UT THREE

UNDERWATER TECHNOLOGY

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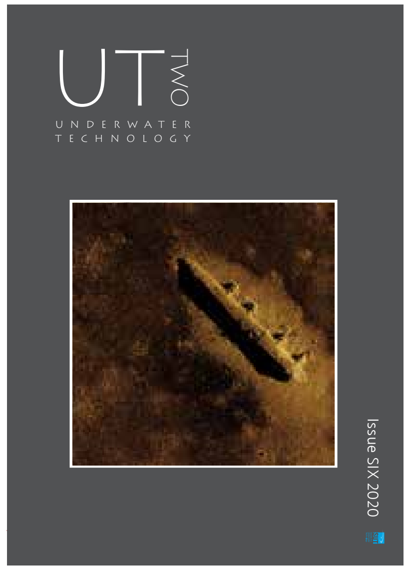


NEWS

IR MONITORING

C-Kore Systems has completed a successful campaign with a major oil operator in the North Sea. The C-Kore tooling rapidly located the source of low IR on the field and allowed the operator to quickly confirm the health of the rest of the system.

C-Kore's subsea testing tools are used by operators and installation contractors around the world on both fault-finding operations and new installation campaigns.

The Cable Monitor unit confirms the insulation resistance and continuity of the electrical lines while the Subsea TDR unit localises anomalies within 20cm.

With C-Kore's automated units and on-line training, no extra offshore support is needed to run the equipment.

A Senior Subsea Engineer for the operator commented, "We were very pleased how well the C-Kore units worked, and the great support C-Kore Systems provided.

The tools are so easy to use, we didn't need any extra personnel offshore. The testing was completed very quickly enabling us to work out the rest of our maintenance strategy."

C-Kore testing tool

A-FRAME

R/V New Ocean Researcher 1 *equipped with three full MERMAC LARS solutions*

MacArtney has successfully completed its order of a launch and recovery (LARS) system for the Taiwan National University, marking the fifth Ocean Research Vessel (ORV) in the Asia Pacific region to date.

MacArtney Asia Pacific has provided the full launch and recovery system solution for the new vessel ***R/V New Ocean Researcher 1 (ORV 1)***, including slip rings, cables and docking heads with the successful completion of the 1000t research vessel in July 2020.

Behind ***ORV 1*** is the CSBC Corporation, which built the ship for Taiwan National University. Owning two shipyards, CSBC is the largest shipbuilding company in Taiwan.

Now that ***ORV 1*** has passed its Sea Acceptance Test (SAT), researchers from the country's national university can reap the benefits of a highly advanced level of technology that includes no less than ***three*** MacArtney MERMAC LARS systems.

The full scope of supply for the launch and recovery system aboard ***ORV 1*** comprises:

- One MERMAC stern A-frame (15m)
- Two MERMAC side A-frames
- Wireless remote control foldable boom crane with 10t capacity and active heave compensation
- Hydraulic power units for A-frame and crane
- MERMAC storage and traction winch with 6000m of ready spooled stainless steel wire, wireless remote control and constant tension technology
- MERMAC CTD (Conductivity, Temperature, Depth) winch, including 6000m of armoured coaxial cable and slip rings
- Portable MERMAC winch with 4500m of hybrid instrumentation cabling, slip ring and spare cable.

ARMADA PLANS

Ocean Infinity has announced plans for the next phase of its Armada fleet of robotic vessels with a signed contract for eight 78m, optionally crewed robotic vessels.

Initially, these exceptionally fuel-efficient, onshore-controlled vessels will use a skeleton crew onboard. In due course, however, they will be capable of working with no personnel offshore whilst also consuming solely renewable fuel such as ammonia.

The 78m vessels will supplement the current Armada fleet of nine 21m and 36m vessels which are already in production and expected to operational by early 2021. The first 78m vessel is expected to launch in mid-2022.

● Shell and Ocean Infinity have signed a joint development agreement to combine expertise and assets to execute multiclient seep hunter projects.

One of eight 78m, optionally crewed robotic vessels

TESTING CAMPAIGN

The Ocean Exploration Cooperative Institute (OECI), funded by NOAA's Office of Ocean Exploration and Research (OER) will acquire a DriX Unmanned Surface Vessel (USV) from iXblue.

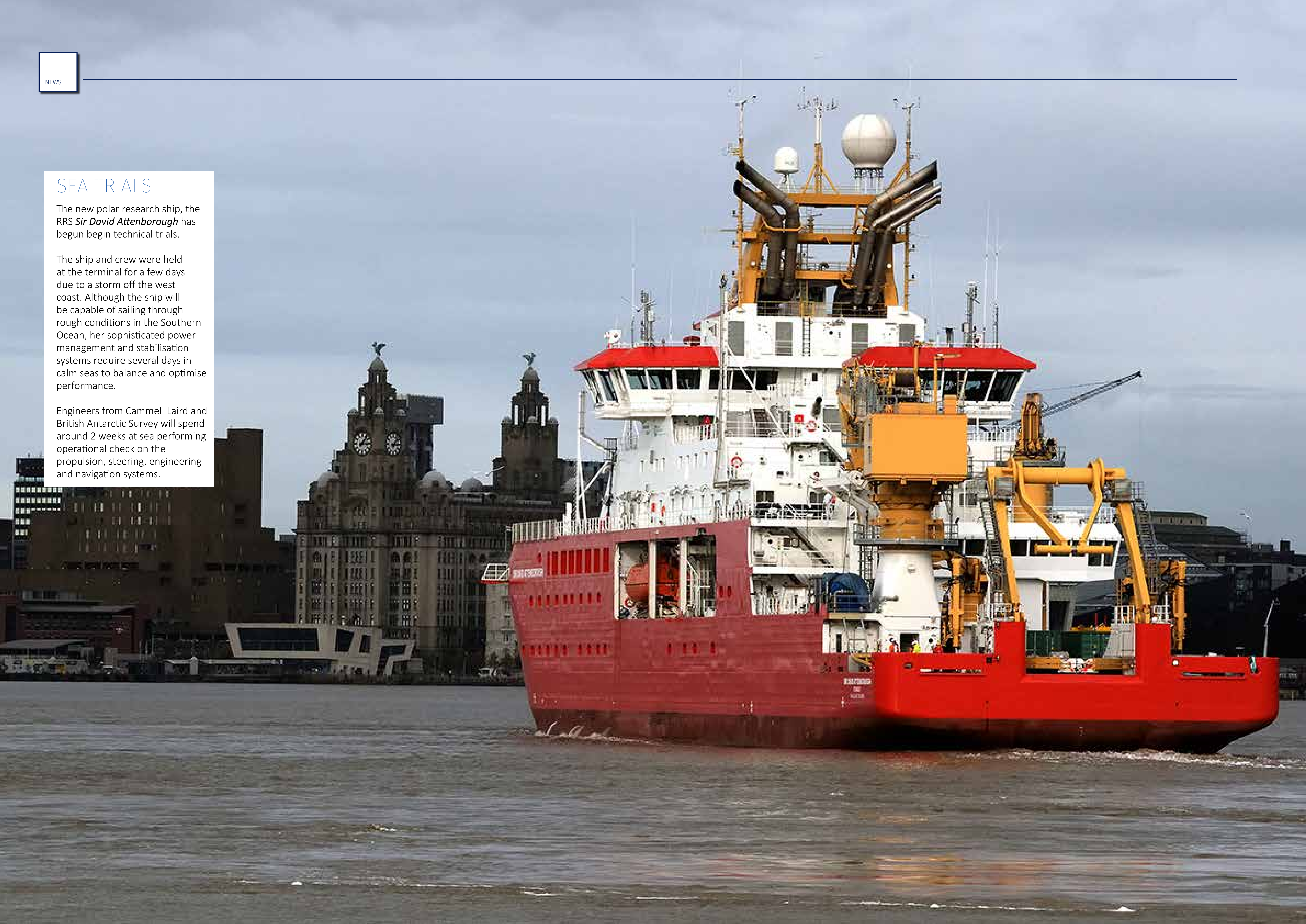
This contract consists of one DriX USV along with a novel custom-designed Universal Deployment System able to launch and recover the USV as well as other AUVs. The autonomous solution is expected to be put to sea by mid-2021.

Along with the innovative Universal Deployment System, other features that led to the selection of the DriX were its mission endurance, ability to operate at high-speed and excellent offshore seakeeping ability.

"The ability to launch and recover unmanned surface vessels as well as other autonomous systems like AUV's from the same launch and recovery system allows us to support a range of collaborative ocean exploration operations from a single research vessel, said Larry Mayer, Director of the Center of Coastal and Ocean Mapping and the University of New Hampshire's co-PI on the Ocean Exploration Cooperative Institute.

"With these collaborative, multi-vehicle operations we hope to greatly expand the footprint and efficiency of ocean exploration."

The University of New Hampshire will operate the new DriX.



SEA TRIALS

The new polar research ship, the RRS ***Sir David Attenborough*** has begun begin technical trials.

The ship and crew were held at the terminal for a few days due to a storm off the west coast. Although the ship will be capable of sailing through rough conditions in the Southern Ocean, her sophisticated power management and stabilisation systems require several days in calm seas to balance and optimise performance.

Engineers from Cammell Laird and British Antarctic Survey will spend around 2 weeks at sea performing operational check on the propulsion, steering, engineering and navigation systems.

OFFSHORE CHARGING BUOY TO REDUCE EMISSIONS

Maersk Supply Service and Ørsted, have formed a partnership to test an innovative charging buoy that can bring green electricity to offshore wind farm service vessels and potentially to a wide range of maritime vessels.

The buoy can be used to charge the smaller battery- or hybrid-electrical vessels and to supply power to larger vessels, enabling them to turn off their engines when laying idle. By substituting fossil-based fuels with green electricity, virtually all emissions are eliminated while the buoy is in use.

The prototype buoy has been developed by Maersk Supply Service while Ørsted is responsible for the buoy's integration with the electrical grid at the offshore wind farm.

The charging buoy will be tested in the second half of 2021, where it will supply overnight power to one of Ørsted's service vessels.

Upon technical validation and commercial ramp up, the electrical charging buoy has significant potential, short to medium term, to contribute positively to reduce emissions for the maritime industry.

This will happen through displacing tens of thousands of tons of fuel consumed every year in the wider maritime sector by enabling inactive vessels to turn engines off and replace energy consumption and charge batteries with renewable electricity.

Within five years of global operation, Maersk Supply Service has the ambition to remove 5.5 million tons of CO_2, additionally avoiding particulate matter, NOx, and Sox. The charging buoy is applicable as a mooring point outside ports, in offshore wind farms, and near vicinity to other offshore installations.

Additionally, it will further help limit the increasing vessel congestions and remove air pollution in port areas.

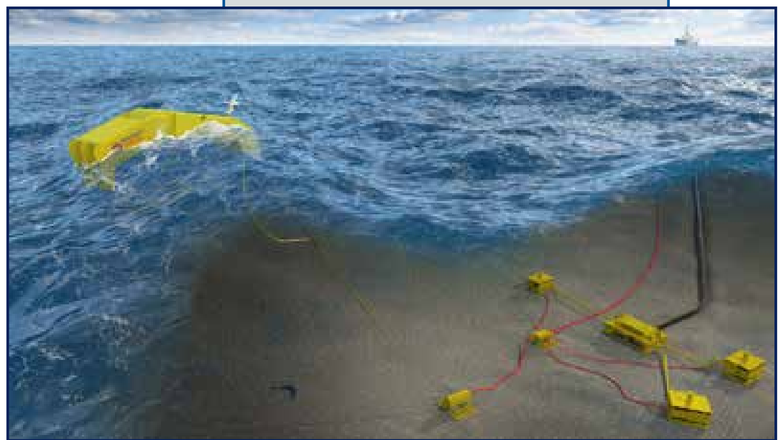
MOCEAN WINS FUNDING

Mocean Energy has raised £612 000 equity seed funding plus £250 000 from Innovate UK to advance the design of their Blue Star wave machine and drive its adoption in subsea oil and gas.

"Blue Star has been created from first principles to operate autonomously in remote locations and deliver green energy for a range of applications – including scientific ocean monitoring, aquaculture, oil and gas, and delivering energy to remote communities.

The first prototype will commence testing at the European Marine Energy Centre in Orkney next year enabling Mocean to advance our engineering design, including a new power take off, moorings and umbilical, and will deliver additional grant support to our project partners Newcastle University's Electrical Power Research Group and Rosyth-based electronics-specialists Supply Design.

The Oil and Gas Technology Centre will look to use Mocean Energy's Blue Star wave energy converter and EC-OG's HALO subsea energy storage system to power subsea tiebacks or residential AUVs.



Blue Star wave machine

SUBSESA POWER: THE NEXT STEP

Following ABB's successful validation of the world's first subsea technology power technology system last November, the company in association with OneSubsea, has conducted a new test demonstrating that 8-megawatt (MW) shaft power is available with one single Variable Speed Drive (VSD) connected to a compressor.

Using OneSubsea's multiphase wet gas compressor (WGC6000) operating in a hydrocarbon loop, the test was conducted in a shallow water pit at OneSubsea's facilities on Horsøy, off the coast of Bergen.

Per Erik Holsten, Managing Director of ABB in Norway said: "The integrated test proves that we have a robust and reliable high power subsea VSD for submerged pumps and compressors like OneSubsea's WGC6000 and those from other manufacturers."

Funded by industry partners Chevron, Total and Equinor, the test took place during the summer. With lockdown travel and social restrictions prevailing the teams at ABB and OneSubsea carried out much of the work remotely, culminating in a virtual event with over 100 attendees from around the world, witnessing the test.

By successfully completing this milestone, both ABB's VSD and OneSubsea's multiphase compressor Have achieved Technology Readiness Level 5 (TRL5) and are ready to be deployed to the market. Together they offer a disruptive optimisation of subsea processing and tie-backs.

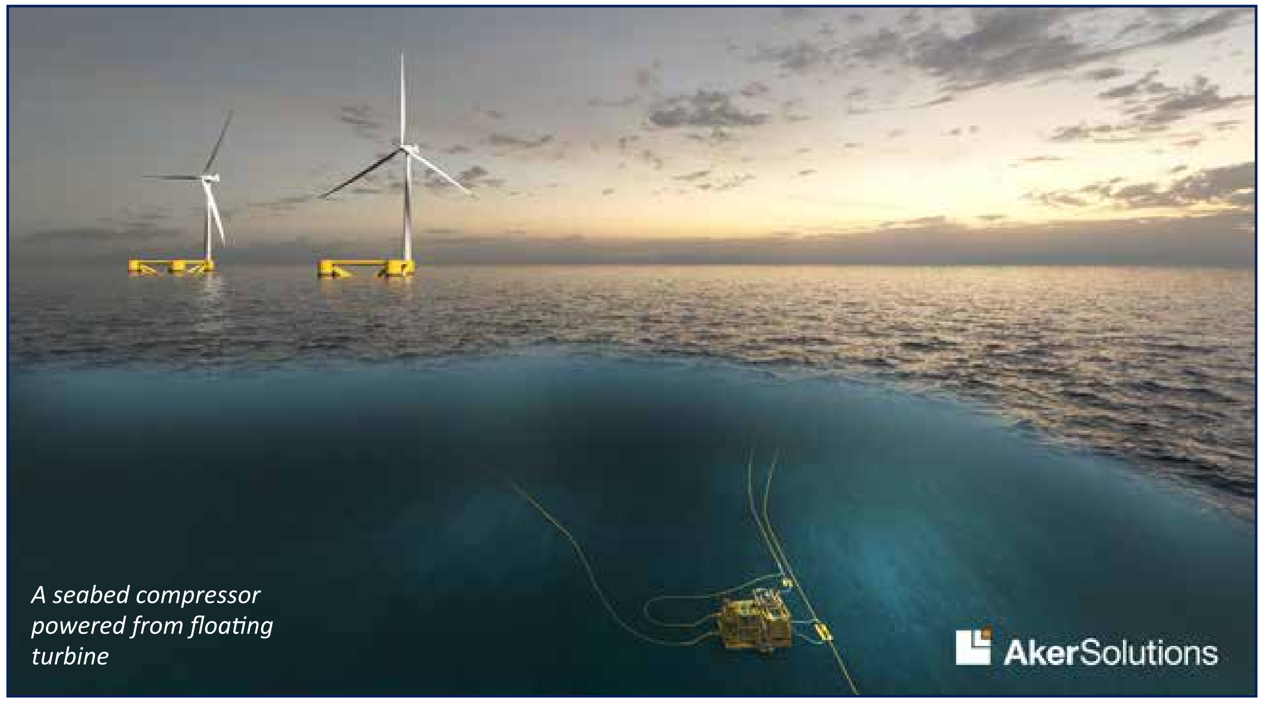
ABB's VSD

VARIABLE SPEED DRIVE

The Variable Speed Drive forms a major component of ABB's state-of-the-art subsea and power distribution and conversion system, that was proved commercially viable in world first at the end of 2019.

