The use of Slocum gliders to deliver near real-time environmental data for the Oil & Gas and Mining industries

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Blue Ocean Monitoring

Leader in providing innovative operational and environmental ocean data solutions.

- **Experienced Metocean data service provider specialising in autonomous systems**
- **Solution driven sensor networks for Oil & Gas, Mining and Environment**
- **Offices in Perth, US, UK, Singapore & strategic alliance with group in South Africa**
- **Largest commercial Slocum glider fleet globally**
- **Master Services and Supply Agreement with Teledyne Webb Research. Exclusive 3rd party service provider for Australia and SE Asia region**
- **24/7 'Follow-the-Sun' operations & piloting capability**

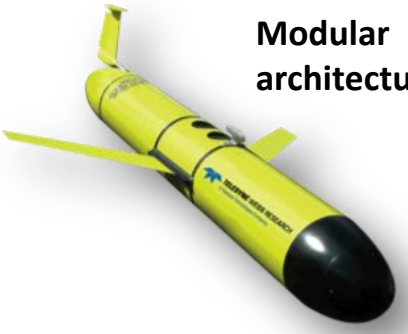
Teledyne Webb Research Slocum Glider

Ultra-efficient, buoyancy propelled autonomous underwater vehicle

Slocum gliders use small changes in buoyancy to move through the water column this is converted to horizontal motion by wings, resulting in a saw-tooth dive profile

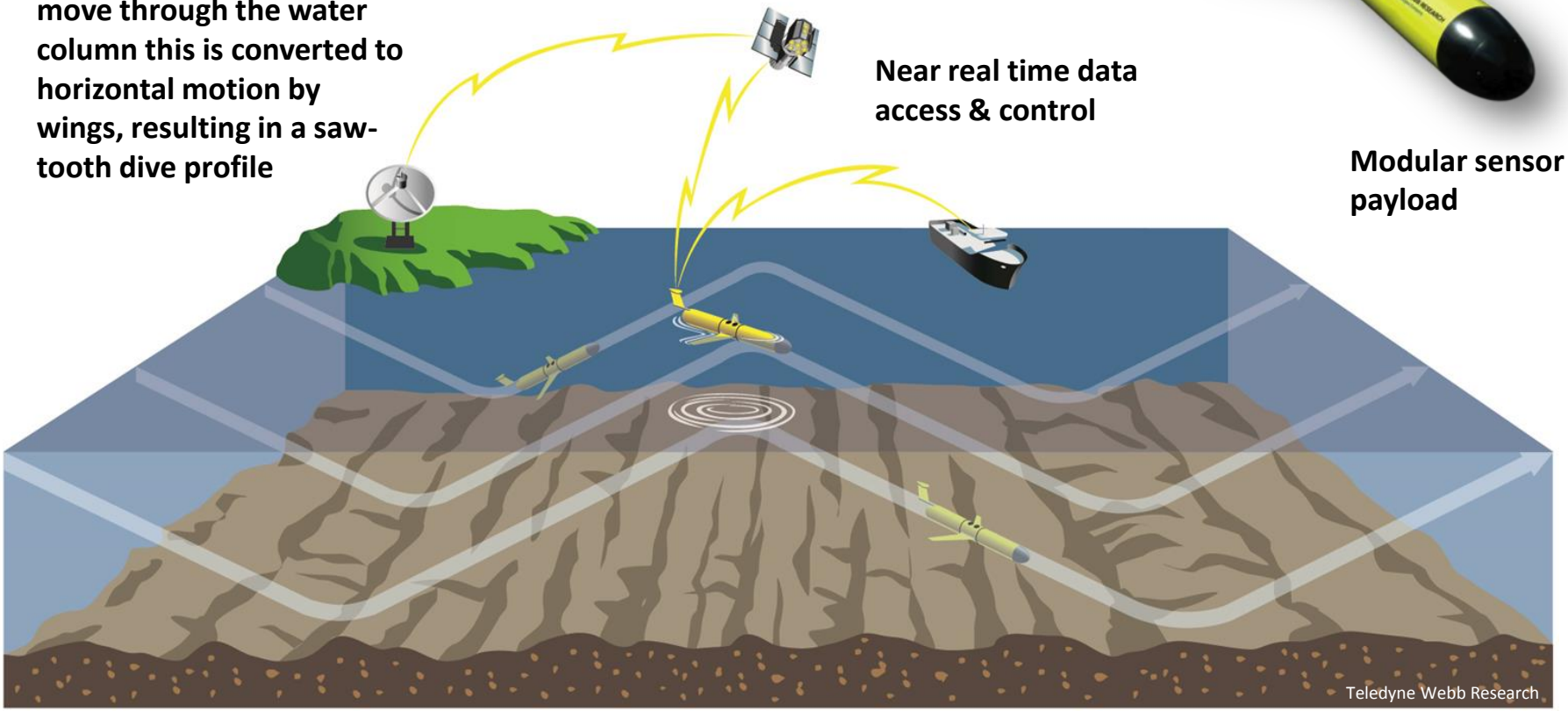
Communication by RF or Iridium & ARGOS position beacon

