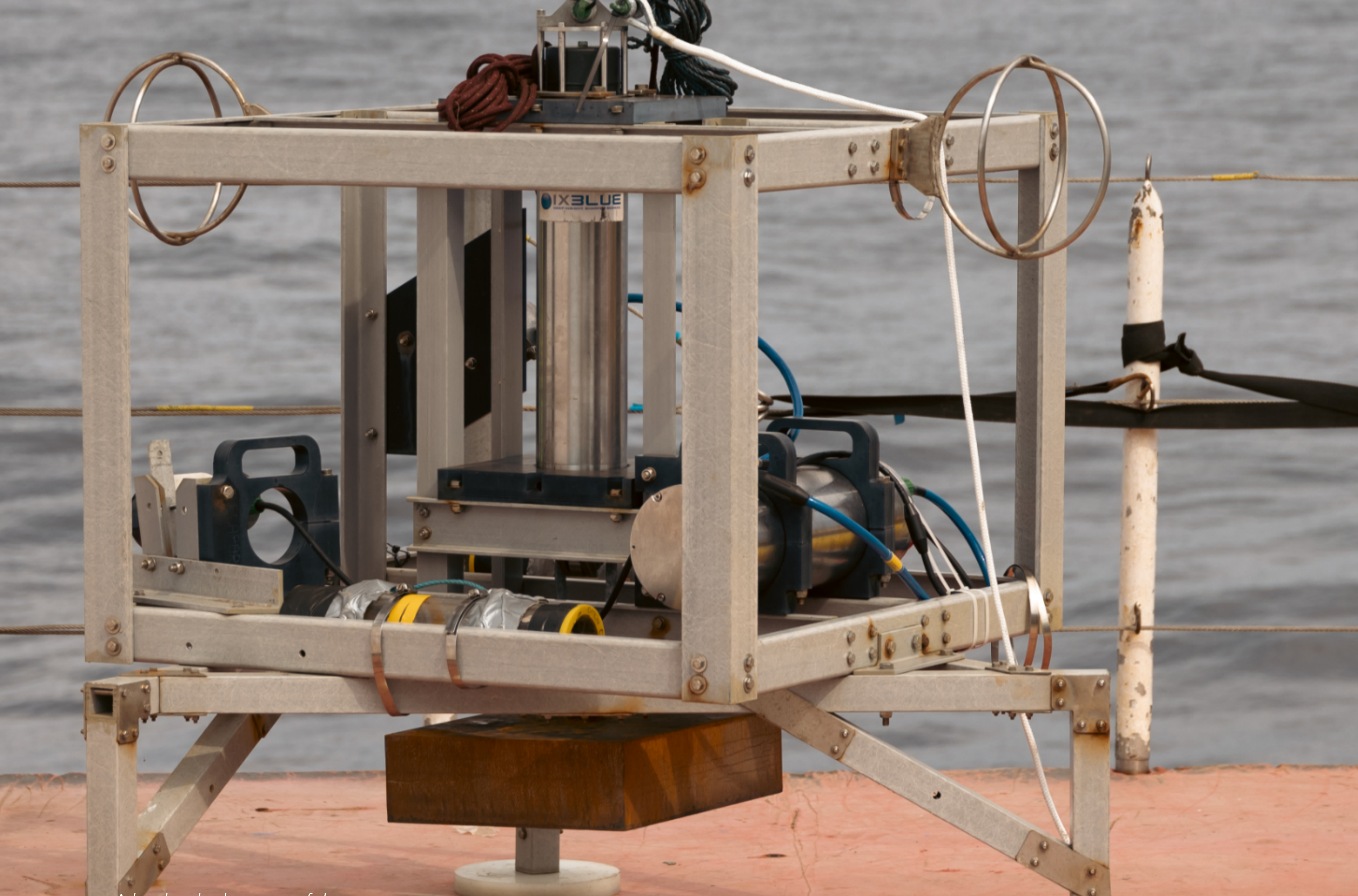
ADVANCING SEAFLOOR IMAGING

NOC'S NEW STANDARDISED CAMERA SYSTEM FOR MARINE SCIENCE



A lander deployment of the new camera system

Engineers in the National Oceanography Centre's (NOC) Marine Autonomous Robotic Systems (MARS) team are leading the way in the advancement of marine technologies. They have developed a new standardised stills camera system to get a best of all worlds; crisp seabed imagery accessible across applications and disciplines, reducing barriers to entry and helping science join the dots.
Dan Roper, MARS, explains

