturning circulation in a project described in more detail in this report. Indeed, this project would not be possible without our two institutes working together. BODC is forging new partnerships with British Antarctic Survey and Sea Mammal Research Unit managing all of their marine data. POL, the National Oceanography Centre, Southampton, and Plymouth Marine Laboratory are collaborating in developing a new generation of community ocean circulation models. Here, our recent investment in a new computer cluster will prove its worth – running our ocean models four to five times faster. Further, partnerships are enabling costly platforms such as the RRS James Cook to efficiently support several interdisciplinary projects while at sea, such as the Scottish Association for Marine Science and POL joint cruise in July 2008 studying ocean mixing processes.

Looking ahead, I think the marine community is well placed to solve the pressing marine problems associated with climate change through our innovative use of partnership, as explained in this Annual Report. I welcome your feedback about any aspect of the report.

Andrew Willmott

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1. We have excellence in four distinct areas: sea level science; numerical modelling of ocean margins; science, engineering, and technology for in situ ocean observation; marine data management.

2. Prof Andrew Willmott and Caroline Isaac (IBM) unveil POL’s new cluster.
As the climate changes, sea-level is rising; and there are changes to ocean circulation and formation of sea ice which may produce important feedbacks on local and global climate. POL scientists, led by Chris Hughes, are using measurements and models to understand the different causes of sea level variability and ocean heat transport. POL technologists, led by Peter Foden, are using novel instruments to make these measurements, with new equipment designed to meet evolving needs.

The oceans are full of eddies – swirls of water on scales of about 100km. This means that measurements of current or sea level only tell us about eddy variability at that location. To monitor the effect of the ocean on climate, we need to be able to measure the total water (warm and cool) transport across entire ocean basins, averaging the effects of these eddies. Measuring currents right across the ocean is impractical but we can measure pressure differences instead. Eddies even make satellite sea level measurements difficult to interpret. In a series of studies of eddies, Rory Bingham and Chris Hughes with Ric Williams and Vassil Roussenov from the University of Liverpool used computer models of ocean circulation. They found that eddies have a much smaller effect on pressure at the sea floor than that of sea level. The pressure differences are related to water transport across the whole basin. The models show that measuring pressures on the western side of the Atlantic should allow recording of long-term variations in the ‘Atlantic Conveyor’ circulation which warms Europe. This is excellent news for developing a cost-effective, long-term, Atlantic Conveyor monitoring system.

1. Northward flow of water across latitude 43°N, as a function of depth and time, in the OCCAM ocean model. Top panel shows actual transport, and bottom panel shows what would be calculated from measurements of pressure at the western boundary only. Units are millions of cubic metres per second, per kilometre of depth.
Lazy winds

What makes the ocean go? One way of answering is to ask where its energy comes from. A big source is the winds – it’s thought that winds provide about one terawatt (a million megawatts) of power. Chris Hughes and Chris Wilson have looked at new satellite measurements that allow us to see the wind stress and ocean currents on finer spatial resolutions than have previously been possible. They reveal an important new effect. The stress depends on the difference between wind speed and ocean current, although in calculating the stress the much slower currents are often ignored. However, the effect of the currents is always to reduce the power input into the ocean, whichever direction they are in. Much of the energy in the currents is at small length scales, so we would expect accounting for the currents to reduce the power input by wind stress. The new satellite measurements allow us to see these small scales. They confirm that accounting for the currents reduces the power input by wind by 20%, to somewhere between 0.7–0.8 terawatts.

Will the Gulf Stream halt?

The Natural Environment Research Council research programme RAPID (2001–07) studied rapid switches in climate, with a focus on possible changes in the Atlantic Ocean’s overturning circulation. This overturning circulation is partly responsible for the existence of the Gulf Stream. By bringing warm waters from the tropics to midlatitudes it helps moderate European winters. Since 2004, POL has been taking part in the observational part of RAPID, supporting a line of deep ocean measuring instruments off the coast of Nova Scotia (Canada). Oceanographic expeditions in 2006 and 2007 to recover and redeploy these have given us three years of bottom pressure and deep ocean temperature and salinity data. We are analysing these valuable data at POL which will soon be released for use by the wider scientific community. POL continues this important research in collaboration with the Bedford Institute of Oceanography (Canada). Funding comes from the new NERC research programme RAPID-WATCH (2007–14).

Large volcanic eruptions and sea level

Large volcanic eruptions inject aerosols into the stratosphere. Over several years these gases cool the Earth’s surface. After major eruptions a drop in the heat content of the global oceans is seen. But measurements of the impact on global sea level are not convincing. Svetlana Jevrejeva and colleagues investigated the impact of major volcanic eruptions on global sea level. Using data from about 1000 tide gauge stations they looked at the five largest eruptions in the last 150 years. Contrary to model results, the data show a significant rise followed by a dip in sea level. The rise and much of the dip cannot be explained by changes in heat content affecting ocean volume. A modification of the global water cycle produces changes in the mass of the ocean. The associated result is a large part of sea level change. These changes in sea level are similar in size to those caused by large El Niño events.
Migrating water

Just as some birds make annual journeys, large volumes of water move between the oceans and the continents every year. Globally-averaged sea level reaches its lowest value during the Northern Hemisphere’s winter. This is when the continents store more water in the form of snow. However, the oceans do not go up and down uniformly around the world. In coastal areas where large volumes of water are stored – such as Bangladesh during the rainy season – the added mass of the stored water depresses the land. This produces a gravitational attraction that pulls more ocean water to the region, causing sea level to rise. Mark Tamisiea examined the balance between these local effects and the background, averaged signal at tide gauge sites. Better understanding of this part of sea level variations can help to remove the year-to-year variability in tide gauge data used to determine long-term sea level rise.

Global warming and waves

Judith Wolf and James Leake have examined the effect of climate change on waves in the North Atlantic and UK waters. They used two possible future climates: one representing a ‘medium high’, the other representing a ‘medium low’ emissions future. They ran wave models for different time periods. The ‘present-day’ (1960-1990) period was driven by Met Office/Hadley Centre winds for a simulated present climate for comparison with another simulation for a ‘future’ time (2070-2100). On the Atlantic scale, increases in mean and extreme winter wave heights were forecast for both future climates. A strong positive change was forecast for winter in the NE Atlantic and SW of the UK for both mean and maximum wave heights. The increased wave height in the NE Atlantic was accompanied by a reduction in the mid-latitudes of the North Atlantic. This spatial pattern agrees with previous studies. The ‘medium high’ emissions future shows stronger changes because of its larger increase in winter storm intensity and frequency. In the southern North Sea increases in mean, maximum and extreme winter wave heights were forecast for both future climates, except very close to the UK coast. In general, wave heights decreased in the seas to the north of the UK. The changes in winter wave heights will have a significant effect on the forecast coastline morphology. Average wave energy reaching the coast and extreme wave heights hitting the coast will increase leading to greater coastal erosion. This work, done in collaboration with the Tyndall Centre for Climate Change Research Coastal Simulator project, will produce a GIS-based tool for coastal managers with a pilot project focused on the Norfolk coast.

Polynyas and climate

Polynyas are irregular openings in the winter sea ice cover of the polar oceans. They range in size from 10 to 100km and play an important role in climate. Polynyas warm the atmosphere and thus moderate polar winters. Also, as sea ice grows inside polynyas, the surrounding ocean becomes denser. This denser water sinks and forms the deep waters that are part of the global oceanic inter-hemispheric circulation. In the Arctic, most polynyas form near to coasts – created by the offshore transport of ice by winds. Ian Walkington from the University of Liverpool and Miguel Maqueda and Andrew Willmott from POL have developed a new mathematical model of polynyas. The model, based on conserving ice mass and momentum, predicts polynya evolution under various environmental conditions. It is more realistic than traditional polynya models based solely on conserving ice mass. While these admit polynya solutions that open to a steady state in hours to days, the new model creates polynyas that open much more slowly, or even indefinitely. Its predictions show that polynyas might produce larger amounts of ice and dense water than previously expected.
Tides and ice in the Arctic

Global Climate Models used to make future climate predictions do not include tides in the ocean physics. Does this matter and how does including tides affect the ice and ocean circulation in computer models? Using POL's coastal ocean model system (POLCOMS), Clare Postlethwaite studied the Arctic. The effects of including tides are complicated, with some areas growing more ice and some less. The Pechora and White Seas have up to 25% less ice when the model includes tides. As tides move ice away it meets deep warm water brought to the surface, also by the tides and melts faster. Other regions like the islands of Svalbard, have up to 10% more ice. This happens when the tides make large cracks in the ice, giving space for new ice to form. Clare is now looking at how these changes affect ocean circulation and will soon be expanding the work to cover the whole Arctic.

