



SERPENT

scientific and environmental roV partnership
using existing industrial technology

annual report 2005

collaboration... education... research... innovation...



Foreword

This is the second annual report from the SERPENT Project and I am pleased to say that things continue to develop, the project has grown, our science has evolved for the better and we have a bright prospect for the future. Although the project has continued to expand rapidly since its inception in 2003 and official start in March 2004, this year we have taken some significant steps towards wider international recognition, highlighted in this report. During the 2005/2006 period our core goals have continued to expand through collaboration and engagement with our growing list of project partners in both science and industry.

This engagement still continues to be a major learning curve for all us in the project. Working in partnership with one of the world's most demanding and vibrant industries provides challenges and experiences we would not normally see during our normal academic lives. It is this excitement and potential for new directions that fuels the passion of everyone connected with the project to see it succeed yet further. Working with practical and enthusiastic people offshore is still a major source of inspiration and influence on the evolution of the project - it is the part of SERPENT that really makes it tick, and I would like to express my gratitude, on behalf of all the project team, for the support we have received offshore over the course of 2005.

This year has seen huge public and media attention surrounding the marine environment, from giant squid, to whales in the Thames and the new BBC Planet Earth series coming in 2006! SERPENT has played a key role in showcasing footage and imagery from the deep ocean collected over the duration of the project through a variety of media sources from TV and radio to newspapers and the web. This coverage has allowed our website to grow significantly and with it our new education and outreach programme.

Strong partnerships are the linchpin of the projects' success. Continued support from our founder partners and all our new partners enables a globalised agenda for SERPENT. New work in Egypt, India and Norway is on the horizon thanks to new partnerships and the recommendations by our longer-term supporters.

We have seen several new additions to the project team over the last year and look set to continue into 2006 with more new posts and collaborations on the horizon.

I hope you enjoy reading our highlights and agree with us that it has been an exciting year of offshore activity, and we hope the project will continue to grow stronger during 2006 and beyond!

Best Wishes,



Ian and the "growing" SERPENT Team

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SERPENT Team

Project Leader

Dr Ian Hudson, National Oceanography Centre, Southampton (NOC,S)



Research Team

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 Dr Ben Wigham, OceanLab, University of Aberdeen
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Associated Research

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Outreach Team

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Collaborative Research

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 Dr Adele Pile, University of Sydney (UoS)
 Dr David Booth, University of Technology, Sydney
 Dr Emma Johnston, University of New South Wales
 Dr Murray Thomson, University of Sydney
 Prof. Chari Patiaratchi, University of Western Australia
 Dr Mark Benfield, Louisiana State University
 INIP – National Institute for Fisheries Research, Angola
 Natural History Museum, Angola
 BCLME (Bengeula Current Large Marine Ecosystem)



Graduate Researchers

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 Katie Robertson (UoS)
 Gareth Andrews (UoS)
 Donald Scott (NOC,S)
 Paul Roberts (NOC,S)



ROV crew members Allan Cairns and Wagner Leal on the Sedco Express, Angola

Rationale

The SERPENT Project (Scientific & Environmental ROV Partnership using Existing iNdustry Technology) is a collaborative programme between scientific partners, institutions and a network of major oil and gas operators and contractors. SERPENT is hosted at the National Oceanography Centre, Southampton (NOC,S), one of the world's largest research and teaching organisations specialising in deep-sea science and oceanography. The project centres around the opportunistic and ad-hoc use of ROVs (Remotely Operated Vehicle) in operational settings during periods of non-essential use (stand-by time) and the utilisation of data collected as part of routine offshore work and previous environmental assessment.

Our mission

“Through close collaboration with key players in the oil and gas industry, the SERPENT project aims to make cutting-edge ROV technology and data more accessible to the world's science community, sharing knowledge and progressing deep-sea research. The programme will interact with science and conservation groups globally and transparently communicate our findings to the public to increase the awareness of our fragile marine resources.”

Our Priorities

- Catalogue and describe new and novel marine species
- Examine global distributions of key deep-sea species
- Examine effects of climate change in the deep ocean
- Inform regulators and industry about key marine issues
- Inform the public about the deep-sea environment
- Encourage best practice during offshore activities
- Engage industry to answer the call for marine biodiversity

Where are we working?



Missions: UK

The West of Shetland area and the North Sea still remain a clear focus area for SERPENT Project activities. During this last period several missions have taken place on a range of rigs and vessels within the UK Continental Shelf (UKCS) from water depths of 100–500+m. The activity in the UKCS is on the rise and 2006 will see new deep-water developments in the Faroe-Shetland Channel area for Total at their Laggan development and also new exploration for Shell and Chevron in water depths of over 1000m far West of Shetland. These new, exciting developments in conjunction with the activities in the North Sea together with continued work with BP around their West of Shetland operations at Schiehallion, Foinaven and Clair provide a very stable base from which to build our new research projects that started in October 2005.

North Sea: Buzzard Project

SERPENT Mission Partners: Nexen Inc, Fisheries Research Services, Marine Laboratory and OceanLab

Nexen's Buzzard field is set to be one of the largest in the North Sea. Through their collaboration with SERPENT, it is also the focus of a unique project aimed at following the changes in a marine community from trawled seabed through to the artificial reef and refugium created by the platform itself and the surrounding safety zone where vessel activity is limited.

Over the last two years, scientific partners, FRS and Oceanlab have worked together with SERPENT staff at NOC,S to gather background data on the fish and invertebrate community before installation of the platform began. Two baseline surveys were completed in August 2004 and April 2005. The latter utilised FRS research vessel *Scotia* and finished just days before installation work began. A multidisciplinary approach has been taken by the research team, using traditional survey methods such as sediment grabs and trawls alongside alternative techniques that can be used in the safety zone in the future to compliment ROV observations. These techniques include the use of a baited time-lapse camera (ROBIO) which takes photos of the fish and other benthic species attracted to a standard bait package at pre-set intervals, e.g. every minute. The number of

species observed on camera, the first arrival time and maximum number of each species observed can be used as relative indices of diversity and abundance. These data can be compared over time and between different sites to identify changes in the fish community.

As well as sampling the future site of the platform, the baseline surveys included a nearby "control" site. This site can be re-visited in the future to carry out baited camera deployments for comparison and has been included as a regular station on the biannual groundfish survey and an annual towed TV survey for *Nephrops norvegicus*. Nexen have also provided ROV footage from pre and post lay pipeline surveys and installation observations. This footage will provide a useful comparison with future ROV observations and is being analysed by NERC/Nexen-funded student, Andrew Guerin.

In May 2005, installation work began at Buzzard; three platform jackets and a wellhead deck were installed, water injection, gas export and oil export pipelines were tied in and drilling of eight initial production wells began. Nexen have provided exciting qualitative footage from ROVs indicating large schools of juvenile gadoids aggregating around the structures. A short five day *Scotia* cruise in January 2006 collected baited camera and trawl data from the control site and outside the perimeter of



Image of haddock and crabs attracted to bait during January 2006 deployment

the safety zone, 700-1000m from the platform itself. Young haddock and whiting were also observed on camera and in the catch. These results highlight seasonal patterns in fish and invertebrate abundance that must be taken into account when interpreting the time series.

Nearly 40 camera deployments have now been carried out at the Buzzard field and these have attracted a wide variety of fish and invertebrates. *Scotia* will be re-visiting the control site at Buzzard in April, but the important step now is to move sampling effort closer to the platform in order to assess the build up of the fish and invertebrate community around this *de facto* artificial reef. To achieve this, Nexen and SERPENT partners are preparing to send a baited underwater camera system out with Buzzard's stand-by vessel to carry out deployments within the 500m safety zone. This will provide in-field data that can be compared

directly with previous and ongoing baited camera deployments further away from the platform in order to elucidate changes in species diversity and abundance. However, to get really close to the platform and map the encrusting fauna building up, and observe the distribution and behaviour of fish and invertebrates now living there, ROVs will be an essential tool. The first offshore visit by a SERPENT scientist is planned and will focus on developing simple survey protocols to collect quantitative data.