The system enables companies to access a reliable supply of up to 100 megawatts of power, over distances up to 600km--and down to 3,000 meters water depth via a single cable. It is expected to help transform offshore oil and gas operations, enabling increasingly remotely operated, autonomous and subsea powered facilities in the ocean space. ABB brings groundbreaking potential to the offshore hydrocarbon industry and new frontiers in the ocean space.

Renewables-powered SUBSEA COMPRESSION



A seabed compressor powered from floating turbine

The argument for adding compression is unambiguous.

If compression is added at the start of the field development, the higher production rate gives increased early revenue. Adding compression as the field plateaus means that it can continue plateau production for longer while boosting at any time can provide increased total overall recovery.

Historically, compression has been added either from a topsides or onshore station. This requires the gas to be pulled from the wellhead and up through an upstream pipeline before it reaches the compressor. A more efficient alternative is to carry out the compression subsea.

In both cases, the resistance from the pipe must be overcome but keeping the gas at high pressures results in smaller losses than if the pipe were at a lower pressure. Consequently, when compared with an equivalent topside or onshore compression system, a subsea compression station requires substantially less energy.

In 2015, production started on the Asgard subsea compression station and has recently celebrated 5 years of operation.

“Since production commenced on Asgard, the facility has provided better-than-expected performance," said Andrew Grant, senior process engineer at Aker Solutions. "At present, we are working on developing the Jansz Io subsea compression facility and facing the next stage of challenging design parameters.

"The new compressors will operate in deeper water, further from the host facility at higher flow rates and operating pressures.

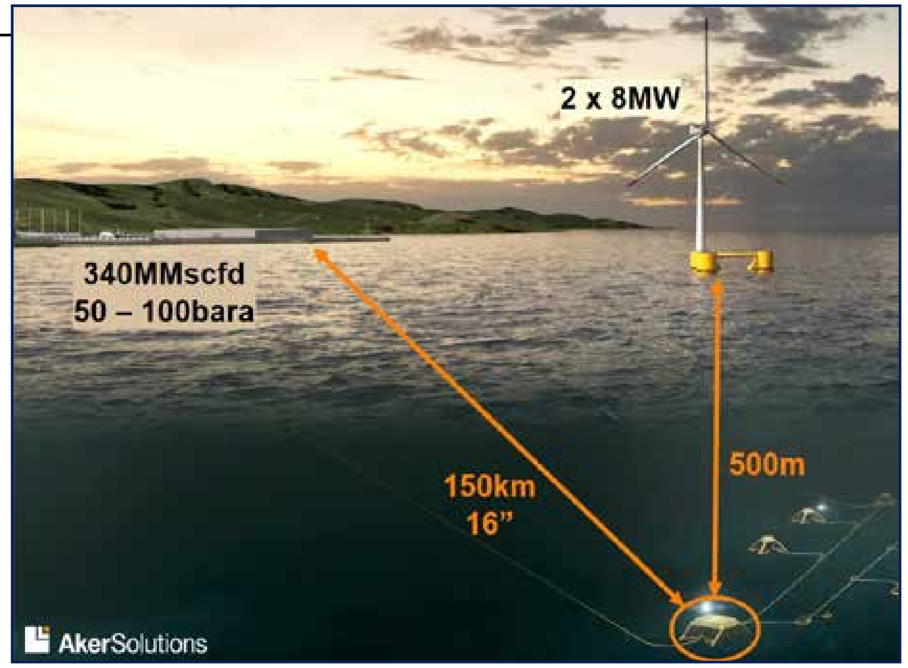
"Both projects consist of a dry gas compression design where the fluids are separated prior to boosting.

"This means that both the pump and compressor require separate high voltage strings, and getting sufficient power in the correct form is one of the main challenges with subsea systems.

"At one time, the only solution would be to provide the power from land or a nearby platform. The recent developments in renewable energy systems, with increasingly higher power ratings, could result in these new energy sources being a candidate for supplying power to a subsea compression station.”

A characteristic problem with most renewable power sources is that the energy fluctuates, and this must be accommodated for in the system design. It only becomes a problem, however, when keeping the compression turbine running at top speed, continuously. It disappears by simply electing to carry out the compression only when power is available. It does, however, require a compression system able to speed up or down on demand.

“We have examined a number of case studies where power from renewables could be harnessed,” said Grant.



Case studies

ONSHORE HOST

One such example is an onshore host facility capable of processing 340 MMscfd and accommodate arrival pressures from 50 to 100 bar. In this example, the subsea compression facility is located 150km from the host facility and the pipeline connecting the two has a nominal diameter of 16in.

"The compression facility sits 500m below the two wind turbines, each with a maximum power output of 8 MW," said Grant. "The subsea facility has the same power rating as the existing Asgard compressor. A constant suction pressure of 100bar is assumed which is not too far of what we would see in reality.

"With little to no wind, a small amount of production can be maintained by bypassing the subsea compression station. Once wind speed picks up enough to provide the compressor with a MegaWatt of power, the compressor can operate at minimum speed. As the speed picks up, compression increases to its maximum.”

SUBSEA PRODUCTION/HIGH WIND

In this example, the host facility production rate is 340 MMsfcfd but the subsea compression facility is capable of achieving production rates in excess of this. As a result, energy storage in the form of line packing can be introduced.

"Line packing is the name given to the procedure of allowing pressurisation of the pipeline during sustained periods of high wind. This enables production to continue for a certain time even after windspeeds drop.

"In an illustrative 30hr period, we start at steady state operating conditions with 10 MW of power available from the wind turbines. This allows for a constant production rate at the subsea and host facilities, and a host arrival pressure of 50 bar.

"The example assumes the wind speed increases and decreases linearly, with a peak speed at 9 hours. After a couple of hours, compression power reaches its maximum and the pipeline pressure begins to climb.

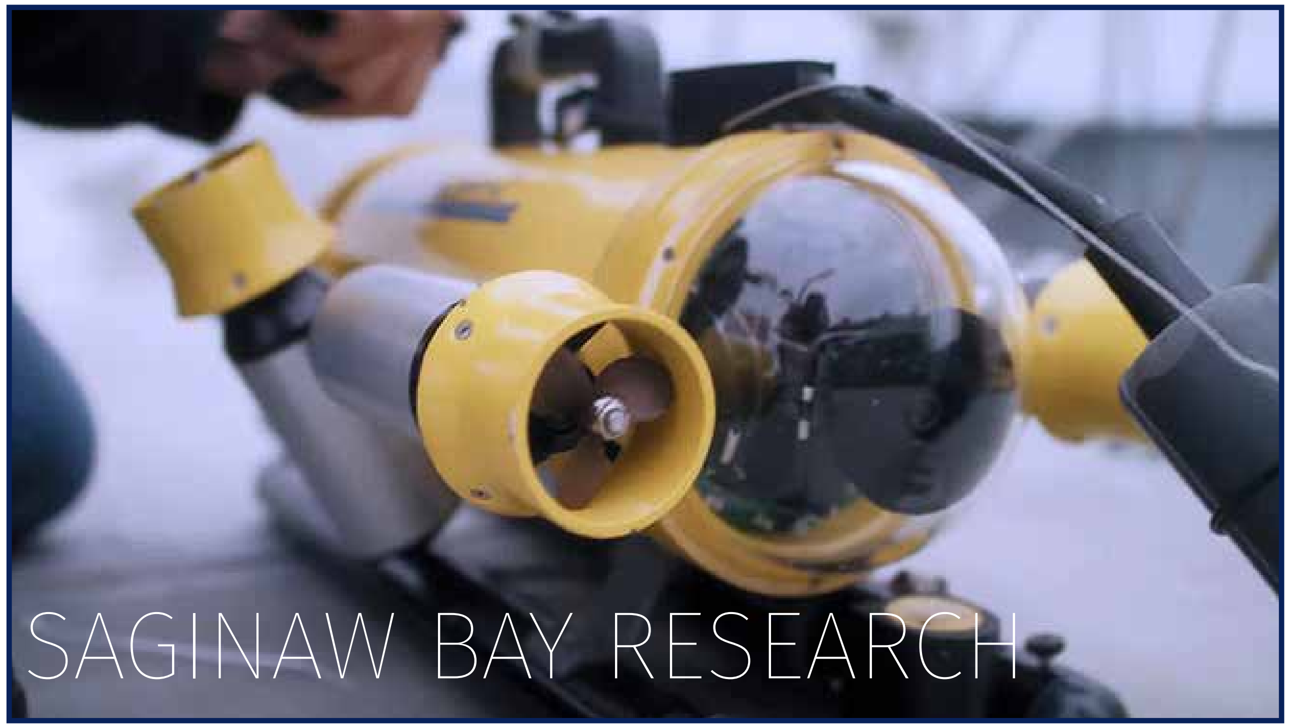
“Once the wind speed and thus, the compression power begins to fall to a point at which it is no longer possible to maintain the host production rate, the pipeline starts to 'unpack'. Full host production can be maintained for at least 1.5 hrs upon loss of power.”

There are transitions from very high wind speed to very low wind speed or low to very high windspeed and in the want of better the lack of statistical analysis an that this happened 80 times in the year. This means that in total, at least five days of full production that can be maintained as a result of line packing. It gives at least 1% more full production up time.

For this example, an average host production rate of 288scf/d for the entire year of operation can be attained.

"It is reasonable to assume that onshore facilities have a gas gathering network rather than a single production pipeline,” said Grant. “Additional pipelines in the network can be also used for line packing.”

It is also possibile to employ energy storage in the form of batteries, making use of the additional capacity of the wind turbines during periods of high wind where the compressor cannot use all available power. Voltaic solar panels can also be used conjunction with wind turbines to keep the compressor spinning during periods of low wind.



SAGINAW BAY RESEARCH

Saginaw Bay's warm waters serve as nursery grounds for many fish species and support the fisheries of both Saginaw Bay and the main basin of Lake Huron. Historically, inner Saginaw Bay contained rock reefs that provided critical habitats, spawning grounds, and juvenile areas for many native fish species.

This includes Walleye, Smallmouth Bass, and Suckers during the spring and Lake Whitefish, Cisco, Lake Trout, and Burbot in the fall.

As human development increased in Michigan, this critical habitat was largely lost due to sedimentation resulting from land use changes such as logging and agriculture. The loss of inner Saginaw Bay's rock reefs contributed to the 1940s collapse of Saginaw Bay's Walleye fishery and negatively impacted local populations of Lake Whitefish, Lake Trout, Burbot, and other species. The reefs were determined to be in dire need of restoration to bring back the ecosystem that once thrived.

The results of a multi-year assessment found that conditions in the inner-bay were suitable for restoration, with the Coreyon Reef identified as a priority restoration site. With financial support from the Environmental Protection Agency and Saginaw Bay Watershed Initiative Network, the collaborative reef restoration team began moving forward with the design, permitting, construction, and restoration of the Coreyon Reef. The purpose of the rock reef restoration project is to restore off-shore rock reef spawning habitats that benefit Walleye, Lake Whitefish, and Lake Trout to name a few.

The project was approved and funded by a Great Lakes Restoration Initiative (GLRI) grant of $980,000 and a grant of $25,000 from Saginaw Bay Watershed Initiative Network (Saginaw Bay WIN). The total project is just over $1 million. In the end, two acres of reef habitat were restored.

Construction began in early 2019 and completed by the fall of 2019. The process was recorded and a documentary was filmed featuring the initial post-construction examination work. The documentary premiered at the Thunder Bay International Film Festival in January 2020.

Dr David Fielder (Michigan DNR) and his team was a major contributor to the project. Michigan DNR will be evaluating the relative attraction of the new reef to different fishes. One acre was one type of rock while the second acre was another type of rock, and the differences in productivity can be measured.

Michigan is partnering with Purdue University on the post-construction evaluation of the reef.

JW Fishers SeaLion-2 Remote Operated Vehicle (ROV) was also a key part of this project. The ROV was used as a visual aid to ensure that the rocks were placed correctly and it was also used to monitor the new reef's activity. Dr. Fielder stated

"We did also use our JW Fishers' SSS-dual frequency side scan sonar for additional assessment but unfortunately the filming didn't capture that. On the whole, JW Fishers' equipment played a central role in that habitat work.

We will be going back out there at 'ice out' to take another look (with hopefully better visibility)." Ice out, as Dr. Fielder mentioned, is when the Spring thaw allows for sufficient melting to continue operations.

FAST DIGITAL IMAGING

As industry prepares to manage its Covid 19 response, many businesses have been forced to review the way that they operate. This is particularly true within the underwater survey sector.

In the recent past, some offshore operators have begun to embark on major initiatives for increasing automation. Automated systems are highly accurate and reliable while the lower carbon footprint and the reduced exposure of humans to potentially dangerous environments are very appealing. Indeed, the sudden desire to decrease offshore manning has become particularly topical with many looking for alternatives after finding it difficult to travel.

One of the most human-intensive underwater operations is subsea inspection. This, however, is vital in order to ensure that the condition of structures, particularly pipelines, retain the necessary integrity. Over the decades, routine monitoring has shifted from being carried out by divers to using underwater vehicles, particularly ROVs. Unfortunately, the requirement for surface vessel support can make the operation very expensive.

Already, many are turning from remote to autonomous vessels and vehicles. Not requiring the same degree of surface support, these can traverse along the pipeline at greater speeds as they record images. The downside of autonomous vehicle inspection is the imagery cannot be easily examined in real time. Interpretation has to wait until the data is retrieved at the end of the inspection run.

Tethered systems, conversely, are better at interrupting planned inspections to investigate unexpected anomalies, able to deviate from plans and zoom into an area of interest before proceeding. They can carry out additional spot dives.

Most underwater systems use video. High definition (HD) and ultra-high definition (UHD) systems are readily available on the market. Pipeline-tracking software can automatically guide the vehicle to ensure that the downward pointing camera is always focussed at the target.

In order for continuous video to work, the image needs to be sufficiently illuminated. If the intensity is not strong enough, the video imagery becomes less effective.

Just over 10 years ago, Cathx Ocean entered the subsea inspection market. Along its journey, the company has developed a number of innovative tools designed for operations on autonomous vehicles.

“Capturing a moving image at anything over 0.5 kt can often introduce motion blur into the video footage,” said Frank Lennon, Product Manager at Cathx Ocean.

These speed limitations can mean extended vessel deployment– it is not uncommon for a standard video survey to take over a month to complete at a substantial cost.

“Looking to improve efficiency, we decided to approach the problem from an alternative direction based on stills cameras being able to produce higher definition images than video cameras.

“The Cathx Ocean Imaging System captures images at a frame rate of three images a second as the vehicle traverses over the pipeline.

"The actual frame rate is decided pre-mission to ensure 50%–70% overlap. This is important when the images are used with photogrammetry and mosaic software tools that rely on feature-matching from one image to the next.

"The level of detail captured in an image from a Cathx imaging system is ideal for machine vision algorithms.”

This approach affords a significant advantage.

Autonomous vehicles have a finite energy payload. Once the cells are exhausted, the vehicle needs to return to a base for recharging. An important property for equipment used on vehicles, therefore, is low power consumption. Unfortunately, this is largely incompatible with the need to continually shine high-intensity lights downwards, possibly for many hours, to illuminate the inspection target.

A key difference between stills and moving imagery is that videos are illuminated by constant light while photos use a high-intensity flash. A considerably lower electric charge is trickle-fed into the capacitor banks and discharged on demand to create the rapid light.

“We use a strobe lighting system called the Pulsar I, which provides a large increase in the lumen output in comparison to standard ROV lighting,” said Lennon. “It is characterised by far shorter light pulses but with higher power intensity to ensure the field of view is always fully saturated with light.

3D IMAGING

In recent years, laser imaging has emerged as a very useful tool for subsea inspection.

Transmitting a laser line towards the target forms a three dimensional point cloud which can be fed into graphics software to produce an imaging model that can be viewed in three dimensions.

“Sending out laser beams into an area bleached with light is not always successful because of the lack of contrast available," said Lennon.

"Conversely, emitting a light pulse into the blackness of the sea makes any target and reflection stand out. All the actions are synchronised by the camera’s processing and operating system

“We have enjoyed significant success in the oil and gas industry when surveying pipelines. Trunk lines that are hundreds of kilometres long, need to be surveyed every year or so. This used to take survey companies 30 to 40 days and now we can do it in under ten.