Happy birthday

Transporting 625 times more water a year than the Amazon River, the Antarctic Circumpolar Current (ACC) is the mightiest current in the ocean. The ACC is the only current connecting the three major oceans – Indian, Pacific and Atlantic. Because of its depth (2000–4000m) and width (1000–2000km), it contributes to isolating Antarctica from the rest of the world.

The Drake Passage is the region of the ACC between South America and Antarctica, a strategic point for global ocean circulation. Here the ACC is constricted to its narrowest and so is ideal for measuring its water transport and variability. This requires measurements of north-south bottom pressure differences across the entire width of the current. With this in mind, POL first deployed pressure recorders in the Drake Passage in 1988. Now, on the 20th anniversary we celebrate having built one of the longest and most important deep-ocean datasets in the world. We hope to continue this important long time-series well into the future.

Excited eddies in the Southern Ocean

The Southern Ocean is the region around Antarctica, where the world’s largest ocean current – the Antarctic Circumpolar Current – connects the major oceans together while isolating Antarctica. Strong eastward winds blow over this current, and in recent years these winds have become stronger. Simple computer models suggest that this means colder surface temperatures in the Southern Ocean, as the effect of the winds is to push cold surface water northwards across the current. However, observations show the opposite: the Southern Ocean has been warming.

Chris Wilson is working with colleagues from the Australian National University, British Antarctic Survey, and the National Oceanography Centre, Southampton. He is using a computer model of the ocean to show that this warming effect is caused by eddies. Stronger winds put more energy into eddies, which then become more effective at mixing warm water across the barrier formed by the Circumpolar Current, into the Southern Ocean. Most climate models do not allow eddies to form. It is important to understand this mechanism so a way of simulating the effect of eddies can be devised enabling the model ocean to respond correctly to climate change.
Our coastal and shelf seas are vital for shipping, fisheries, aggregates, renewable energy, and leisure. But our coastal environment also receives waste water, nutrients and contaminants. To understand the complex continental shelf marine system we are developing computer models based on observations of processes on scales ranging from the global impacts of shelf seas to the details of how sediments are moved around our coastline.

Rob Hall and John Huthnance, with Ric Williams from the University of Liverpool, study water mixing on the continental slope north of Scotland. In September 2005, on a POL-led cruise with participants from the Scottish Association for Marine Science and the Netherlands Institute for Sea Research they measured this mixing. They found detailed profiles of density show vertical mixing at up to a hundred times the background rate of the open ocean. Warm Atlantic water (above 500–600m depth) sits on top of cold Nordic Sea water. Waves travel as undulations along the boundary between the two waters. These waves have enough energy to carry out this vertical mixing. There is also much tidal energy. Shorter waves also contribute significant energy to mixing. They have to lose their energy as the Atlantic/Nordic waters’ boundary comes against the continental slope – rather like surface waves breaking on a beach.


2. A schematic of wave energy fluxes (excluding depth-average tidal currents) on the slope north of Scotland (white bars), against a background of density (colour and values) and orientation of wave currents at the main tidal frequency $M_2$ (black lines).
Oceanography from sound

Geophysicists use seismic sounding to show layering below the sea floor. A recent finding is the technique also shows layering within the sea – mostly where temperature changes abruptly. Ruben Alvarado and John Huthnance are taking part in the ‘Geophysical Oceanography’ project to assess and interpret this oceanic imaging. With part EU-funding the project has partners in Durham, Germany, France, Portugal, Spain and Italy. If validated, the method would give oceanographers an unprecedented combination of spatial coverage and detail of internal structure.

Tidal cycles and biology in our shelf seas

Jonathan Sharples researches the possible effects of the spring-neap tidal cycle on the biology of shelf seas. Changes in the sea depth and strength of tidal currents lead to some regions of our shelf seas being continuously vertically mixed all year. Others develop a warm surface layer during summer. The boundaries, called ‘fronts’, between these regions are often sharp and clearly seen in satellite images of sea surface temperature. These fronts are sites of increased biological activity during summer, with increased growth of plankton providing food for fish and seabirds. In UK shelf seas, tidal currents change by a factor of 2 between spring tides and neap tides.

Our partners got good seismic images of structures in the water column. For comparison, hundreds of XBT profiles were taken during the seismic recordings. The data show strong but variable Mediterranean Water flow along the slope and suggest that near-bottom profiles and turbulence differ between spring and neap tides.

This equates to almost a factor of 10 change in the amount of turbulent mixing. Jonathan wants to know how such a dramatic change in the physics at a front might affect biological production. By using a simple computer model he shows that including the spring-neap tidal changes in current speeds at the front leads to a widening of between 2 and 6km of the average front position. This gives about 70% more plankton production compared to a model that does not include the spring-neap effects. This important result has implications for POL’s modelling of the physics and biology of our shelf seas. Any shelf-wide computer model that aims to accurately simulate the impacts of fronts on biological production needs to be able to include that distance.
Sound images, moving sand and the triad

The transport of sediments continually alters the boundary between the land and the sea, changing and reshaping its form. For over half a century we have been trying to understand the physics of sediment transport. Sediment movements can be thought of as a triad – the interactions between the bed, water flow and moving sediments. For example, flow separation and vortex generation because of flow over ripples on the seabed influences sediment suspension. The shape of the ripples also contributes to flow resistance and the flow structure near the bed. The ripples themselves are a product of the local sediment transport. Peter Thorne with Alan Davies of Bangor University measured this triad using innovative techniques based on sound. They are developing new insights into why and how sediments move. Their acoustic measurements are used to assess recent developments in modelling sediment movement. Peter and Alan expect that these observations, coupled with developing theoretical ideas, will make further steps towards the elusive goal of predicting our evolving coastline and estuaries.

Ben Moate has made significant progress in verifying the acoustic backscatter characteristics of irregularly shaped inorganic sediment suspensions having broad particle size distributions (PSDs). Measurements have been collected for the first time on various broad PSDs. These include log-normal, bi-modal, and top-hat, and show close agreement to theoretical predictions. This work has recently been extended to encompass sediment suspensions with broad PSDs consisting of multiple mineralogical constituents. These suspensions more accurately represent natural seabed sediments.

Wave signals travel the Atlantic

Satellite altimetry clearly records sea-surface undulations on the western boundary of the North Atlantic, coinciding with the path of ‘coastal trapped’ waves over the continental shelf and slope. These waves are important as they provide the means by which a change in one part of the ocean can lead to changes elsewhere. They control how quickly distant regions respond. Eleanor O’Rourke has used numerical modelling to calculate the form of the waves and the speed at which they travel – anticlockwise around the North Atlantic Ocean. She found the waves can travel at several metres a second. And their shape and speed are sensitive to the sea floor slope between the shallow shelf sea regions and the deep ocean. Coastal trapped waves do not explain all the altimetry sees and research continues using an idealised Atlantic set-up of a general ocean circulation model.

Liverpool Bay and Dee Estuary

Andy Lane, Alex Souza and our modelling team have produced the first computer simulation of Liverpool Bay using a fine resolution (180m grid) model with a new wetting and drying scheme. As the tide comes in water covers the beach (wetting) and as the tide recedes the beach reappears (drying). Using new LIDAR bathymetry, this scheme allows accurate tidal simulations in an area with a large inter-tidal zone including the Mersey, Dee and Ribble estuaries.

