

# Davey Jones' treasure locker

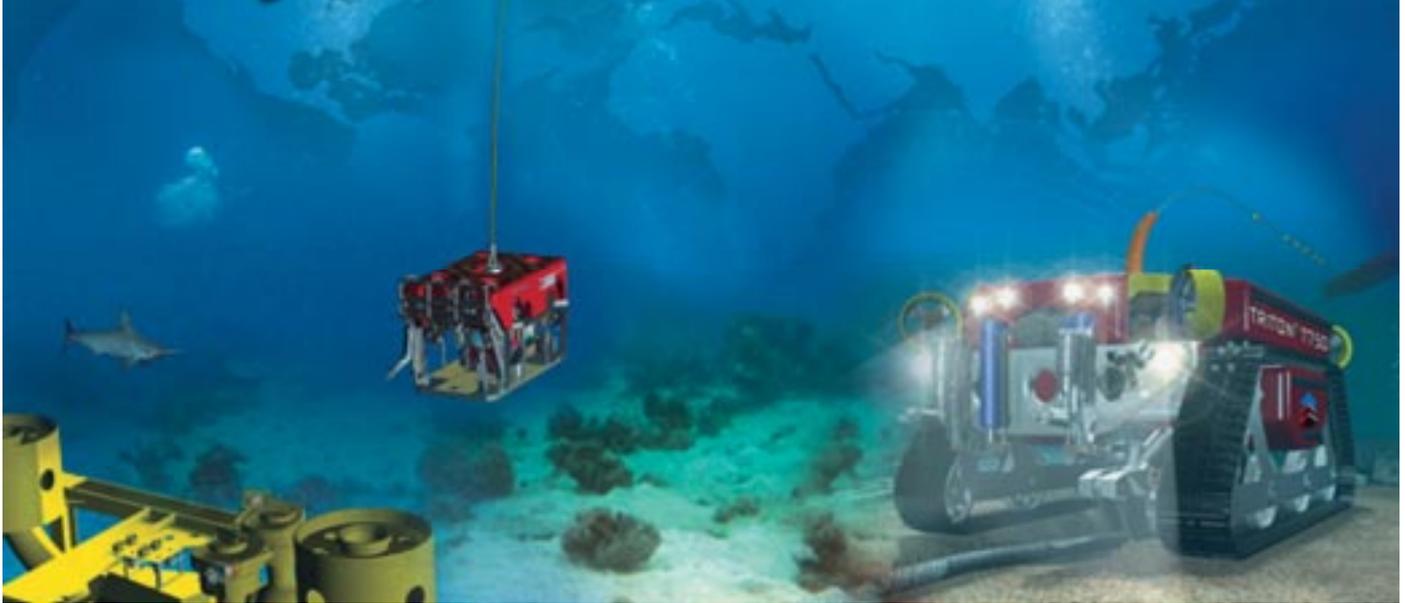


Image Courtesy of Canyon Offshore Inc.

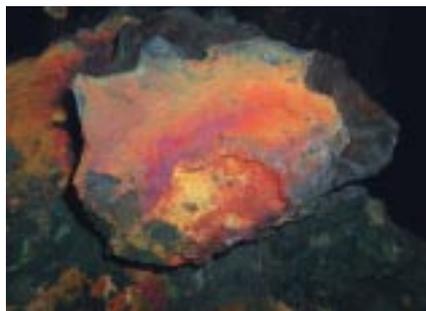
John Chadwick examines undersea mining techniques being developed for Nautilus Minerals and Neptune Minerals as they rush to mine massive seafloor sulphide deposits, and looks at the innovations of Subsea Minerals

Some seafloor mining is already underway, notably the well-established offshore diamond mining of companies like De Beers Marine Namibia, which is owned by De Beers (70%) and Namdeb (30%). It mines off the southwest coast of Namibia in the Atlantic 1 licence area of Namdeb, as the exclusive contractor. DBMN operates a fleet of five mining vessels, of which it owns four and time charters one. The vessels are the mvs *Debmar Atlantic*, *Debmar Pacific*, *Gariiep*, *Grand Banks* and *Ya Toivo*. The mining system used on four of the vessels is airlift-drill technology, with a 6.8 m diameter drill bit working in overlapping circles on the seafloor. The fifth vessel uses a 220 t track-mounted crawler. Mining takes place on the ocean floor at water depths ranging from 90 to 140 m.