The Buzzard platform is expected to be completed and producing oil towards the end of 2006. It is anticipated that, as this collaboration goes into its third year, a programme of monitoring from stand-by vessel and ROV will be well established and the first results will be emerging of how the marine life beneath the waves has responded to this new artificial reef.



Surface marking for baited camera with the Buzzard platform and Galaxy III in background



A shoal of Pollock. Image courtesy of the BBC NHU on the Sedco 704 mission

North Sea: BBC–SERPENT Mission on the Sedco 704

SERPENT Mission Partners: BBC, Transocean, Subsea 7

During this last period SERPENT has engaged with the BBC Natural History Unit on the new Planet Earth series, which started this year to great acclaim. During this collaboration SERPENT and the BBC worked in the North Sea, deploying and using a new high resolution digital time-lapse camera system. Series Assistant producer Dr Penny Allen and cameraman Peter Kragh spent a week in August testing the new equipment on the Transocean’s Sedco 704 rig in the North Sea. During the mission they carried out two successful time-lapse sequences working closely with the Subsea 7 ROV on-board, observing the seafloor and showcasing how life can move both quickly and slowly over a 24-hour period in what seems to be a barren place!

The pioneering system is smaller than a conventional lander, and can be put in position and monitored by an ROV - unlike its larger cousin, which would be left for several days. A system failure would therefore be noticed quickly, and rather than losing 24 hours of time the camera can be returned to the surface and reconfigured. Although this trip was only a scoping mission, great forward steps were made with the system that will later become valuable during deep-water operations elsewhere with the SERPENT Project.



Dr Penny Allen and cameraman Peter Kragh on the Sedco 704 with the Subsea7 ROV crew. Image courtesy of the BBC

North Sea: Subsea Viking

SERPENT Mission Partners: BP, Subsea 7, BBC.

In 2005 the team on the Subsea Viking also assisted in helping the BBC to capture new footage for the Planet Earth series in addition to collecting further new footage for SERPENT Project in the vicinity of Foinaven and Schiehallion as part of our long-term monitoring of the

species and habitats in this area. During the trip Dr Penny Allen spent two weeks working closely with the two Hercules vehicles carried on the Subsea Viking using a high resolution video camera system (Atlas), high powered ‘daylight’ lighting systems and a digital format recording unit. During the mission we had the opportunity to see how fitting the most up to date underwater camera equipment to an active work-class ROV would work in the field. We can’t give the game away as to what was filmed - you’ll have to wait until Planet Earth is screened in the autumn of 2006 for that! We can say that this would not have been possible without the hard work of Subsea 7 and BP to back this ambitious project, still working within the golden rules of SERPENT Project.

North Sea: Transocean Rather, Clair Field

SERPENT Mission Partners: BP, Transocean, Subsea 7

Clair is a relatively new field for BP in the West of Shetland area, but in slightly shallower water than our normal research sites, hosting a number of interesting and important species like large long-lived sponges, *Lophelia pertusa* corals, iceberg plough marks and iceberg drops stones. During a new well programme, SERPENT collected video footage prior to drilling activity on the Transocean



Whiting. Image courtesy of the Rovtech ROV team on the Heather Alpha 2002 jacket inspection

Rather as well as sediment samples. The research goal is to re-sample this area at the end of the well period to monitor recovery and recolonisation, and to map the spoil distribution from the resulting well. The ability to sample before and after a drilling event is a new concept that is being taken forward under the SERPENT Project. Using in-field data collected at high resolution with a timed and discrete drilling event will allow new research into the impact and recolonisation of the seafloor by macro and megafauna that reside in the general locality. This study will form a basis for a new research project that started in 2005 to look at the recovery of impacted sites in the deep sea.



Wolffish. Image courtesy of the Rovtech ROV team on the Heather Alpha 2002 jacket inspection

Missions: Australia

The coastline of Australia and its continental shelf provide 1.5x the area of the terrestrial land mass of this continent. To help explore this vast deep-sea landscape SERPENT has entered into a local partnership with Woodside Energy Ltd., Santos, Transocean and Subsea 7 together with a consortium of Universities led by the University of Sydney, incorporating the University of Western Australia, University of Technology, Sydney and the University of New South Wales. The SEA (South East Asia) SERPENT part of the global programme is now expanding through a series of new offshore missions and projects and new industry partners.

Enfield Site

The Enfield Development is situated approximately 40km offshore, north-west of Australia's North West Cape. The site lies close to a number of environmentally sensitive areas including the Ningaloo Reef and associated Marine Park. At its closest potential point, the proposed development is located approximately 35 km from the North West Cape and 16 km from the boundary of the Ningaloo

Marine Park (Commonwealth Waters). The water depth across the licence area varies from 400 metres in the east to over 550 meters in the west.

Browse Site

The Browse Gas Project includes the Brecknock, Brecknock South and Scott Reef discoveries, representing a very substantial undeveloped gas and condensate resource. Studies have confirmed that Browse could underpin Western Australia's second liquified natural gas production hub and supply natural gas to Australian markets.

Pluto

The Pluto gas field lies about 190km north-west of Karratha in Western Australia. Four sites are under consideration for the onshore LNG plant. They include the Burrup Peninsula, West Intercourse Island and Cape Preston, all near the Woodside-operated North West Shelf onshore gas plant, and Onslow, further south. The water depth at this site ranges from 400 to 1000 metres.



Grey reef shark, *Carcharhinus amblyrhynchos*

Australia: Enfield 1

SERPENT Mission Partners: Woodside Energy Ltd, Transocean, Subsea 7

This first Enfield mission on Transocean's Jack Bates in April aimed to expand upon the baseline environmental surveys carried out in the area on behalf of Woodside Energy Ltd. Detailed ROV megafaunal video surveys provided quantitative data on megafaunal ecology; particularly abundance, diversity and distribution in this area. The techniques developed in this survey enabled a more detailed and targeted approach for subsequent surveys.

Eight days of ROV operations allowed completion of six 100m video transects to assess megafaunal abundance, diversity and distribution in the area. There is only one habitat type at ENCO 1 and 2 - soft sediment, with no evidence of rock formations or hard bottom. Preliminary analysis indicated a low density and diversity of megafauna, including echinoderms (asteroids, echinoids, ophiuroids, and holothurians) along with lots of crustaceans and bottom dwelling fish.

Australia: Enfield 2

SERPENT Mission Partners: Woodside Energy Ltd, Transocean, Subsea 7

Key to the second mission to Enfield was the filming of part of Earth Report, a documentary about SERPENT. The footage included the ROV control room on Transocean's Jack Bates at work as they examined shark populations around the riser area and general shots of the rig.

A new digital camera on the ROV took the first digital stills from the Enfield location were taken. The 5 megapixel camera allows us to examine the biodiversity of the area using images of the seafloor and local species. Fascinating populations of sharks were found at around 70m below the rig hanging around the riser, possibly attracted to the smaller bait fish that also reside in this area. Other notable species included a red frogfish (above), walking on its



A red frogfish, *Chaunax pictus*

pectoral fins as it bides its time waiting for unsuspecting prey.

Australia: Enfield 3

Woodside Energy Ltd, Transocean, Subsea 7

This third mission on the Jack Bates revolved around conducting detailed ROV megafaunal video surveys, again to provide quantitative data on megafaunal ecology. A series of experiments were also carried out to quantify the expression of heat shock proteins on deep sea organisms from within and outside of drill spoil (see student section).

ENCO3 displays a soft sediment habitat type similar to those encountered in the first Enfield mission, and data indicates a high density and diversity of megafauna. Echinoderms (asteroids, echinoids), crustaceans (prawns and large isopods), eels that live in the sediment and some bottom dwelling fish were all noted.

Baited traps were deployed to attract mobile megafauna, and examined every 24 hours. Isopods and amphipods were collected for heat shock protein analysis. The baited traps also attracted a variety of prawns, crabs, eels, amphipods, isopods and fish, and initial examination of data suggests a difference in the diversity of organisms that visit the traps inside and outside the drill spoil area. Isopods, shrimp and eels only appeared to visit traps outside of the drill spoil.