POL’s newest monitoring platform – Sediment Transport and Boundary Layer Equipment (STABLE III) – makes near-bed sediment transport measurements in shallow water. Deployed for the first time in the Dee Estuary in 2007, it uses the latest acoustic and optic instruments to measure suspended sediments. It has an acoustic ripple scanner to measure bed forms and acoustic Doppler systems to measure flow. STABLE sits on the seabed for months. It quietly uses sound and light to measure the interacting sediment triad of the bed ripples, flow and sediment movement. We are using these measurements to test our latest sediment transport models.
Radar’s eye view of the seabed

With a peak spring tidal range exceeding 10m, the Dee estuary has a complex system of sandbanks and channels. To understand how the estuary is evolving it would be helpful to regularly see the positions of the sand banks and channels and the waves and currents creating these features. Paul Bell has mapped the bathymetry and tidal currents in the estuary by analysing marine radar (X-band) image sequences. Located on an island in the estuary, a marine radar records ten minute sequences of sea surface images once an hour to 4km with 7.5m grid spacing. Provided waves are visible on the radar images, by fitting a wave dispersion equation to the recorded wave behaviour the water depth and mean current are mapped with grid spacing of about 100m. Comparing survey data with water depths and currents measured using this new technology, the radar derived depths are within +/-1m of the survey data.

Extreme sea levels

We need information on extreme sea levels because of development pressures in flood risk areas and the increased flood risk related to climate change. Storm surges are the sea surface response to strong winds and atmospheric pressure. Kevin Horsburgh and Chris Wilson have been working with scientists at the Hadley Centre for Climate Prediction and Research. To estimate the future storm surge climate around the UK, they are combining computer models of storm surges with regional climate models. Climate model predictions contain much uncertainty, so they used an ensemble approach where key atmospheric parameters were perturbed over 17 different model runs.

Increased computer power means the team were able to improve on previous work by analysing full 150-year model runs, rather than short time periods. They found that 21st century changes in the storm surge component of extreme sea level were small. And that change in mean sea level should be of most concern to engineers and planners. Projected changes in mean sea level are not geographically uniform. So, to estimate the implications for the UK coastline, the team had to combine global expansion of sea level with ice melt terms and local land movement. For the southern North Sea an average change in sea level between today and 2100 is estimated to be 0.5m.

Some of the global climate models used by the Intergovernmental Panel on Climate Change (IPCC) project larger changes in European storminess. Kevin and Chris are doing more work to assess the differences between these forecasts and our ensemble of models.
Technology is fundamental to our ability to make observations. The need is for reliable platforms with instruments that measure the required parameters and appropriate data communications. While there has been tremendous progress over the last two decades, many science goals are elusive because we do not have the tools to make the necessary observations and measurements. Our work here targets developments for specific science requirements and looks to long term needs.

Phytoplankton absorb carbon dioxide through photosynthesis and are a primary source of food for fish. Concentrations of these basic marine plants can be in patches of a kilometre or less across. The traditional succession of individual measurements from a ship does not distinguish them. In addition, much summer plankton growth concentrates in a thin layer which is below a surface layer where nutrients have been used up by earlier plankton, but where there is still enough light to enable growth. We want to collect data from these layers to try to understand the structure and movement of the phytoplankton patches. To distinguish the patches we need measurements a few tens of metres apart in the horizontal and a few metres apart in the vertical.

Mike Smithson and Dave Jones have designed a ‘chain’ of instruments (fluorometers to measure chlorophyll and temperature recorders) for towing behind a ship. The design is simple with self-recording instruments attached to a wire. Although the instruments need to record at the same time, modern timing is accurate enough that they can be independent rather than synchronised. This significantly reduces the complexity of the chain and makes for much easier deployment. A heavy weight (depressor) at the bottom end of the chain keeps it as vertical as possible. Although the chain will stream out at faster towing speeds, pressure sensors on some instruments allow us to calculate their depths. A crucial part of the development has been the design of a special clamp for attaching the instruments to the wire. This should reduce the time for deployment (and recovery) from two or three hours to about ten minutes.

The chain with 30 instruments was ready for trials in April 2008 before its planned use for scientific measurements in the Celtic Sea in the following July.
Indian Ocean Tsunami Warning System

After the disastrous Indian Ocean tsunami in December 2004, the Intergovernmental Oceanographic Commission has been leading efforts to develop an Indian Ocean Tsunami Warning System. They need frequent data (every minute to detect tsunamis) almost immediately (in near-real-time to provide maximum warning). POL pioneered the use of the Broadband Global Area Network (BGAN) to retrieve sea level data from remote locations. Peter Foden, Jeff Pugh and Simon Holgate developed the instrumentation, taking advantage of the global broadband internet connection offered by BGAN. In cooperation with Inmarsat (the owner and operator of BGAN) prototype instrumentation has been successfully tested at Gladstone Dock in Liverpool. Further test stations are planned for Trincomalee, Sri Lanka and Ascension Island in the South Atlantic. See also Permanent Service for Mean Sea Level, page 25.

Telemetry – data from afar

We want to receive data from instruments in the sea and at remote locations without waiting for their recovery. We want to control remotely their data-recording pattern, e.g. to concentrate on periods of particular interest.

MYRTLEX is a prototype deep ocean lander that can remain on the sea bed for up to ten years. Using the latest developments in acoustic and satellite telemetry, MYRTLEX could be the core of a deep ocean observatory network, allowing bottom mounted instruments to be interrogated and controlled remotely from the laboratory. MYRTLEX is equipped with a series of ‘data capsules’ which can be released from the sea bed and float to the surface. Data can then be transmitted back to POL in Liverpool.

The POL Data Telemetry Buoy complements ocean bottom mounted instruments like MYRTLEX and Irish Sea Coastal Observatory instrumentation. This telemetry relay provides the vital real-time connection back to the laboratory, needed to monitor and change the mode of operation of instrumentation on the sea bed. The buoy can accommodate a range of telemetry systems. Acoustic modems are used to transfer data and commands between surface and sea bed and radio telemetry is used to relay data back to the base station at POL.

Steve Mack and Chris Balfour carried out telemetry trials using MYRTLEX and the Telemetry Buoy on RRS Discovery in the Celtic Sea in September 2007. This was the first cruise specifically for instrument research and development for the NERC Oceans 2025 Programme. Commercial Benthos and LinkQuest deep sea acoustic modems were successfully tested for long distance underwater data transfer. They were also linked via BGAN and Orbcomm to monitor data and demonstrate our ability to re-configure deep ocean instruments remotely. From POL we could monitor and control sea bed logging of temperature sensors or current profilers, etc. Remote data transfer from MYRTLEX data capsules, using Iridium, Orbcomm and BGAN, was shown to operate correctly.

Microlander

Microlander is the patented, POL-designed frame for easy deployment from a standard launch tube, unfolding to a stable sea-floor instrument platform. Trials were carried out in Loch Etive near Oban during November 2007 using the SAMS research boat Seol Mara. The trials were very successful. Free-fall, release and recovery tests were carried out in up to 120m water depth. Additional tests were made using the newly developed launch-tube and telemetry systems. Results of the trials have been sent to the company that has manufacturing rights for Microlander.
Computer models are important tools for studying the marine environment. As an international leader in modelling coastal and shelf seas we use models to explore how different processes interact; explain changes and forecast the future. We use model systems including POLCOMS (POL Coastal Ocean Modelling System) and NEMO (Nucleus for a European Model of the Ocean) and are developing them to improve their accuracy and capability.

Mathematical models are important tools in studying properties of the sea, such as water temperature and currents. The models use grids, their size ranging from meters to hundreds of kilometres depending on the properties we are studying. Recently, we have been studying the relationship between turbulent mixing and internal waves. Internal waves are caused by the ocean's internal density differences as opposed to the waves on the ocean's surface. This needs models with fine resolution grids and including many detailed processes. Prof Jarle Bernsten, of Bergen University, recently spent a year at POL working with Jiuxing Xing and Alan Davies studying the sensitivity of model results to the grid size and treatment of mixing. They examined internal waves created at a steep sill because of tidal flow and found that depending on certain conditions, namely super-critical (strong current), results are sensitive to grid sizes, but under other conditions, namely sub-critical (weak current), results are much less sensitive. Different mixing schemes can influence tidal energy going into irreversible mixing, which also depends on different conditions of the flow. These results can help us to design better and more efficient numerical models.