Subsea photography has been and remains an important tool in marine science. While a huge amount can be learned from broad swath acoustic techniques such as multi beam sonars, for very fine resolution measurements, nothing quite matches the resolution and information richness of optical images. Combined with high-speed strobe light sources, motion blur can be reduced in stills images, providing greater detail than freeze frames from rolling video, even with identical pixel resolution and focal length.

This type of camera system can be useful for a number of applications, including wide area ecological surveys and fixed location timelapse photography.

NOC has been operating both autonomous underwater vehicle (AUV_-mounted and timelapse lander cameras for some time. However, historically, these have used different camera systems to address needs specific to each application, each of which has its own challenges.

SHEDDING LIGHT ON OCEAN LIFE

By taking tens of thousands of images of the seabed over a wide area, marine scientists can count species abundance in each image then average it out over a large area to statistically determine population densities.

This requires high resolution images to be able to accurately identify species – and the smaller the species, the smaller the pixel size required. Wide area coverage also typically involves mounting the camera on a moving platform, such as an autonomous underwater vehicle (AUV). This makes xposure time (the amount of time over which the light is measured) critical, to reduce any potential blur.

Timelapse images, where a camera is mounted to a lander frame, and images are taken periodically over the course of up to a year, also offer a wealth of information to marine scientists. This is a cost-effective way to understand long-term changes, such as how sedimentation changes though the seasons or the spawn cycles of coral.

Here, depth of field is an important requirement, to capture as much of the scene as possible. But this means operating with as narrow an aperture as possible, which means the sensitivity of the camera's sensor is the limiting factor.

The AESA new generation camera system on Autosub 5

ONE SIZE FITS ALL

While, historically, different systems have been developed for both applications, MARS decided to develop a single system, harsh environment capable that could be used across both.

There are clear benefits to having a single system. A one-size fits all system would mean savings in terms of operator training and maintenance of systems and toolchains. It allows marine scientists to make a direct comparison of images taken in either application, which means it's easier to determine if a species identified by one system is the same as a species identified in the other – something that's not a given when using different systems.

THE AESA SYSTEM

The new system builds on decades of work developing subsea systems, including underwater cameras and the highly successful previous generation of NOC Autonomous Ecological Survey of Abyss (AESA) stills camera system.

This system used a 5 mega pixel (MP) charge-coupled device (CCD) machine vision camera (formerly the default for laboratory grade digital photography), coupled with a Xenon high speed flash gun with a 1 millisecond exposure time.

Using a telescopic lens focusing on about 1 m sq of seabed at a time, it was able to resolve pixels down to 1mm in size, allowing identification of creatures down to a few centimetres in size.

Ready to be used in fixed locations or on mobile platforms

NEW SENSORS, NEW DESIGN

However, Sony, which manufactured the CCD sensor used in this system, has completely stopped making CCD sensors. This is because it now uses lower cost, lower power and now equally if not better performing, complementary metal oxide semiconductor (CMOS) sensors – the type more commonly found in consumer electronics such as smart phones and webcams.

So, for the next generation NOC AESA camera, a new sensor was selected from the Sony StarVis range of CMOS machine vision sensors, specifically designed for operation in low light applications and have become particularly popular amongst astronomy photographers.

The StarVis sensors also offer a higher pixel count, but they have a limitation around exposure time related motion blur, due to being on a moving sensor platform (the AUV). Instead, we decided to use the increased pixel count to increase the amount of the seabed that is captured with each photograph.

This was supported by retaining the AESA's Xenon high-speed flash gun, providing exposure times that could not be matched by LED flash systems in such a compact form.

Finally, and critically, the system was built from the ground up with corrosion resistance in mind, so full ocean depth (6,000 m) titanium pressure housings were used, creating possibly the most corrosion resistant camera system at sea today.