However, it is Nautilus Minerals (Canada and Australia) and the UK's Neptune Minerals that have caught the attention of many in the industry in the last couple of years. In the former's case, that interest has translated into three leading international resource companies taking shareholdings - Epion (22.4%), Teck Cominco (7.2%) and Anglo American (5.7%). Both companies aim to tap vast offshore resources and plan to mine high-grade seafloor massive sulphide (SMS) deposits of copper, zinc and silver.

Mine planning is well underway for the first Nautilus (and the world's) seafloor copper/gold mine in 1,500 m of water at the Solwara 1 project in Bismarck Sea in Papua New Guinea (PNG), 50 km north of Rabaul township. Nautilus holds more than 370,000 km<sup>2</sup> of tenement licences and exploration applications in the territorial waters of PNG, Fiji, Tonga, the Solomon Islands and New Zealand along the western Pacific Ocean's Rim of Fire.

Neptune has granted exploration licences totalling more than 278,000 km<sup>2</sup> in the territorial waters of New Zealand, PNG, the Federated States of Micronesia and Vanuatu. It has completed its second and third exploration programs, Kermadec 07 and Colville-Monowai 07, offshore New Zealand. During Kermadec 07, Neptune discovered two new hydrothermally inactive SMS zones over which the company plans to lodge a mining licence



application. It has exploration applications covering 434,000 km<sup>2</sup> pending in the territorial waters of New Zealand, Japan, Commonwealth of Northern Mariana Islands, Palau and Italy.

## Major Nautilus progress

Last December Nautilus awarded a contract worth approximately £33 million to Soil Machine Dynamics (SMD) of Newcastle upon Tyne, UK, for the design and build of two Seafloor Mining Tools (SMTs) for Solwara. At the time Heydon said, "the placing of this first order is a historic step in the creation of a new industry and a major milestone for the Nautilus team, who continue to meet the development timelines for the delivery of the Solwara 1 Project. Nautilus is on track to commence commissioning for mining operations by the third quarter of 2010, subject to timely PNG government approval.

SMD is one of the world's leading subsea equipment manufacturers. Founded in 1971, it is a privately owned engineering company specialising in the design and manufacture of complex engineering systems. With a combined experience of nearly 50 years, SMD has delivered over 300 subsea machines and 200 pieces of deck equipment.

*Copper on the seafloor*

Significant steps have been taken in the design and build process for the three key components of the mining system. The SMT contract, which is the first of the three contracts, was awarded after a four-month competitive tendering process that involved several other major offshore Remote Operated Vehicle (ROV) and mining equipment supply contractors. Nautilus chose SMD for the strength of its design and competitive approach and says it looks forward to "working with the SMD team to deliver the world's first seafloor massive sulphide (SMS) mining tool."

Over the three months leading up to this, Nautilus' focus had been on the tendering for the provision of the three key mining system components; the SMT, the Riser and Lifting System (RALS) and mining services, including provision of the mining vessel. Nautilus' approach was to lock-down the contracts for the SMT and the RALS first. The mining services contract will then be awarded as the configuration of these subsea systems has bearing on the optimal surface vessel configuration that the mining contractor will be required to provide.

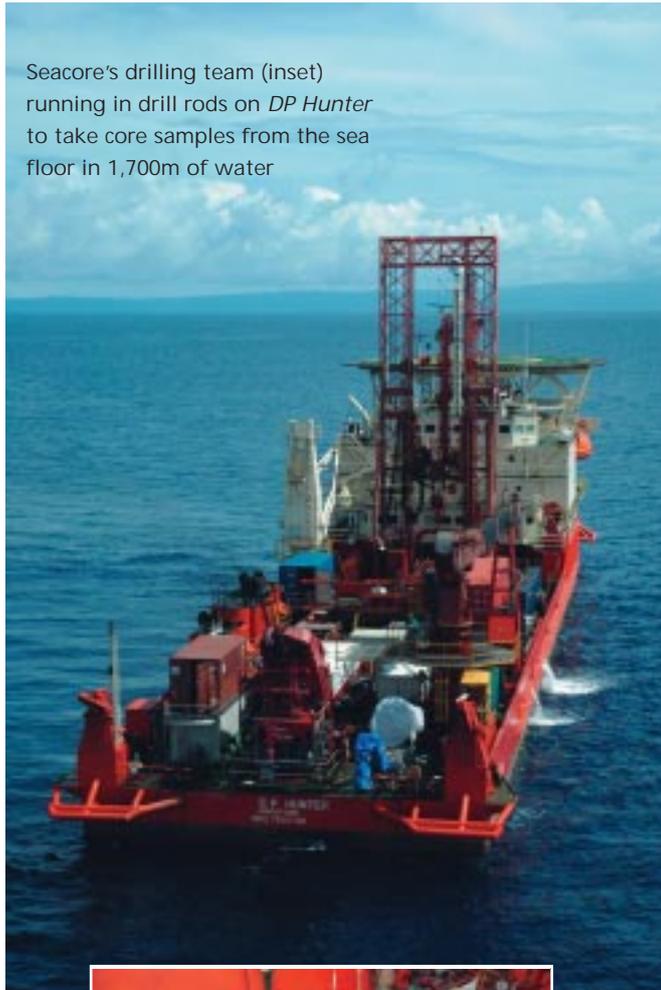
A competitive, paid, front-end engineering design (FEED) program was launched for the RALS, involving 'world's best' international contractors. This will run for eight weeks and Nautilus selected the RALS design and build contractor in the first quarter of 2008.