1. Water mixing (shown by temperature) created at a steep sill, showing sensitivity of results to model grid size. The upper panel has a 100m grid, the lower 12.5m.
Eric Jones and Alan Davies have recently completed a computer modelling study of the Irish Sea. They wanted to find out if past ‘forecasts’ of the motion of the sea could be equalled, or improved on, using the best computer models available today. The focus of the study was a storm surge in the Irish Sea during November 1977. The event, modelled in the 1990s, used the best computer models available then. The new models using new techniques are just as good and have some significant advantages. These include: improved representation of coastlines; less computing time; and are easy to extend. Scientists will be using these new modelling techniques to give better warnings of damaging storm surges in the coming years.

Convection in shelf seas

Most of the world’s oceans are temperature stratified so water temperature is higher near the surface than at depth. However, in the shallow waters of continental shelves, tide and wind mixing makes some regions well mixed throughout the year, others only stratify in summer. Being able to model the distinction between these regions is critical to accurate forecasts of physical and biological properties of these seas. Jason Holt with Lars Umlauf (Institute of Baltic Sea Research, Warnemünde) have recently coupled POLCOMS to the General Ocean Turbulence Model. The coupling significantly improves modelling of fronts between well-mixed and seasonally stratified water, particularly the variations between spring- and neap-tide conditions. This work shows how important ‘shear-induced convection’ is in finding out the mixing properties of shelf seas. This process involves vertical changes in velocity and horizontal gradients in temperature moving denser water over lighter water, which causes mixing. This process has previously only been associated with near coastal regions of freshwater influence.

Carbon fluxes in shelf seas

Because they are shallow and close to the land, shelf seas are regions of exceptionally high biological production. They account for about 15% of the phytoplankton (microscopic plants) growth of the whole ocean in about 7% of the area. As in the open ocean this leads to a high draw-down of carbon dioxide from the atmosphere. But in shelf seas this carbon is not as easily lost from the system because it cannot simply sink into the deep ocean. Using multiyear simulations of the POLCOMS-ERSEM coupled hydrodynamic ecosystem model we studied the carbon fluxes on the North-west European continental shelf. These show the shelf seas are an efficient exporter of carbon to the deep ocean. Despite most of the phytoplankton growth decomposing and returning its carbon back to the water, the circulation pattern flushes this water, high in dissolved inorganic carbon, off the shelf into the deep ocean.
Our Coastal Observatory is presently in Liverpool Bay but we have plans to incorporate the rest of the Irish Sea. It is set up to study the environment of a typical coastal sea and how it responds to change, especially climate change. We are continuously developing and testing the observatory that gathers, forecasts and displays measurements in real-time.

The Coastal Observatory consists of measurements, numerical modelling and a web display. There are five main measurement strands, each with complementary time and space characteristics:

a) Fixed-point time series – in particular two mooring sites, measuring currents, waves, temperature and salinity; a met station on Hilbre Island and tide gauges.

b) Spatial surveys of water column properties nine times a year using RV Prince Madog.

c) An instrumented ferry, the Liverpool Viking, which daily completes a round trip between Birkenhead and Dublin.

d) HF radar measurements of surface currents, waves and winds.

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

The measurements started in August 2002 and now span over five years, involving 50 cruises. The measurement suite is augmented this year with pCO₂ and dissolved oxygen sensors. An underwater glider has been purchased.

1. The Coastal Observatory MapViewer allows you to get information contained within the monitoring and modelling parts of the website using an interactive map based system.
Stratification

Liverpool Bay is shallow (mostly less than 50m), has strong twice daily tidal currents (over 1ms^-1 at spring tides) and receives significant fresh water from the rivers Conwy, Clwyd, Dee, Mersey and Ribble. Consequently, the water column stratifies intermittently on tidal, spring/neap and monthly timescales. Persistent stratification rarely lasts longer than a few days. Studies of the vertical and horizontal gradients of temperature and salinity show that Liverpool Bay stratifies about 50% of the time. This is usually through a combination of the near surface water being warmer (spring and early summer) and fresher. In autumn and winter the near surface water is cooler (therefore potentially heavier) than the near bed water for about 12% of the time. Stability is maintained since the surface water is fresher than near the bed. Mostly, the near shore waters influenced by run-off from the rivers, are fresher than offshore waters but for about 5% of the time this is not so. This reflects changes in the wind-driven part of the circulation. Water column structures contrast with region – near Anglesey it remains well mixed throughout the year because tidal currents are stronger. To the south-west of the Isle of Man where tidal currents are weaker and water depth greater, the water column stratifies in summer. This horizontal and vertical variability is important for exchanges between estuaries and the sea but makes forecasting challenging.

Non-tidal currents

Semi-diurnal tides dominate the dynamics of the Irish Sea. We have studied the non-tidal dynamics of Liverpool Bay by combining Acoustic Doppler Current Profiler, HF radar and pressure recorder measurements. The main conclusions are:

a) There are persistent long-term mean currents, shoreward near the bed and offshore near the surface with speeds of about 0.05ms^-1, weaker at middepth, driven by the horizontal density gradient (see 2006–07 annual report).

b) The depth-averaged wind/storm driven currents are weak, rarely exceeding 0.3ms^-1, probably because Liverpool Bay is semi-enclosed. The HF radar near surface currents have a strong correlation (~0.7) with the winds with an amplitude of just less than 1% of the wind speed. In contrast the currents at depth don’t correlate with the wind.

c) Significant energy is still present at tidal frequencies in the residuals, after subtracting estimates of the coherent tides, for both currents and elevations/pressures. This is because of the strong tides and weak residual currents.

d) There is no energy at the inertial frequency. These currents, with a 14.9 hours period for Liverpool Bay, are common near surface in stratified waters. Perhaps high-level tidal mixing prohibits their generation.

Liverpool Bay model

A suite of computer models stretches from the Atlantic Ocean to the north-west European shelf at 7km horizontal resolution. This continues to the Irish Sea at 1.8km resolution and on to Liverpool Bay a resolution of 180m. Accurate local predictions need resolution of at least 180m. However, including surfacing and covering of sandbanks as the tide rises and falls is demanding. The Liverpool Bay model has been run for tidal forcing and tested against surface currents measured by the HF radar system. Its development will incorporate wind forcing, river discharges and forecasting suspended sediment movement.
The National Tidal and Sea Level Facility (NTSLF) is the UK centre of excellence for sea level monitoring and coastal flood forecasting. We advise policy makers, planners and coastal engineers on the impacts of sea level rise.

Rising sea levels and possible changes to our storm climate have marked implications for coastal protection and marine management. Managing the risk and developing the best forecasting systems, demands a thorough understanding of the science that controls sea level rise, storm surges and coastal flooding.

The NTSLF manages precision, real-time tide gauges at 44 sites around the UK. Sophisticated telemetry systems make the data available for operational coastal flood warning. With university partners we also use GPS technology to measure vertical land movements resulting from melting of the glacial ice sheets.

Our engineers develop advanced communications electronics that allow sea level information to be transmitted by satellite and over the internet. They evaluate and use new techniques for sea level measurement, including radar and acoustic instruments. The NTSLF is of strategic importance to government, local authorities, the public and the scientific community. We are also responsible for monitoring sea level in the British Overseas Territories, and at strategic sites in the south Atlantic, as part of our contribution to international climate research.

1. The UK tide-gauge network. UK image courtesy World Wind/NASA Earth Observatory.
2. Performance of the numerical model (solid line) compared to tide gauge observations (crosses) at Lowestoft and Sheerness for 8–11 November 2007. The graph shows the surge height in metres, red diamonds denote the times of high water.
Warning systems

Storm surges are the effect of the weather (low atmospheric pressure and strong winds) on the sea surface. They can raise sea level by 2–3m. We need storm surge warning systems to guarantee the safety of coastal communities and reduce economic loss. Jane Williams, Chris Wilson and Kevin Horsburgh are responsible for improvements to computer models used for coastal flood warning. These models run four times a day at the UK Met Office, forecasting up to two days ahead.