DEPLOYMENTS

The system has been deployed as a time lapse camera on a lander in both the Clarion Clipperton Zone (CCZ) in the Pacific Ocean and at the Porcupine Abyssal Plane Sustained Observatory (PAP-SO). Two-years' worth of timelapse shots has been successfully collected, along with a number of shorter deployments focusing on higher frequency phenomena.

The AUV-based system was field trailed August 2023 from the RRS Discovery during engineering trials in UK waters. Following positive results, the system was deployed in January 2024 on the SMARTEX expedition in the CCZ, collecting around 18,000 seabed images in about 5,000 m water depth. These are being used to help understand this little explored deep seabed environment.

NEXT STEPS

Moving forward, there is always a desire to keep up with the latest technology. While this does provide the highest quality images possible, in many instances its more important that the scientists can compare images taken from one year to the next.

This is particularly important when using the latest artificial intelligence (AI) image recognition techniques, as changes to the capture methods can invalidate training.

For this reason, we don't plan to iterate the AESA camera system as frequently as commercial product lineups and are committed to supporting this next generation of AESA camera system through until 2035.

18 MONTHS OF DEEPSEA MONITORING

In May 2023, The University of Western Australia (UWA), led by Dr. Todd Bond, embarked on a landmark project to explore and monitor Australia's deepest Marine Parks. Central to this endeavour was the deployment of two custom-built, long-term observatories, each equipped with SubC Imaging's Autonomous Timelapse System.

These observatories are enhancing scientific understanding of deep-sea biodiversity and ecosystem connectivity by enabling continuous, autonomous data collection over 18 months.

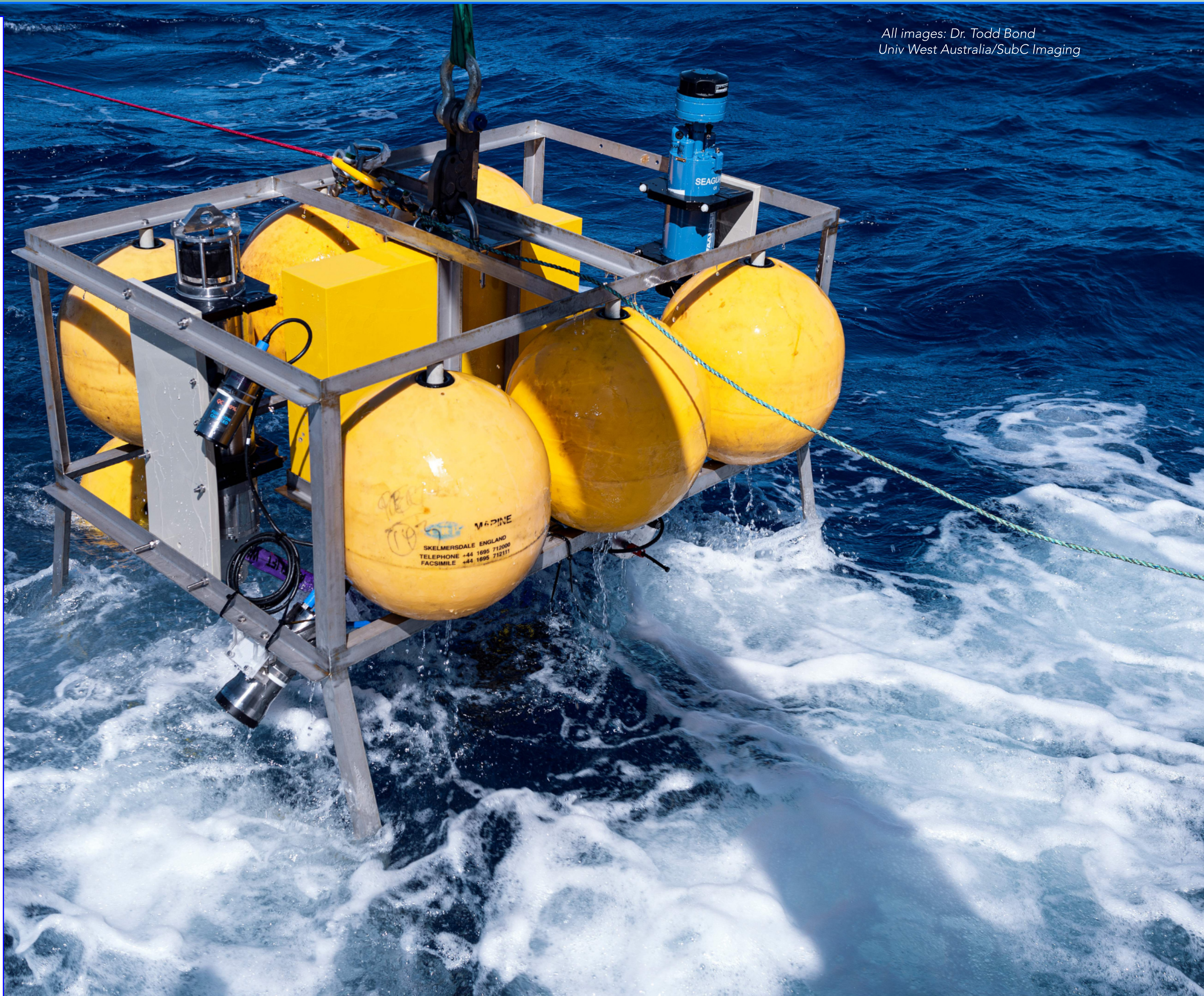
Australia's Marine Parks, including the Perth Canyon Marine Park and Gascoyne Marine Park, represent one of the world's most extensive networks of protected deep-sea ecosystems. Despite their ecological significance, these regions remain largely unexplored due to the technical challenges of operating in the deep sea and their sheer size.