Near real time data access & control



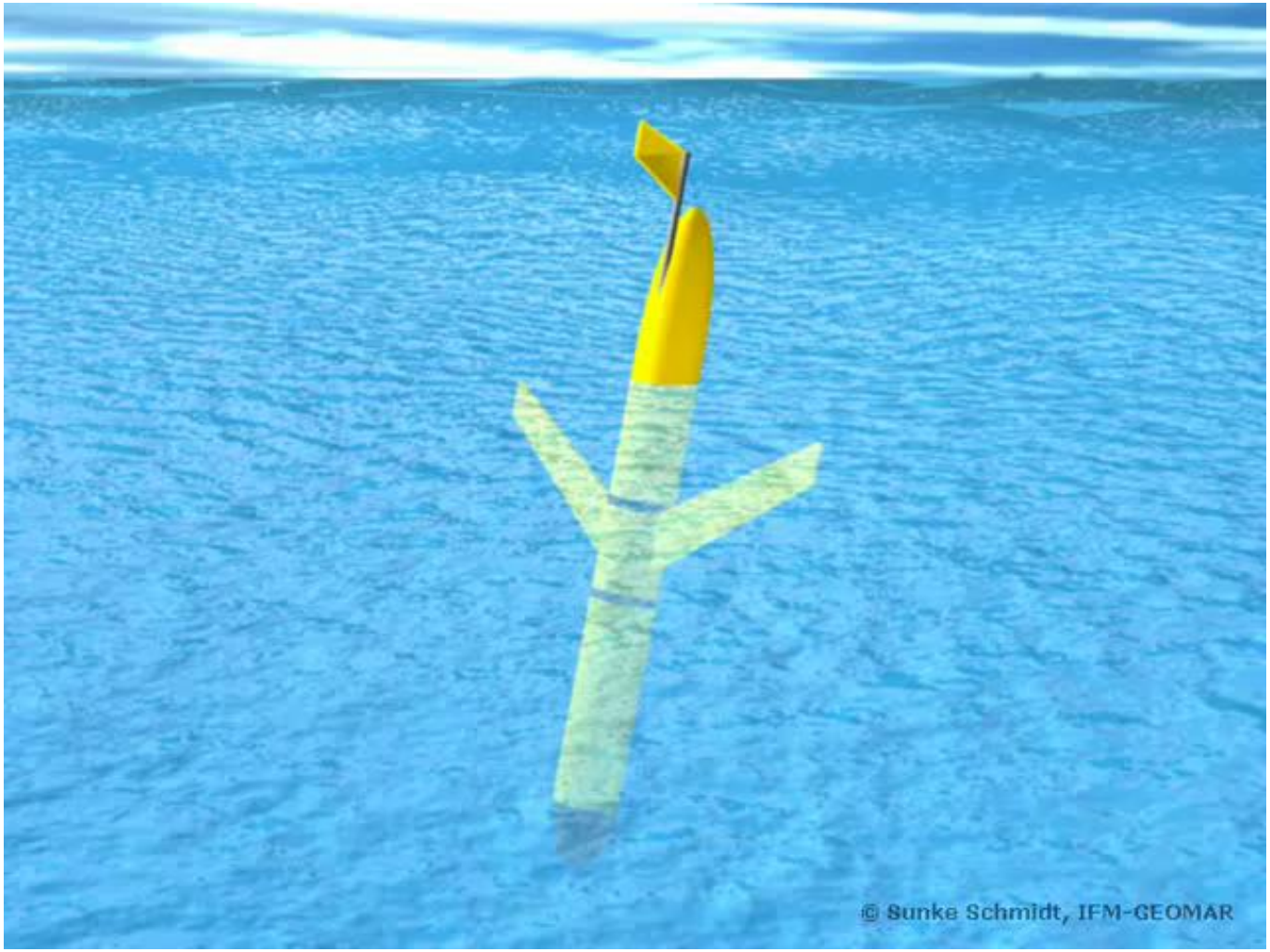
Modular architecture

Modular sensor payload



Vessel-Free Operation – Deploy/Recover from vessel then operate independently

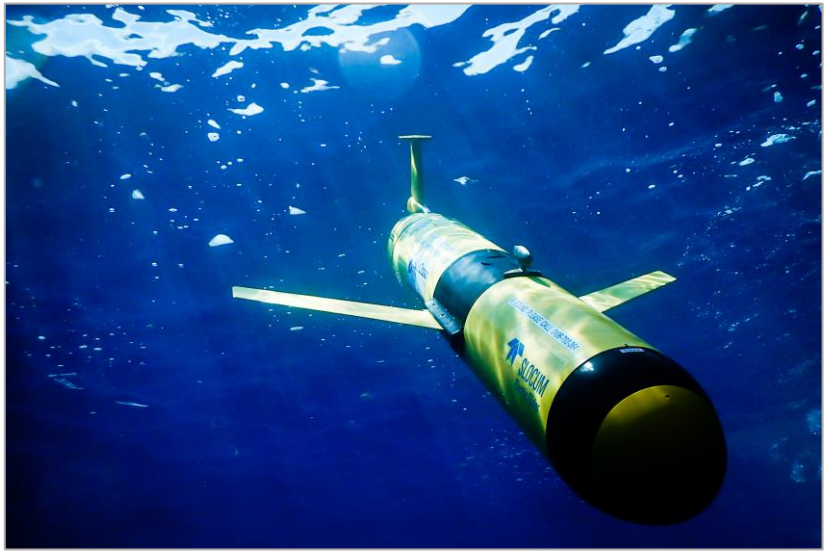
Teledyne Webb Research Slocum Glider



Advantages

Effective, highly capable tool for ocean data collection

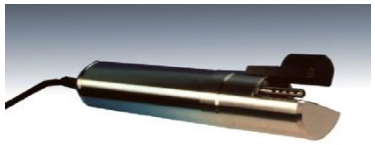
- **Low cost**
- **Ultra-long duration**
- **Low HSE risk**
- **Near real-time information & control**
- **Low logistical requirement**
- **Address multiple applications**