On 9 November 2007, the east coast of the UK experienced the worst storm surge for 50 years. The fear was this event would be as bad as the North Sea storm surge of January 1953 that was responsible for 2000 deaths in England and the Netherlands. During the November surge, the modelling system provided accurate estimates of water levels throughout the whole event. Using the most accurate wind forcing the forecast surges were accurate to within 1cm at Lowestoft (where some minor flooding did occur) and 8cm at Sheerness. Accurate predictions for Sheerness are important since they decide the closure of the Thames Barrier.

At the time of the storm an ensemble surge forecasting system was under evaluation. Ensemble forecasting measures the inherent uncertainty in weather prediction, by making multiple numerical simulations giving confidence to those responsible for the emergency response. For this event, there was no significant change in flooding when the most extreme forecast was chosen. Although it is clear the surge prediction model performs well, future improvements include data assimilation of real-time tide gauge data and coupling the effects of wind waves and storm surges.

UK contribution to GLOSS

POL maintains several tide gauges throughout the South Atlantic and Antarctic oceans. The records of sea level produced by these gauges represent an important contribution to the Global Sea Level Observing System (GLOSS) as there are few islands in the Atlantic Ocean in comparison with the Pacific. Island records tell us about sea level far from the coastal ocean where most tide gauges are located and are especially useful for calibrating sea level measurements made by satellites. Sea level measurements at these remote locations also allow POL to provide accurate tidal predictions for the inhabitants of British Overseas Territories.

During 2007 we installed a new tide gauge at King Edward Point in South Georgia. The last time there was a tide gauge here was 1959. Now, thanks to satellite communication, data is received by POL and updated on our website every 10 minutes – see: http://www.pol.ac.uk/ntslf/networks.html

In 2007 we also:
• upgraded the system at the British Antarctic Survey base at Rothera to send data in near real-time
• repaired the tide gauge at the Ukrainian run Antarctic base of Vernadsky, enabling data to be sent back in near real-time via Geostationary Operational Environmental Satellites
• installed a new transmitter at Port Stanley in the Falkland Islands to send back data via Meteosat
• made a brief maintenance call into Signy Island.

The Tide Gauge Inspectorate – Dave Smith, Les Bradley and Darryn Gaudie – continued with the programme of refurbishment, maintenance and development at the 44 sites of the national tide gauge network. All but Hinkley Point now have new data-logging systems. Real-time data availability throughout the year was 97%. At Immingham, the tide gauge building was removed because of engineering work at the dock entrance. Installation of a temporary tide gauge ensures data continuity. On completion of the engineering work the gauge will be resited at the dock entrance. Other major projects included moving tide gauges at Liverpool and Lowestoft in response to quayside alterations. A new gauge at Portbury will replace the important tide gauge – sited on an ageing jetty – at nearby Avonmouth.
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.

Freely available geospatial applications provide an easy, cost-effective method for communicating data to many audiences. The exciting element of such systems is their ability to simultaneously display diverse data from different sources, known as mash-up data, thus revealing new information and knowledge that would otherwise be hidden.

Currently, our National Oceanographic Database (NODB) index includes 53,164 data series from 125 different organisations. Within our data request area you can build your search, select data series, view your selection on an interactive map, modify your selection and opt to receive the data as BODC netCDF and/or ASCII format before submitting your final request to us for processing. We have recently included a facility to deliver a Keyhole Markup Language (KML) for use with freely-available geospatial applications to display information. Combined with a document server URL allowing the viewing of full metadata reports, this makes an ideal data browsing tool.

The facility is available for all data within our National Oceanographic Database (NODB). It includes physical, geophysical, chemical and biological measurements from the sea, land and air. Within a year all our data holdings comprising more than 100,000 series and over two million unique measurements will be available for viewing and download via the web.
In order to provide, and respond, within a changing climate, to, the evidence required for sustainable development within a clean, healthy, safe, productive and biologically diverse marine ecosystem the UK maintains a network of monitoring systems.

The United Kingdom Directory of Marine Observing Systems (UKDMOS) is a searchable database of marine monitoring activities and is available to browse at www.ukdmos.org.

This new internet-based tool allows searching for monitoring programmes to help coordinate monitoring across different organisations. UKDMOS contains metadata on parameter groups measured, frequency, start dates and other fields which can be searched spatially using GIS. UKDMOS is for the whole marine community and specifically a key output for the UK Marine Monitoring and Assessment Strategy (UKMMAS). The technical build of the directory has relied heavily on outputs from the EU funded SeaDataNet project (www.bodc.ac.uk/projects/european/seadatanet) and the submission of content is funded by the Department for Environment, Food and Rural Affairs (Defra) and the Scottish Government. Updating of content is expected to be completed once a year between November and February when monitoring programmes for the following year have been drafted, however, updates will be accepted at any time.

The monitoring programmes in UKDMOS may also be searched and viewed with other European monitoring programmes in the European Directory of the Ocean Observing System (www.bodc.ac.uk/projects/european/edios).

Contact ukdmos@bodc.ac.uk for further information.

A new portal enables users to find data held in the managed archives connected to the NERC DataGrid (NDG) catalogue (http://ndg.nerc.ac.uk/discovery). It provides ‘discovery’ metadata (information about data sets), harvested regularly from the NERC Data Centres and other providers in the UK and worldwide.

There are entries for marine sciences, atmospheric sciences, earth sciences, earth observation sciences, polar sciences, terrestrial and freshwater sciences and hydrology. You may search by entering terms as free text and/or restricting temporal and spatial coverage. The Service employs the NDG vocabulary server to provide a semantic search, allowing you to maximise your returns by selecting an alternative, related search term.

This is the first step toward an integrated data delivery system. Future enhancements may eventually enable users to compare and manipulate data from many sources.

1. The GEBCO World bathymetry is hosted by BODC: www.gebco.net or www.bodc.ac.uk/projects/international/gebco.
2. Data collected by the British Antarctic Survey at Rothera and available from our National Oceanographic Database.
Working for the marine community

Making information and knowledge available to the marine community is a key element of BODC’s role. We have pioneered a proactive approach to managing complex multi-disciplinary 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. Much of the data has been paid for by public funds. BODC stores the information securely and promotes its continued use.

In 2007–08, BODC:

- handled 75,000 enquiries
- received 194 sets of data, from 36 organisations in 12 countries
- published the National Tidal and Sea Level Facility annual report for 2006 (www.pol.ac.uk/ntsll/reports.html)
- launched a new web service providing an international inventory of moored current meters (over 32,000 records from 140 organisations in 22 countries) held in our National Oceanographic Database (see www.bodc.ac.uk/data/information_and_inventories/current_meters).

We answered enquiries from organisations and private individuals engaged in leading-edge science, students working on research projects in universities and schools, offshore industry impact studies and wealth creation, as well as requests for information to help central and local government meet statutory responsibilities.

4. One of over 6000 current meter series available from our National Oceanographic Database.

BODC maintains ‘Investors in People’ standard

BODC first achieved the Investors in People (IIP) standard in March 2002. We are delighted to have recently passed a post recognition review.

IIP is a national quality standard which defines good practice for improving an organisation’s performance through its people.

Our staff are our most important asset. We are dedicated to ensuring that they have the right knowledge, skills and motivation to work efficiently.

The IIP assessor reported that BODC’s key strengths include:

- continued organisational planning – including consultation and input from employees
- effective management support at all levels across the organisation
- planned training and development activities
- equal opportunities to contribute ideas
- good communication activities
- a good team environment with staff feeling valued and appreciated for their efforts.