Benthic octopus

Australia: Pluto Well

SERPENT Mission Partners: Woodside Energy Ltd, Transocean, Sonsub

In August, Dr Adele Pile visited the Sedco 704 at the Pluto site to expand on environmental baseline surveys and examine species composition in the area. Five days of ROV operations allowed the completion of four transects to be carried out to assess megafaunal abundance, diversity and distribution in the area.

Preliminary analysis of the data suggests a low density and diversity of life, comprised of megafauna consistent with soft bottom communities and including a host of crustaceans - spider crabs decorated with sea anemones, prawns, snapping shrimp, and large isopods. Bait traps attracted a variety of prawns, isopods, and fish and our observations indicated no difference in the diversity of organisms that visit the traps inside and outside the drill spoil areas. Video footage also revealed strange eels that burrow into the sediment tail first. When disturbed, they escape by contracting backwards into the sediment and burrowing away forward rather than swimming out of the sediment. Specimens were also collected for heat shock protein analysis as at our other research sites.



Browse area: Nautilus. (c) AIMS



Browse area: Ophiuroids and shrimp. (c) AIMS

Australia: Browse Area

Working on the Atwood Eagle drilling rig, a Subsea 7 ROV team carried out a comprehensive video survey of the ecology of the Browse area to act as a comparison with our research sites at Enfield and Pluto. As Browse is a new exploration site for Woodside we felt it was important to understand the resident biological community with a view to examining the key species and how they might be affected by further exploration in this area. One of the most interesting findings of this project was that within two months of the completion of drilling there was significant recovery in the benthos when compared to a study carried out shortly after drilling was completed. During July the dominant species were scavenging decapods (Crustacea), while in September Echinoderms (sea stars) dominated. These differences suggest that within fairly short periods of time the Browse seafloor community is starting to re-set following a localised disturbance constrained within a 60m diameter impact area.

Missions: Norway



A cusk fish - Boa Deep C

This last year has seen the SERPENT project expand into the Norwegian sector, an area with a great history of marine science dating back to the work of Sars in the early 1800's. We are pleased to announce that following a successful mission with Shell and our new collaboration with Statoil we have started to develop a new portfolio of research sites from the Barents Sea to the Norwegian Sea in water depths of 200m to 1800m. Over the next year we will be setting up experiments and collaborations, and exploring new areas of the Norwegian sector with a view to making this area an integral part of the project.

Onyx: Transocean Leader

SERPENT Mission Partners: Shell, Transocean, Oceaneering

The Onyx SW drilling project was the first collaboration between Shell EPE and the SERPENT Project. It took place at 300m water depth off the coast Norway in the Norwegian Sea

sector. A one week trial mission was undertaken on the drilling rig Transocean Leader operated by Transocean, using an ROV system operated by Oceaneering. The project aimed to categorise and document all the visible species that were found around the Onyx area.

One of the main issues facing deep-sea exploration and the prediction of impacts is the effect of physical and biological disturbance on the benthic community. The mission sought to assess the extent of seabed disturbance at an active drilling site and how this affects species diversity, distributions and abundance.

SERPENT Project Partner Dr Ben Wigham spent one week offshore accompanied by Ann Montgomery, a Shell E&P Environmental Advisor. They carried out a series of ROV surveys of the general ecology and also successfully operated ROV coring tools specially developed for SERPENT. Results showed that this site was very similar to

our research in the West of Shetland area. They encountered over 20 different species around the rig and mapped their distribution using the ROV. The mission was our third on the Transocean Leader and it once again shows that the expansion of the project is significantly helped by the buy-in of offshore staff.

In addition to this mission we have also been collecting images from the region through a collaboration with the ROV installation vessel Boa Deep C. The images on these pages were taken with a digital stills camera and represent an important resource to SERPENT as we build up research plans for the area based on the species and environments we have seen so far.

Uranus

SERPENT Mission Partners: Statoil, Oceaneering, Ocean Rig

This mission resulted from the fledgling collaboration between SERPENT Project and Statoil ASA. The Uranus well represents the first of a series of projects offshore Norway scheduled over 2006. The main aims of the first mission were to familiarise the different partners within the project of the practicalities of SERPENT, in addition to starting the generation of scientific and environmental data from the survey area.

The background knowledge of the Barents Sea deep-sea communities is relatively limited and some of the specific aims of this new program include increasing our understanding of impact related disturbances and how to improve their management. Specifically we aimed to investigate how the processes of drilling affect the Uranus drilling site.

During the mission several large iceberg scour marks were surveyed, and a host of interesting species were noted, including predatory anemones and swarms of krill!



Hagfish feeding frenzy - Boa Deep C

Missions: Gulf of Mexico



A crab guards its lunch

Despite a difficult time for the offshore industry and inhabitants of the Gulf of Mexico area, SERPENT still managed to carry out some new pioneering work in collaboration with our partners BP, Chevron, Transocean and Subsea 7. Our links with Transocean's drillship the Discoverer Deep Seas (DDS) continued with more images and

footage collected by the ROV team that included potential new species, unique observations of rare fish species and behaviours. Thanks as always to Tony Kastropil for his tireless support of the project. The DDS also played host to the BBC Natural History Unit carrying out a time-lapse camera shoot for their new Planet Earth series.

In addition we are using footage collected from BP's Puma site to examine the controls of biodiversity and links to sediment type as part of a research project training new students in deep sea ecology. Added to this, our new partnership with Louisiana State University and Dr Mark Benfield adds a midwater science angle to the project. We are confident 2006 will be another good year for research in this region.



A strange, unidentified 'sock'!



A deep-sea lizard fish, *Bathysaurus ferox*

Louisiana State University (LSU)

Using Industrial, Deepwater, Remotely Operated Vehicles to Census Planktonic Organisms

This project, operated by Mark Benfield (Louisiana State University Department of Oceanography and Coastal Sciences) and funded by the National Oceanic and Atmospheric Administration's Office of Ocean Exploration (NOAA), is designed to census organisms living in the water column. While the focus is on macroplanktonic organisms and micronekton, so little is known about the biodiversity of the waters over the outer continental shelf and continental slope, that the project is interested in any organisms encountered by ROVs. Geographically the project is concentrated on the northern Gulf of Mexico but will add data from West African waters because both regions are likely to have similar fauna. This study provides an excellent opportunity for student involvement and three undergraduate students from LSU are working in the lab on video analysis. Moreover, an intern from the Marine Advanced Technology Education Center (MATE) will join us this summer to supervise the students and work with the ROV operators to develop more effective survey techniques.

Delays imposed by hurricanes Katrina and Rita prevented trips offshore during the autumn and winter but Mark used the time to undertake water survival, HUET, Safe-Gulf and HSE training courses. With the assistance of SERPENT, the LSU team has established excellent working relationships with both ChevronTexaco/Subsea 7



Hercules 8 ROV on the Discoverer Deep Seas. Image courtesy of Tony Kastropil

and BP/Oceanneering. Mark visited Transocean's Discoverer Enterprise in February 2006 to discuss data collection with the ROV groups. Additional visits to drillships and platforms are planned for April and May and the target is to have data collection from at least six different platforms underway by the end of May. Contact has also been made with the Census of Marine Life and Census of Marine Zooplankton programs and it's hoped that links can be established with both initiatives in the future.



Dr Mark Benfield, Louisiana State University



A siphonophore



Missions: West Africa

The oil and gas industry in Africa has continued to expand in 2005/06 and we have developed new links providing footage from Angola, Nigeria, Ivory Coast, Mauritania and Equatorial Guinea. Many new field developments are under way providing long-term access to rigs and vessels in water depths from 100m to over 2500m, by far the largest range of habitats anywhere in the project. As African waters are true biodiversity hotspots many new species, habitats and research are expected in the coming years. The West African margin systems provide a host of different habitat types from canyon systems to chemosynthetic communities and abyssal plains, not to mention a wide variety of large charismatic species above the water!