The mining services contract will be finalised in the second quarter of 2008, following a subsequent competitive, paid, FEED study with several high calibre international groups. These groups were short-listed before the end of 2007. The objective of the design program was for contractors to assess the subsea mining equipment (i.e. the SMT and RALS), identify the required integration with the proposed vessels and demonstrate that the contractor groups are proposing optimal vessel configurations. Under the mining services agreement, the successful contractor will provide the mining support vessel and manage the daily production operations on a performance incentives basis.

Following the engineering study and the award of the mining services contract, the company says it will be in a position to announce its target capital expenditure and operating costs.

Also in December 2007, Nautilus announced that Golder Associates had completed the

Seacore's drilling team (inset) running in drill rods on *DP Hunter* to take core samples from the sea floor in 1,700m of water



world's first NI 43-101 compliant resource estimate for a SMS system at Solwara:  
 Indicated mineral resource: 870,000 t at 6.8% Cu, 4.8 g/t Au, 23 g/t Ag, 0.4% Zn.  
 Inferred mineral resource: 1.3 Mt at 7.5% Cu, 7.2 g/t Au, 37 g/t Ag, 0.8% Zn.

The estimate from Golder was based on the results of 111 core drill holes drilled from the seafloor in 2007, surface mapping and sampling (133 samples), and supporting information from 35 core holes drilled in 2006. The estimate was further supported by an electromagnetic (EM) survey, which very effectively outlines the surface extent of massive sulphide mineralisation. A cutoff of 4.0% Cu was used.

Heydon noted the importance of Nautilus' mine plan drilling of a portion of the Solwara 1 deposit, trialing new remotely operated deep-

sea drills, being accepted as competent to qualify for a NI 43-101 resource. "This is a big step forward for this new industry. We are focused on outlining a pipeline of mineral deposits which we could aggregate over time using a mobile ship supported mining system. Apart from the Solwara 1 Deposit, we have to date, identified seven other prospects in PNG and have title over at least 10 mineralised areas in territorial waters of the Kingdom of Tonga.

The Solwara 1 resource is a subset of the Solwara 1 deposit. The resource is open to the west and at depth where 38% of holes drilled this year finished in mineralisation. The mineralised system is exposed at the surface and well supported by the EM survey which effectively maps the surface expression of copper-rich mineralisation. This provides us with confidence in the extent and continuity of the resource. Indicated and Inferred resources are categorised based on drilling density and drill core recovery with no fundamental geological difference between mineralisation in the different resource classes. We are confident that additional drilling

could quickly upgrade the resource in the inferred category if desired."

The Solwara 1 deposit is located on a volcanic sea mount. It consists of a zone of massive sulphides overlain by a thin zone of barren or weakly mineralised sediments. Base-metal rich chimneys occur above much of the massive sulphide deposit. The massive sulphide zone exhibits strong geological continuity and correlates well with a distinct electromagnetic anomaly on the sea floor.

## Solwara processing

Towards the end of February, Nautilus announced preliminary results from its first phase mineralogical and metallurgical investigations of ore from a representative 1.2 t drill core sample recovered during the 2007 drilling campaign at Solwara 1. David Heydon, Nautilus' CEO said: "The results of the mineralogical program conducted at G&T Metallurgical Services of Canada and the initial phase of metallurgical work carried out by AMMTEC of Australia, provide clear evidence that the Solwara 1 material is a 'simple ore', that should produce a commercial grade copper concentrate with low impurity levels and good recovery."