Investors in People is a continual assessment and we are likely to be reviewed again 2011.
National support – monitoring air-sea carbon flux

Atmospheric carbon dioxide (CO₂) plays a crucial role in regulating the Earth's temperature. Concentrations of CO₂ are 40% greater than pre-industrial concentrations and at their highest in human history. Their rise is directly due to activities such as the burning of fossil fuels (e.g. coal, petrol) and large scale changes in land use (e.g. deforestation). The rapid rise of CO₂ in the atmosphere has been directly linked to observations of global warming at the Earth's surface.

The oceans have absorbed about one half of the rise and are moderating the impact of rising CO₂ on the climate. Understanding how the oceans' capacity to absorb CO₂ may change in the future is fundamental to improving climate change predictions.

CARBON-OPS is a NERC funded project (see www.bodc.ac.uk/carbon-ops) to develop an automated supply chain of ocean surface and atmospheric CO₂ measurements from selected UK research ships to operational end-users. Measurements and supporting data are sent in near real-time via satellite to Plymouth Marine Laboratory and then forwarded daily to BODC. Here they undergo initial automated quality control and processing, are displayed on the web and made available to the project partners.

Later, data are rigorously checked and the end products used for testing ocean carbon models and to develop environmental indicators of CO₂ uptake by the oceans together with the related impacts on global climate, ocean pH (acidity) and the health of marine ecosystems.

5. Sourced from Forster et al 2007 FAQ2. Atmospheric concentrations of important long-lived greenhouse gases over the last 2,000 years. Increases since about 1750 are attributed to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion air molecules, respectively, in an atmospheric sample. © Intergovernmental Panel on Climate Change (IPCC).

Building partnerships – managing marine data

As part of a coordinated approach to marine data management, BODC have entered into partnerships with the British Antarctic Survey (BAS) and the Sea Mammal Research Unit (see www.bodc.ac.uk/partners/introduction). Data will be loaded into BODC databases so that they will be searched and downloadable alongside our entire data holdings. Recent releases include: data from the long-term monitoring (January 1997 to present) of a nearshore marine environment close to BAS's Rothera base in the Antarctic and the delivery of real-time temperature; and salinity profile data from tags attached to seals for incorporation into Met Office models.

6. NERC Polar Research Vessel RRS James Clark Ross underway near the British Antarctic Survey base at Rothera in the Antarctic.

7. A Southern Elephant seal fitted with a SMRU tag for transmitting, by satellite, measurements of water column temperature and salinity.
The PSMSL is the international mean sea level databank. Since 1933 it has been responsible for the collection, analysis and distribution of sea level data from the global network of tide gauges. It is a member of the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) and operates under the auspices of the International Council for Science. It is supported by FAGS, the Intergovernmental Oceanographic Commission and Natural Environment Research Council.

The PSMSL, set up in 1933 as the global data bank for long-term sea level change information from tide gauges, celebrates its 75th anniversary in 2008. To mark this event we are organising or co-organising three special meetings and symposia.

The first is at the European Geosciences Union 2008 conference in Vienna in April and the second at the British Association Science Festival in Liverpool in September. PSMSL will also sponsor The Geological Society of London's William Smith meeting ‘Observations and Causes of Sea-Level Changes on Millennial to Decadal Timescales’.

PSMSL data set

PSMSL’s data holdings now total more than 56,000 station years from around 200 stations, with 1000 station years of mean sea level data received in 2007. In addition, PSMSL and the British Oceanographic Data Centre are working to bring together the higher frequency (e.g. hourly values) delayed mode sea level data with the mean sea level data set. This will improve efficiency and provide more effective data delivery.

Mean sea level data are being added from new tide gauge installations in poor coverage areas, such as Ocean Data and Information Network for Africa tide gauges. There have also been important data sets received from other data sparse regions, such as Indonesia and South America. Significant historic data sets have been added to the higher frequency data set from Norway, extending back to 1927. In addition, long time series have also be acquired for two of the French Global Sea Level Observing System sites, with the record from Brest beginning in 1860.
The PSMSL data set starts in the 19th century. Merging it with several much older sea level records – held by the PSMSL, but not in the ‘standard’ data set – has produced a new sea level reconstruction. The curve rebuilds global sea level (GSL) since 1700 and shows evolving GSL acceleration during the past 300 years. The observational evidence shows that sea level acceleration up to the present has been about 0.01 mm/yr and started at the end of the 18th century. Sea level rose by 6cm during the 19th century and 19cm in the 20th century. If the conditions that set up the acceleration continue, then sea level will rise 34cm over the 21st century. Long time constants in oceanic heat content and increased ice sheet melting imply the latest Intergovernmental Panel on Climate Change estimates of sea level are too low.

These findings are published in Geophysical Research Letters 2008.

Global Sea Level Observing System (GLOSS)

PSMSL plays a major role in managing the Global Sea Level Observing System (GLOSS). PSMSL actively took part in the 10th meeting of the Group of Experts on GLOSS, their particular involvement being in improving access to the sea level data streams.

IOC Fellowships

PSMSL hosted two scientists under the Intergovernmental Oceanographic Commission Indian Ocean Tsunami Warning System Fellowship programme. In September, Dr E M S Wijeratne from the National Aquatic Resources Research and Development Agency in Sri Lanka visited POL for a three-month fellowship. In October, Mr D Sundar from the National Institute of Oceanography in India arrived for a six-week fellowship.

Africa and Western Indian Ocean sea level data

PSMSL has been working with the Intergovernmental Oceanographic Commission (IOC) to improve the sea level network in Africa. We have carried out quality control and made available delayed-mode sea level data from several new and upgraded tide gauge stations around Africa and the Western Indian Ocean. These tide gauges are installed as part of the Ocean Data and Information Network for Africa (ODINAFRICA) programme and the Indian Ocean Tsunami Warning System (IOTWS).

Real time data transmission

In December, Philip Woodworth attended a ceremony at Inmarsat headquarters in London to mark signing an agreement between IOC and Inmarsat. Under this agreement, Inmarsat will provide Broadband Global Area Network (BGAN) transmission service for 50 sea level stations in the Indian Ocean. BGAN provides broadband data connectivity via communications satellites enabling transmission of sea level observation every minute. The current system using meteorological satellites transmits data every 15 minutes. Time saved by faster transmission represents significant progress; in the eastern and north-eastern Indian Ocean, a tsunami wave can hit the shore in about 30 minutes. PSMSL and POL staff were the first to suggest using BGAN to send sea level data and subsequently demonstrated its capability to improve the speed of tsunami warnings and therefore to save lives.
Our Applications Team are at the front line for dealing with all of POL’s enquiries from large commercial companies through to members of the public. A wide range of products and services will help you to get the most from our science.

The Applications Team

Tides past and present

POL has provided a national and international tidal prediction service since 1924. The modern methods of tidal prediction used throughout the world are based on the work of Dr Arthur Doodson who worked at the laboratory from 1919 up to his retirement as Director in 1960.

We have continued to develop and refine the analytical methods used to compute the tides. Coupled with advances in modern computer hardware and software, we have the most accurate tidal prediction system available.

Data are collected from the UK National Tide Gauge Network – developed and maintained by the National Tidal and Sea Level Facility at POL for the Environment Agency (EA). Analysed using the latest techniques they give us accurate harmonic constants – the basis of all tidal predictions.

The Applications Team are pleased with the award of a five-year contract to be the sole provider of tidal data to the EA, the Storm Tide Forecasting Service (STFS) and the Scottish Environment Protection Agency (SEPA).

The EA are responsible for issuing flood warnings for the UK and for managing the Thames Barrier – London’s primary defence against coastal flooding. The cost of getting this wrong could be as much as £30bn.

1. Our data has a wide range of uses: studying Nephrops Norvegicus, GBR Olympic bid, flood defence and renewable energy.
Scampi study

The Nephrops Norvegicus (Dublin Bay prawn, Norway lobster, langoustine or scampi) fishery in the Western Irish Sea is worth around €21 million yearly. PhD student Annika Clements, from Queens College, Belfast, used our POLPRED software in her study of Nephrops Norvegicus to try to find out the density of the Nephrops burrows. This information will allow for improved stock assessment. It also provides the basis for further research on the ecological niche and long-term sustainability of Western Irish Sea Nephrops Norvegicus.