“We use Cathx's SOLID post processing system to optimise image collection, using functions such as flat field correction, orthorectification, optical distortion correction and sharpening."

This high-definition low power technology has made this the imaging system of choice on Autonomous Vehicles like Kongsberg’s HUGIN, Teledyne Gavia’s SeaRaptor and International Submarine Engineering’s (ISE) Explorer vehicles.

This allows the Cathx camera to operate at low exposure thus reducing motion blur and this in turn means the vehicles can travel faster and cover more distance.”

The camera that Cathx Ocean has developed is no ordinary device but a smart system which controls all the peripheral Cathx equipment, while also incorporating information from other sensors on the vehicle such as a depth sensor.

This means that the operator always knows the camera position relative to the seabed, a property useful ensuring that the images are always in

focus and that sufficient light is distributed to the target.

During a typical camera survey, the light is turned on to capture the image. The darkness between the strobe pulses, however, gives the imaging system another significant advantage – it allows 3-D laser data to be captured.

The simultaneous capture of two datasets would not be possible during traditional video surveys

“Mechanically, it would be quite possible to capture more, but recording too much data can take up space.

"We normally capture in 4K UHD mode but this can be drop down to conventional HD mode if data storage space becomes an issue" concluded Lennon.

3D COLOUR POINT CLOUD

With the unique data collection process employed by Cathx Ocean another data deliverable available to clients is 3D colour point cloud.

Colour laser point cloud is the result of taking the original 3D laser data and combining it with the 2D images of the same scene. The image pixels that have known corresponding 3D points into world space are positioned into a point cloud.

This dataset provides all the visual benefits with a photogrammetry model but can be processed in a fraction of the time.

Additionally, it is highly accurate as it uses laser data to build the model and as it does not have to rely on feature matching and image blending to create the finished model which can affect the accuracy.


3D Point cloud

STEREOPHOTOGRAMMETRY

COMBINING COMMERCIAL APPLICATION WITH ACADEMIC RIGOUR

Martin Sayer, Managing Director, Tritonia Scientific Limited

Stereophotogrammetry, sometimes referred to as Structure from Motion (SfM), is a computer-based technique that can generate highly complex three-dimensional point-cloud models using image-based material obtained relatively simply and quickly. It is a rapidly evolving tool that is highly adaptable and can be based on most videographic or photographic data where there is significant and relatively consistent overlap between frames or images.

SfM software identifies thousands of discrete points within an image. The three-dimensional movement of the points in relation to each other is tracked between successive images with the two assumptions that the camera is moving and that the structure is static. As the points become located within an xyz framework, three-dimensional structure is generated, firstly as a point-cloud, secondly as a mesh where the points become joined, and then as a textured mesh where fragments of the images are attached back onto the mesh to complete the models.

The advantages coming from underwater SfM modelling are many, one is the reduction in survey time because of a decreased need to undertake measurements *in situ*. By transferring any quantitative assessment from the underwater structures to a computer model, accuracy is improved and can be checked easily through replicated measurements.

A broadscale reconstruction of Helensburgh pier, combined from aerial and sub-tidal surveys, made to map the underwater structure of the pier and the areas of damages caused by collisions and fire.

The models also provide a permanent record of the targets permitting comparisons to be made over time. Although surveys that are purpose-designed produce better results, some models can be generated from 'video of opportunity' where the primary purpose of the survey was unrelated to SfM. In some instances, models can still be produced from videos taken many years ago and support a 'Back to the Future' approach to some forms of monitoring.

A 3D model of coral coverage on an oil platform leg at 40+ metres depth in the Gulf of Thailand. The model was generated from ROV video of opportunity.

Tritonia Scientific, a company based near Oban on the west coast of Scotland, owns and manages a unit that specialises in underwater stereophotogrammetry. It started using SfM in 2013 to support a range of underwater academic projects while operating as the Natural Environment Research Council's National Facility for Scientific Diving.

A diver setting up a temporary quadrat with scaling bars prior to collecting the photographs required to generate a 10 x 10 m 3D model of impacted coral in the Indian Ocean.

The initial challenge was to take SfM software, that had been developed for terrestrial applications, and make it work for imagery obtained underwater. There were numerous commercial and open-source SfM software packages available and they varied in aspects of user-control, the numbers of images that could be modelled, the outputs available and time taken to process the models.

In addition to choosing the most optimum software there was also a requirement to invest significantly in advanced computer capability.

Dr Andrew Mogg is employed as a full-time photogrammetry postdoctoral researcher at Tritonia and has seen the technique evolve markedly over the last few years.

"Initially the accuracy and precision of the underwater models was very dependent on the type and quality of the image data.

More recently, the software has evolved to become more adaptable and, if the initial survey material has proper scaling and orientation information, we are satisfied with the quality of the models being delivered."

Tritonia Scientific has applied SfM modelling in support of a range of academic research projects. It is a technique that is widely employed in coral reef research and Tritonia has used it as a way of more accurately assessing the levels of carbonate production of reefs, in studies of reef complexity, combining it with fluorescence photography to estimate the settlement of juvenile corals, and as a method to base assessments of the efficacy of small-scale marine protected areas. In temperate waters stereophotogrammetry has been used to quantify the rugosity and percentage coverage of mussel beds, and to determine and identify the optimum habitat types for endangered shark nursery sites.

The company has even used overlapping scanning electron micrographs to estimate the surface area of microplastic fibres that had been ingested by deep-ocean animals.

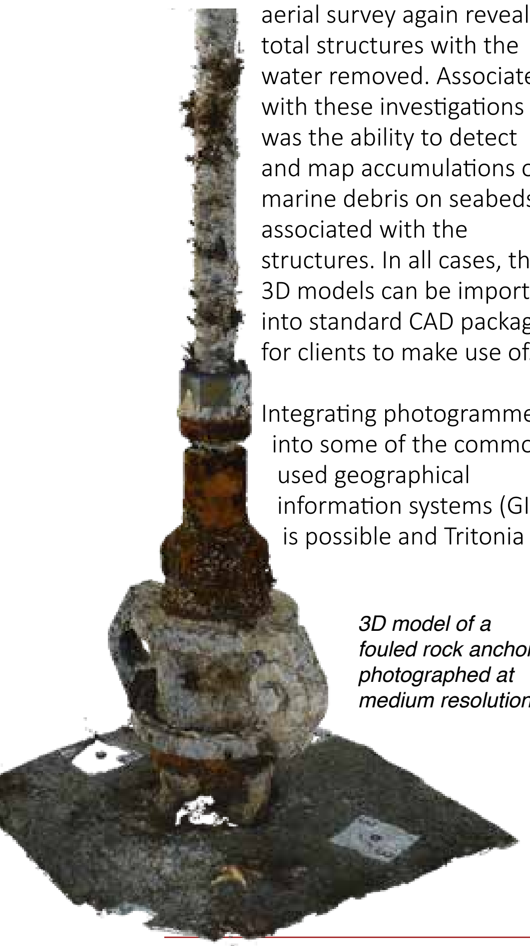
"The variety and flexibility of how the technique can be applied has few limits" says Andrew. "There are, however, always choices to be made based on the size and complexity of the target to be modelled, the methods to be used to capture the imagery, the desired resolution of the outputs, and the eventual file sizes of the finished models.
The range in size of the models we have produced is significant. We have delivered broad-scale models using aerial drone footage from 5 x 5 km surveys of glaciers in the Arctic, down to some at the micron level for subjects photographed using microscopy.

When diving, the size of model can be influenced by dive times and water visibility, but optimally configured camera and lighting equipment, combined with the ability to join multiple sub-models together seamlessly, can produce detailed models under challenging conditions. In the final result, the water 'disappears' to reveal structures that could never normally be seen in their entirety."

In 2018, the unit became privatised as Tritonia Scientific Limited and the team expanded to undertake projects with more commercial focus while retaining an academically based approach. Initial work included using modelling to quantify the types and volumes of biofouling on oil and gas platforms designated for decommissioning in tropical regions such as Thailand and Angola.

The growth of soft and hard coral on marine structures can be substantial in warm waters and add significantly to the weight of jackets intended for removal. Once the models are created, it is a relatively straightforward operation to ‘remove’ the jacket structure digitally and reveal the total volumes attributable to biofouling.

Tritonia has also used stereophotogrammetry to complement diving-based principal inspections of shallow inshore submerged structures such as piers, harbours, slipways and breakwaters. The objectives varied but the new SfM techniques supported identifying and quantifying physical defects and damage while, at the same time providing an overall view of the subtidal structures. Combining underwater models based on imagery obtained at high water with ones generated using low-water drone-based aerial survey again revealed total structures with the water removed. Associated with these investigations was the ability to detect and map accumulations of marine debris on seabeds associated with the structures. In all cases, the 3D models can be imported into standard CAD packages for clients to make use of.



3D model of a fouled rock anchor photographed at medium resolution

insert (below left) showing close up detail

Integrating photogrammetry into some of the commonly used geographical information systems (GIS) is possible and Tritonia has invested recently in new compact through-water GPS equipment that supports accurate georeferencing of the models.

Even though SfM produces high quality and highly accurate models, their sizes will often be limited by operational constraints and while their use may have to be contained to targets of interest, it remains important to ensure that their location and orientation are consistent. Kathryn Dawson, a postgraduate research assistant who works at Tritonia, and is responsible for assimilating SfM into GIS applications, explains:

“Underwater surveying is a perfect scenario for using SfM. In addition to the 3D models, the technology can also create orthomosaics. These correct for the perspective of the camera and the different distances that each point is from the camera, and are powerful mapping tools in instances where seabeds are not flat.

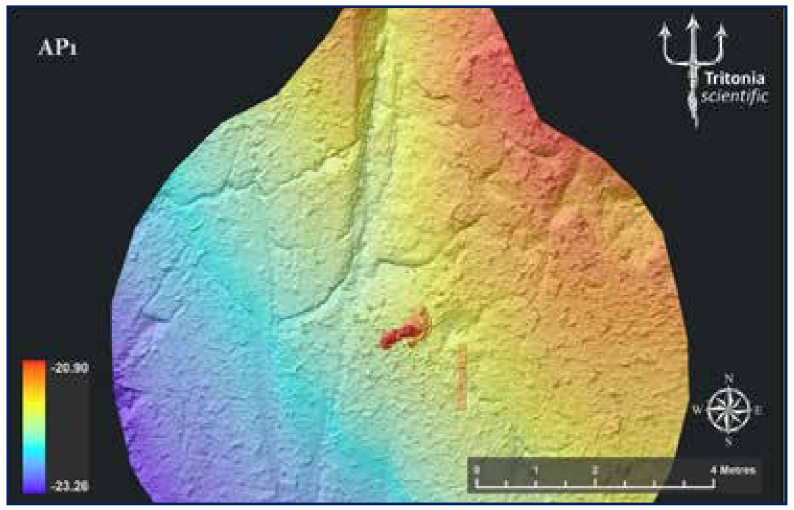
If accurate depth and levelling controls are included in the raw image data, then additional depth contouring can be added to the orthomosaics to generate digital elevation models. The GPS locator modules we are now using are so small, that they can simply be attached to the cameras to provide accurate locational data required for GIS integration.”

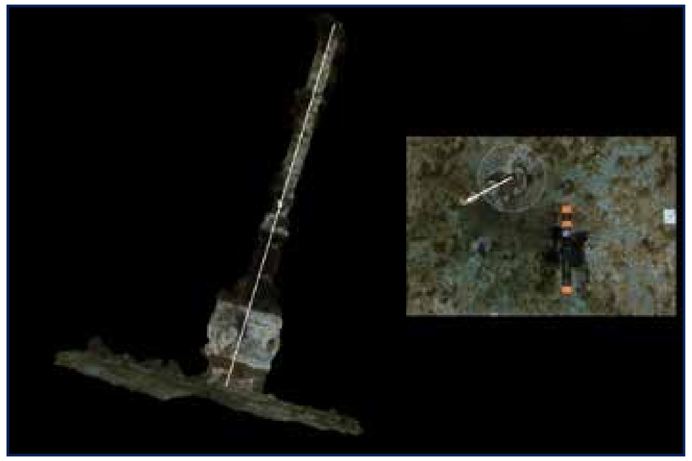
Combining georeferenced orthomosaics and digital elevation models with detailed 3D modelling is used by Tritonia when undertaking habitat mapping for environmental assessment. It has been particularly useful when conducting monitoring programmes for the aquaculture industry, when producing accurate habitat information for regulators and for surveying marine protected areas.

Tritonia has successfully employed remotely operated and autonomous underwater vehicles (ROVs and AUVs) for extending the areas that can be covered using SfM techniques for these broader-scale surveys.

The most recent application for this technology has been through a research partnership between Tritonia and Sustainable Marine Energy Limited. As part of their integrated tidal energy systems, Sustainable Marine Energy provide innovative anchoring and mooring systems that are used both for marine renewable energy projects and in aquaculture.

An example of a medium-scale digital elevation model of a rock anchor site





An example of the type of information that can be measured from a model. In this case the metrics taken were that the anchor was projecting 136cm from the seabed, at an inclination of 16° from the vertical and 249° from North

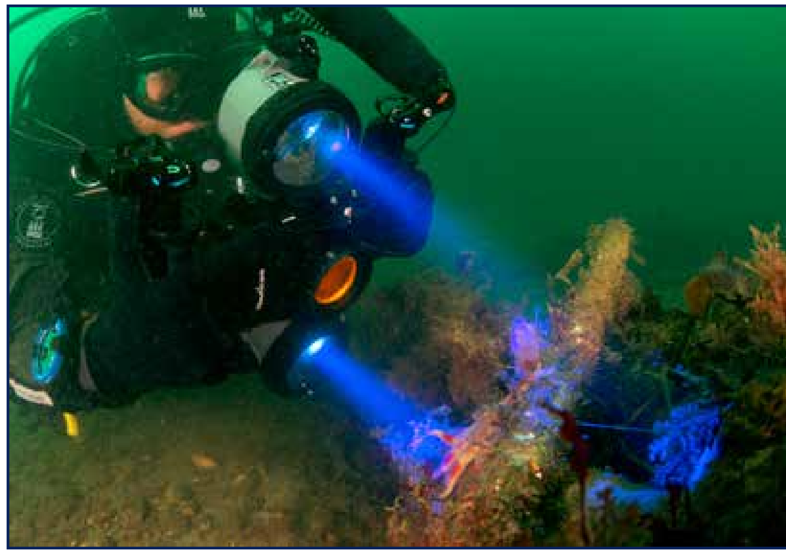
The two companies have been working together to evaluate stereophotogrammetry combined with orthomosaic-based mapping as methods for measuring and monitoring the condition of the direct embedment anchors. High-resolution 3D-models combined with point-cloud comparison methods can quickly and accurately quantify areas of deterioration or erosion in the anchors, in addition to measuring the exact depth of penetration. Level-controlled and digital elevation models have determined the direction and extent of the angle of the anchor’s penetration, and georeferenced orthomosaics were used to provide feedback on the anchor positioning.

Tritonia Scientific is basing its use of stereophotogrammtetry on proprietary ‘black box’ software and, in order to be certain of the accuracy and precision of its models, undertakes a range of testing and evaluation based on the transfer characteristics of the inputs and outputs.

There are some very basic limitations to the methodology caused by the movement of non-static animals and plants that are attached to or associated with the structures. These can ‘confuse’ the software but, in general, if the movement is relatively large and doesn’t obscure the basic imagery, then most moving objects will vanish from the resultant models.

However, where covering organisms, such as seaweeds, exist then they may have to be removed first, particularly if they obscure areas of specific interest. Some moveable structures such as mooring chains and swivels can be modelled if they are relatively static in mid-water or through the use of multi-camera systems to capture imagery from many directions simultaneously.

When the models are being used for measurement, then dependable accuracy will only be possible where the raw image data can be related to in-situ scaling and orientation controls. For depth elevation modelling, frequent independent recordings of depth are required, and Tritonia is involved in a project to deliver methods for estimating depth accurately based on continuous pressure measurements corrected in real-time for conductivity variations.



Evaluating the additional benefits of combining stereophotogrammetry with fluorescence photography.

3D RENDERING

SAVANTE CONDUCTS PHOTOREALISTIC IMAGING

Over the past decade, advances in underwater imaging has meant that it is possible to make 3D renders of structures at very high definition and speeds. Existing heritage video footage taken by companies can also be converted to 3-D.