Angola: Sedco Express Block 18

SERPENT Mission Partners: BP, Transocean, Oceaneering

Our partnership with BP and Transocean in Angola has gone from strength to strength this year with the arrival of Transocean's Sedco Express from Brazil. The Express is a gigantic dual activity semi-submersible rig that will be staying in the Angola

Block 18 area for the next five years, providing a staging post for SERPENT Project research in Angola. Project leader Ian Hudson spent two weeks in



A potential new species

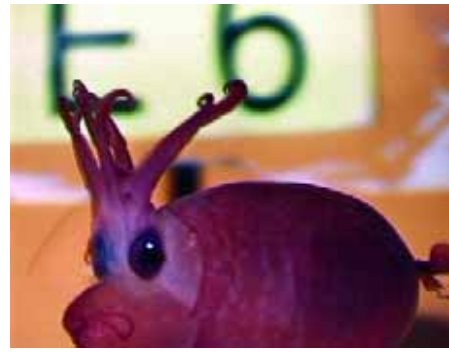
Angola in 2005 and a week offshore early in 2006 on the Express carrying out the first active mission in this area. Working at 1400m water depth the Oceaneering ROV crew helped to survey the well site area, describe the resident community and also find a potentially new species of fish (image above). In addition, Ian gave presentations about the SERPENT project to over 120 of the 160-strong crew, highlighting the keen interest in the environment by the rig crew. Not only was the sea-floor life fascinating but regular visits from turtles, whales, dolphins, manta rays and even whale sharks provided a marine biologist's dream and suitable viewing for the rig crew during break time! The whole mission was very engaging and a great start to the Angola campaign and SERPENT project collaborations with local scientists.

The Oceaneering ROV crew on the Sedco Express



Nigeria

Nigeria has long been one of the major hotspots for oil exploration offshore Africa, and this year we were treated to a selection of some amazing images collected from around the Bonga field. Although we are yet to visit this area, the images we have been sent show a wealth of deep-sea biodiversity and species that don't look real at all – enter the piglet squid! We are grateful to the efforts of Alan Kinnear and his ROV colleagues for their time and effort and hope to see more in 2006 and host our first offshore mission.

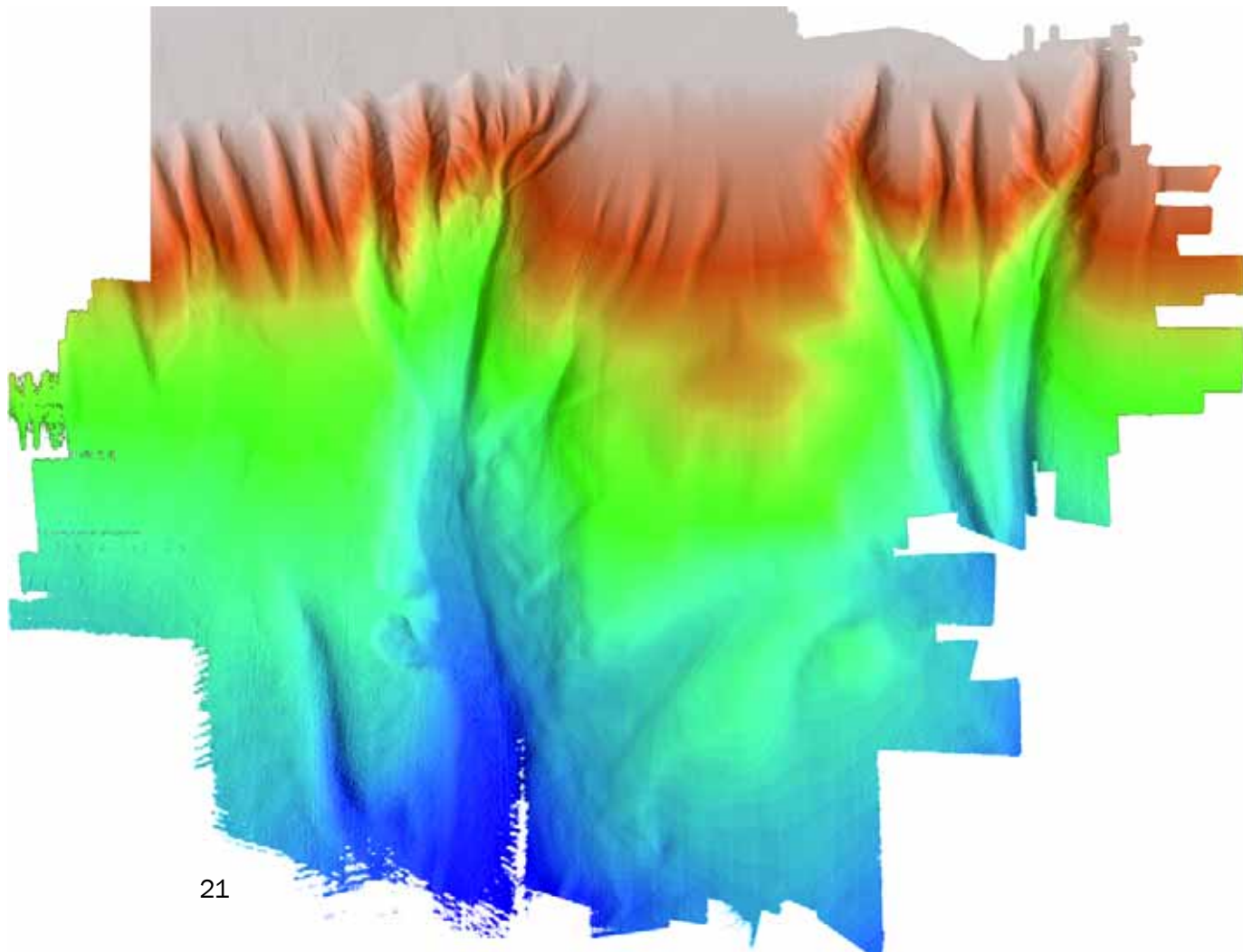


A *Helicocranchia* sp. 'piglet' squid

Ivory Coast

A new link with CNR International has allowed the project to investigate a canyon system off the Cote D'Ivoire by means of a large and comprehensive ROV survey of the Baobab field. The Subsea 7 vessel Seisranger spent nearly a year working in this area from 100m to 1500m depth carrying out pipeline surveys across a large canyon feature. This footage has provided a new research project for SERPENT, in addition to the potential to map a large area using ROV video. The project is examining how biodiversity is controlled by depth and sediment across a large dynamic area (read more in the student project section).

Bathymetric map of the Baobab field



Mauritania

Although this work was carried out in the 2004/05 campaign the data from the Woodside Tiof field has been extensively developed and researched this year as part of a new MSc project. Once again, large volumes of ROV survey footage have been used to map the biological community offshore Mauritania in a unique and detailed way. Many interesting species have been observed, and linking this type of footage to classic ecological questions has given rise to an excellent project (read more in the student section).