The mineralogical work was carried out by G&T on composite samples recovered from Solwara 1 during the 2007 drilling campaign, as documented in the Resource Report completed by Golder and Associates, released on February 1, 2008. The program was designed to provide data to optimise the flotation process design. The following key points have been concluded from this mineralogical work:

- Chalcopyrite is the dominant copper ore mineral
- The gangue is pyrite, barite, anhydrite and minor silicate minerals, all of which are readily separated from chalcopyrite using standard flotation techniques
- The majority of the massive sulphide tested is course grained. Grinding tests indicate effective liberation with a likely primary grind size of 80% - 50 micron
- The principal impurity element arsenic is held almost exclusively in the mineral arsenopyrite. Grinding tests indicate that the arsenopyrite is readily liberated from the chalcopyrite and flotation will produce concentrates with acceptable arsenic contents
- The copper concentrates will likely contain significant gold contents and in some cases payable levels of silver. Further work into gold and silver deportment is underway.

## Technology specialists

Nautilus has brought together an extensive group of engineering and technology collaborators from the offshore oil & gas and the metals & minerals sectors: Technip is a world-leader in engineering, technology and construction services for the oil and gas and petrochemical industries. It ranks among the five major players in full-service engineering and construction services in the field of hydrocarbons and petrochemicals. Technip is advising Nautilus on its offshore vessel and mineral extraction technologies. Hatch is a leading global consulting, engineering, technologies, information systems, and project and construction management organisation. Hatch currently has a team of 70 staff and consultants conducting front end engineering and design on Nautilus's proposed onshore processing activities. Perry Slingsby Systems is the world leader in manufacture of deep ocean ROVs for the oil/gas and telecommunications industries. Vehicles to 750 kW are manufactured for applications such as deep sea trenching for pipe and cable laying and for sub



Deploying the Rovdrill

sea construction activities to 3,000 m.

Allan Spencer, Business Development Manager, Geotechnical Systems, explains that dedicated seabed coring rigs require dedicated vessels and handling systems to deploy and recover and have limited global availability. Perry Slingsby's Rovdrill® was successfully engaged in the Solwara 1 drilling campaign during 2007, with favourable results. "The [Rovdrill] which sits on the seafloor recovering drill cores up to 19 m in length has gone from

an idea, to design, to implementation within a year. This is a significant technical achievement – and bodes well for future exploration and mining activities." David Hayden, CEO, Nautilus Minerals, said last September 4.

"In summary, Rovdrill is a technically and commercially practical solution for a range of seabed survey, construction geophysical and geotechnical tasks. The system, when interfaced with a host ROV of opportunity is currently capable of operating in water depths of 3,000 m, or less, as limited by the depth rating of the host ROV of opportunity," Spencer explains.

"This system differs from other portable seabed drilling and coring rigs currently available in that it integrates 100% with the host ROV and as such utilises the ROV power and telemetry capabilities thus considerably simplifying and economising on complex and expensive equipment requiring mounting to the drill rig."

Rovdrill uses conventional terrestrial drilling and coring technologies and equipment, subject to minor modifications required to certain of the tooling to allow it to be compatible with higher ambient pressures in deep water operations. The system can be easily reconfigured for RC drilling without major alteration to the base system.

"Rovdrill mobilises onto an existing work class ROV spread, all deployment systems, electrical power and hydraulic services are provided by that ROV



ROV fitted with rock cutter for bulk

spread, negating the requirement of having additional dedicated/specialist equipment on hand to complete the installation.”

“First Generation Rovdrill has limitations as a broader geotechnical tool, including coring depth capability being limited to 18 m to retain compatibility with the existing host.” A second generation Rovdrill design is currently in progress which aims to expand on the original concept and move the tool forward into a broader offshore geotechnical investigation arena.

Canyon Offshore is an international operator of deep ocean ROVs for the oil/gas and telecommunications industries. It owns equipment for sub sea construction as well as trenching for pipe and cable laying at depths to 3,000 m.

