Research to understand natural variability and best-practice methodologies for marine monitoring at carbon capture and storage sites

CSIRO is leading a series of interconnecting research projects in Gippsland, Victoria, Australia that will inform development of methods and guidelines for marine monitoring of offshore carbon capture and storage (CCS) projects.

Establishing a robust evidence base

Carbon capture and storage (CCS) involves capturing carbon dioxide (CO_2) emissions from industrial sources, compressing it, and then transporting it to a suitable site where it is injected deep underground for its long-term storage. Implementing this technology will help Australia to lower its contribution of CO_2 emissions to the atmosphere.

Establishing a robust measurement and monitoring process for CCS activities is a key requirement to enable confidence and certainty to the community around storage of the CO_2. It is also a legislative requirement when approving CCS activities in Australia, that a robust measurement, monitoring and verification (MMV) program is implemented.

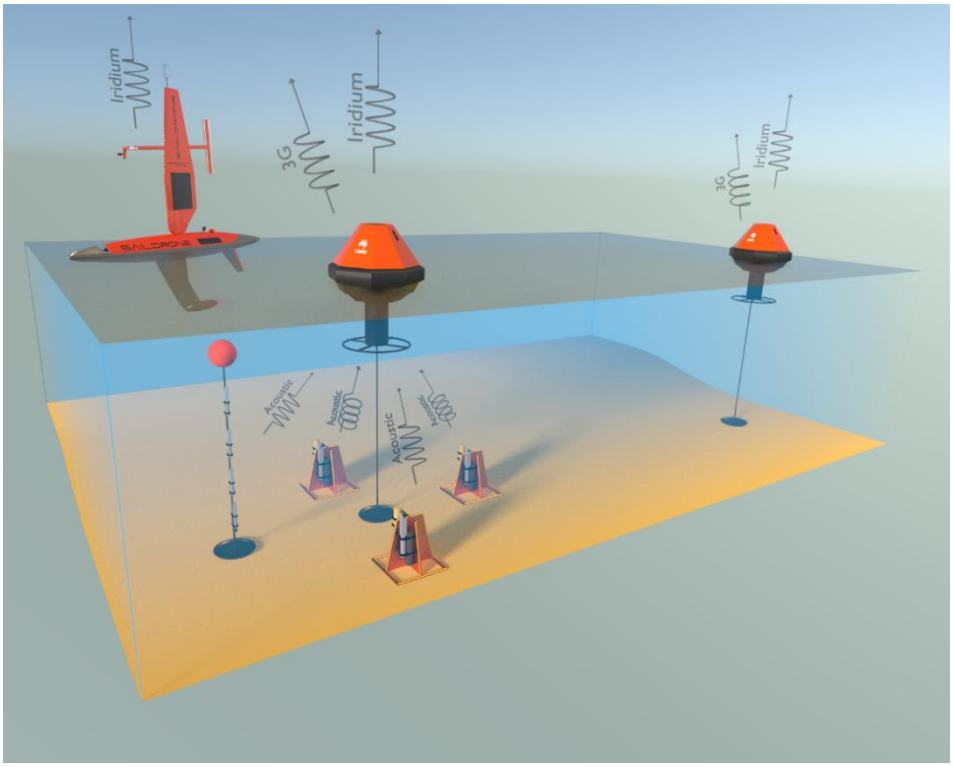


Illustration of equipment (moorings; landers and unmanned surface vehicles) to be used in the CSIRO research.

CarbonNet, a project funded by the Australian and Victorian governments, is investigating the potential for establishing a commercial-scale CCS network in the Gippsland region, Victoria. This site could see the injection of up to 5 million tonnes of CO_2 per year over a 25-year period.

CSIRO is leading research to inform methods that could be used as part of an MMV program in shallow coastal marine environments.

CSIRO and the Gippsland Region

Since 2017, CSIRO have been leading research in the Gippsland region to provide new knowledge to inform cost-efficient MMV applicable to shallow coastal waters.

The two key objectives of the research have been to:

- gain knowledge about the Gippsland coastal subsea environment and its natural variability.
- develop accurate, cost effective best-practice MMV methods that can measure and correctly attribute small changes in dissolved CO_2 and gas bubbles in shallow-coastal ecosystems.

To achieve these objectives the CSIRO executed targeted field activities in coastal waters off the Gippsland region in water depths of less than 30 m. This included surveys to collect environmental data to investigate variability in the marine area and identify any unusual coastal seabed features, and the deployment of a range of state-of the-art monitoring technologies.

As part of planning this work, CSIRO has ensured all the necessary permissions have been sought and has also assessed risks to minimise and mitigate any identified impacts to the marine environment and its marine users.