Sensors

Flexible sensor platform, key sensor constraints are power consumption & weight





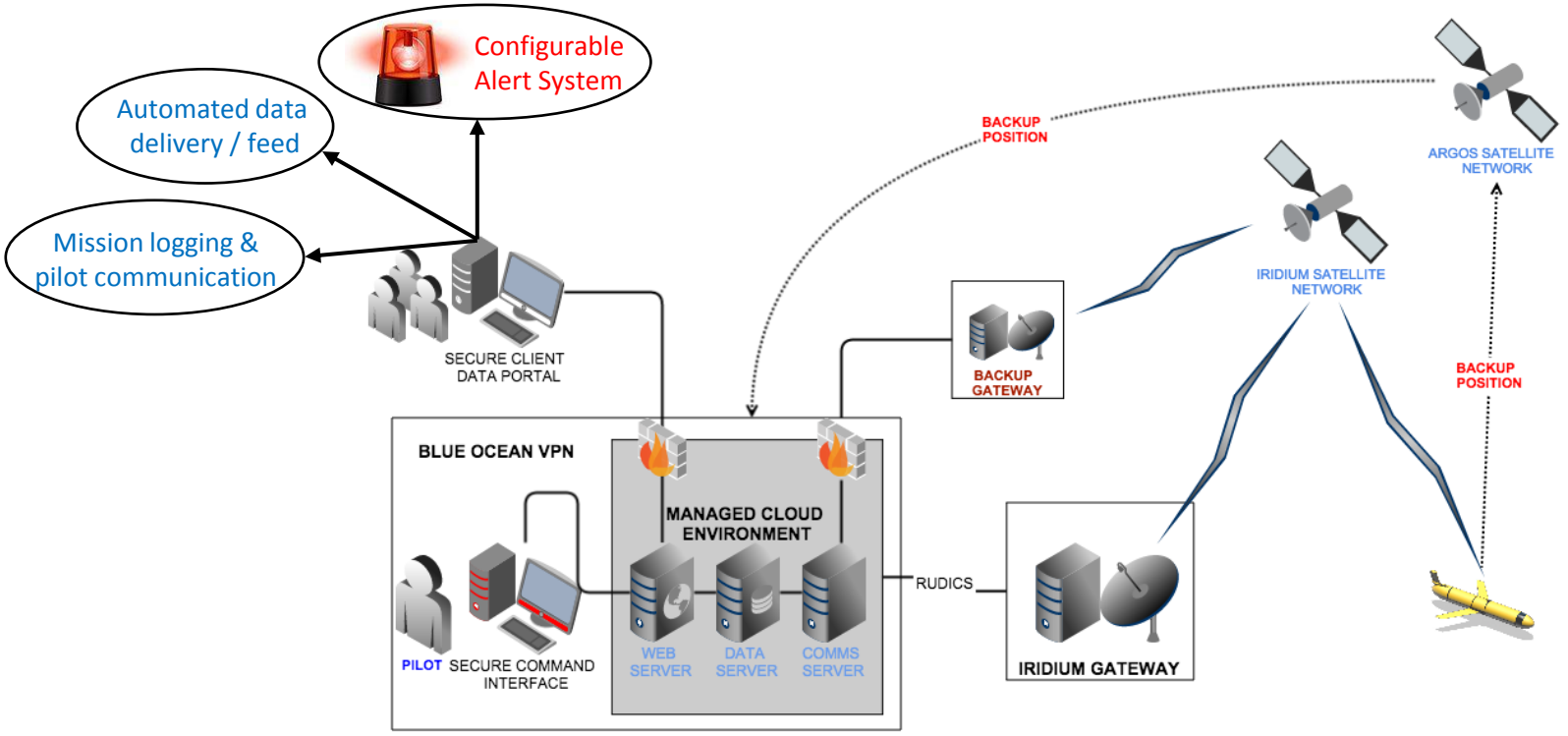







Blue Ocean Data Systems

Cloud based data acquisition, management & visualisation system.

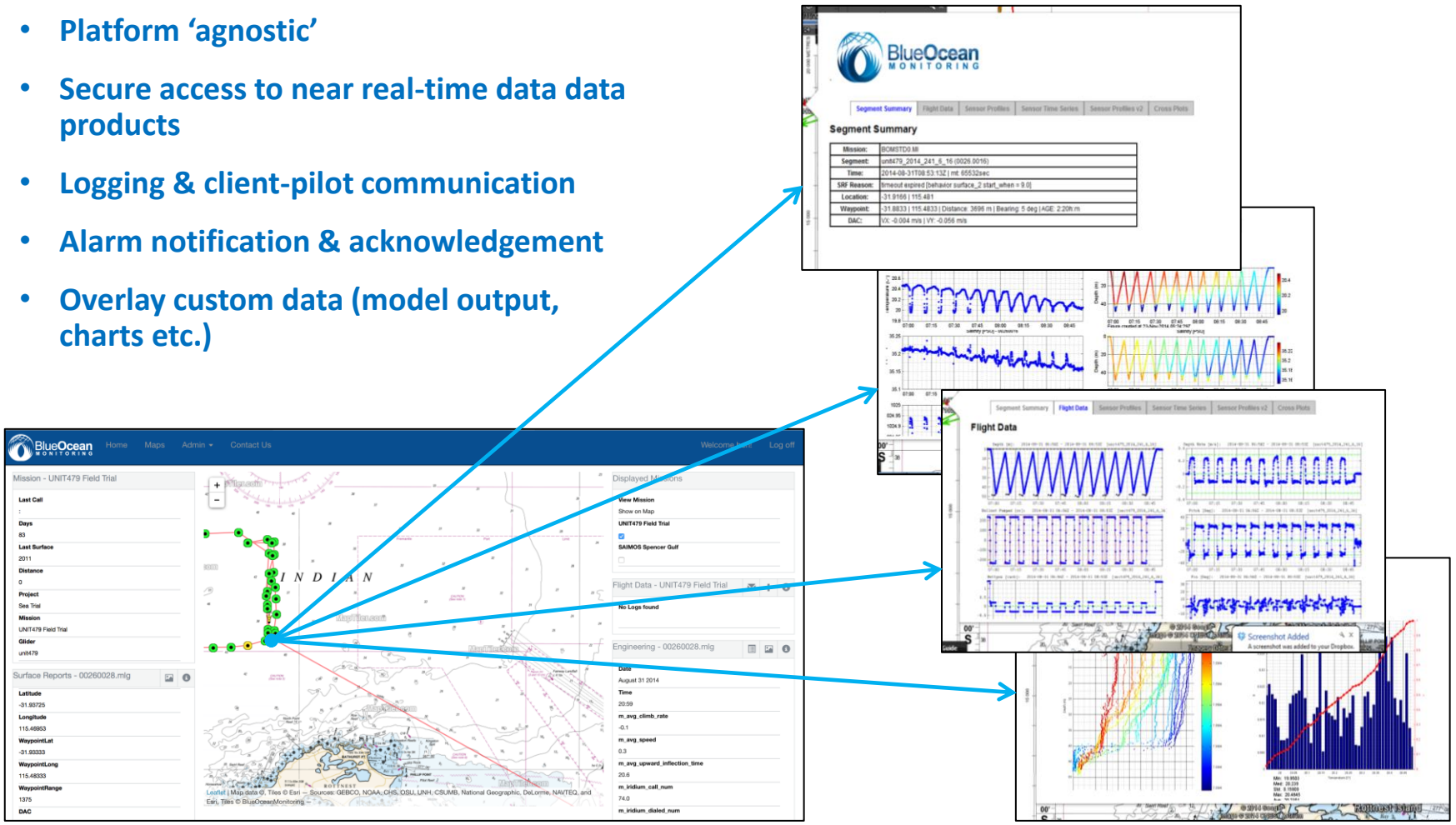


Multi platform input, real time acquisition, QAQC, product generation & web based distribution

Blue Ocean Data System

Web based secure client portal

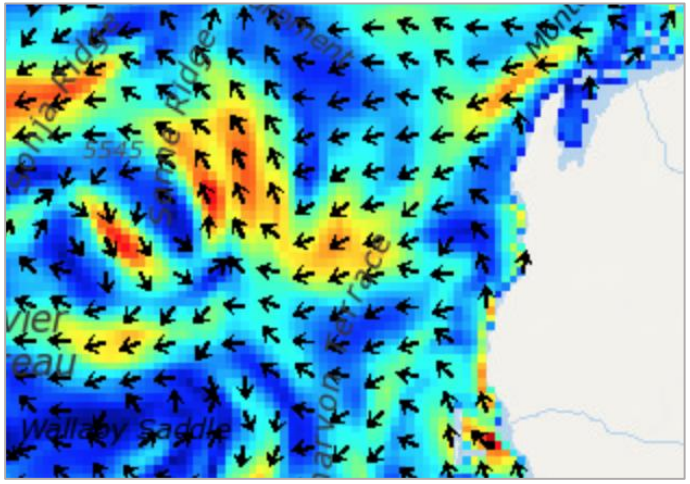
- **Platform ‘agnostic’**
- **Secure access to near real-time data data products**
- **Logging & client-pilot communication**
- **Alarm notification & acknowledgement**
- **Overlay custom data (model output, charts etc.)**