To address this knowledge gap, Dr. Bond and his team designed a project with three key objectives:

1. Explore, describe, and understand what animals inhabit Australia's deep sea beyond 1000m.
2. Analyse connectivity between deep-sea animals across different locations.
3. Continuously monitor two abyssal plains, located 1000km apart, for 18 months.

Achieving these objectives required overcoming several critical challenges:

● Extreme Depths: Operating at depths exceeding 5000m required technology capable of withstanding immense pressure and low temperatures.



All images: Dr. Todd Bond Univ West Australia/SubC Imaging

IMAGING


SubC's Autonomous Timelapse System

- Long-term Timelapse Imaging: Continuous, autonomous, high-resolution timelapse imaging over long periods was previously challenging.

- Operational Durability: The system needed to maintain functionality without intervention for months in challenging conditions.

- Integrated Data Collection: Integrating imaging, environmental sensor data, and physical samples into a unified solution was essential for success.

Addressing these challenges demanded an innovative, adaptable solution capable of reliable, long-term performance in one of the world's most demanding research settings.

UWA selected SubC Imaging's Autonomous Timelapse System as the core imaging solution for their observatories. The system integrates a high-performance Rayfin camera and subsea LED lights, along with intuitive software for seamless programming and operation.

Designed for long-term, battery-powered deployments, this system enabled UWA to achieve remote, continuous monitoring at depth greater than 5000m.

The SubC Autonomous Timelapse System offers key features tailored to deep-sea research:

- Extreme Depth Performance: Reliable operation at depths up to 6000m.

- Customisable Timelapse Programming: Allows users to schedule image and video captures and adjust settings for lighting, focus, and exposure.

- Battery-Efficient Hibernation Mode: This optional feature can extend deployment durations by conserving power between imaging intervals.

- Comprehensive Integration: Supports additional tools such as sediment traps and oceanographic sensors, creating a multifunctional observatory system.

As Dr. Bond noted, "The SubC Autonomous Timelapse System was big part of the success of this project. Being able to capture high-quality data in the deep sea over long periods wouldn't have been possible without this unique hardware and software.

It's the only off-the-shelf system I've come across that combines very high quality timelapse imaging with a hibernation mode, which is exactly what we needed to monitor Australia's deep sea. It's made a huge difference in how we study these ecosystems through time and has given us insights we couldn't get any other way."

IMPLEMENTATION

Deploying UWA's custom-built observatories required meticulous planning. Each observatory featured SubC's Autonomous Timelapse System accompanied by a suite of oceanographic sensors to measure key environmental parameters like conductivity, temperature, and oxygen levels.