Going for GOLD

Our long history of helping Britain’s sailing team (Team GBR) continued as we developed a custom version of our POLPRED software. This was specially configured with a model of the seas around Qingdao. In the 2007 pre-Olympic regatta, Team GBR topped the medal chart with five gold medals out of a possible eleven – Australia coming next with just two.

Weather reports showed that strong winds were present on only three of the eleven race days. This means the team’s knowledge of the tidal currents provided by POLPRED may have played a significant part in their success.

Energy update

The first version of the UK Marine Renewable Energy Resources Atlas published by the Department for Business Enterprise & Regulatory Reform (BERR, formerly the DTI) was a great success. Following this, they commissioned a project to produce an improved version taking account of latest developments. We provided a custom data set from our new 3D model at five depths which showed the potential electrical energy available from tidal currents. The atlas is freely accessible through a webGIS interface at http://www.renewables-atlas.info/
As part of the International Polar Year the University of Manitoba runs the Circumpolar Flaw Lead System Study (CFL), a multiyear Climate Change study in the Arctic. The CFL includes an exciting outreach programme allowing high school students to take part. As a partner in CFL (modelling Arctic Ocean circulation and sea ice), we were invited to choose a student and teacher for the two-week science expedition.

We ran a competition for a student to make a presentation on ‘The Role of the Arctic in Climate Change’. Out of entries from eleven schools, Emma Brown, from West Kirby Grammar School, won.

In March 2008, Emma and her teacher, Mandi Szuplewski, met the Inuit people of Tuktoyaktuk and Inuvik in the Northern Territories. With other students and teachers from Spain, China, Canada and the USA they learned about the diverse Inuit culture and how climate change is affecting the environment and their way of life.

Then, aboard the Canadian Ice-breaker CCGS Amundsem, guided by an international team of research scientists, the students and teachers carried out field experiments on the Arctic sea-ice and in the ship’s laboratories.

‘Life on-board the ice-breaker was brilliant, it made me realise this is what I want to do. I’m interested in science and this has brought home how important it is to do research that tells us about climate change. It was an experience I shall never forget,’ said Emma.

Since returning home, Emma and Mandi have given presentations to teachers and pupils at their school and held an open evening telling people about their experiences and research that helps us to understand how our planet is changing.

Mandi said, ‘It’s been a fantastic opportunity that neither of us ever dreamed we would have.’
**Nutrients down the Mersey**

Students from Childwall School, Liverpool, are seeing what life as a scientist is like by working with our researchers. Using data collected from our Irish Sea Coastal Observatory the GCSE Science students are finding out how nutrients from the River Mersey mix through Liverpool Bay. They are finding where the nutrients come from, how they vary over a year and how concentrations have changed as the Mersey becomes cleaner. They will visit the research ship *RV Prince Madog* during preparation for a survey of the Irish Sea and POL to discuss which may result in problems for fish.

The collaborative project, funded by the Royal Society, will be showcased at their Summer Science Exhibition in London in July. Jonathan Sharples says, ‘This is the third project I have worked on with Childwall School. It’s exactly the local outreach we aim to do with our Coastal Observatory. I find it great fun – the kids can have remarkable insights into marine science and really get a lot out of quizzing a “real” scientist.’

2. Emma Brown keeps warm in the Canadian High Arctic.

3. Mandi Szuplewski helps a research team drill down into the frozen ocean to extract a tubular ice-core.

4. Jonathan Sharples shows Childwall School students how waters of different densities mix.

5. Graham Tattersall shows why boats float at the Scientriffic show in Wrexham.

**A taste of outreach**

Chris Hughes had an article in the Sunday Observer about the Gravity and Ocean Circulation Explorer.

Kevin Korsburgh was interviewed for BBC Timewatch series, he was also interviewed for BBC News24 regarding the unusually large storm surge on the 9 November 2007.

We supervised three Nuffield students producing a range of publicity leaflets for the Coastal Observatory.

We supervised groups of work experience students from Liverpool and Wirral schools cataloguing data and producing posters explaining our research.

We exhibited to a family audience at the Blue Planet Aquarium.

POL scientists provided advice to the Royal Yachting Association supporting their preparations for the Olympic Games in China.

In November and December 2007, we took part in three one-day events for students aged 14–16, ‘Climate Change – Responding to the Challenge’. Organised by SETPOINT for The Institution of Engineering and Technology, the events aimed to encourage students to take an active part in the ‘Climate Change’ debate at school and at home. And inspire them to aim for a career in science, engineering, mathematics or technology. At the start of each session, TV personality, Johnny Ball, gave a talk on his take on climate change. Following this, students and teachers visited climate related exhibits.

Judith Wolf and Paul Bell staffed our stand at Aintree Racecourse, John Huthnance and Roger Proctor at the North East Wales Institute, Wrexham and Polly Hadziabdic with Phil Knight at Blackburn Rovers. Over 1500 students and teachers visited the events. Johnny’s talk and the displays created much debate. Our poster display – A Drowning World – explaining three climate change related topics: sea level rise, storm surges, and melting Arctic Ice. Other exhibitors included: Resource Efficiency Network, British Energy, Unilever, University of Liverpool, Lancaster University, Sefton Council, Merseytravel and the University of Central Lancashire.

While at the North East Wales Institute, we were invited to take part in Wrexham’s Science Festival in March. Here, Chris Hughes gave a well-attended evening lecture on climate and sea level. The following day at ‘Scientriffic’, a family science show, Eleanor O’Rourke and Graham Tattersall staffed our stand of hands-on demonstrations, poster displays and monitoring equipment. The hands-on experiments were a great attraction. Throughout the day there was always a large group of youngsters trying out the experiments, allowing parents to find out about our research – or just watch the fun.
Finance

Where we get our funding

From NERC (£k)

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External funding (£k)

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## Where we spend our funding (£K)

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<th>British Oceanographic Data Centre</th>
<th>POL Applications Team</th>
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## 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**
- Permanent Service for Mean Sea Level (FAGS, IOC, UNESCO and NERC)
- Development of radar altimetry data processing in the oceanic coastal zone (PSMSL) (ESA)
- Attribition of ocean climate change signals in the Atlantic (NERC (RAPID))
- Gravity improvement of continental slope and shelf sea ocean circulation modelling (ESA)
- Paleo-tide and wave modelling (Private sector)
- The determination of a new global GPS-derived surface velocity field and its application to the problem of 20th century sea-level rise (NERC)

**Shelf and coastal processes**
- Acoustic and optical backscatter from flocculating sediments (NERC)
- CoFEE (NERC)
- Development and Dissemination of Information on Coastal, Fluvial and Estuary Extremes (University of Bristol/EPSRC)
- EPSRC Floods (Defra)
- Estuarine Morphology (NERC)
- Field Observation and Modelling of the Sediment Triad (EA)
- Future proofing the surge model from changes in the Met Office forcing model (NERC)
- Geophysical Oceanography – a new tool to understand the thermal structure of dynamic oceans (University of Durham/EA)
- GRIDSTIX (NERC)
- HYDRAVLAB III (EU)
- Increased Frequency Sea Level Monitoring for Tsunami (EA)
- Marine Biogeochemistry and Ecosystem Initiative in QUEST (NERC)
- SURGE Modelling Ensemble Pilot Study (EPSRC)
- Sustainable Marine Biosources (NERC)
- Thames Estuary 2100 for Phase 2 review of storm surge scenarios (EA)
- TRANSFER (NERC)
- POL INERTIAL (University of Liverpool/NWDA)

**Science for sustainable marine resources**
- Marine Biogeochemistry and Ecosystem Initiative in QUEST (NERC)
- 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)
- Global Coastal-Ocean Modelling (NERC)
- Marine Environment and Security for the European Area (EU/NERC)
- Olympics 2008 (Royal Yacht Club / Met Office)
- Pre-operational model development (NERC)
- DUST UP (NERC)