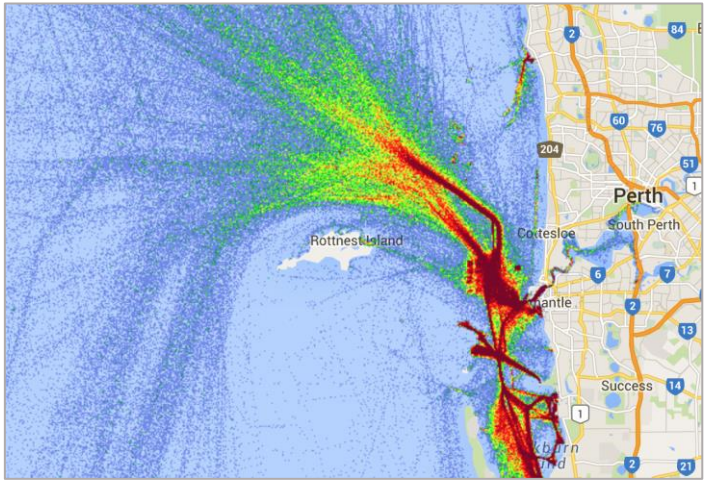


Operational Challenges

Operational areas hold unique challenges for long duration autonomous systems

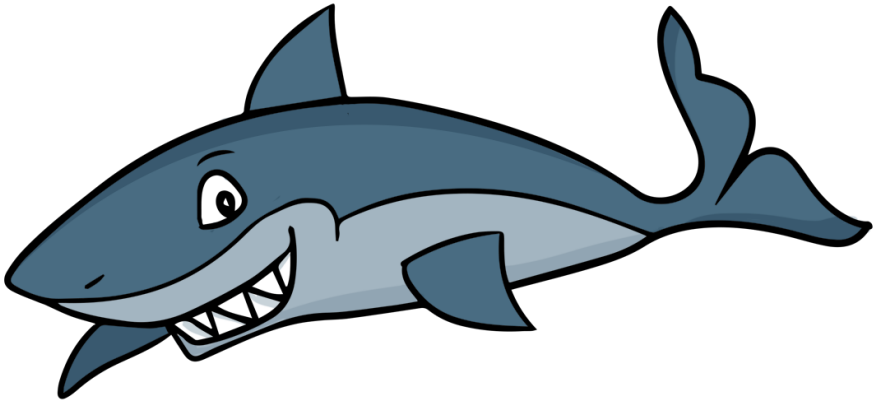
- **Strong currents**
- **Large density ranges**
- **Fishing activity - ghost nets & discarded gear**
- **Unauthorized retrieval**
- **Vessel traffic**
- **Bio-fouling**