A sediment trap, positioned 300 meters above the main frame, captured falling organic material to provide insights into the seasonality and quantity of falling marine snow.

Components were carefully assembled and lowered into the sea, with the main frame and its steel ballast descending to depths of 4300 and 5100 meters.

Despite last-minute delivery delays for critical parts and challenging weather conditions, the team successfully installed the observatories, setting the stage for 18 months of continuous, autonomous data collection.

RESULTS

UWA's observatories advanced the understanding of deep-sea ecosystems in several key ways. High-resolution images captured every 12 hrs provided new insight into benthic activity linked to marine snow dynamics, revealing seasonal ecosystem changes and long-term environmental patterns. The optional hibernation mode played a pivotal role, conserving power and ensuring uninterrupted operation throughout the deployment.

In addition to the two observatories, baited landers deployed for 6 hours captured footage of rare and novel species, including snailfish, robust assfish, and deep-sea prawns, some of which were documented in Australian waters for the first time.

Data from sediment traps and oceanographic sensors further revealed connections between oceanographic conditions and benthic life, shedding light on how marine snow sustains these ecosystems.

Collectively, the observatories provided a robust dataset that not only enhances current knowledge but also serves as a foundation for future expeditions and long-term monitoring.


Autonomous Timelapse System on a frame

PHOENIX

GYRO-STABILISED UNDERWATER GIMBAL

A perennial issue with photography is 'camera shake'.

In stills photography, a blurred image can result from camera movement while the shutter is open, while in a video, watching the subject image gyrate across the screen makes uncomfortable viewing. Post- processing can sometimes correct unwanted movement, however, when video imaging using lenses with longer focal lengths, the shake may be enough to move the subject completely out of the frame.

One solution maybe to employ some sort of mechanical stabilisation in the form of a gimbal.

Some consumer electronics gimbals use accelerometers to measure movement from a point and feed a counter-movement back to the platform to cancel this, effectively keeping the camera stationary. The most advanced commercial camera gimbals, however, are Gyro-stabilised.

These work by using a spinning gyroscope to set the base position. Motors are then employed to make continuous small adjustments if the movement deviates from this. The result is stable imagery, even from long-distance lenses mounted on fast moving helicopters and aeroplanes.

One company that has been active in supplying gyro- stabilised cameras is the New Zealand

company **Immortal Camera Systems**. Mostly mounted on helicopters, boats, planes, jetskis and cars, the company has recently explored the idea that there might be some value by adapting the technology to be used underwater.

"An underwater gimbal has to probably withstand even more severe shock loads, that in an aerial application, especially when passing through the air/water transition zone " said Brad Hurndell, CEO of Immortal.

"Many film companies often get underwater footage by attaching cameras to poles and lowering them down from boats. The drawback to this is that the cameras have to remain at a fixed angle and move are subject to the up/down movement of the boat.

"The advantage using a gyro stabiliser is that it can once it is locked on to a moving target, it can track the subject automatically against a stabilised horizon. The camera can even pan up and down, all without being subject to unpredictable shock loading of waves or sudden currents.