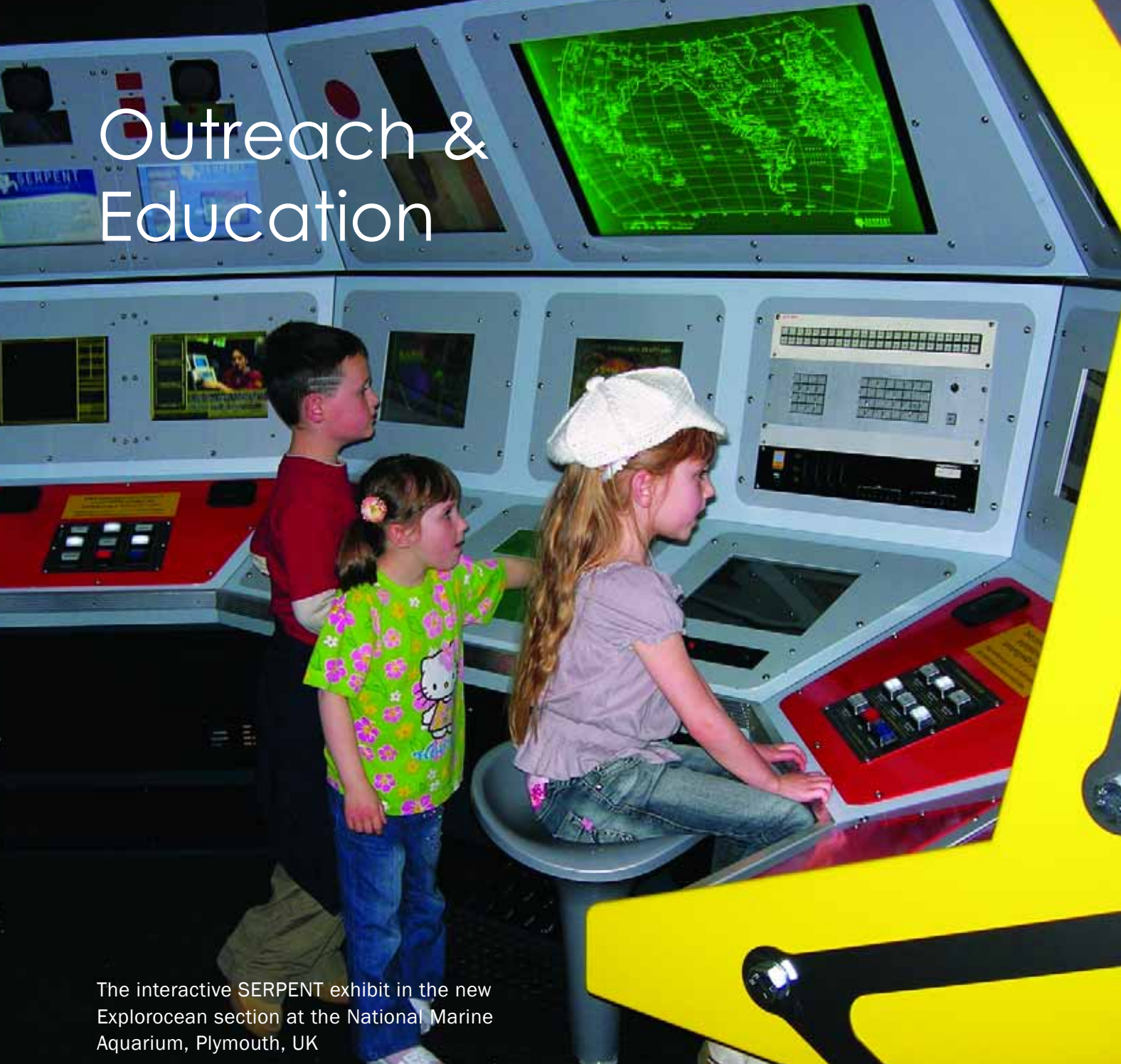


Images clockwise from top left: *Actinoscyphia* sp. Venus Fly-trap anemone, *Bolecera* sp. anemone, *Bathyraja* sp. ray, an octopus at play and at rest, and an *Alepocephalus* sp. fish.

Missions: India

We have continued to receive footage from the Belford Dolphin over the last year. New expansion into this area in 2006 will hopefully allow SERPENT, through Transocean, to engage some Indian academic and industry partners to further explore their deep-water habitats.

Outreach & Education



The interactive SERPENT exhibit in the new Explorocean section at the National Marine Aquarium, Plymouth, UK

The rapid progress and expansion of the project over the last two years fostered a natural requirement for further outreach efforts to communicate our findings to the public. To fulfil this need, we have employed a full time Outreach Coordinator, Lis Maclaren. Funded by Transocean,

the role started in June 2005 for an initial fixed period of 2 years. The past 12 months have proved to be a dynamic year for our outreach programme and some of the key initiatives and achievements are detailed in the following section.



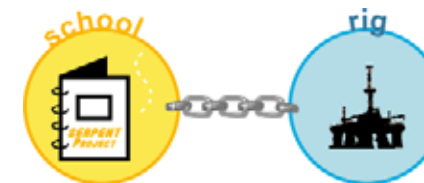
New Format Website & Communications

A new format and structure for the SERPENT website was completed in August. Designed to fit in with a new consistent style of communications for the project, some of the new features include easier and smoother video viewing and mini-sites for active projects. The educational section of the website is also under development, aiming to provide

activities and information about the deep sea to the public and provide online teacher resources. SERPENT Scene, our newsletter, has also been revamped and is now released quarterly, in addition to a suite of new posters and fact sheets.

BBC World Earth Report

Early in 2005, Project Coordinator Ian Hudson worked closely with the Earth Report team to help in the production of a 25 minute documentary about SERPENT. The documentary was shown several times on BBC World in June and again in September, and has proved a useful tool in publicising the project. Filming of the documentary would not have been possible without the enthusiasm and help from Transocean and their clients, allowing the team to visit rigs around the world.



School - Rig Links

2005 saw the start of a new initiative to establish links between schools and rigs via the SERPENT Project. Working closely with Transocean and Subsea 7,

a pilot for the programme took place early in 2006. This followed a successful visit to the participating school in November by Lis Maclaren and a great deal of groundwork and organisation by Bob Clark from Transocean. The pilot project involved a daily live video link-up using web-cams between the Paul B Loyd Junior rig off the West of Shetland and the Charleston School in Aberdeen. The children from class P7/S1 designed experiments for Lis and the ROV crew to take to the sea floor using the ROV, and the results were filmed and discussed with the class. The link was reinforced by the use of educational materials supplied by OEC in class and visits by members of the SERPENT and Transocean team. The pilot was considered to be a success and we are hoping to roll the programme out to more schools and rigs around the world over the next year.



Lis Maclaren and the Subsea 7 ROV crew on-board the PBLJ

Exhibit at the National Marine Aquarium, Plymouth

Towards the end of 2006, the SERPENT team worked closely with the National Marine Aquarium in Plymouth to help in the development of a SERPENT exhibit in the new Explorocean wing of the building. The new section of the aquarium opened at the beginning of March 2006, and features SERPENT in the main Explorocean space. The exhibit consists of a mocked-up ROV control room, with multiple video screens showing snippets of video footage from SERPENT. The main element, the ROV controls, allow children to navigate to different rigs and regions around the world and find deep-sea animals, interacting with an 'ROV pilot' and real SERPENT scientists on screen. With some 500,000 visitors a year to the aquarium, the exhibit should prove to be a fantastic awareness tool for the project.

DEEP

deep-ocean exploration education project

DEEP Educational DVD

Towards the end of 2005, we took the first steps to start to secure funding for the development of an innovative and educational interactive DVD about the deep-sea. The DVD would include educational material based around SERPENT aimed at a spectrum of educational key stages, presented in a dynamic and enjoyable format. We are hoping development will progress quickly in 2006 to give us a valuable educational tool that we will initially be able to distribute to schools around the UK as a free resource - and if successful, around the globe.



BBC Filming for 'Planet Earth'

Our strong link with the BBC was cemented during 2005 by our involvement in the filming

for a new flagship BBC natural history series, Planet Earth. The producer of the hugely successful Blue Planet, Alastair Fothergill, and his team have worked tirelessly on the new 11-part series, one episode of which revolves around the deep ocean. This episode will feature footage taken from the Gulf of Mexico and the West of Shetland. These shoots were enabled through links with SERPENT, and the goodwill of Transocean and Subsea 7. Due to be shown on BBC1 in two batches over 2006, the series should prove to be very successful and should result in a movie spin-off pencilled-in to be premiered at the Berlin Film Festival in February 2007.

Offshore Energy Center (OEC) Educational Materials

SERPENT has been working closely with the OEC, based in Houston, to become a key component in many of their educational materials. Some of these resources, which are distributed to more than 30,000 school children in the USA, are transferable to school curricula around the world. Where possible, we will include the materials in our own educational programme.

Image and Video Database

We have been busy digitising and cataloguing all our video footage and images over the last few months. We are now in the process of developing a comprehensive web-searchable database containing all these materials and accompanying information that will become live later this year.