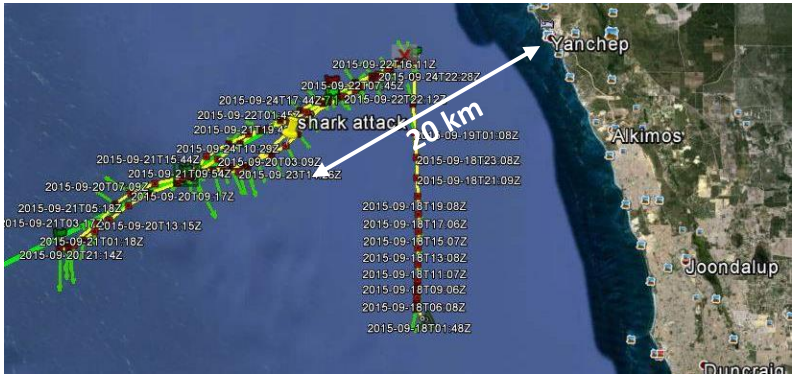




Operational Challenges

Marine life interaction





Source: UWA

Case Study 1

Environmental Compliance – Produced Formation Water Survey

Oil Detection

North-west Australian 'Oil-in-water' EX/EM Spectrums

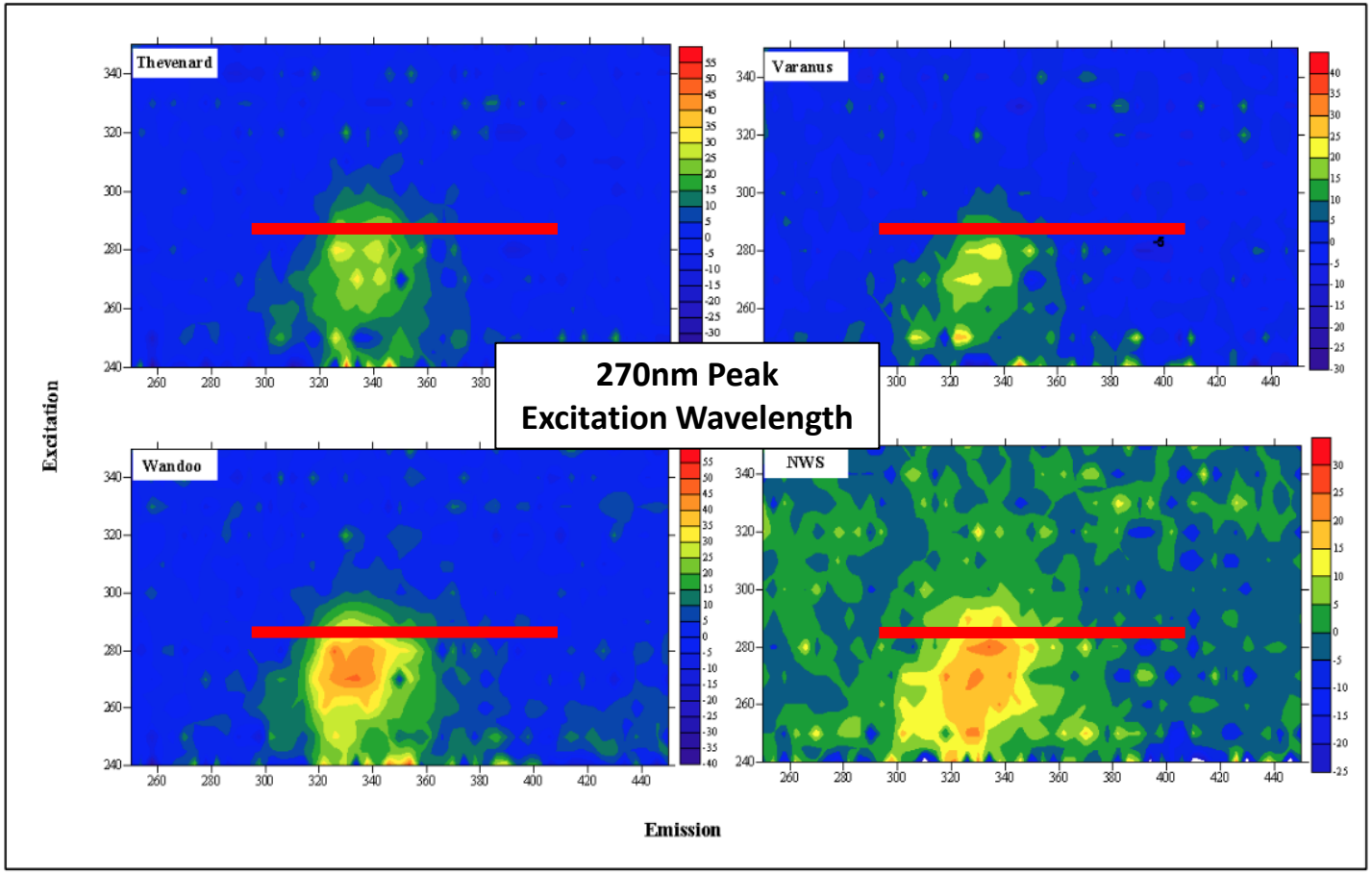


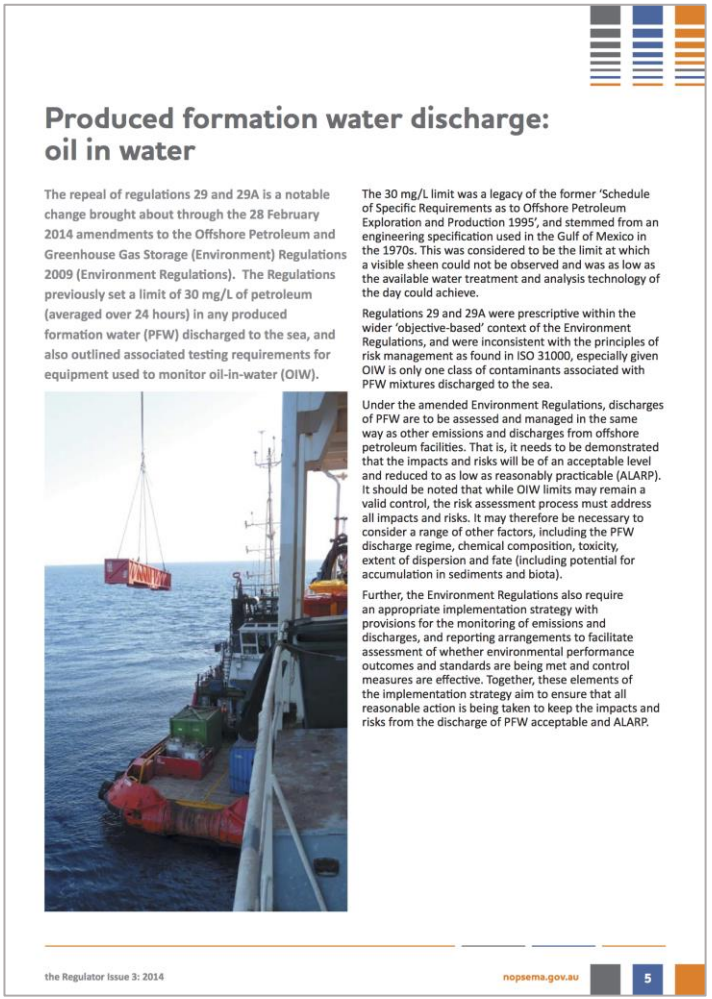
Figure: Oil in water EEMS Response at 100ppm Concentration (Harrison, 2012)

= Turner C3 EX/EM range (EX 285nm EM 350/55nm)

Oil & Gas

Regulatory changes in Australia

- **Recent change to regulations regarding Produced Formation Water (PFW) discharge (NOPSEMA)**
- **Burden of proof now falls on operator to demonstrate environmental compliance**
- **Operators are looking to new innovative solutions to achieve compliance**



Produced formation water discharge: oil in water

The repeal of regulations 29 and 29A is a notable change brought about through the 28 February 2014 amendments to the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations). The Regulations previously set a limit of 30 mg/L of petroleum (averaged over 24 hours) in any produced formation water (PFW) discharged to the sea, and also outlined associated testing requirements for equipment used to monitor oil-in-water (OIW).

The 30 mg/L limit was a legacy of the former 'Schedule of Specific Requirements as to Offshore Petroleum Exploration and Production 1995', and stemmed from an engineering specification used in the Gulf of Mexico in the 1970s. This was considered to be the limit at which a visible sheen could not be observed and was as low as the available water treatment and analysis technology of the day could achieve.

Regulations 29 and 29A were prescriptive within the wider 'objective-based' context of the Environment Regulations, and were inconsistent with the principles of risk management as found in ISO 31000, especially given OIW is only one class of contaminants associated with PFW mixtures discharged to the sea.

Under the amended Environment Regulations, discharges of PFW are to be assessed and managed in the same way as other emissions and discharges from offshore petroleum facilities. That is, it needs to be demonstrated that the impacts and risks will be of an acceptable level and reduced to as low as reasonably practicable (ALARP). It should be noted that while OIW limits may remain a valid control, the risk assessment process must address all impacts and risks. It may therefore be necessary to consider a range of other factors, including the PFW discharge regime, chemical composition, toxicity, extent of dispersion and fate (including potential for accumulation in sediments and biota).

Further, the Environment Regulations also require an appropriate implementation strategy with provisions for the monitoring of emissions and discharges, and reporting arrangements to facilitate assessment of whether environmental performance outcomes and standards are being met and control measures are effective. Together, these elements of the implementation strategy aim to ensure that all reasonable action is being taken to keep the impacts and risks from the discharge of PFW acceptable and ALARP.

Oil & Gas

Produced Formation Water (PFW) survey

- **PFW survey conducted for Woodside Energy Ltd & BMT Oceanica**
- **Data used to guide field sampling strategy in near real-time**
- **Sensor payload included WET Labs FLBBCD, Turner C3 & Seabird CTD**
- **Fluorescence based hydrocarbon detection**
- **Lab verification of sensors with PFW sample from facility**
- **Key benefits**
  - Reduce standard survey frequency & implement regular glider based surveys
  - Significant cost reduction
  - Persistent data collection
  - Long term in-situ data to improve circulation & dispersion modelling