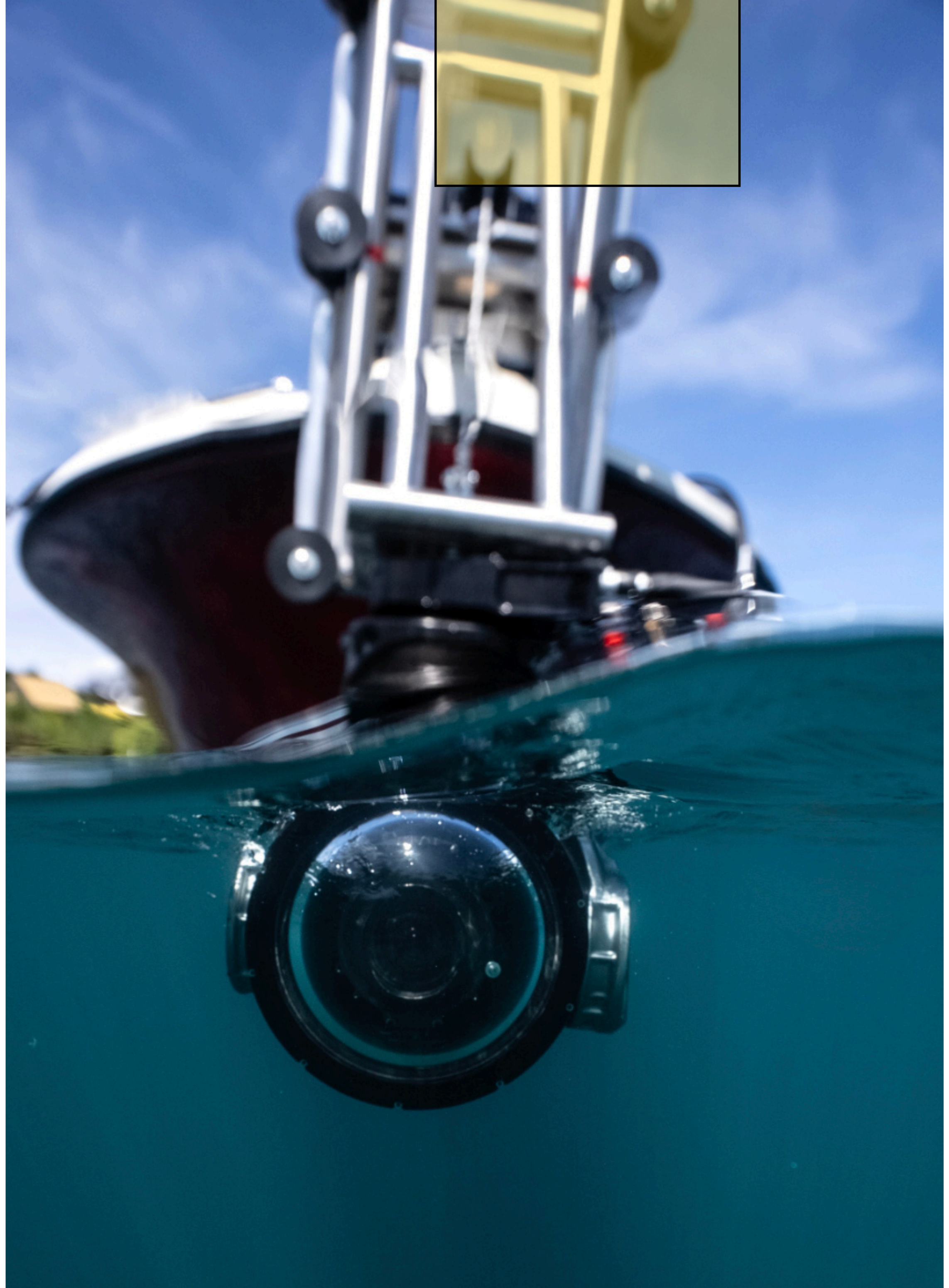
"It would be ideal, for example, when following a humpback whale that's moving at a reasonable speed but too fast for a diver to keep up."

BODY

At the front of the unit is a custom-made dome with a diameter of around 250mm. Behind this, is the pressure isolated housing the camera into which, it is possible to fit a vast array of cameras and lenses. It weighs around 30kg excluding camera and lens, or nearer 50 kg with the camera equipment. It is neutrally buoyant in water.

Sensors allow the user to monitor and maintain a stable internal pressure. The controller can commuicate with the body via Ethernet Video and the images are transferred to surface via Fibre optic – Ultra high definition lossless video. It supports WIFI and Cellular access for configuration and live remote support. Cutting edge, modern electronics to remove obsolescence risks

"We see its greatest usage in the top of the photic zone – at least in the top 5m but probably mostly residing in the top couple of metres," said Hurndell. "We probably



don't want to go too much below this, as in practical terms, colours change if the camera is too deep. As such, we have taken a design depth of one atmosphere as a starting point, although its internal pressure compensation system gives it the potential for considerably deeper applications.

The body is designed to be securely attached to a vehicle – perhaps on bow of the boat or on water jets but has a track record with helicopters, boats, planes, cranes and cars - basically any unstable platform - in applications moving at 500 knots and generating 5G of force. We believe that the maximum underwater speed will be around 12Kts.