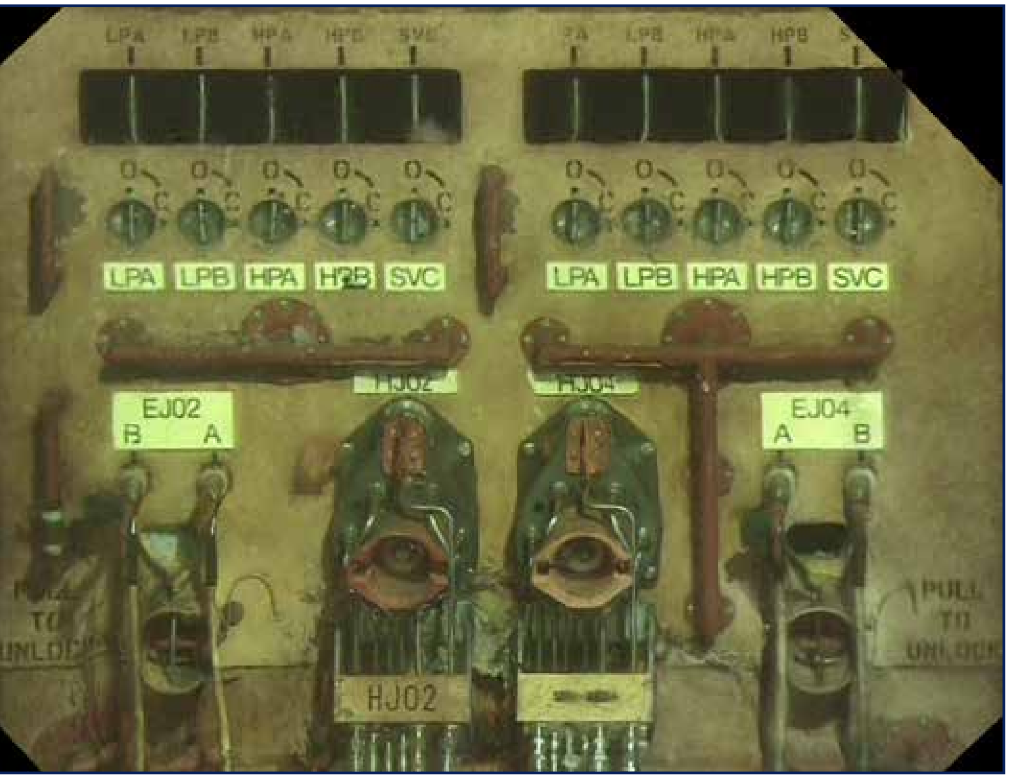
One such exponent of this technology, Savante, has not only worked up its own camera designs, but is also offering new and cost effective ways of deploying them.

“This year has seen a combined collapse of the oil price and the ravages of COVID” said Grant Thomson, principal at Savante."There has been a huge rationalisation in the market but an uptake in the demand for globally delivered imaging services."

In the past year, Savante has invested a lot of money in new technologies, to increase processing speed. Projects that once took days can now be delivered in 20 to 30 mins.

“Our biggest market is carrying out inspection by making photorealistic high-resolution digital 3-D models of objects," said Thomson. "We originally offered services under a framework agreement but more recently, we have concentrated on bespoke projects.

“We used to install tools on third-party ROVs but projects were sometimes delayed due to waiting on the vehicle. We have now purchased our own mini-ROV which is small enough to fit into a helicopter.



3D rendered model of UTA and SDU

"This was bought off-the-shelf but now the only original parts are the flotation framework and thrusters. The latest iteration has eight lateral thrusters."

PHOTOGRAMMETRY

“We have made considerable improvements in our subsea photogrammetry technology" said Thomson.

"Photogrammetry involves capturing images and feeding them into an engine to create a 3-D CAD model.

There are two basic types

MONOCULAR

This is based on a single camera system.

“Our Vector cameras are used for a wide range of applications from fish imaging to high-speed pipeline survey,” said Thomson. "The cameras are capable of 400 frames/second without image blur.

Conversely it is possible to run the cameras at lower speeds of maybe 5 to 10 frames/second and produce 85 – 120 megapixel images. Today, many subsea vehicles such as ROVs, towfish or drop frames, have at least one camera that we can exploit.”

Importantly, over the past 30 years or so, a tremendous amount of video data already has been accumulated by offshore operators. This was based on SVHS formats with a resolution of 320 by 240 pixels, but even these can be used in some cases.

Applications include the measurement of geometry changes, possibly identify movement and generally indicate potential future problems.

“The 3-D model produced from a single video camera can not be really considered a digital twin as the user still needs ***a priori*** knowledge about the object. The technique can determine shape from the image, but not scale," said Thomson.

"It may be possible, however, to calculate this. If the user, for example, knows the pipeline's actual diameter or radius of curvature, it is possible to calculate the scale on the image. With that knowledge, it can be used to measure other parameters such as wall thickness loss or impact dents.

Nevertheless, monocular photogrammetry can be used for a large number of applications such as identifying the presence explosive ordnance for the military or recognising anchor strikes on pipelines. It is possible to strip back coatings on pipes, look at concrete wall loss or image offshore boulders on the seabed.

It can also be coupled with acoustic technology to show such events as marine growth on the concrete mattress or image seabed scour.

Monocular requires a high quality strobe. Instead of incorporating off-the-shelf strobes with a refresh rate of every 4.5 seconds, Savante’s house-designed strobe can achieve rates of nearer 80 per second, nearer 360 times faster than the original technology.

STEREO VISION

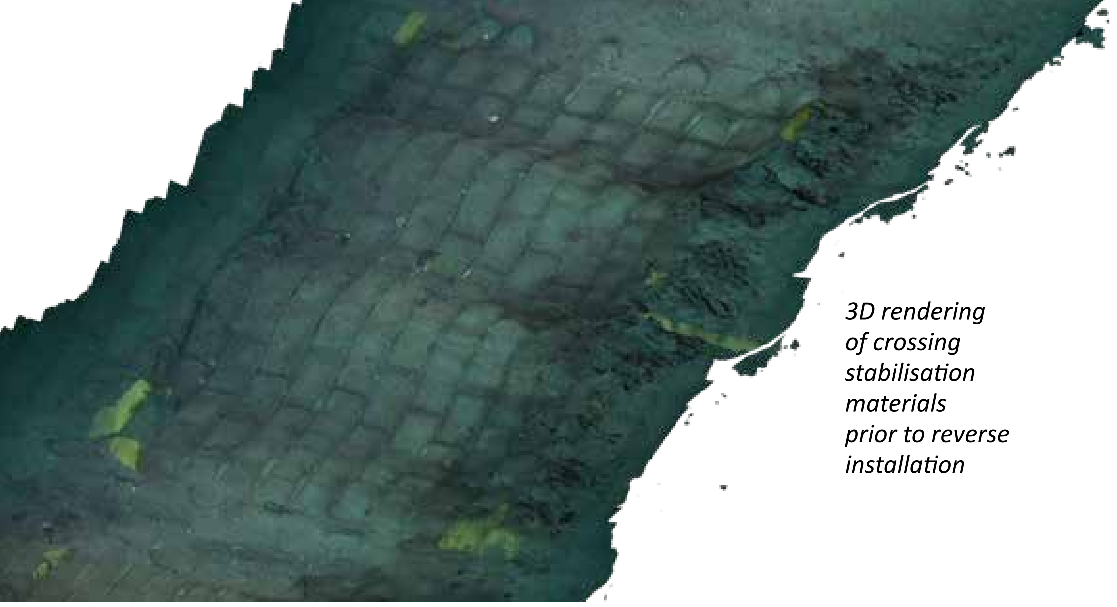
Binocular vision has been an extraordinarily successful evolutionary strategy throughout the animal kingdom. From a pair of images, it is possible for the brain to calculate relative depth. This is also true of stereo photogrammetry.

“The key advantage of this is that the 3D data from a stereo imaging system is already calibrated and as such does not require a scale bar," said Thomson. “We combine our cameras with a very fast processor which can marry the two images up. By correlating thousands of points, it is possible to create a 3-D model.

Stereo systems have a 20% enhancement when compared with

3D rendered model of Conductor and Guide Clamp: General Overview

3D model of Conductor and Guide Clamp: Close-up showing guide profile



3D rendering of crossing stabilisation materials prior to reverse installation

3D rendering of platform members and conductors

monocular photogrammetry systems video technology."

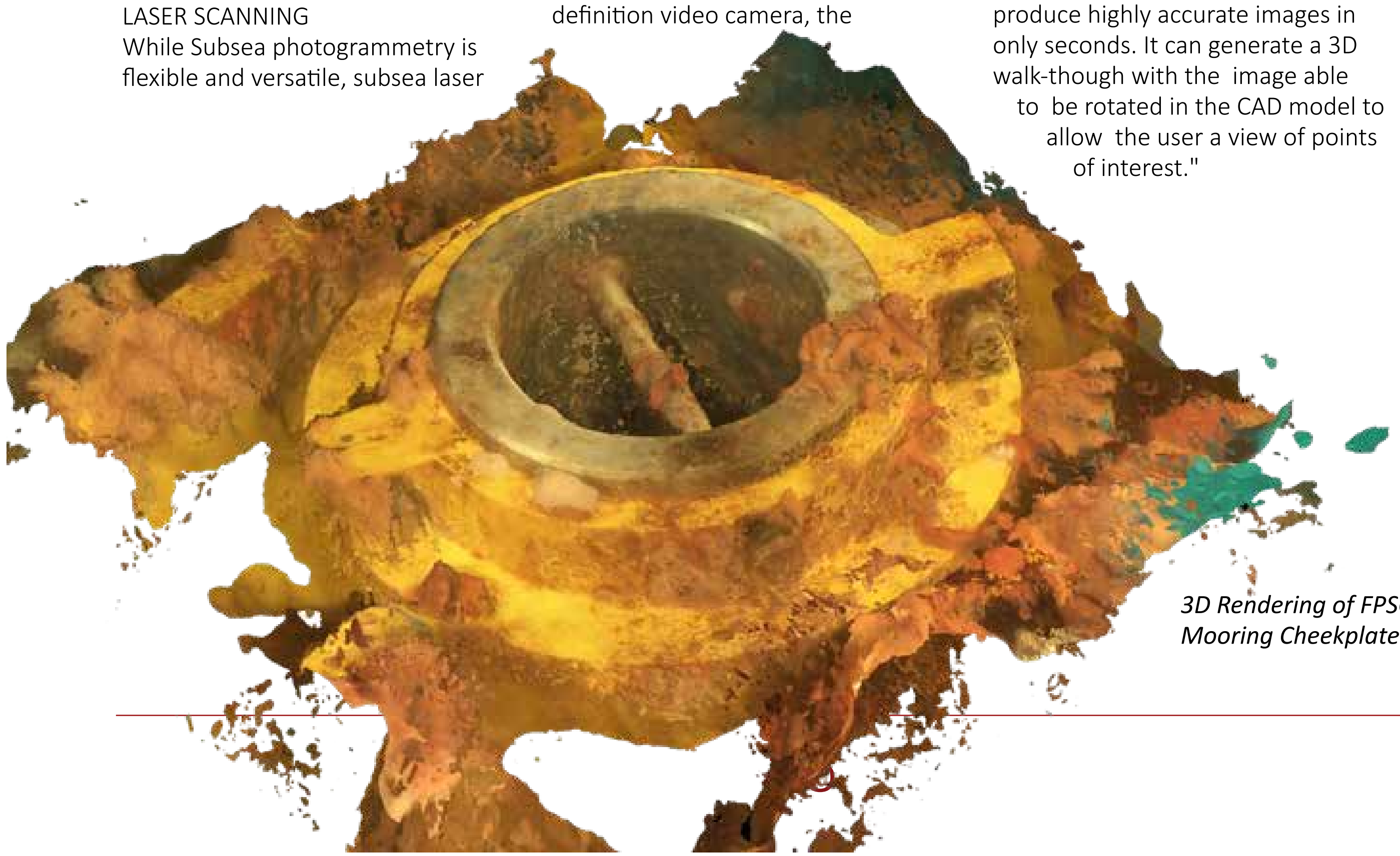
Savante has named its stereo camera 'Vergence'. It incorporates a pair of 20Mp cameras in a 133 mm diameter housing. This design affords an immediate advantage in that the optics and electronics can be kept at the same temperature and pressure. The video camera can capture images at 30 frames per second with the data being fed into a 60 TB onboard storage module. The camera pair is supported by a 1 microsec, 120k Lumen strobe and a 3D laser profiler.

Instead of using a single Vergence camera, it is instead possible to combine a pair of monocular Vector cameras for the same effect.

LASER SCANNING
While Subsea photogrammetry is flexible and versatile, subsea laser scanning provides an alternative, higher performance technology. It provides repeatable, high precision measurements to even develop a photorealistic digital twin.

"We developed our own high definition video camera, the equivalent of what is often referred to as fast digital imaging," said Thomson. "We also optimised all the lenses that goes in front of it.

"This can be used to scan images at around 60 times a second to produce highly accurate images in only seconds. It can generate a 3D walk-though with the image able to be rotated in the CAD model to allow the user a view of points of interest."



3D Rendering of FPSO Mooring Cheekplate

LEAK DETECTION

OceanTools' new DyeTector technology is based on the principle that if light of a certain wavelength is directed onto a specific dye, it causes that to dye fluoresce and emit light at a different wavelength. When introducing this dye into a material such as hydraulic fluid in a subsea control system, therefore, it is possible for the DyeTector to immediately recognise any leakage.

The DyeTector product range includes the D7 ROV-mounted single-dye detector, the D9 diver-held detector and the D10 ROV-mounted dual-dye detector. The output is fed into surface software (or into the display built into the diver-held unit) to warn of the presence of dye, clearly and unambiguously, even sounding an audio alarm if a threshold is reached.

"One traditional problem of trying to detect a leak, is the presence of strong ambient illumination. This is because the reflected light emitted by the dye can be at a very low intensity, it is often easily washed out by the ROV's far more powerful lighting," said Kevin Parker, Managing Director of OceanTools.

"The DyeTector, however, incorporates very innovative processing techniques to avoid this problem. This means the ROV's lights can be left on while the DyeTector is in use."

CEMENT
As well as detecting leaks from subsea infrastructure, dyes may added to the cement used in casing cementing operations when drilling. When the cement returns to the surface, the DyeTector can notify the cementing company and allow them to cease pumping cement. "This could mean very significant cost savings as, typically, operators need to pump 200-300% of the calculated cement to take account of losses into cracks and fissures," said Parker.

The DyeTector

The DyeTectors are produced in Aberdeen with the titanium housings being machined in OceanTools' in-house CNC machine shop. The units are offered with a 6000m depth rating as standard with shallower 1000m units being offered as an option.

There are three main dye types in use for subsea leak detection. These are rhodamine, fluorescein and ultraviolet. Fluorescein is progressively being phased out due to it's environmentally unfriendliness. OceanTools DyeTectors are able to detect all three dyes.

OIL DETECTION IN WATER

For many years, Long Wave InfraRed (LWIR) cameras have been established a useful tool for the detection of oil spills, however, they do have specific shortcomings.

This prompted, Polaris Sensor Technologies to develop Pyxis, a novel camera system able to generate more reliable imagery. It has proven itself to be a vital tool for oil spill detection.

Pyxis is mall enough (3.5in x 2in x 2i) and light enough (less than 0.5lb) to be mounted on an unmanned vehicle yet robust enough to withstand constant salt spray on an open water oil rig.

The Pyxis camera works by capturing both LWIR data and polarization data, superimposing them into a single image, thus providing the best possible detection capability regardless of which method is providing a stronger signal.

“Sometimes, LWIR radiation provides a stronger signal than polarization when detecting an oil spill," said Pyxis sales manager John Rauseo, "while at other times such as in the hours of darkness, when the oil has reached thermal equilibrium with the water, when waves confuse the scene, or when oil becomes emulsified, then polarization gives a stronger signal.

Pyxis camera

The camera was the subject of testing at the Ohmsett National Oil Spill Response and Renewable Energy Test Facility located in Leonardo, New Jersey, USA.

NIGHT-TIME TESTING

Floating "boxes" (4 walls with no bottom) were placed in a pool. Oil was deposited in them. Their function was simply to help prevent the oil from leaking out into the surrounding pool water.

The visible camera immediately showed good contrast between the oil (black) and the clear water during the hours of daylight. At sundown, the entire image was black,

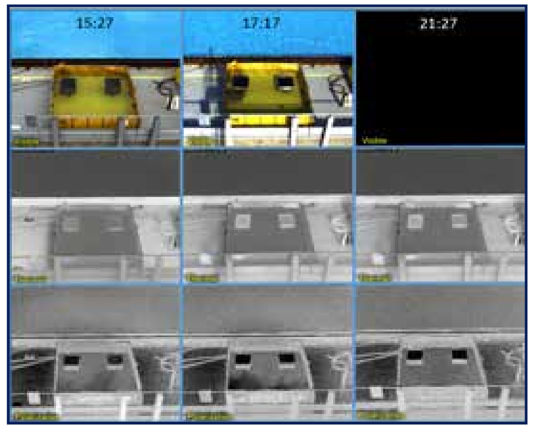
The thermal imagery also shows relatively weak contrast in all three pictures between the grey water and the lighter grey oil, although at least there was a recognisable image at nighttime, as opposed to the visible camera.