**Sustained observation**
- UK tide-tide gauge network (NERC)
- Western Atlantic Variability Experiment (WAVE) (NERC (RAPID))
- Changing Coastlines; data assimilation for morphodynamic prediction and predictability (University of Reading/NERC)
- European COnsortium of shelf sea Operational observing and forecasting system (EU)
- Improved Drift Forecasting in Coastal Water (NERC)
- International Network of Coastal Observing Systems (NERC)
- The fate of freshwater in tidally stirred shelf seas (NERC)
Publications list
2007–08

ISI®-listed Publications


Other Refereed Publications


Staff lists

Proudman Oceanographic Laboratory staff

Directorate
Director
Prof Andrew Willmott
Prof John Huthnance – Deputy Director
Mrs Sian Coughlin – Accountant
Mrs Linda Ravera – PA to Prof Andrew Willmott

Sea Level Research
Prof Phillip Woodworth – Head
Dr Rory Bingham
Mr David Blackman
Dr Kevin Horsburgh – Director NTSLF
Dr Chris Hughes
Mr Miguel Morales-Maqueda
Dr Mark Tamisiea
Mrs Jane Williams
Dr Simon Williams
Dr Chris Wilson

Permanent Service for Mean Sea Level
Dr Lesley Rickards – Director
Mrs Kathy Gordon
Dr Simon Holgate
Dr Svetlana Jevrejeva
Dr Andrew Matthews

Coastal Processes Research
Prof John Huthnance – Head
Dr Laurent Amoudry
Dr Paul Bell
Dr Kyle Bettridge
Mr John Howarth
Mr Phillip Knight
Mr Andrew Lane
Mr Ben Moate
Dr Matthew Palmer
Mrs Rose Player
Dr Jonathan Sharples
Prof Peter Thorne

Modelling Research
Dr Roger Proctor – Head

Ocean Engineering & Technology
Dr Michael Smithson – Head

Tide Gauge Inspectorate
Mr Dave Smith – Head
Mr Les Bradley
Mr Darryn Gaudie

Applications Team
Mr Colin Bell – Head
Mrs Lisa Eastwood
Mr Kevin Ferguson
Ms Jill Moore

Information Technology
Dr Colin Stephens – Head
Miss Jane Black
Mr David Cable
Mrs Margaret Mahon
Mr David Plant
Mrs Julie Tunstall

Business Support
Ms Julie Leader – Head
Mrs Cathy Burke
Mr Dave Butler
Miss Janet Clifford
Mr Craig Corbett
Mr Dave Evans
Mrs Pamela Ferguson
Mrs Jingbo He
Mr Peter Hunt
Mr Derek Johnson
Mr Andrew Kennedy
Mrs Mary Linnane
Mr John Mackinnon
Miss Pat McGuirk
Ms Nadina McShane
Mrs Linda Parry
Mrs Veronica Scott
Mrs Jean Smith
Mr Robert Smith
Mr Phillip Worrall

Students
Ruben Alvarado (EU-NEST Project GO)
Leslie Aveytux (Mexican Science Council)
Chris Beattie (NERC)
Ben Carroll (University Studentship)
Clare Davis (NERC)
Alice Galbraith (NERC/CASE)
Raul Gonzalez (Mexican Science Council)
Rob Hall (NERC)
James Hove (University Studentship)
Angela Hibbert (NERC)
Eleanor Howlett (NERC)
Kerry Marten (NERC/CASE)
John Maskell (Isle of Man Government)
Jonathan Massey (Staffordshire LEA)
David McCann (Bangor)
Hayley Mills (POL/Liverpool)
Rowena Moore (Industrial CASE/Airbus)
Rory O’Hara Murray (University Studentship)
Eleanor O’Rourke (NERC)
Jamie Rodney (NERC)
William Thurston (NERC)
Jennifer Waters (NERC)

University
Liverpool PhD
Baja, California PhD
Aberdeen PhD
Liverpool PhD
Liverpool MPhil
Liverpool PhD
Liverpool PhD
Liverpool PhD
Bangor PhD
Bangor PhD
Liverpool PhD
Staffordshire BSc
Bangor MSc
Liverpool PhD
Liverpool PhD
Liverpool PhD
London PhD
Leeds PhD
Sheffield PhD

British Oceanographic Data Centre staff

Directorate
Director
Dr Juan Brown
Dr Lesley Rickards – Deputy Director
Dr Roy Lowry – Technical Director

Mr Terry Allen
Miss Jenny Andrew
Miss Zoe Aston
Mr Darren Bayliss
Miss Elizabeth Bradshaw
Mr Justin Buck
Dr Claudia Castellani
Dr Mark Charlesworth
Dr Julie Collins
Miss Stephanie Contardo
Dr Raymond Cramer
Dr Richard Downer
Dr Gaynor Evans
Dr Sean Gaffney
Ms Polly Hadzidablic
Mr Malcolm Hearn
Mr Mark Hadden
Miss Corallie Hunt
Dr Frances Kellie
Dr Adam Leadbetter
Mr Stephen Loch
Mr Quyen To Luong
Mrs Elizabeth Macleod
Mr Ed Mawji
Dr Robin McCandliss
Mr Paul McGarrigle
Dr Gwensnelle Moncillité
Miss Mary Mowat
Mr Michael Nelson
Mrs Lise Quesnell
Miss Louise Ryan
Ms Kay Thorne
Mrs Karen Vickers
Miss Pauline Weatherall
Mr Geoffrey Williams

Dr Dave Cotton – Marine Data and Information Partnership Manager – hosted by BODC
Glossary

Advection
The horizontal transfer of heat or other properties.

Aerosols
Clouds of solid or liquid particles in a gas.

Altimetry
Measuring altitudes, or heights.

Amplitude
The maximum displacement (from average position) in a periodic wave.

Backscatter
The deflection of waves or particles from their original direction.

Bathymetry
Underwater depth.

Convection
The movement of currents within fluids.

Correlation
A mathematical way of showing how similar two things are.

Cotidal chart
A tidal chart with lines joining places where the tide has the same phase; for example, where high waters occur at the same time.

DLL
A Dynamic Link Library is a set of functions that can be executed, or data that can be used by a Windows application.

Ecosystem
A system formed by the interaction of a community of organisms with each other and their physical environment.

Fresh-water front
The front of an advancing mass of fresh water.

Geodesy
The study of the shape of the earth and the determination of the exact position of geographical points.

Geospatial
The combination of spatial software and analytical methods.

GIS
Geographic information system.

Hydrodynamics
The study of the behaviour of fluids.

Hydrology
Water on the earth and in the atmosphere.

Isotherm
A line connecting points having the same temperature at a given time.

Latitude
An imaginary circle around the Earth running parallel to the equator.

LIDAR
Light detection and ranging.

Metadata
Information about data.

Mid-latitudes
The area from the tropical regions towards the polar regions.

Morphology
The evolution of land forms.

Neap tides
A period during the month when the tidal range is at its least.

NMF
National Marine Facilities – an integral part of the National Oceanography Centre, Southampton.

Northern Hemisphere
The hemisphere to the north of the equator.

Northeast wind
A wind blowing from the north towards the east.

Phytoplankton
Small primitive chlorophyll-containing aquatic organisms.

Resuspension
A renewed suspension of sediment particles after they have settled on the seabed.

Salinity
The saltiness of a solution, in particular sea-water.

Seabed lander
An instrumented frame that sits on the seabed.

Semi-diurnal
Happening twice a day.

Spring tides
A period during the month when the tidal range is at its greatest.

Stratification
The division of a body of water (or atmosphere or rocks) into layers with different values of, for example, temperature or salinity.

Telemetry
Transmission of data from remote sources by satellite or other means.

Thermocline
A layer in a body of water with a temperature gradient separating surface water from cooler lower water.

Timeseries
A series of measurements taken over a period of time.

Underwater glider
A unmanned underwater vehicle that measures water properties while using its fall and rise through the water column to generate forward motion.

Water column
A vertical column of water from the sea surface to the seabed.

Wind stress
The force exerted by the wind across the ocean surface.

X-band radar
Similar to a ship’s radar.

XBT
Expendable bathythermograph.