It has a nodal roll axis with an unmatched 360° continuous range of motion.

"We see this as an untapped or unexplored market

segment. Fundamentally, our background is film and television, particularly in natural history programmes where filming in adverse conditions might be difficult for divers. It may be cold, dangerous or require filming for long periods of time such as filming chasing/ hunting or following pods of dolphins, but there may also be military applications.

"Our system is compatible with basically any modern camera and lens," said Hurndell." We manufacture a series of different brackets

"While the underlying technology is proven the submersible version is now at at the end of its testing phase. We are currently assembling systems to send to our first customers."

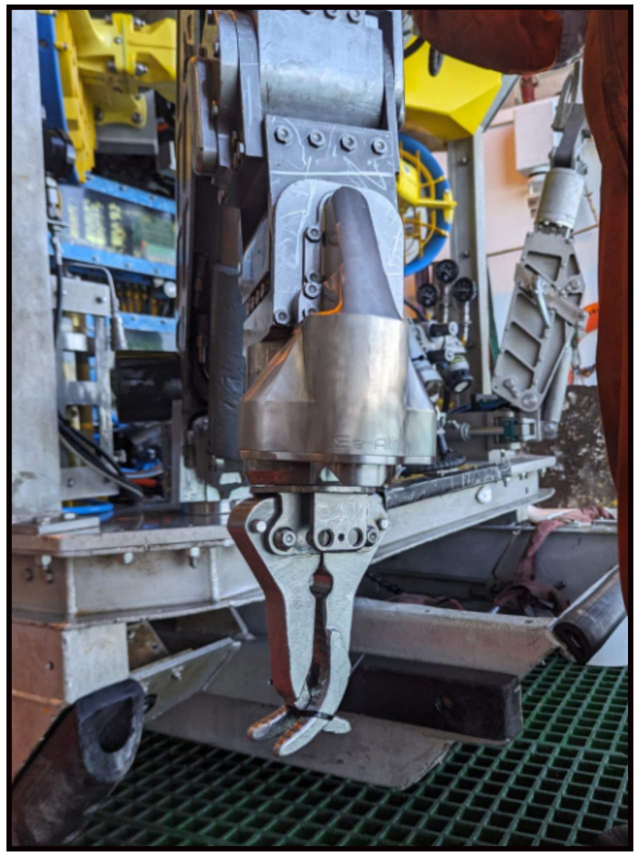
ADCAP

MANIPULATOR WRIST CAMERA

The Advanced Capability (ADCAP) Manipulator camera kit from Australian-based company Se-Alt is designed to serve as a direct replacement for standard Schilling Robotics T4 wrist cameras. This next-generation camera system delivers good imaging capabilities, improving inspection and fault-finding tasks in subsea environments.

With enhanced zoom, focus, and lighting features, the camera provides full 1080p 60fps HD-SDI resolution, ensuring clear visuals even in challenging underwater conditions.

Equipped with a 10x optical zoom and a further 16x digital zoom, the camera allows for both manual and automatic focus adjustments, offering precision control over visual inspections. Exceptional low-light visibility and integrated image stabilisation reduce blurring caused by vibration, further enhancing the quality of captured footage.



Camera on a manipulator

Wrist Cam

One of the key advantages of Se-Alt's camera is its high-performance LED lighting system. The camera features an increased lumen output, offering both high and low beam settings to suit varying operational needs. As an additional enhancement, UV fluorescence detection LEDs are currently under development, further expanding the system's functionality for specialised inspections.

Seamless integration with existing Schilling Robotics OEM master controllers ensures that operators can control power, camera, and lighting functions without requiring additional training.

The familiarity of control mechanisms streamlines adoption and minimises downtime. An optional joystick controller is also available, providing operators with manual control over zoom and focus commands.

Engineered for extreme subsea conditions, it is depth-rated to 3000m, making it a reliable choice for deepwater inspections. It is based on the Tamron MP3010M-EV camera solution and incorporates a lightweight, compact 5-megapixel sensor. Featuring a high-sensitivity Sony IMX335 STARVIS CMOS sensor, the camera offers approximately 5,140,000 effective pixels and supports all HD modes up to 1080p/60.