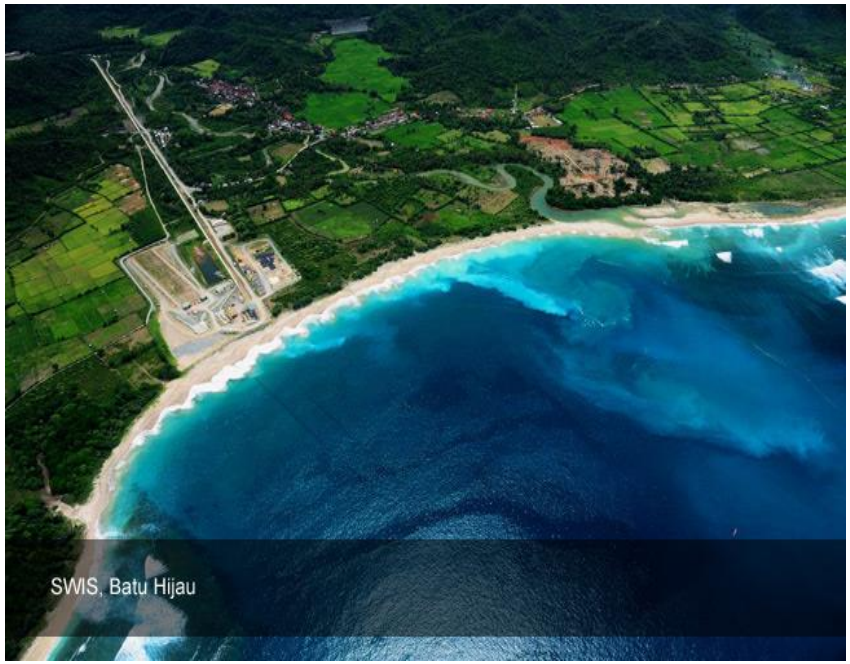
Case Study 2

Environmental Compliance – DSTP Monitoring & Alarm System

PTNNT – Batu Hijau

Marine tailings disposal system to minimise environmental impact

- **Batu Hijau, Sumbawa, Indonesia**
  - Newmont Mining's Indonesian subsidiary (PTNNT) commenced operations at the Batu Hijau mine in 1999
  - The Government of Indonesia and PTNNT selected the Deep Sea Tailings Placement (DSTP) as the preferred tailings management plan to reduce the environmental impact
- **DSTP Operation**
  - Tailings flow via gravity as a slurry to the edge of the Senunu Submarine Canyon through a pipeline 3.2km offshore at a depth of 125 meters, below the biologically productive photic zone
  - Due to the greater density of the slurry, the tailings is predicted to migrate into the Senunu Canyon and settle at depths greater than 3,000 meters

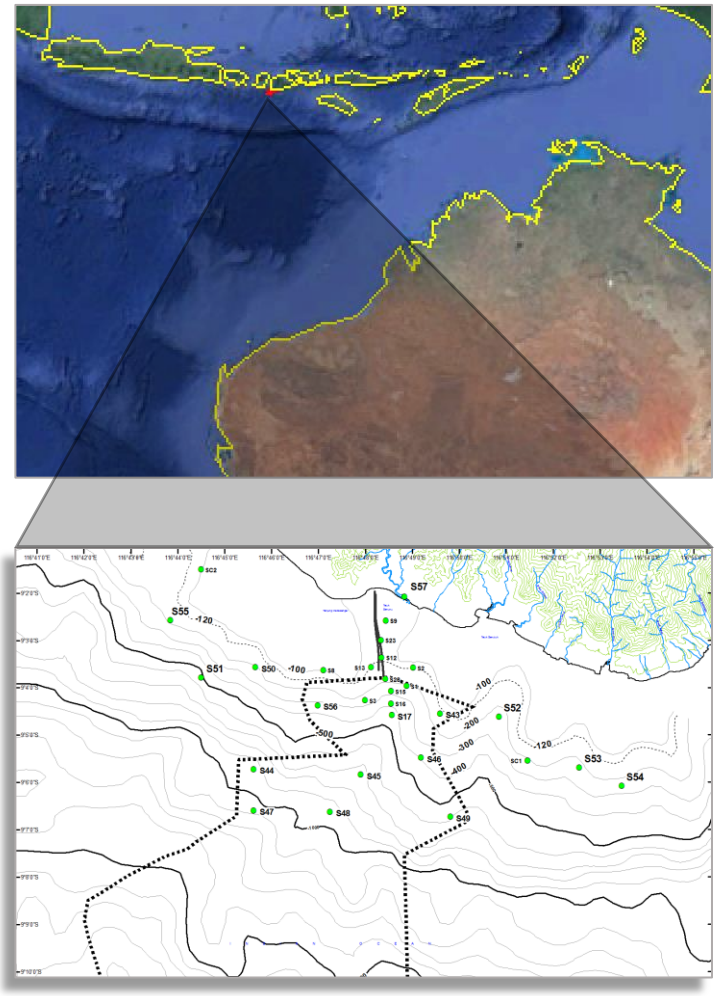


PT Newmont Nusa Tenggara

DSTP Monitoring & Alarm System

Deep Sea Tailings Placement (DSTP) Monitoring

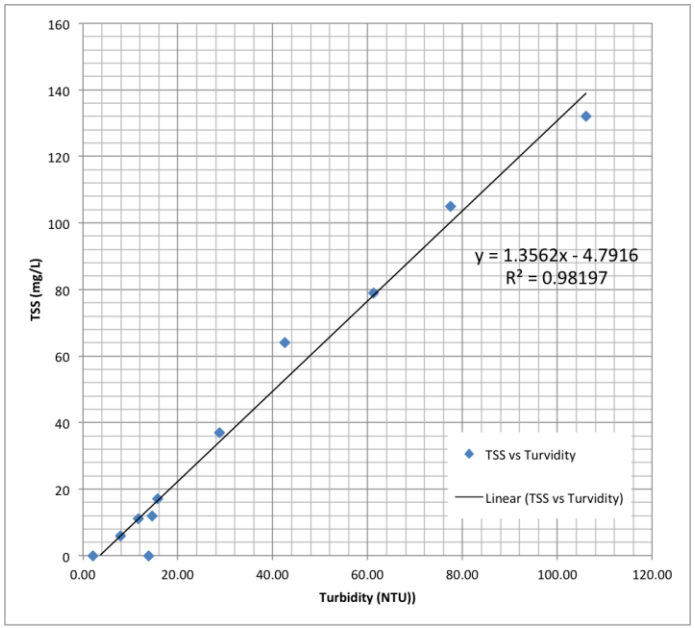
- **As part of tailings permit, Indonesian Government requires PTNNT conduct ongoing Total Suspended Solid (TSS) monitoring**
- **Compliance Zones A, B & C**
- **Existing method was to conduct regular vessel based sampling with lowered frame (CTD & FLNTU)**
- **Glider payload included WET Labs FLNTU, WET Labs BB3SLO & Seabird CTD**
- **Alarm, notification & acknowledgement system implemented**