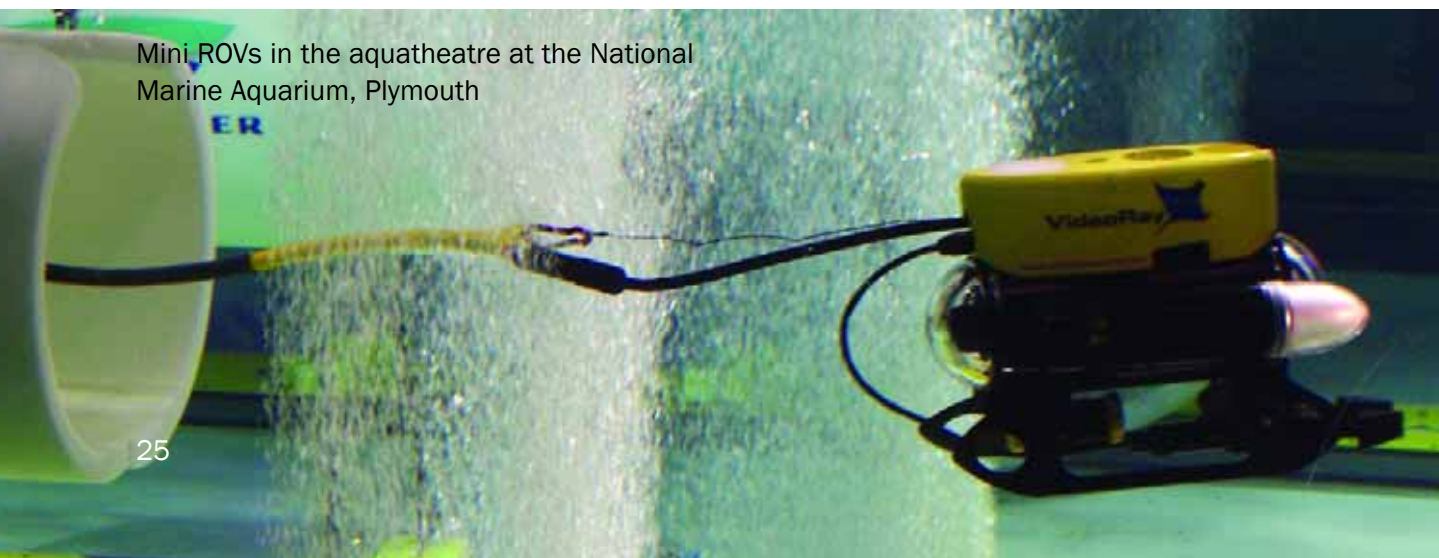
Poppie and Millie Foster-Starr taking part in SERPENT activities during National Science Week

National Science Week

National Science Week aims to celebrate science and its importance to our lives, providing an opportunity for people of all ages across the UK to take part in science, engineering and technology activities. The National Oceanography Centre, Southampton, held an Ocean and Earth Day on the 18 March this year that attracted in the region of 2,500 local visitors, ranging from toddlers to octogenarians. The SERPENT Project featured heavily, providing a large stand with various activities for guests, manned by members of the team. Approximately 250 people also sat in on two lectures about the project given by Lis Maclaren, showcasing some of the riveting video footage and images from our archives. Interest in the project was intense and seems to be a useful conduit to raising awareness of the deep sea to the local community.

DIEPS

DIEPS is a knowledge transfer programme within SERPENT that will be developed in 2006. It will conduct strategic and fundamental scientific research in collaboration with the deep-water oil & gas industry as well as environmental policy formers, implementers and regulators (e.g. World Wide Fund for Nature, Joint Nature Conservation Committee, Fisheries Research Services, Department for Environment, Food & Rural Affairs, and the Department for Trade & Industry). Dr Daniel Jones will coordinate DIEPS and will seek to take the science generated from SERPENT into policy setting and regulation to promote better understanding and cooperation.



Mini ROVs in the aquatheatre at the National Marine Aquarium, Plymouth

Research Students & Projects

Since the project began, SERPENT has continually used its link with industry to underpin new deep-sea science and projects associated with this collaboration. Since 2003 we have so far had two successful PhDs awarded based on data collected from the project, two MSc projects and even more BSc projects. This last year has seen further increases in our research and training output. With three new PhD projects already underway and more planned in the UK, USA and Australia, our commitment to using SERPENT as a vehicle for cutting-edge research and training is moving to the next level. A summary of some of this research is listed below - the future generation of deep marine science looks in safe hands!

Andrew Guerin PhD: Artificial Reefs: Links to Oil and Gas Operations”

“Artificial structures placed on the sea bed inevitably attract life, sometimes in vast quantities, thus functioning as ‘artificial reefs’. The purpose of my PhD project is to determine the extent to which offshore platforms in the North Sea (UKCS) aggregate marine life and what benefits this may provide to organisms.

I have been on two cruises with FRS to the Buzzard field (Nexen, Inc.), once prior to platform installation, and once after the subsea structures were in place. Fishing surveys and baited camera deployments were used to establish the numbers of fish and invertebrates present. Sediment grabs were taken to examine the organisms living within the sea bed, and fish stomachs were sampled to assess diet. Video footage of ROV pre-installation surveys is being examined for fish and invertebrate numbers.

These and other methods will be continued in and around the Buzzard site to construct a picture of the life associated with the structure and observe how this community develops during the first two years of the life of the platform.”

Paul Roberts BSc Project

“This project uses data collected from an ROV study around BP’s Puma deepwater asset in the Gulf of Mexico. This area has a mixture of seafloor habitats, which in turn support a series of different ecosystems and species. The aim of this project is to survey, enumerate and identify the species within the wider Puma area and how they relate to sedimentary features.”

Nina Rothe PhD: Recolonisation in the Deep Sea: Experimental Approaches using Remotely Operated Vehicles

“Over the last few months I have been working on my literature review, summarising current knowledge on recolonisation and succession processes in deep-sea benthic communities with respect to disturbance by oil and gas industry drilling activities.

I have also started to analyse pre-drilling ROV video footage from the Clair Field, West of Shetland, counting and identifying benthic megafauna. Within the next few months, I am planning to revisit the Clair Field in order to collect post-drilling sediment samples and video data, which will allow me to compare distribution and abundances of organisms prior to and following drilling perturbation.

Opportunities to visit the Norwegian Sector have recently become available. Besides collecting sediment samples and video footage to study the macro- and megabenthos, bioturbation experiments will allow me to assess the impact of well drilling activities on the community as a whole.”

Sarah Murty PhD: Deep-Sea Ecophysiology - Experimental Approaches with ROVS

“Since October 2005 I have been working on my literature review summarising the physiological adaptations of organisms that allow them to survive in the deep sea, and the effects of drilling fluids on the physiology of shallow-water organisms. In addition, I have been carrying out initial aquarium-based tests with the Benthic Incubation Chamber System (BICS) on shallow water organisms. Within the next few months, I am planning to carry out drilling-fluid based ecotoxicology tests on selected species of shallow-water echinoderms, and to deploy BICS in-situ at depth from a rig. I have completed the BOSIET and EBOST survival courses to permit me to visit a rig.”

Tania Smith PhD: Sexual chemistry of the deep sea

“My project examines the nutritional link between diet and reproduction in the deep sea. I visited the Paul B Lloyd Jnr rig in April 2005 to accompany a BBC representative filming part of the Earth Report about the SERPENT project. The trip gave me invaluable experience in what life is like on (and under!) the rig as well as getting a feel for the kind of science that can be achieved using the ROVs.

Fifteen hours of underwater footage was taken over the visit, detailing the different fauna and flora under and around the rig. This ranged from fishes such as ling, redfish and monkfish, to invertebrates such as urchins, sea snails and crabs. The zoom on the camera was surprisingly good, facilitating observations of the animals and their behaviour without disturbance. The visit showcased the dexterity of ROVs in terms of both manoeuvring and undertaking delicate work with the manipulator arms. This means future feeding experiments using the ROV and benthic chambers can be planned easily with the knowledge gained from the trip.”

Don Scott BSc Project

“I have been looking at an area on the Ivory Coast off the coast of Africa. The region I am studying consists of a canyon system that starts at approximately 700m and drops to a depth of around 1500m. The image displayed on page 21 is sounded bathymetry of the sea floor taken on site by CNR International. Using footage from the survey ROV, I will be plotting the tracks followed, using ArcGIS, onto the high resolution bathymetry. Once this is completed I will be looking for spatial patterns in the distribution of the fauna that inhabits the sea floor in this area. A selection of statistics including Spearman’s Rank, Shannon-Weiner diversity index and other biodiversity indices are then to be applied to the results in order to assess how the ecosystem of this deep-sea region functions. I will then be looking at the controls on this ecosystem in order to define how the habitat thrives.”