Polarization, however, gives a consistently strong contrast of black oil on grey water at all times of day.

VISIBLE THERMAL POLARIZATION

The laboratory conducted a continuous test to show nighttime performance between thermal imagery and polarization imagery

Polarization provided far better contrast over thermal IR imagery at almost all times although there was a small time window when the rising sun heated the oil faster than the water. This resulted in the thermal imagery having a stronger contrast but within an hour, the polarization imagery once again showed a stronger signal than the LWIR data.



Images at different times of day

WAVE ACTION

“In the presence of waves, if you didn't know to look for oil, then you wouldn't know that a contaminant was in the water in either the visible or the thermal imagery," said Rauso. "Only the polarization image provided a strong enough contrast to make it obvious that some kind of contamination exists.

Shortly after the wave pool was turned on, the oil quickly migrated out of the containment boxes and spread over a much larger surface area, with Polarization able to best show the spread.

EMULSIFIED OIL DETECTION TESTING

It is often relatively easy to detect solid oil slicks on the water surface, but it becomes more difficult if the oil becomes emulsified.

In an actual oil spill, floating oil ages and changes properties significantly due the action of UV radiation and the waves. As the oil emulsifies, the detection capability of various techniques can be severely degraded.

In particular, detection methods based solely on LWIR can suffer dramatically.

"Polarization detection also yields significant benefits under these conditions," said Rauso. " One of the tests conducted during the Ohmsett research involved trying to create emulsified oil."

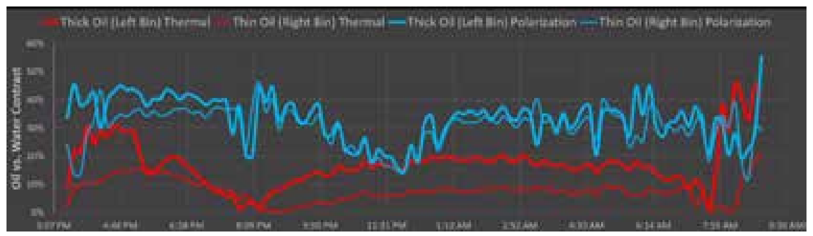
Oil was left on the surface of a calm pool and exposed to the sunlight for several days so any chemical changes caused by UV radiation had sufficient time to take effect. One hour before the test was conducted, the wave generator was engaged.

Despite the mixing and emulsifying that occurred from the wave action, the researchers obtained a strong signal in the visible waveband and in polarization. It was not possible, however, to clearly identify the oil in the water in the thermal imagery.

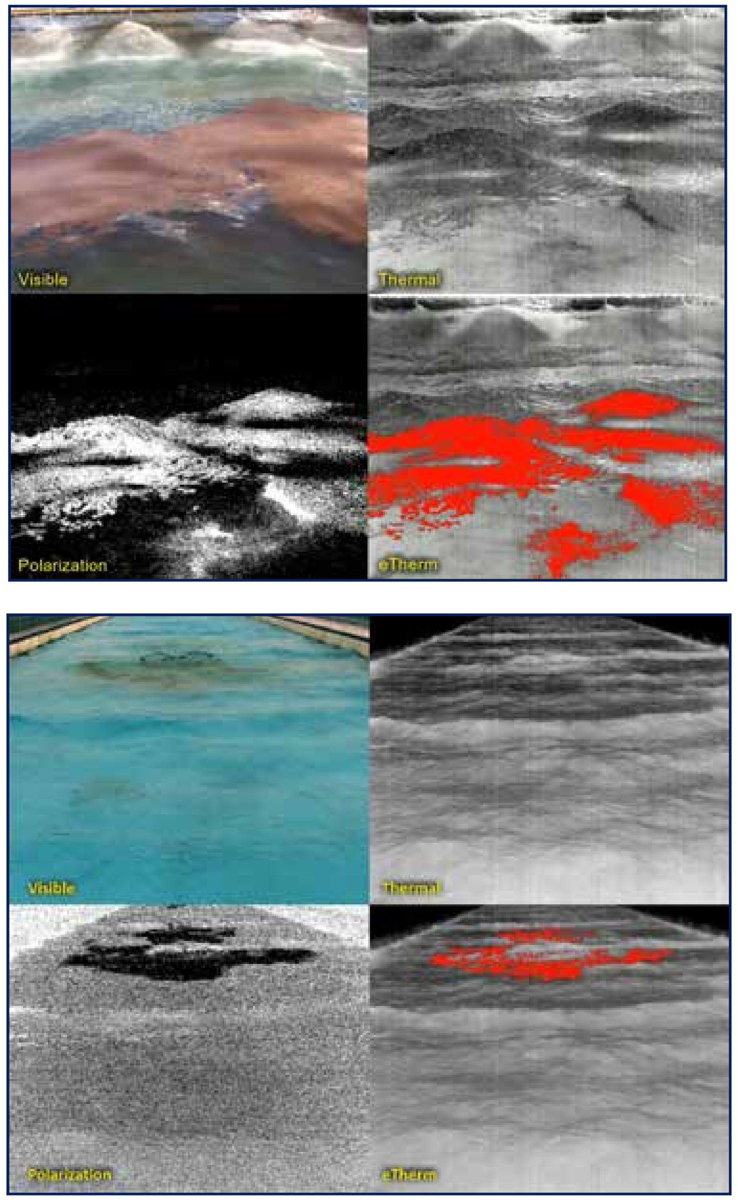
These tests and others performed by Polaris have shown that, in most situations, polarization imagery gives a much stronger signal when trying to detect oil on water than does thermal IR imagery alone.

However, Polaris Sensor Technologies' Pyxis camera does not force the user to choose between polarization and thermal imagery – it provides both.

"The Pyxis thermal/polarization hybrid camera captures the LWIR data and the polarization data in each frame, thus allowing the user to view only the thermal imagery, only the polarization imagery, or both in a fused image called eTherm," said Rauso.



Imaging contrast performance: Thermal IR imagery vs. Polarization Imagery



Oil deposits viewed using different techniques

ADDITIONAL TESTING

"Other less rigorous tests not conducted at Ohmsett imply that vegetation and water fowl that have oil on them can also be identified by Pyxis, however, it is difficult to ethically perform this testing on a large scale," said Rauso.

"Additionally, due to the nature of polarization, the minimum detectable thickness of oil with the polarization signature is approximately 50 microns but depends on ocean and weather conditions.

"This amount is very close to the minimum thickness typically considered to be worthy of recovery, so the physics of polarization itself helps prevent false positive detections

MINSAS INCOPRORATED IN GAVIA AUVS

Teledyne Gavia, manufacturer of Gavia, SeaRaptor and Osprey AUVs, has integrated the Kraken Robotics MINSAS Interferometric Synthetic Aperture Sonar (SAS) into its vehcles.

The MINSAS is an off the shelf configurable Interferometric Synthetic Aperture Sonar (SAS) which replaces high end sidescan systems at an affordable price, while delivering significantly higher resolution, range, and area coverage rates (ACR).

The increased range and resolution and associated higher ACR of SAS over traditional systems can significantly expand the capabilities of Teledyne Gavia AUV systems for a variety of tasks for naval, scientific and commercial applications
During the initial integration of the Kraken MINSAS at Teledyne Gavia facilities in Kopavogur Iceland a Gavia class vehicle was utilized.

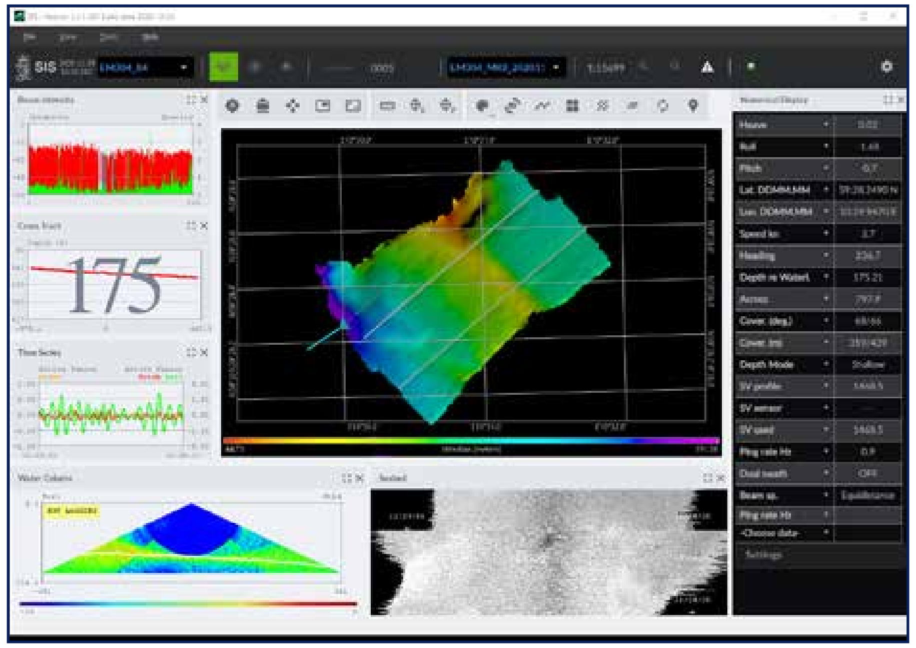
Due to the modular design of the Gavia AUV it was possible to use a Kraken MINSAS demonstration payload that was designed for a third party AUV along with a Gavia module adaptor to conduct sea trials.

The ability of Gavia AUVs to carry payloads from other commercially available AUV systems further highlights the benefits of a truly plug and play modular system for unmatched versatility.

The Integration and testing of the MINSAS culminated in operations with the Icelandic Coast Guard to examine targets of interest including what is believed to be the remnant of a B-24 bomber operated by the RAF for ASW patrols during WW2 and shipwrecks from the same period found in Icelandic waters.

Equipping the Gavia AUV with Synthetic Aperture Sonar enables the Gavia AUV to provide both bathymetry and high resolution / high area coverage sonar coverage which is ideally suited for a variety of applications including mine countermeasures, SAR and other operations where speed of response and actionable data are paramount.

The low logistics Gavia class vehicles will utilize the MINSAS 60 system while the larger Osprey and SeaRaptor AUVs are capable of carrying the larger MINSAS 120 configuration.



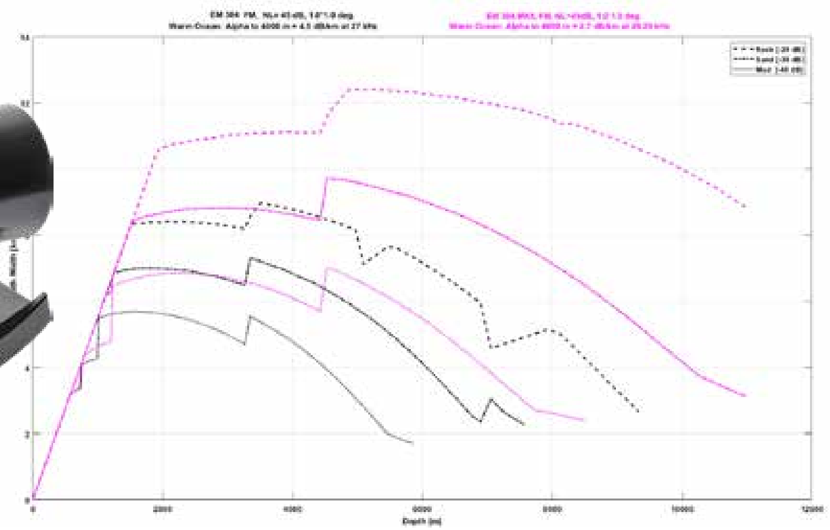
EM 304 MKII

Kongsberg Maritime has launched its EM 304 MKII to its portfolio of deep-water multibeam echo sounders. Underpinned by a brand new KONGSBERG-designed wideband transmitter working in the 20-32kHz band with a nominal frequency of 26kHz, the new mapping system significantly improves upon the performance of the MKI model, boosting range from a previous maximum of 8,000m to full ocean depth, and increasing swath performance by up to 75%.

In addition, the EM 304 MKII delivers an unprecedented 0.3° x 0.5° resolution – the highest achieved by a deep-water multibeam echo sounder – yielding optimal performance and precision. Meanwhile, the system's modular construction and flexible transducer design make installation easy and enable it to be adapted to fit almost any size of vessel.

As part of a new EM technology platform designed to anticipate and address future challenges, the EM 304 MKII is compatible with a novel KONGSBERG-developed datagram format.

This supports several innovative features such as extended backscatter calibration, and more features are already in development. The new format is supported by Kognifai, KONGSBERG's open digital ecosystem, which provides operators with the potential to transform their survey operations via digitalisation.



IWBMS

NORBIT Subsea has supplied a iWBMS (Integrated Wideband Multibeam System) to PD Ports.

With a fully integrated and tightly coupled multibeam survey system, the NORBIT iWBMS provides high data quality and ease of use for PD Ports who operates in challenging environmental conditions.

Benefiting from high resolution and wide coverage, the NORBIT system will be used for hydrographic, engineering and dredging surveys.

NORBIT iWBMS

EVOLOGICS LAUNCHES USBL

EvoLogics has developed a new, fully integrated USBL buoy, based on the company's S2C USBL devices. It comprises a USBL transceiver with a built-in battery, mounted to a floating unit with an on-board PC, GNSS receiver with dual antennas, and a Wi-Fi access point.

The design concept of the system derives from fishing floats that remain highly stable even in rough seas thanks to their long stems and minimal cross-section near the surface.

This allows the elongated buoy to remain stable in harsh conditions, and when deployed close to a vessel hull or pier walls, where the waves are taller.

This integrated system eliminates the need to use external GNSS receivers for geo-referenced positioning of underwater targets. Dual GNSS antennas provide accurate yaw measurements without being affected by magnetic interferences. The optional RTK increases precision and accuracy. Moreover, as both sensors are part of the same hardware assembly, it is not necessary to calibrate the relative position of the USBL and the GNSS receiver.

The on-board PC runs the pre-installed SiNAPS, EvoLogics positioning software. The user can access USBL positioning data by connecting to the Wi-Fi access point of the buoy and opening the web-based SiNAPS interface. SiNAPS allows to operate the system and visualize the location of the buoy and target transponders. Furthermore, positioning data can be streamed as NMEA strings and input into other applications that can process this information in real-time.

The buoyant body of the unit is made of carbon and glass fiber composites, making it lighter, more compact and robust than conventional designs with foam-based floatation collars. The system packs up into a single case and can be easily transported, assembled and deployed by a single operator.

The buoy is available with all models of the EvoLogics S2C USBL range.

Fully integrated USBL buoy

OMG!

Teledyne Marine announced the recent sale and deployment of three APEX profiling floats to NASA's Jet Propulsion Laboratory in Southern California.

The three floats were equipped with RBR CTD sensors, Short-Burst-Data for communication over the Iridium Satellite Network, and special parachutes for air deployment.

The rise in global sea levels will be a major environmental challenge for the 21st Century. For this reason, it is of increasing importance that we improve our methods and understanding for predicting this process.

A recent major initiative to do this has been led by JPL Scientist, Dr. Josh Willis and his team, who are studying the role that the ocean plays in melting Greenland's coastal glaciers.

The NASA based initiative, known as 'Oceans Melting Greenland' (OMG), will observe changing water conditions on the continental shelf surrounding Greenland over a six year period. This will also include detailed measurements from the narrow fjords that dot the Greenland coast since these fjords are a critical component in modelling the interaction between the ocean water and the glacial ice.

A potential new tool in this study has been provided by Teledyne Marine in the form of the 'Autonomous Profiling Explorer' (APEX) float. These floats provide a platform for a variety of sensors, drifting with the ocean current while descending and ascending between the surface and some predefined depth, and all the time taking sensor measurements which are then telemetered back to a data-server via satellite. APEX floats can also be deployed by aircraft using parachutes, which makes them ideal for exploring areas that can be difficult to access such as the coast of Greenland.

In September of 2020, three APEX floats were deployed using a Basler DC-3 TurboProp aircraft over the continental shelf along the west coast of Greenland as part of the OMG project. These floats had the specific task of measuring water temperature and salinity at different depths on the continental shelf along the coast over a period of a year or more.