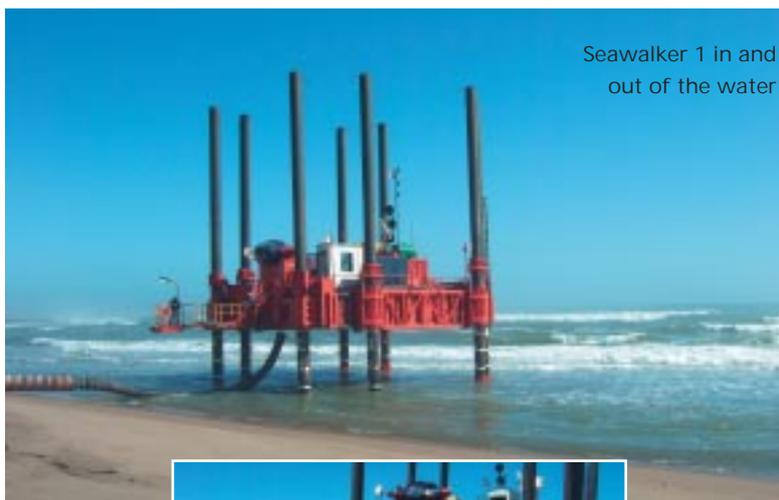
Sandvik, based on its experience in roadheaders for hard rock tunnelling and of bolter miners for the coal industry, is providing cutting head technology to the project. At its Austrian test facility it has conducted tests of the engineering properties of SMS samples supplied by Nautilus.

Williamson and Associates conducted the geophysics program for Placer Dome in 2005 (now owned by Barrick Gold) that led to the delineation of the Suzette field in which Solwara 1 is contained.

## Subsea Minerals

Back in 2006, Seacore (now owned by Fugro) successfully completed one of the most challenging exploration projects in its 30 year history, drilling and recovering core samples of Nautilus deposits from the floor of the Manus Basin in the deep western Pacific Ocean, north of PNG. Seacore, operating at a water depth of 1,700 m, drilled boreholes at over 30 locations and took core samples up to 20 m into the seabed. The deposits are formed in mounds and hydrothermal vents or chimneys, produced by deep convection circulation of sea water generated by submarine volcanic activity.

For the Solwara project Seacore used its own heave compensated R100 drill rig mounted onto the chartered multi-service construction vessel *DP Hunter* to provide the drilling and sampling services. Seacore complemented this equipment with a special drill string and suite of drilling tools for the taxing contract. “This was one of Seacore’s most challenging projects,” said Seacore Exploration Division



Seawalker 1 in and out of the water



Commercial and Contracts Manager Mark Richards at the time. “We were operating in water over a mile deep and coupled with the sea floor topography, with its collapsed hydrothermal chimneys, surrounded by precipitous sedimentary mineral deposits, made it challenging to implant the drill bit. This tricky operation was helped by previous high definition 3D topographical mapping of the seabed and, in some instances, the use of an ROV with a camera, supplied by the client.”

Robert Goodden, the founder of Seacore, has launched himself headfirst into a challenging new marine mining venture, Subsea Minerals. This, he feels, could be equally or even more rewarding than Seacore, which became one of the world’s leading specialist marine and offshore construction and exploration drilling contractors. Fugro purchased Seacore in May 2006.

Marine minerals mining was a new venture Goodden was already spearheading within Seacore before the takeover. A marine mining division had been formed, called Seacore Mining, and special innovative equipment designed and built in-house. Seacore has continued to focus on its core activities of marine and offshore construction and exploration drilling, and now under the control of Fugro Goodden believes the company he founded in 1976 has a much stronger future. However, as part of the Fugro deal Goodden personally retained the marine mining interests that had been built up in Seacore. Since the takeover there has been a positive and close

relationship between Goodden’s new mining company and Fugro Seacore. There is an expectation of synergies between the two organisations and Fugro Seacore is already providing Subsea Minerals with services on its new project.

Goodden owns 100% of Subsea Minerals and has exclusive access rights to mining related intellectual property in Fugro Seacore. These include, for example, the designs for the two innovative

eight legged walking jack-up platforms, which Seacore designed and built in-house. These jack-ups can move and operate completely independently in rough seas, strong currents or on beaches and other inter-tidal locations, considerably boosting the productivity of a variety of traditional jack-up platform operations.