Katie Robertson Honours Project: Heat shock proteins as indicators of stress in marine organisms

“Heat shock proteins (hsp) are a universal biomarker of abiotic and biotic stress, so a fundamental understanding of hsp expression will provide insight as to how organisms are experiencing their environment. This study aimed to determine whether industrial deep-sea drilling disturbances along the Northwest shelf of Australia leads to increased expression of hsp70 in deep-sea scavengers.


First, I determined if benthic macrofauna are deterred by drill spoil by analysing Lebensspuren (animal tracks) from four different well sites. Results indicated little difference in the numbers of isopod tracks between zones of heavy, moderate and low spoil zones, inferring that drill spoil does not deter isopods. Although isopod tracks were found in all zones surrounding the drill site, we wanted to know if isopods perceive drill spoil as a stressful environment. Isopods and amphipods were collected from within and outside of drill spoil zones and analysis of tail muscle showed no hsp70 expression. This indicated no significant difference in stress levels in amphipods found in zones of drill spoil compared with those outside of drill spoil zones. In laboratory studies with the isopod, a known hsp70 inducer and drill mud increased hsp70 expression over controls. Isopods were collected from outside of the drill spoil, brought to the surface, and immediately exposed to seawater (control), copper sulfate or 5% drill mud. Hsp70 expression was measured on four key tissues of deep-sea isopods: tail muscle, maxillary glands and the swimming and respiratory pleopods. Ultimately, isopods can express hsp70 as a result of environmental stress but do not do so in the natural environment as a response to disturbance associated with drilling activity.”


Claire Fletcher Masters Project

“My project involved the analysis of ROV footage of the seabed surrounding oil production centres and water injector wells in the Enfield development area, North West Australia. Distinct concentric zones of disturbance were revealed, radiating outwards from well heads, with decreasing severity.


The most heavily disturbed regions were dominated by scavenging anemone crabs (*Parapagurus pilosimanus* aff.), whereas species composition around water injectors showed a high prevalence of filter feeding organisms. Areas around water injectors showed more diversity, whilst oil wells displayed greater dominance by one species, the anemone crab. Low disturbance zones were more species rich than heavy zones; volume of drill spoil was greater at oil wells and thus disturbance was more severe. The local anemone crab population appears to concentrate in disturbed regions to take maximum advantage of the reduced-competition conditions. ROV observations allow very detailed analysis of drill spoil, together with appreciation of the patchiness in spoil deposition and species composition, and as such is the best available tool for ecological analysis of oil exploration activity.”

New Partnerships

 An agreement between SERPENT Project and Norway's largest oil and gas company, Statoil, was set up at the start of 2006. The project will allow access to rigs working with Statoil in the Barents and Norwegian Sea from water depths of 200m to 1800m. Later this year, the Polar Pioneer will drill a new well in Barents Sea, and we are all excited to be taking research into this new, dynamic area.

 Through Dr Mark Benfield at LSU and the ROV and rig team on the Discoverer Deep Seas, LSU and SERPENT were successful in an application to the US science agency NOAA for a one year pilot project to look at carrying out unique visual surveys of the midwater and twilight zones using rig mounted ROVs. We look forward to the progression of this project in 2006!

In connection with the new LSU link, we have agreed with BP Gulf of Mexico Deepwater Projects that we will work closely on three of their contracted rigs this year in the US Gulf of Mexico. Three Transocean drillships and semi subs, the Discoverer Enterprise, Transocean Marianas and Deepwater Horizon will be involved in collecting more footage from deepwater areas across the whole of the Gulf of Mexico.

 The Australian Museum are experts in the field of education, communication and also taxonomy. We are pleased that this year we are working together to communicate the species we find off the Australian coast as part of the AM Fishes website, a site visited by huge numbers of users each month. This is sure to increase the output of the SERPENT project in Australia.


This period CNR have provided a large amount of ROV data collected from the Ivory Coast by the Seisranger. This data has formed the basis of a new research project for a student at NOC,S. The project looks at the ecology of a canyon system and is showcased in our student section. We hope that this is the start of a new potential link with CNR.



 Links with Total have grown steadily since the first Laggan mission. Working with Total UK we are set to engage on a new project at Laggan working with the Total Foundation for Biodiversity and the Sea. The project will seek to examine new species around the Faroe-Shetland Channel area and communicate this science to Total and the general public.

We are pleased to be working with our collaborative academic partners and Woodside Energy LTD, Australia's largest oil company. We are working in the Enfield, Pluto and the Browse Basin areas on the Sedco 703, Jack Bates and the Atwood Eagle. This collaboration has already contributed to two student projects and will build yet further within Woodside for 2006!



 Our existing link with founding partner Transocean was further strengthened this year with the start of our new Outreach Coordinator. Lis's post has been funded for an initial two years by Transocean, a role which incorporates communications together with a new educational programme.

This year we have been working closely with the National Marine Aquarium in Plymouth on a new SERPENT exhibit hosted in their new Explorocean section. The support from the NMA has been fantastic - find out more in the outreach section of this report.



Events

It has been another busy year for all the project team, attending meetings, giving presentations and seminars across the world. There are too many to mention in total, so below are a few of the highlights from the last period.

Total Symposium

The corporate foundation for biodiversity and the sea is a separate body to Total, but under a board of directors including the Total CEO, the foundation has a cycle of environmental themes and the next theme for 2006-2009 is deep-sea biodiversity. The SERPENT Project was invited to the kick off symposium in Port Cros, France, as a shining example of industry-science collaboration. We hope 2006 will bring a Total UK and Foundation project with SERPENT for the UK!

IADC

The International Association for Drilling Contractors held its first Environmental Conference in October in Norway. The conference included talks by project partners from industry and academic science as well as by NGO's such as Conservation International and Bellona, providing a new dimension to this flagship industry event. Project Coordinator Ian Hudson gave a key note presentation, winning the best paper award. The SERPENT team also gave a series of talks over a very successful and well attended dedicated half day session, chaired by Bob Clark of Transocean.



The majority of the SERPENT team at the IADC Environmental Conference - minus Bob Clark!

Transocean Environmental Forum

Founding project partner Transocean, the world's largest drilling contractor, held its first environmental forum in 2005. This forum brought all the regional divisions of the company to Houston to discuss environmental issues and how Transocean can play a leading role for the future. SERPENT and our project partner the OEC (Offshore Energy Centre) gave presentations to stimulate new connections within Transocean and to expand the project into new areas. The meeting was a great success and some of our new projects for 2006 were generated by this event!

Angola Darwin Funded Meeting

The Darwin Initiative is a DEFRA funded project that aims to stimulate linkages between the UK science community and the developing world. As part of this project SERPENT and BP were successful in an award to host a meeting in Luanda, Angola to bring together potential collaborations partners. As a result we are now set to build a new linkage with Angola based around deepwater exploration. The Sedco Express rig will be the corner-stone on a five-year contract with BP, providing the offshore base for the science component. Exciting times in Angola are on the horizon!

APPEA Meeting Perth

With new projects in Australia with Woodside and Santos in 2005 and more for 2006, the Australian Petroleum Production and Exploration Association hosted a meeting as part of their environmental grouping to showcase the work of SERPENT and to encourage a wider participation in the project within Australia. We are pleased to say that this served the project well and we are hoping to establish new projects in 2006 with Chevron and further work with Woodside and Santos.

Publications & Media

Selected Publications

Nature, Vol 439 23 February 2006. Oil-rig staff get into marine biology.

Ian R. Hudson, Benjamin D. Wigham, Martin Solan and Rutger Rosenberg (2005) Feeding behaviour of deep-sea dwelling holothurians: Inferences from a laboratory investigation of shallow fjordic species. *Journal of Marine Systems*.