Dr. Willis and the team at JPL NASA exploited the fact that APEX floats can be configured to sit on the seabed between descending and ascending, which can be used to limit the distances that the floats drift during each cycle. The floats were also configured to avoid attempting to surface when they detected the possibility of ice.

All three floats have stayed within about 15 miles of where they were deployed, meaning that the strategy of parking them on the sea floor has largely worked so far. One float, deployed in Melville Bay was initially unable to surface and transmit data in the ice covered environment, but was finally able to connect to the Iridium satellite system and transmit all data that that had been collected and stored up to that point.

Now that the floats are operational they could potentially continue transmitting data over a winter season or more.

PLOUGH POSITIONING

Seatools has completed the development, manufacturing and testing of a plough position monitoring buoy. After successful sea trials, the buoy is now being deployed for a subsea cable route clearance project.

Whereas USBL is the conventional way to determine the position of subsea vehicles, this acoustic method fails to function properly for towed vehicles that operate in shallow waters with much ambient noise, such as thruster wash. Looking for a solution that meets the strict requirements for following and registering the defined cable track, Boskalis developed a buoy-based monitoring method that monitors the position of its subsea ploughs and boulder clearance tools.

The buoy monitoring system is based on fairly simple and effective principles. The monitoring buoy is connected to the towed vehicle by means of a steel cable. As soon as the vehicle is placed on the seafloor, the buoy is released. By combining multiple, real-time data, including winch paid out wire length measurement Rovins data, and DGPS data, the position of the plough can be accurately determined in all three dimensions.

The buoy features an integrated subsea winch system whereby it can be fully retracted when launching and recovering the towed vehicle.

Boskalis was responsible for the fundamental concept and operational procedures, Seatools was responsible for concept engineering, detailed engineering, as well as the manufacturing and factory testing of the positioning buoy.

Using hydrodynamic simulations, the behaviour of the buoy was simulated under even the most testing of weather and operational conditions, including the launch and recovery from the subsea vehicle.

BARNACLE BILL

The bill for removing unwanted colonies of marine life on underwater hulls and equipment that go over the sea, can be quickly repaid in terms of improved performance and avoiding species invasion. But what considerations must be taken into account in calculating the net benefit?

When vessels or structures are immersed in the seawater, they may come into contact with a galaxy of different marine organisms. Biofouling or marine fouling describes the undesirable colonisation of plants and animals on the surface of wetted objects.

DRAG

When marine organisms attach themselves to a hull, the resulting increase in resistance may cause vessels to exhibit a marked reduction in speed, an increased transit time and higher fuel costs.

A heavily fouled vessel can require up to 85% more power than a smooth hull to propel it at the same speed.

This makes a considerable impact in the vessel's operational economics. In a normal seagoing vessel, fuel accounts for up to 60% of operating costs. There is a corresponding increase in CO_2 emissions.

Even in semi-static vessels such as drillships, it will increase fuel consumption and hog thuster power for those with dynamic positioning systems.

INVASIVE NON-INDIGENOUS SPECIES

There may be a danger of inadvertently transporting potentially invasive aquatic species from one marine environment to another where they do not occur naturally.

These are known as alien or non-indigenous or species (NIS) and can be transported in distant ports where they threaten to upset the natural marine environment and local ecological balance.

WEIGHT

The physical weight of marine organism colonies can cause a variety of problems.

The images show a Chelonia C-POD echolocation click detector, deployed close to the seabed in the Moray Firth – in a generally sandy area with little hard substrate so these moorings form a rather rare hard surface in a soft sandy/muddy region.

The mooring's surface mark was lost (probably run down by a ship), and the device was not recovered for five years (so this does indeed show a dramatic level of fouling – not a "normal" deployment). The device was ultimately recovered using an ROV. Image: Dr Ewan Edwards

Navigation and oceanographic buoys are more sensitive to marine growths than ships. Being permanently moored, soft bodied fauna can attach to the hull and mooring chains that would be otherwise washed away by moving water.

While this added weight is rarely greater than the buoy's reserve buoyancy and may not affect its operation, it can take time cleaning the buoy prior to repainting.

Fouling can also add weight to cables, putting a strain on the line. This can cause internal structural failure if not accounted for in the design.

UNDERWATER SENSORS

By impinging on oceanographic instrumentation, biofouling can disrupt the quality of offshore measurements such as turbidity, dissolved oxygen, conductivity, pH, fluorescence etc, within days of installation.

Biofouling can reflect, scatter or absorb acoustic signals on sonar and depth sounding equipment by changing beam patterns. It also reduces the ability to receive signals.

Even when devices are enclosed in protective domes or housings, these too can be subject to organism attachment which may block clear readings.

Underwater mechanical equipment such as retractable sonar devices can be prevented from moving freely by organisms attaching to and sealing moving parts.

CAVITATION

When a streamlined flow passes an obstruction caused by biofouling, the disturbance can may result in cavitation. The growths entrap vapour bubbles, and when these bubbles collapse, they can create minute shock waves.

A receiving sonar sensor, trying to detect a weak signal, may pick up this cavitation as background noise.

INSPECTION

A covering can hinder underwater inspections needed to verify integrity of the hull

BLOCKAGES

Colonies of marine organisms can inhabit pipes and conduits. This is particularly true in large diameter salt water pipes such as those supplying fire mains, water injection intakes, etc.

They can also block control ports of subsea trees.

CORROSION DAMAGE

Organisms attaching to metallic surfaces can sometimes result in corrosion damage. They may also damage protective paint coatings although conversely, heavy mats of fouling can sometimes prevent rusting by inhibiting access to the surface by seawater or oxygen.

BIOFOULING INTERVENTION

TYPES

According to the biofouling removal company Hullwiper, examples of biofouling include

Bay barnacle
A fast-growing species with high reproductive potential and tolerating wide fluctuations of water salinity and temperature.

Asian Paddle Crab
Affect biodiversity through aggressive and competitive predation and also carry diseases like White Spot Syndrome Virus that can impact other crab species, prawns, and lobsters.

Asian green mussel
Robust, tolerates various salinity and temperature ranges. (and reaches high densities)

Wakame seaweed
Native to cold temperate coastal areas of Korea, Japan, and China, this species is able to colonise rapidly in mild temperature regions.

European shore crab
Can tolerate up to 3 months of starvation but becomes a voracious predator when it is able to feed.
European fan worm

Colonial tunicate
Aggressive invader that easily reproduces and grows over or smothers existing species.

North Pacific seastar
A voracious carnivorous feeder native to the North-west Pacific, this highly reproductive species is able to establish large populations in new areas. Forming a serious pest to local species like the endangered spotted handfish as it prays on the fish's egg masses.

Depending upon the location, biofouling can start to occur within hours of the metal being immersed in water depending on the temperature.

This is normally commences in the form of a thin and easily removable biofilm of slime and algae, but this can soon act as a haven for to larger macrofauna such as barnacles, mussels and tube worms.

Some calciferous species excrete mineral deposits onto the structure which may affect subsea and marine operations in a number of ways

There are two main ways of removing or at least restricting then biofouling growth - Chemical and Mechanical.

CHEMICAL
Centuries ago, mariners used copper sheeting over the wooden hulls to deter bioaccumulation, however, this method not applicable to steel hulls because the dissimilar metals cause galvanic corrosion, with the iron rusting quickly away.

Manufacturers consequently gradually started to develop paint coatings to restrict marine fouling. Original coatings contained heavy metals such as copper and tin as well as herbicides.

In the '60s the industry found success with an active ingredient TriButyl Tin (TBT) which promised intervals between dry docking of 60 months. Subsequent research, however, found that this was very persistent. Heavy metals accumulated in the livers of larger sea life such as whales and dolphins.

TBT, however, also contributed to imposex (females developing male characteristics). TBT was banned globally in 2008. Post-

Biofouling on a hull

TBT coatings are based on copper and other biocides incorporated in polymeric binders.

ANTIFOULING COATINGS
The challenge is to gradually deliver antifouling materials onto the targeted area over period of time.

There are two major technologies that achieve this.
The main category consist of self-polishing antifouling coatings. These coatings progressively dissolve into seawater and release biocides in the process. Silyl-based coatings typically have much more predicable polishing and thus more reliable performance in this respect.
Another category, silicone-based systems, work like a non-stick pan in that as a vessel gains speed, hydrodynamic shear forces causes macrofauna to fall off.

This mode of action requires the vessel to move at relatively high speed and at high frequency. Otherwise, once barnacle growth cuts through the coating and assert a firm grip, they will not fall off.

In order to ensure permanent protection, it is important that antifouling coatings are reapplied periodically. Older coatings systems used to last for up to 3 years before requiring re-coating but modern acrylics [most antifouling todays are based on acrylic polymers] can last for up to nearer 90 months.

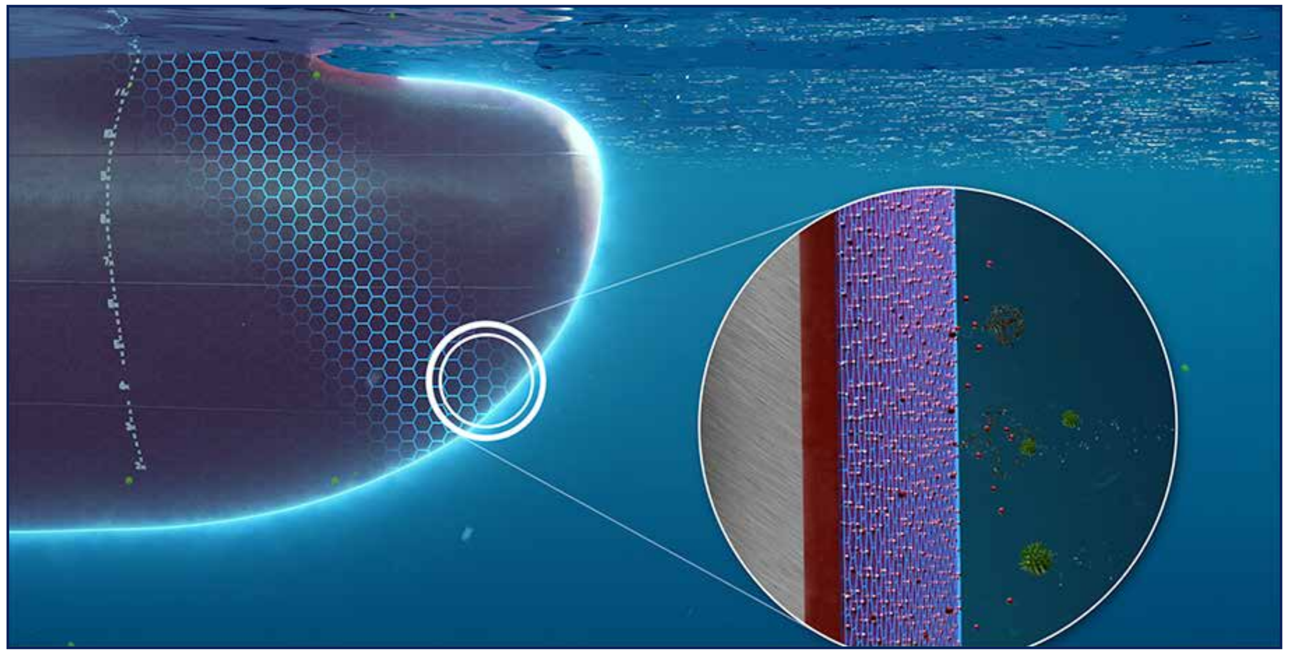
New vessels can sail for 5 to 7.5 years without having to go back into dry dock. When it does dock, however, a recoating programme could take 24 days which is essentially lost revenue.

In the offshore industry, some vessels and structures such as FPSOs and other permanently moored structures have to remain on station for anything up to 25 years. Conversely, most antifouling coatings require the structure to continually move.

Coatings manufacturer Jotun recently announced its new silyl methacrylate-based SeaQuantum III series.

It features microZone technology, an innovation that prolongs... ,
a new technology that prolongs the time between the activation of coating biocides and their dispersal. The biocides are released but they remain in a denser layer closer to the paint surface.

SeaQuantum III has a lower volatile organic compound (VOC) content and higher volume of solids, ensuring compliance with strict local and regional VOC regulations.



Jotun's microZone technology concentrates the biocide particles in a denser layer close to the paint surface.

SLIME

MICROSCOPIC SLIME CAN BUILD UP ON SHIP'S HULLS. SUBSEA INDUSTRIES HAS DEVELOPED A DIVER-OPERATED CLEANING SYSTEM TO REMOVE THIS BIOFOULING

While marine biofouling is often recognised as weeds, barnacles, clams, sponges, kelp etc, what is all too often missed, or disregarded, is the effect of the very early stages of a microscopic biofilm commonly referred to as slime.

Within hours of a clean hull being submerged in the sea, bacteria begin to accumulate.

Hardly visible in its early stages, even a light slime coating has been shown to increase fuel consumption by 8% or more and a heavy slime can result in fuel consumption increases of nearer 18%.

WHAT IS SLIME?
The slime film grows rapidly – the slime bacteria on each square centimetre of surface may reach one hundred in a few minutes, several thousand in the first day and several million in the first forty-eight hours.

After a few days, it may be joined by algae, along with diatoms and protozoa following by the end of the second or third week.

“Build-up occurs on any hull, no matter what it is made of or coated with,” said Manuel Hof, Sales and Production Executive at Subsea Industries. “It is not the case that slime accumulates equally on all surfaces under all conditions.

"This slime layer can build up to 2mm in thickness. The first approach is to ignore it."

Shipowners typically coat their vessels with traditional copper-based and other biocide-leaching antifouling paints and then pay no further attention to the vessel’s underwater hull for 2.5 or 3 years.

At this point, the vessel returns to drydock, is cleaned and the anti fouling coating renewed. In the meantime, however, the vessel suffers a steady, gradual loss in performance.

An alternative approach is to drydock the vessel every few months to pressure-wash the hull and remove the accumulated slime. This is very disruptive to a ship’s schedule, expensive and not always viable.

A third approach is to clean the slime off the hull by underwater cleaning. This is commonly carried out by divers or automated or remotely controlled devices.

In practical terms, this means sending divers down armed with hydraulic machines with rotating brushes which use hydraulic forces to keep them firmly pressed against the side or bottom of the ship while the rotating brushes do their work. They are powered from workboats or trucks on the quayside.

A variety of brushes can be used for different levels of fouling and different coatings. The brushing units are fairly large with several rotating brushes able to rapidly cover large areas of the hull when placed in trained and experienced hands.

Smaller hydraulic brushes or hand brushing are used to clean sea chests and other areas which can’t be reached by the larger machines. There is a close connection between hull and propeller inspection and cleaning. Routine, full underwater cleaning in between drydocking is the best and approach.

SCRUBBING
Scrubbing paints prematurely deplete the antifouling coating, causing them to rapidly re-foul, reducing efficiency and increasing marine pest translocation risks.

The more frequently a hull with an AF coating is brushed or cleaned in the water, the more rapidly it wears out. This then opens the door

Cleaning unit
Image: Subsea Industries

to more serious fouling or requires more frequent replacement which means pulling the vessel out of the water more often with all the associated costs of drydocking, surface preparation, repainting and the off-hire costs for the vessel.

The adverse environmental effects of the increased copper and other biocide discharges into the marine environment.

“One needs only talk to divers who perform underwater cleaning on copper-based anti-fouling coatings to have confirmation of the clouds of toxic red paint that come off the hull under cleaning. The ocean bed and quayside walls become covered with the toxic paint brushed off in the process of trying to remove the slime or other fouling properly.

They report that two or three cleanings can leave a mere 5% of the AF coating on the hull.

SILICONE FOUL-RELEASE COATINGS
While these have been proven to be effective in reducing drag when they are clean, they only make it harder for macrofouling to attach and be released when the ship is under way, especially at speed

It doesnt have the same affect on microfouling or slime.

However, they are also notorious for their mechanical fragility and the ease with which the coating can be damaged. This damage extends to cleaning.

Even with a soft brush, the mechanical effects of underwater cleaning on this type of coating is to damage the coating by scratching and chipping the rather delicate surface. Once the surface has been damaged, it loses its effectiveness dramatically. The cracks or scratches in any hull surface make it easier for fouling to attach.

Ports forbidding in-water cleaning
Because of the excessive pollution and concern about the threat of invasive species spreading, some port authorities forbid in- water cleaning of ships in their port. In some cases this restriction only applies to AF- coated or heavily-fouled hulls. In others, it is indiscriminate.