One of the first ventures Goodden is working on is the co-operation with Namdeb to mine for diamonds in the raging surf along the Namibian coastline. The beaches along the west coast of Africa have been mined for years by small diver operated spreads dependent on the few calm days, which occur each month. Subsea Minerals, using walking jack-up platforms, complete with on board processing equipment to extract diamonds from the dredged material, will enable almost continuous operation in the ultra shallow water or surf zones, dramatically increasing productivity of a mining unit. These ultra shallow water zones have so far not been exploited in any significant way, but the co-operation between his new company and Namdeb, using technologies initially developed within Seacore and Namdeb, will represent a new breakthrough, which Goodden and Namdeb are both excited about.

Cape Town based ADP Projects manufacture mining and processing equipment to integrate with Seawalker platforms. The special on board processing plant will treat hundreds of tonnes of sand and gravel picking out just that handful of gem diamonds that will make the technique worthwhile. Goodden believes that once the walking platforms are established and successfully mining, the demand for them will considerably increase.

Subsea Minerals’ first such project, the Namdeb SML USW project, is now underway at Oranjemund in Namibia. It will use an eight legged walking jack-up platform, originally built by Seacore, together with its associated

onboard extraction and processing equipment and has started eight months of sampling trials. The pumping process to be used is also more energy efficient and environmentally friendly than land based operations. Dredging sands and gravels underwater requires less energy and reinstatement of the seabed is immediate as the technique returns the processed material directly back on the seafloor.

The marine deposits along the coastal strip of West Africa have been mined for 100 years on land where the higher sea levels used to be. The sea levels have also been much lower and the beaches or shorelines during those times are now submerged and are target areas for diamond miners. Currently these zones are being mined out to about 150 m where diamonds are on the seabed.

The current active and dangerous surf zone is also concentrating diamonds by wave action and is an area, which, up to now, has been largely ignored. Namdeb plans to use walking jack-up platforms to walk out through the raging surf and mine one area at about 8-m water depth and later with larger equipment other pre-existing beach levels to 20-m of water. With even bigger walking platforms Goodden believes they will be able to get out to 30-m depth and take another couple of levels. The idea is to mine the area from the inshore areas until ship-based systems become the economical solution.

Goodden has another string to his bow. He has been helping and advising Nautilus since 1997 and has a significant shareholding in the company. He is a technical consultant on the Nautilus Board of Advisors.

## God of the sea

Neptune is not as far advanced as Nautilus, but is nevertheless fast approaching project development. It has 100% interest in three prospecting licences for SMS deposits in New Zealand territorial waters, totalling over 236,000 km<sup>2</sup>. The company says it targeted New Zealand for its initial operations because of:

- Its stable political environment
- Government legislation and support for offshore mineral exploration
- Well established offshore oil and gas marine industry
- An active marine contracting sector which includes ships, platforms and ROVs
- Seamount sites at depths of 120 to 1,800 m under water are well within the operating range for existing technologies.

In Mid-March Neptune signed a letter of Intent (LOI) with C&C Technologies, through its Asia-Pacific operation based in Singapore. C&C

Technologies is one of the world's leading marine survey companies, for the provision of autonomous underwater vehicle (AUV) survey, sampling and vessel charter services. The LOI commits both parties to contract negotiations and project preparations towards Project Trident – a long-term exploration program focused on Neptune's exploration tenements in New Zealand's Exclusive Economic Zone (EEZ). Subject to vessel and equipment availabilities, AUV survey and sampling operations are planned to commence in mid-2008 with continuous operations for a minimum 12-month period, with options to extend to 24 months and beyond.

Neptune's Chief Executive Officer Dr Simon McDonald: "We are very pleased to progress Project Trident, the undertaking of which will allow the company to significantly ramp up its exploration activities in New Zealand. A dedicated survey vessel will allow Neptune to define the SMS zones identified during Kermadec 07 and systematically locate and define SMS deposits which will then have Mining Licence Applications placed over them."

C&C Technologies Asia-Pacific Survey Division Manager, Gad Habiby: "C&C looks forward to working closely with Neptune on Trident and, while carrying out the AUV survey and sampling program, to introducing appropriate new technology to maximise the value of the data set gathered."

C&C Technologies is, according to Neptune, the commercial leader in the use of AUVs for marine survey operations. Last year, the company documented its 100,000th km surveyed by AUVs, a milestone crossed while the C-Surveyor III was working for Shell in the Gulf of Mexico. The AUV services division began operations in January 2001. To date, its AUVs have serviced 56 clients, on 207 projects, in the offshore waters of 12 different countries. C&C integrates and develops new technology in the fields of global GPS positioning, AUV services, geophysical surveys and marine construction survey support. *IM*