Hudson, I. R., Jones, D. O. B., and Wigham, B. D. A review of the uses of work-class ROVs for the benefits of science: Lessons learned from the SERPENT project. *Underwater Technology, International Journal of the Society for Underwater Technology* Vol 26 No 3 2005.

Jones, D., Hudson, I. and Bett, B. (2006) Effects of physical disturbance on the cold-water megafaunal communities of the Faroe-Shetland Channel. *Marine Ecology Progress Series*

Jones, D. (2005) Ecological controls on density, diversity and community structure in polar megabenthos. Ph.D. Thesis, School of Ocean and Earth Science, University of Southampton.

Jones, D. and Hudson, I. (2005) In situ deepwater science onboard an offshore drilling installation. *Marine Scientist*.

The Daily Echo Saturday Review. Secrets of the Deep. 04 March 2006.

NERC Planet Earth Magazine: What lies beneath. Winter 2005.



IADC Drilling Contractor: Science, industry join hands to explore the deep-sea wilderness. Jan/Feb 2006.

Unravelling secrets of The Deep. Trunkline, the Woodside Energy Internal Magazine. Autumn 2005.

Harts E&P Magazine: Sea quest. July 2005



Selected Media Coverage

BBC World Earth Report: 'Little Geek'. July & September

Secrets of the Deep: Ian interviewed on BBC South Today. October

ITV News: Ian interviewed. October



BBC World/News 24: Ian interviewed. October

BBC World Service: Ian, Lis and Dan interviewed. January

BBC South Today: Ian interviewed. February



Sky News: Several features over the course of the opening day of Explorocean at the NMA. February

German TV documentary: Ian and Nina Rothe interviewed. April

Multiple articles on the web - see website for details!

2006/2007 Projects

2006/2007 looks set to be the busiest yet! Listed below are some of our new projects and a brief overview of what these collaborations will entail in the coming months.

Norway: Our new collaboration with Statoil is set to present new challenges and potential for exciting science offshore Norway this coming year. With the project underway and scheduled to the end of the year, we are confident this first year with Statoil will work out well for all concerned, bringing some new academic collaborations in Norway.

Angola: Work with BP in Block 18 and 31 is set to increase in 2006, and with this will come the support network for our Angola capacity building project. It also looks likely that Chevron Angola will join our efforts with their block 14 operations.

Far West of Shetland and Western Isles:

The Shetland area was the starting point for SERPENT and we are pleased that we have been able to continue to develop new projects in this area each year. The coming period of 2006 will see new links with Chevron UK and Shell UK to explore offshore the Western Isles on the Benbecula Prospect and also the Faroe-Shetland Channel on the Rosebank prospect. Both will use the Transocean Rather as the science base and we hope to use this long-term link to train and establish our new postgraduate research projects.

Venezuela: We have formed a new collaboration agreement with Simon De Boliva University to potentially collaborate with SERPENT offshore Venezuela. Although it is early days, the prospect of more access to ROVs and rigs in this area has brought Venezuela onto our world map!

BP Gulf of Mexico: Our links with BP continue to grow, and as a founder partner we are pleased to see our collaboration is expanding into Angola and the Gulf of Mexico.

Nexen UK: More work at Buzzard, Scott Telford and Etrick are planned for 2006. Working with the John Shaw we are set to launch new observation systems into the North Sea as part of the artificial reefs project with Fisheries Research Services Marine Laboratory, OceanLab and NOC,S.

Canada: An exciting new addition to SERPENT is set for 2006. The gap offshore Canada that has remained since the start of the project is now going to be filled thanks to our partners at Chevron. Through internal recommendation, Chevron Canada will be inviting SERPENT to take part in a new landmark

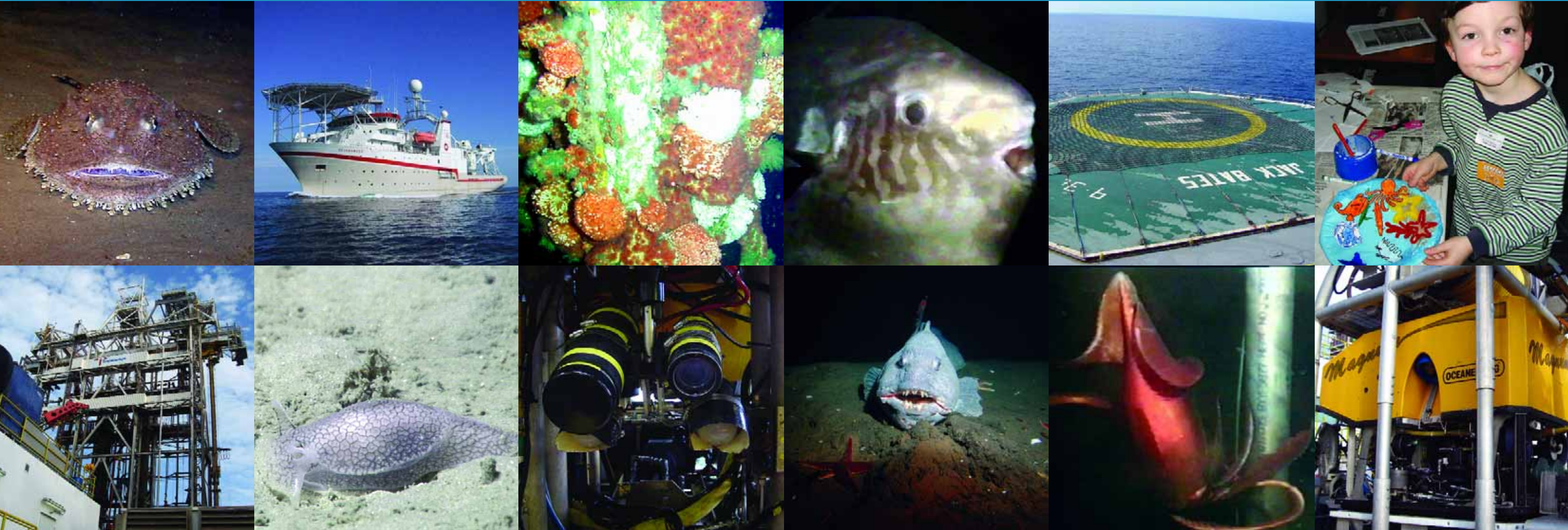


The Henry Goodrich rig on tow off the Canadian coast

well to be drilled offshore Newfoundland this summer in over 2500m of water - watch this space...

Egypt: A visit to the Jim Cunningham in 2005 showed that Egypt and the companies working there were keen to expand their environmental interests in to the deep ocean. Working with Transocean and Shell, 2006 will bring a new opportunity to work offshore in Egypt with the arrival of the Deepwater Expedition. Working in over 2000m of water will bring data from an area that has received little to no ROV attention before!

Top Row, Left - Right: Anglerfish in the Barents Sea, MV Seisranger, *Lophelia* on a marine riser, *Mola mola* sunfish from Australia, Jack Bates helideck Enfield site, SERPENT at Science Week



Images (c) SERPENT Project, National Undersea Research Center, Rovtech and Lundin Petroleum

Bottom Row, Left - Right: Sedco Express dual-activity derrick, deep-sea gastropod, digital ROV cameras, wolffish in the North Sea, *Ommastrephes bartrami* squid and drill pipe, Magnum work-class ROV

Our Partners

Industry

BP (UK)
Subsea 7
Transocean

BP (Angola)
BP (USA)
Chevron (US)
Kongsberg
Nexen Inc.
Oceaneering
Santos
Shell (UK)
Statoil
Total (UK)
Woodside Energy LTD

Academic and Associated

Australian Museum
BBC Natural History Unit
Fisheries Research Services, (FRS), Marine Laboratory, Aberdeen
Louisiana State University (LSU)
National Marine Aquarium, Plymouth
OceanLab, Aberdeen University
Offshore Energy Centre (OEC)
Simon de Boliva University, Venezuela
Smithsonian Institute
Society for Underwater Technology (SUT)
Texas A&M University
University of New South Wales
University of Sydney
University of Technology, Sydney
University of Western Australia
U.S. Geological Survey (USGS)

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