HISTORICAL PHOTOS

as seen on UT2Subsea in LinkedIn

THISTLE 1977

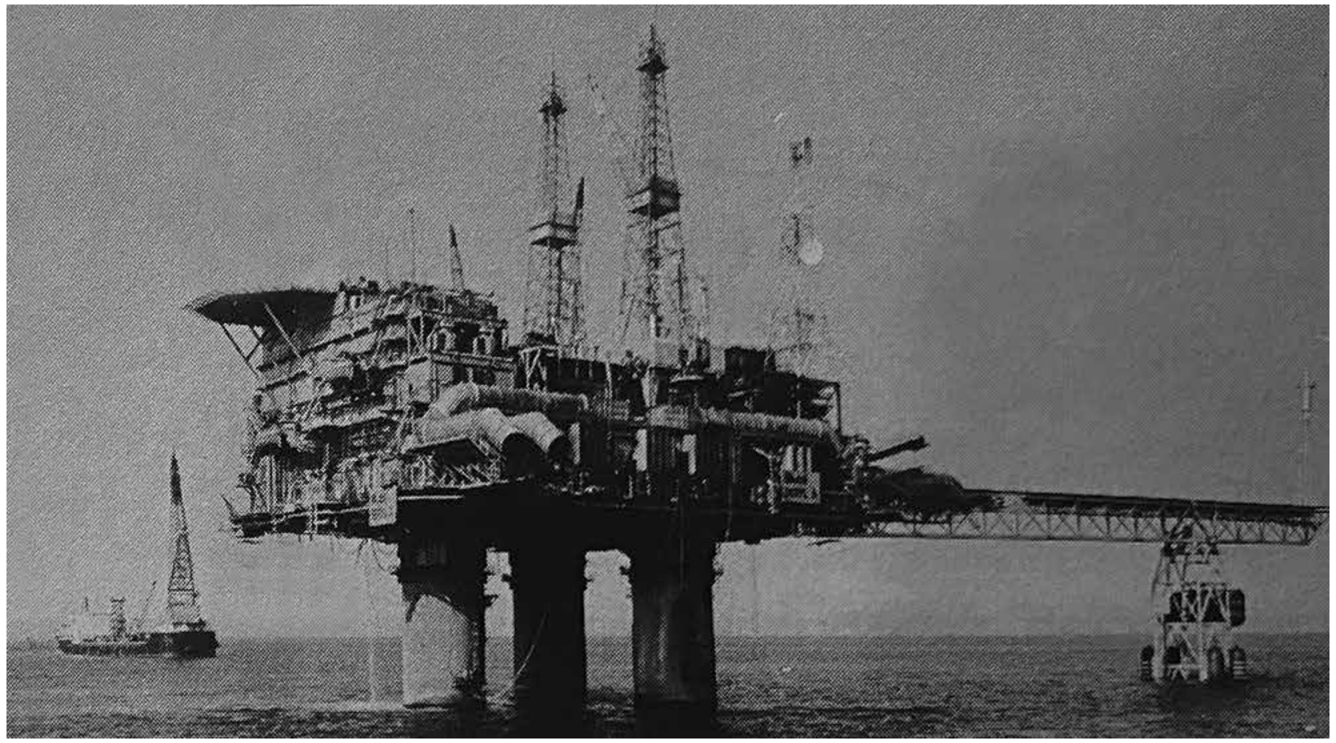
Offshore cranes are able to lift enormous integrated decks onto jackets. This was not always so.

Offshore cranes are able to lift enormous integrated decks onto jackets. This was not always so.

In 1977, 33 production and drilling modules ranging from 1250t to 16,800t were lifted onto BODL's Thistle platform.

A month earlier, 13 foundation modules were installed for the piling operations. 12 of these, totalling 4500t, had to be removed before the permanent modules could be installed.

The ships that carried out the work were the Sea-Troll's Sea Troll and Heerema's Odin, the largest crane in the North Sea with a 2700t maximum of this capacity.



FRIDAY PHOTOS BERYL A 1976

Beryl A consisted of a 15 000t Condeep GBS. A 200m long bridge housed the flare. Its far end was supported by a steel truss tower in 117m of water itself standing on a cellular concrete block.

The flare bridge , designed by Earl and Wright, had to be positioned within a 7.5m radius circle and 6 deg of orientation. Mobil contracted Smit International under guidance from Noble Denton.

In the end, it was installed within 2m of target and 0.5deg orientation.

In the background (I think) is the Micoperi barge PM27 that installed the bridge.

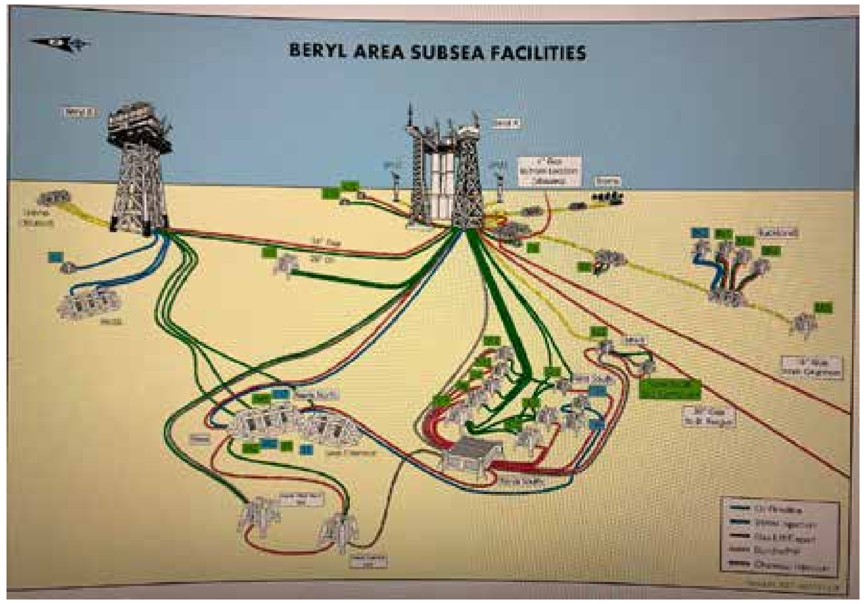
ARDYNE POINT 1978

Ardyne Point 1978
Sorry about the quality of this one. I posted it because I had never seen it before. It is the Cormorant A jacket with Brent C in the background.

Beryl's Subsea infrastructure is world class!
- a museum of development 80s-00s truly amazing.

ExxonMobil lost a lot of knowledge when they sold these factilities on in 2010/11.

This pic is 2007 .... more SS wells added since then.



36" SAGE riser tower installed in early 80's and was a few feet short- 6ft extensions added to the legs. FMC was the SAGE pipeline installer laying from St Fergus to Beryl A. The EMC Barge was the Semac 1. The BP Miller line was laid by a few weeks in advance of the SAGE line and a lot of fun!! was had on the Kommandor Michael? whilst planning on the fly, the final SAGE lay route through an extensive pockmark zone whilst maintaining a 50m separation from the Miller line and avoiding some very wide and deep pockmarks and still keeping inside the original survey corridor. At one time we passed up the new route just in time to avoid a barge shutdown as the barge was two joints from the end of the approved route. No digital comms/data transfer in those days- just telex and floppy discs. Micoperi M7000 used to install the Brae Y piece. They managed to break several ROVs whilst doing so.

Client Reps and PC's had far more control back then, we were trusted to make the right decisions without the need for a Zoom or Teams conference call.

Life moves on and we can't live life back in the 80's and 90's but we had a lot of fun and hard work back then.

HEEREMA CRANE VESSELS,1976.

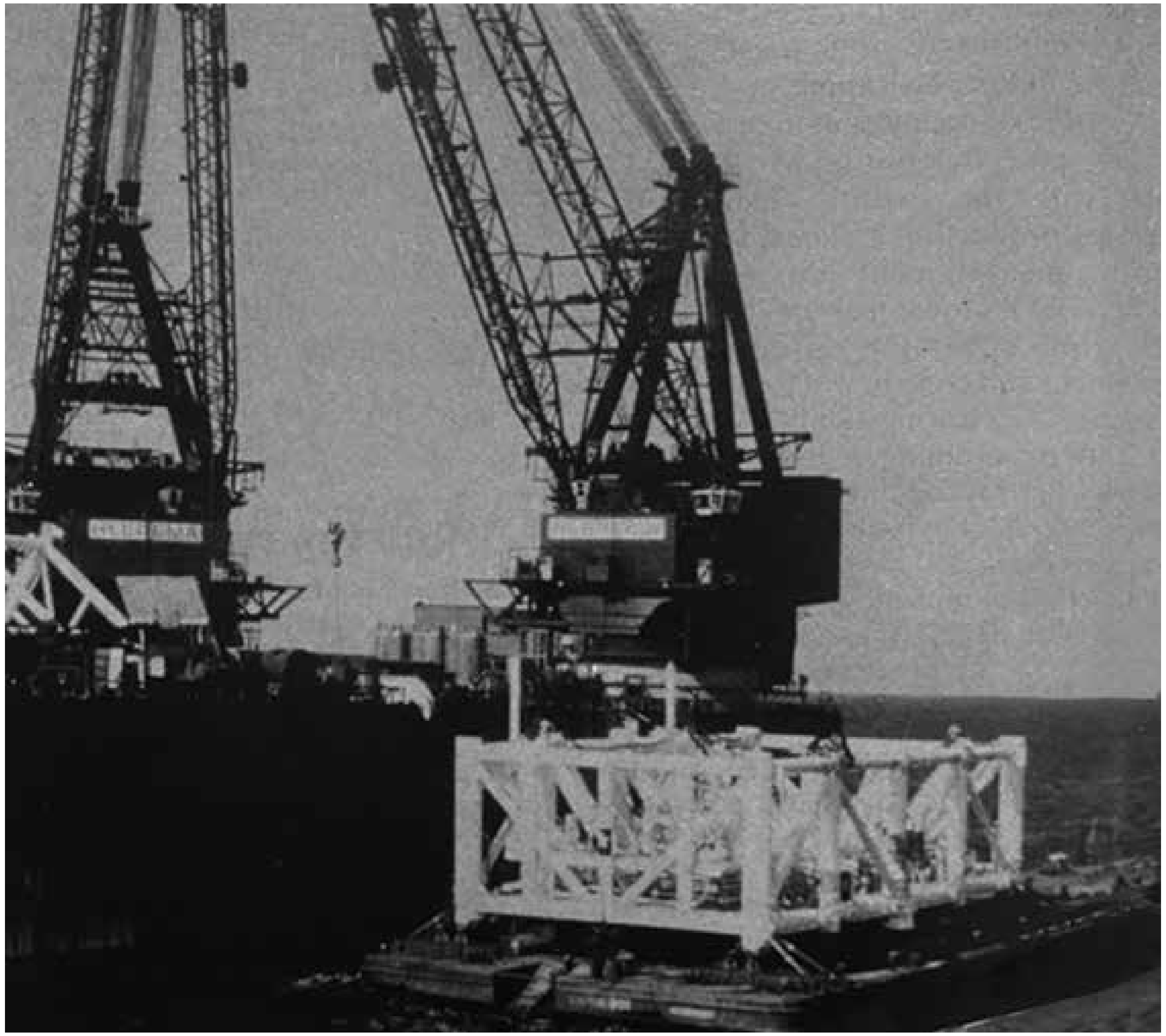
If you own the crane vessel like the Hermod and want to upgrade its crane boom, it is quite handy if you have its sister vessel, Balder, nearby.

HIGHLANDER TEMPLATE 1989

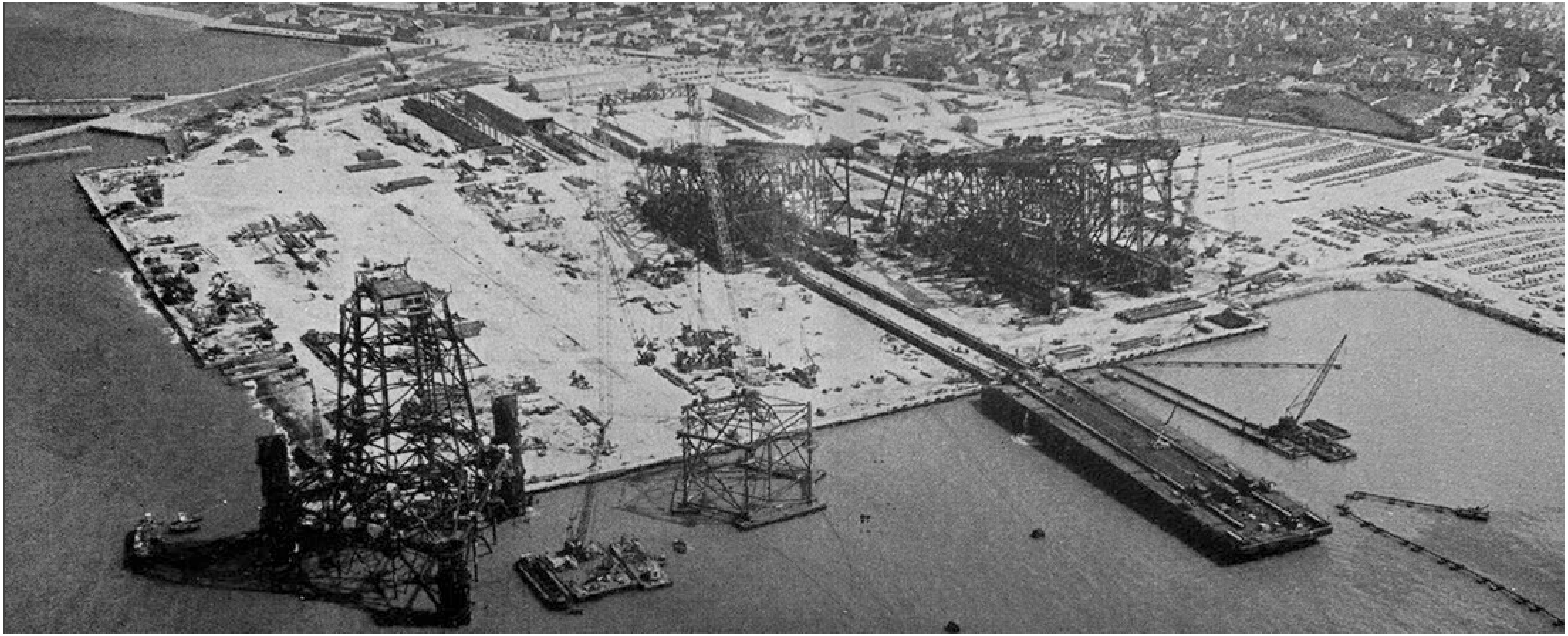
Texaco installed the world's first subsea multiphase meter designed in an agreement with Jiskoot Autocontrol.

Before that time, metering of separate subsea satellites required production to be kept separated from platform production all the way through to a dedicated meter. This meant complete duplication of pipelines and process facilities.

IS says.... Texaco Highlander template (photograph) was designed by Texaco Special Projects team with Flour in London, build at the Isle of Lewis, Arnish Point fabrication yard and installed in 1985. My first job as a graduate engineer, working in London, testing engineer at Arnish Point then follow offshore to commission and start-up. Multi-phase meter was tested in 1989, yet this was not initially subsea. First the meter system was installed on the deck of the Tartan A platform to hook-up to live wells for testing and calibration.