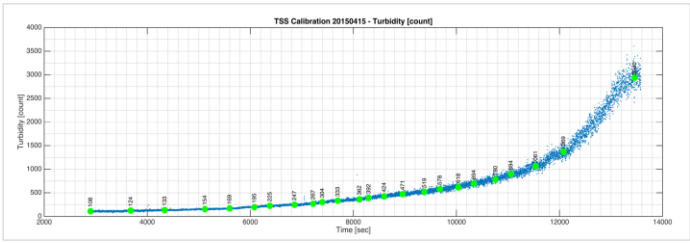


TSS Turbidity Correlation

Calibration experiment to establish relationship between glider based optical measurements and TSS concentration using representative tailings sample

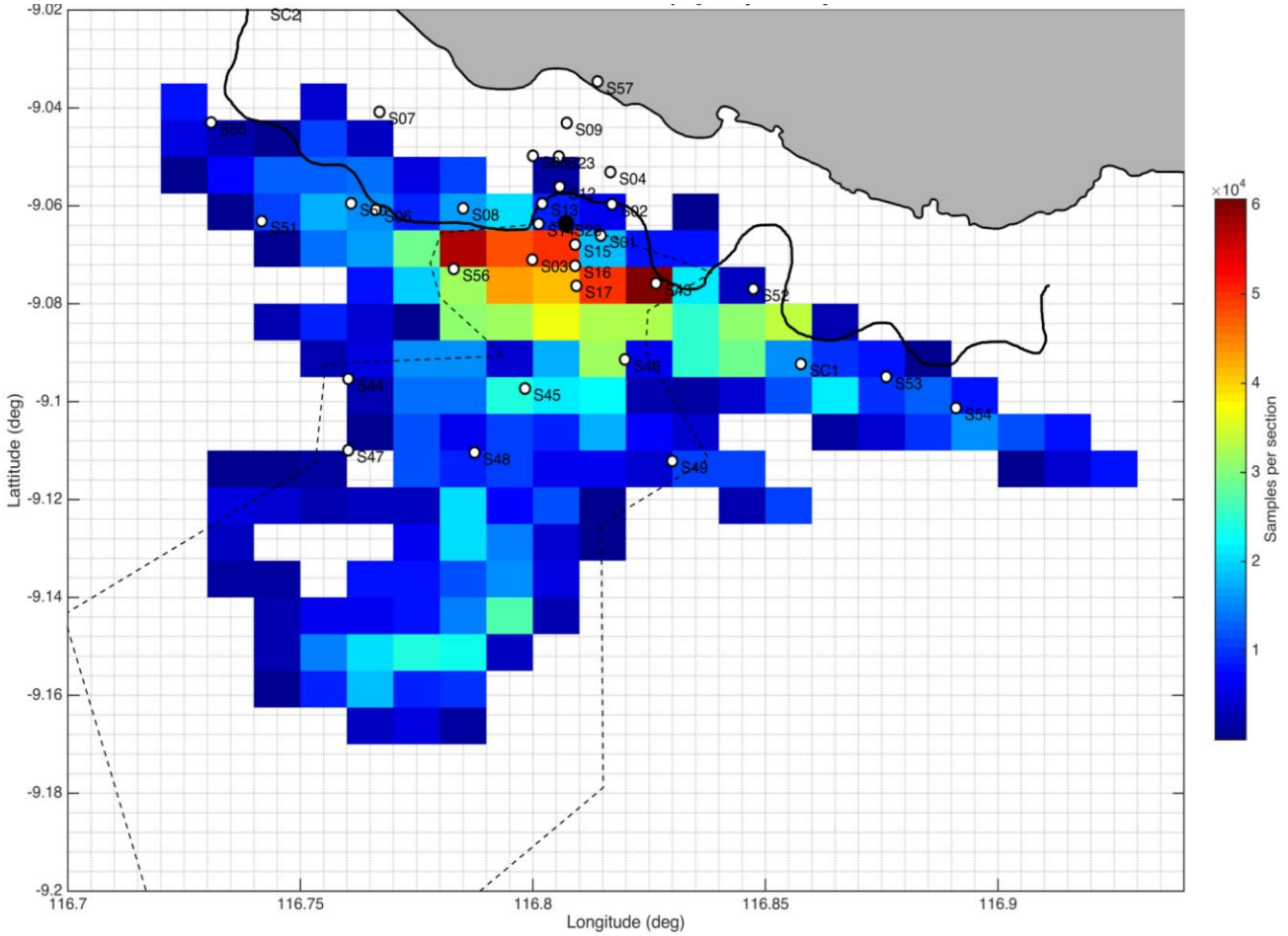
- **Tailings sample from mine**
- **Measurements of Turbidity, Backscatter & Total Suspended Sediment (TSS) concentration**
- **Strong linear relationship between TSS concentration & Turbidity (R^2 ~0.98)**





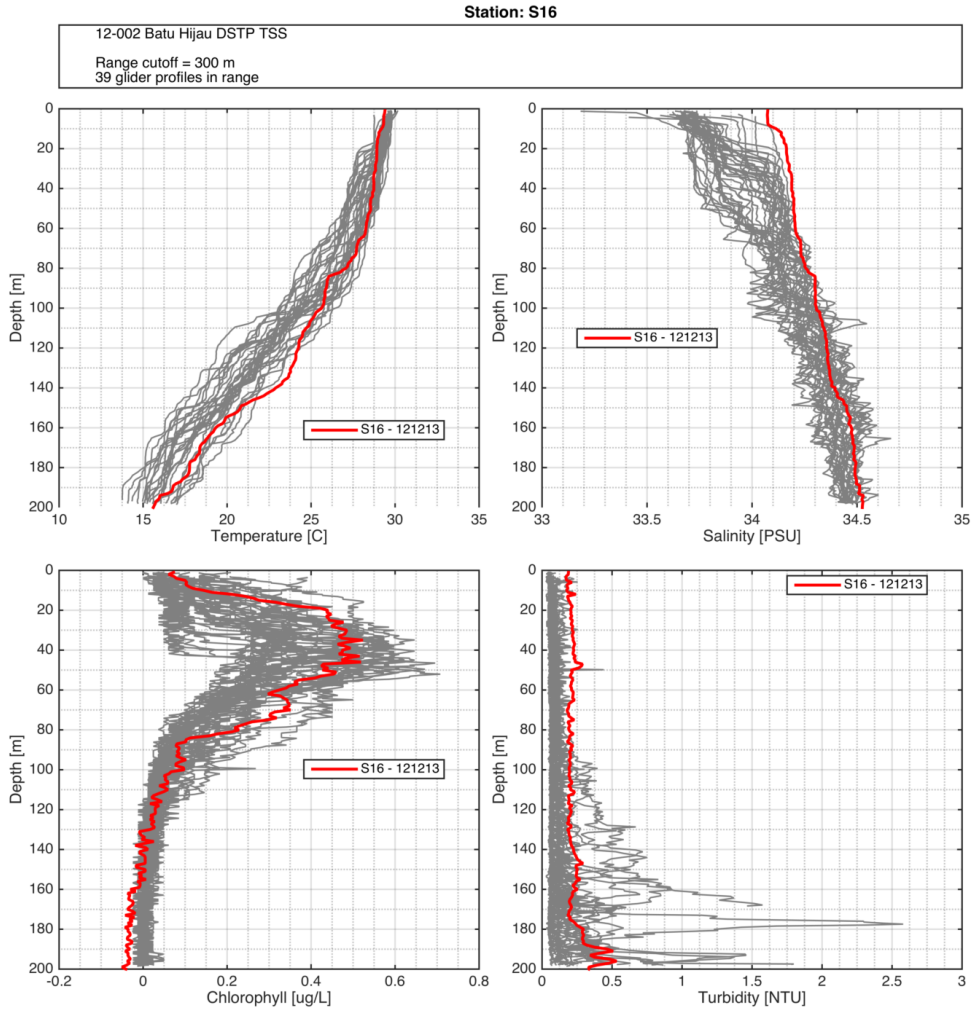
Coverage

Significantly greater coverage of sample sites compared to existing methods



Data Comparison

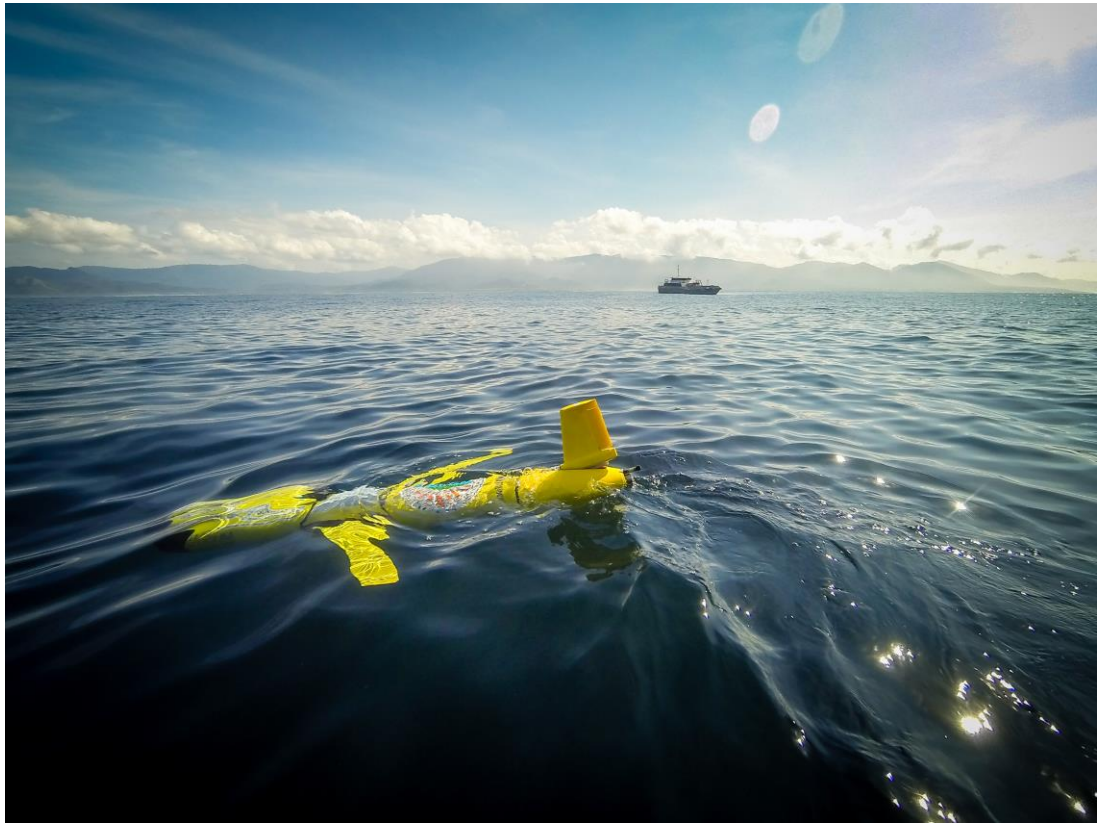
High resolution, persistent measurements



Mining

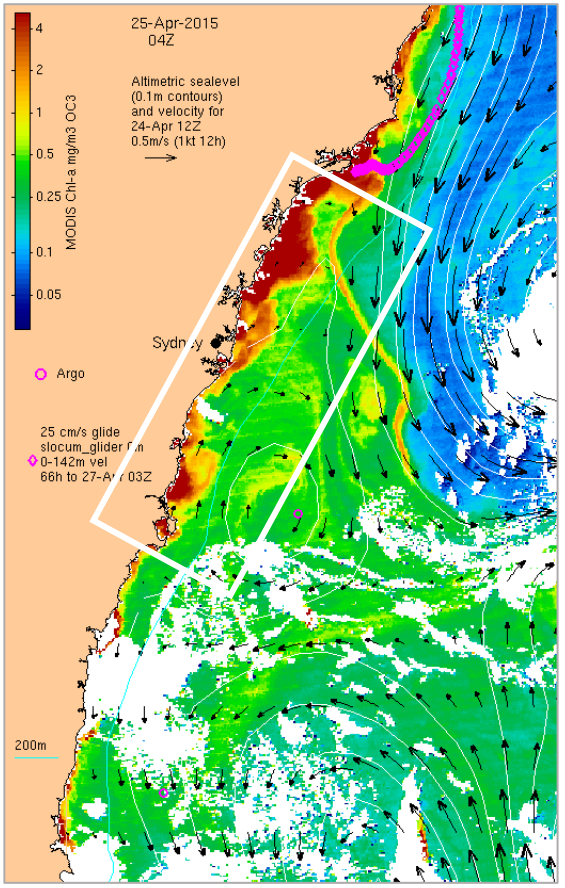
Deep Sea Tailings Placement (DSTP) Monitoring

- **Real-time information – allowing real-time operations management**
- **Significant cost saving**
- **Higher spatial & temporal data density**
- **Method is currently under review by the Indonesian Ministry of Environment**



Key Research & Development

- **Operational data assimilation project**
- **Optimisation of track, distribution & number of vehicles**
- **Data submission into Australian Integrated Marine Observing System (IMOS) public database**
- **Sensor development & integration - working with partners**
- **Control automation**



Conclusion

- **Slocum glider is an effective, highly capable sensor platform**
- **Safe & low cost – increasingly important in the current commercial climate**
- **Utility maximised when using as part of a wider sensor 'network'**
- **Broad range of applications driven by innovation & development of new sensors**
- **Has reached a level of maturity, now widely accepted in the commercial space**

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