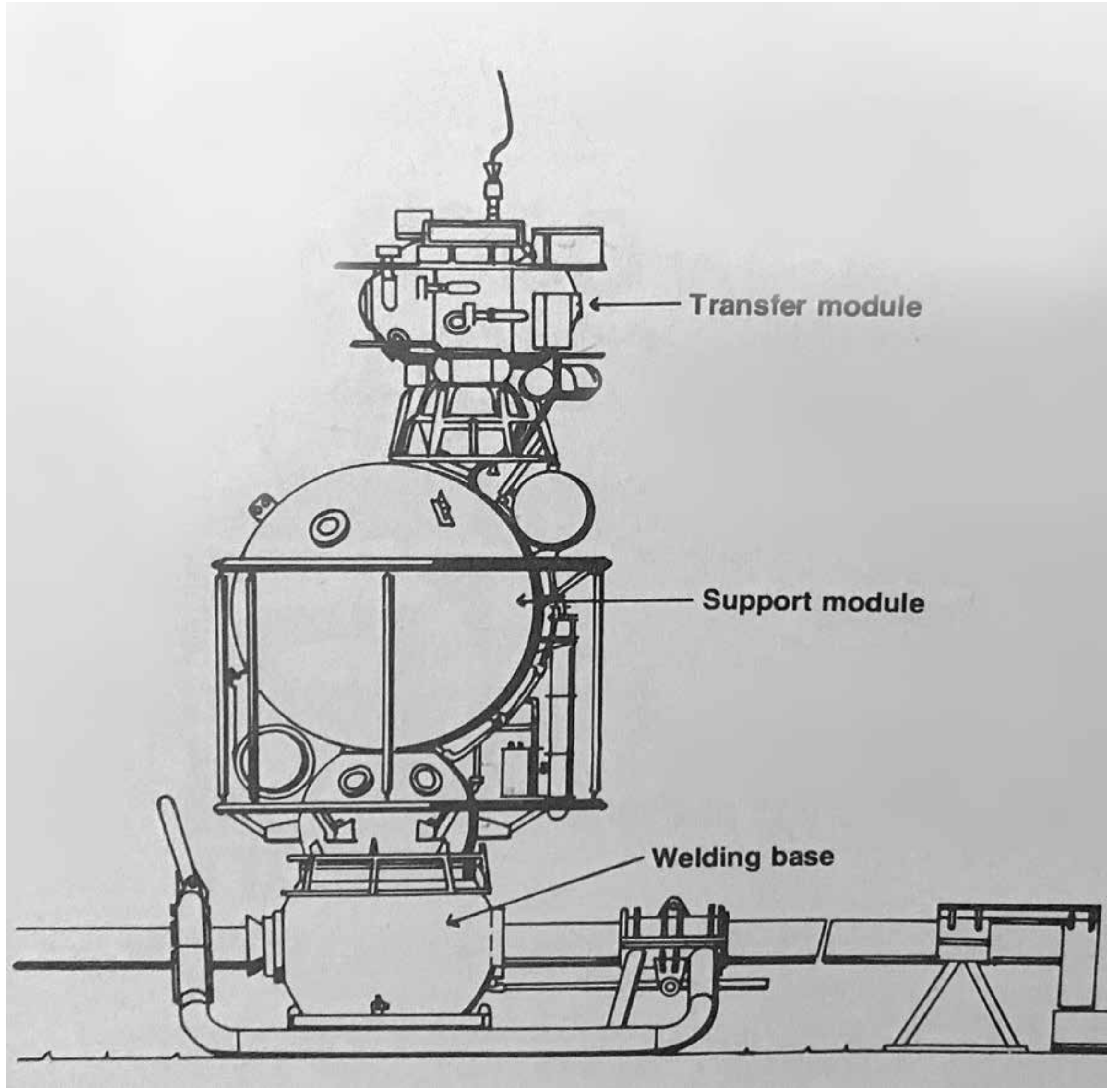
CHERBOURG 1977



The UIE yard. On the left, one Loango platform is preparing for tow-out, while another is in the process of construction. The DP2 jacket is ready for loading onto the barge. Hang on.. Isn't that the Claymore Jacket there as well?

MONTROSE 1978

BAR 347



WELDAP 1977

Underwater 'dry' one-atmosphere welding was rapidly evolving to work in the 300m water depths demanded by North Sea projects.

Weldap was a project carried out by Comex with support from Total, CFP and Elf Aquitaine. The first phase assembled the basic equipment and the second testing phase was carried out in shallow water.

The system was composed of 3 parts- a 3m diameter non-retrievable welding base and a 5m diameter support module. The contained the power supply welding equipment and life support system. A transfer module shuttled relief divers to site.

Once the base was sealed, emptied and brought to atmospheric pressure, the team could enter from the support module.

LEFT: The BAR 347 was capable of laying double-jointed, large-diameter pipe in extreme water depths without the need of a pipelaying pontoon or extended stinger. The vessel measured 650 ft in length by 140 ft in width, with a depth of 50 ft. It was equipped with a centerline elevated ramp with three pipe tensioners that could lay 36-in. pipe in water up to 1,100 ft deep – a seemingly unimaginable water depth at that time. The barge was equipped with 12 mooring anchors weighing 60,000 lbs each. Each mooring winch had the capacity for 10,000 ft of 3-in. diameter wire. This mammoth vessel dwarfed every other vessel in Brown & Root's fleet. Thus the "world's largest pipelaying barge" was launched amid much fanfare at Rotterdam in early 1976.

£2.7million of improvements at Whessoe's Middlesbrough yard in 1985 included a new 5000t heavy load out quay. It conducted a joint venture with Haden Moore to offer a larger range of disciplines.

ERSKINE 1996

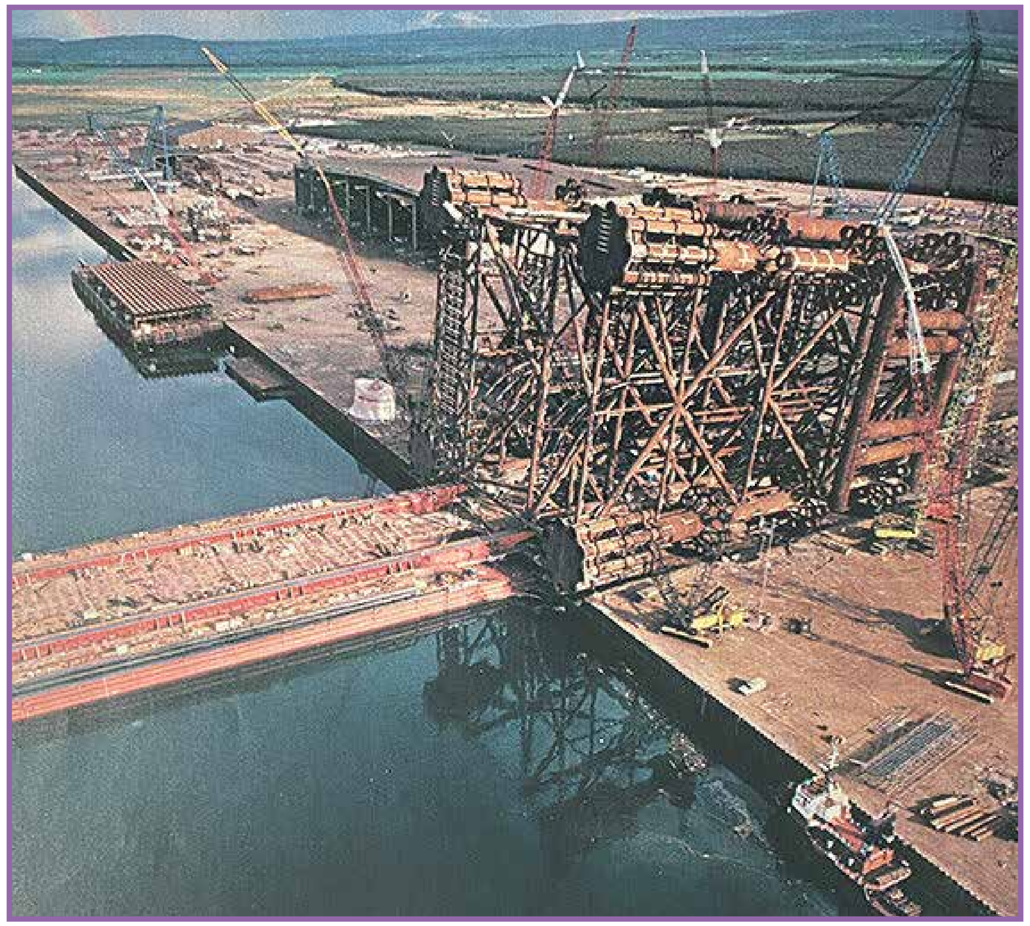
The 2720t Erskine jacket on the Saipem M-44 barge prior to its installation in the field by the Saipem S7000 heavy lift vessel

As seen from the South West

GLOMAR GRAND BANKS, VEROLME BOTLEK 1999

Global Marine Drilling purchased the Maersk Vinlander and drydocked her at the Verolme Botlek yard. Four blister tanks were added on the columns and two outer and inner sponsons added.
It was renamed the Glomar Grand Banks

1983 ARDERSIER



Mrathon's Brae A jacket being built

CLYDE 1987

Britoil's Clyde with the Safe Gothia alongside carrying out hook up and commissioning

1990 ARBROATH

Amoco used the Transworld Drilling's harsh environment deep water jack up Mr Mac on Arbroath.

A 12 slot drilling template was installed in 1979 and semisubmersibles were used to drill three appraisal wells. Field economics could not justify a large steel platform so the plan for Arbroath was a 21 slot normally unmanned platform operated from Montrose.

TOGI 1990

A diverless subsea station installed in 305 m of water to collect and produce from five gas wells on Troll East. The gas was transported to Oseberg for pressure maintenance and increased oil recovery

TESTING SHELL'S EIDER PLATFORM 1985

Shell's Eider featured vertical unguided piles driven by underwater hammers resulting in weight savings. It was the largest platform to be barge-launched (the others being floated out) and was self-upending.
Tests were carried out at the BMT ocean test facility in Feltham.

In the passive system, water slowly flooded through holes in the jacket legs, but buoyancy tanks kept the entire structure off the bottom. This method obviated a conventional ballast control system.

The uprighting sequence was quick making it less susceptible to weather changes

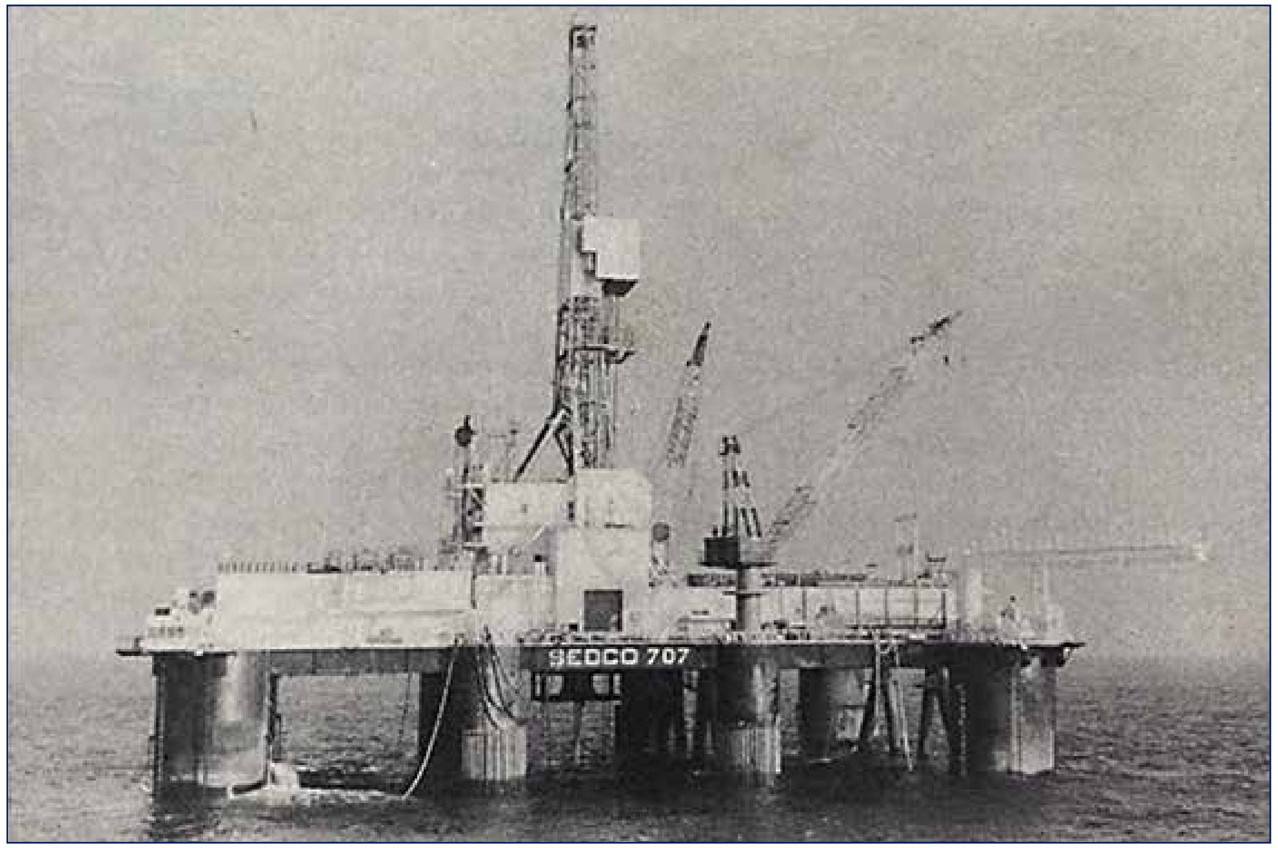
SLEIPNER 1996

The installation of the jacket on Sleipnir T by the S7000. On the left is the slightness a concrete platform bridge-linked to the riser platform and flare structure. At the base of the jacket are 14 m diameter. suction buckets

THOR 1983

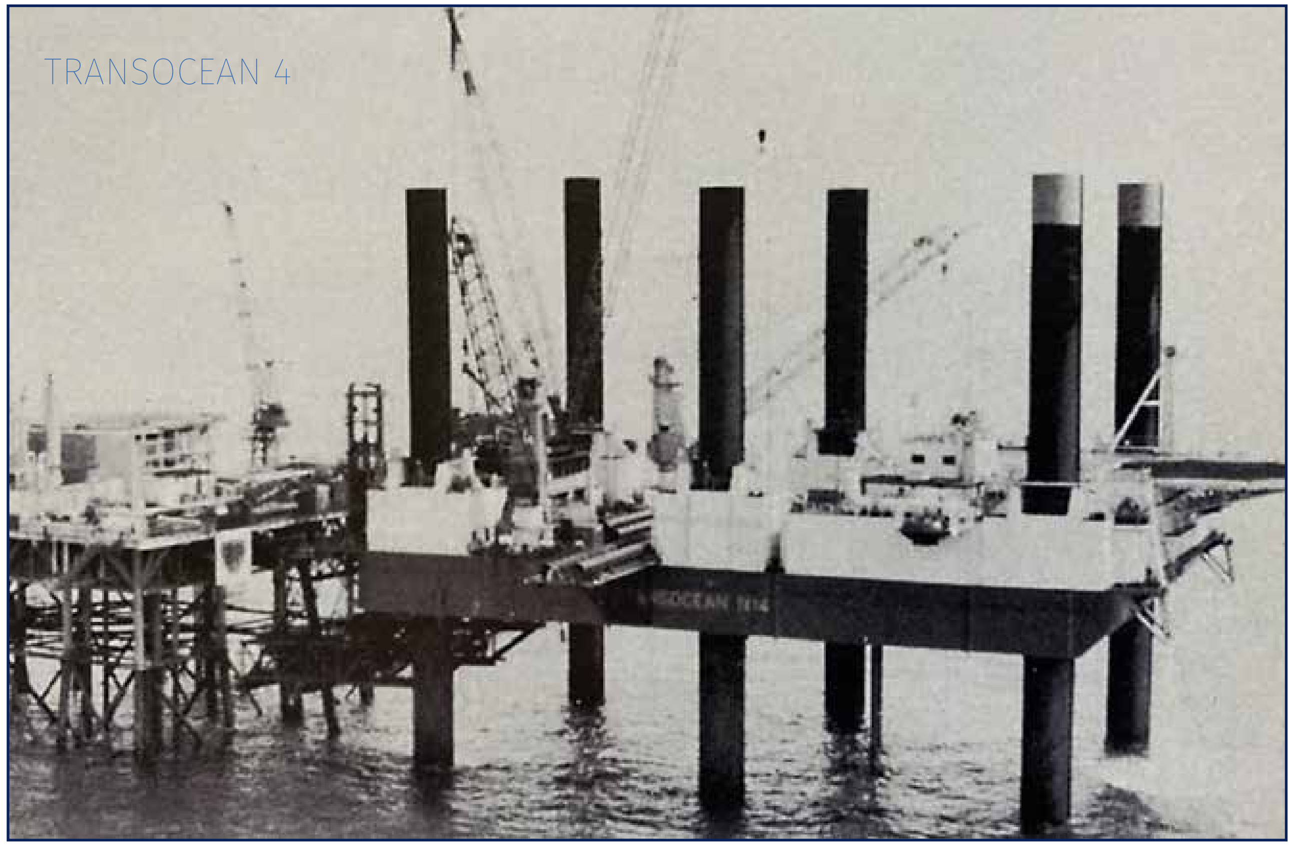
Heerema's Thor barge installing part of the gas compression platform on the Inde gas field -at the time, the largest gas compression project in the world.

SEDCO 707 1977



Working in the Porcupine Trough for Shell after being stacked at Fishguard

TRANSOCEAN 4



We have had pictures of the TO4 next to West Sole before.
Here is another one!

STC DESCARTES
1986

Taken in Cromarty Firth prior to commissioning. Does anyone remember this because I certainly don't. Maybe it existed because I thought it existed.

T'internet tells me that it was built by CFEM in Dunkirk in 1982 and owned by Northern Offshore. It was later renamed Trident XI and then the Maersk Enhancer.

The things you learn on Friday Photos!!