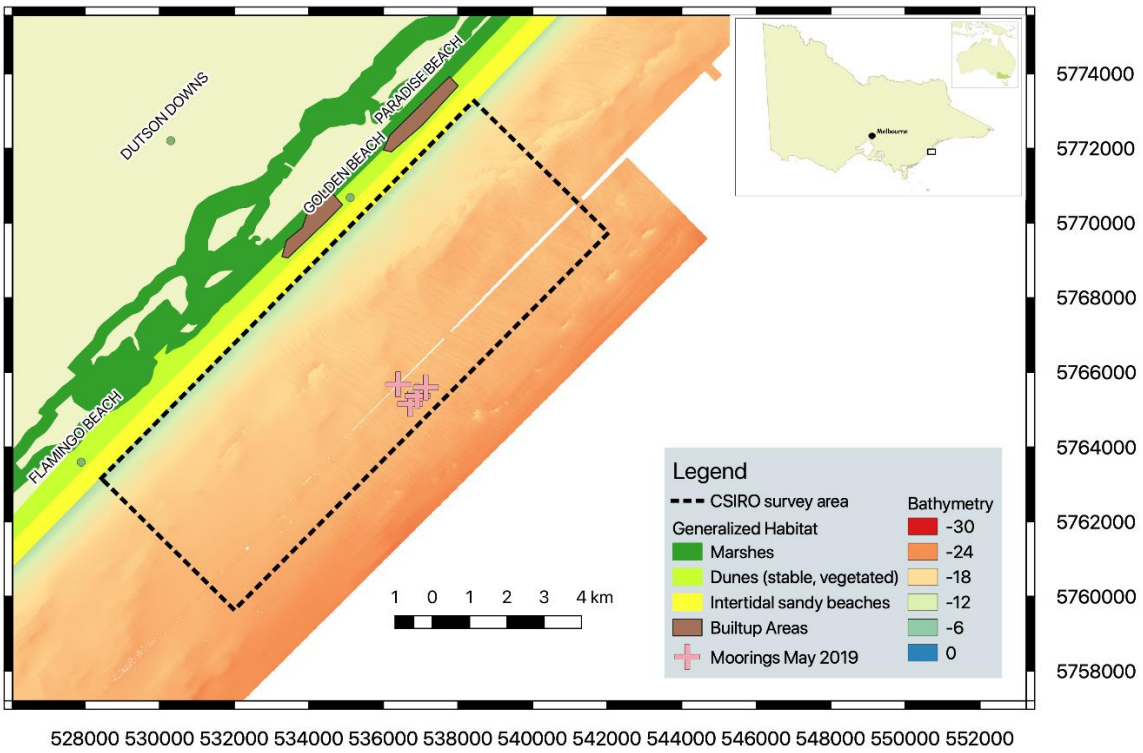
CSIRO requested that all vessels remain more than 500 m away from research equipment deployed in the area. In line with permit requirements, all equipment placed at the research site by CSIRO was removed in August 2020.

Understanding the seabed and its processes

To understand any unique features of the Gippsland region and how variable the site is, CSIRO undertook a range of marine surveys across different times of year. This information will help to understand interannual and seasonal variability which is vital to help inform the scale of monitoring that would be required for CCS projects in the future. The data will also help to identify potential 'false alarms' in any monitoring.

To help characterise the area, researchers gathered data on the area's bathymetry, sediment (size and geochemistry), biology (fish; infauna [what lives in the sediment] and macrofauna [what lives on the sediment]); and oceanography (water speeds; wave heights, water chemistry).

The location of the surveys centred on unusual seabed sand-wave like features located offshore of Golden Beach (<30 m water depth). It was initially thought these features might be associated with fluid movements, so have unique biological communities that may require special consideration.



The study area (in the proposed CarbonNet CCS site, Gippsland Region, Victoria) where sampling will occur; and research equipment will be deployed as part of the CSIRO research project.

These sandy habitats were found to support a rich infaunal community of polychaetes, crustaceans and molluscs, but a high level of spatial and temporal variability in sediment infauna abundance and diversity was noted. This may represent a challenge in their use as indicators of disturbance and human impact in the area. Further work will be undertaken to identify taxa or groups of taxa that respond to elevated CO_2.

The species richness and abundance of fish and elasmobranchs observed in this study was generally low, considerably lower than the species richness and abundance of demersal fish reported elsewhere. This may be due to a number of factors including the small spatial scale at which we sampled and the similar nature of the area sampled.

Photographs to show a representative range of sediment types collected using the Smith McIntyre grab during the FTV Bluefin survey in November 2017.

In addition to traditional taxonomic infaunal identification the use of metabarcoding, or environmental genomics has also been used. For the first time the infaunal eukaryote and prokaryote communities have been characterised in the Gippsland Golden Beach area.

The data collected as part of this study represent a significant improvement in knowledge of the nearshore marine environment in the Gippsland region and study area. The study has revealed the processes that continue to shape the geomorphology of the study and the detailed study of sediments, infauna, epifauna and fish species have revealed biological community composition and abundance permitting comparison to existing studies.

Deploying state-of-the-art equipment

Fixed mooring arrays are commonly used in Australia to gather oceanographic data (e.g. temperature, salinity, currents) and provide near real time as well as delayed mode observations. This information is used to inform marine management decisions and calibrate oceanographic models.

In 2018, CSIRO deployed a network of marine moorings and landers (seabed frames) near the CarbonNet site in State coastal waters near Golden Beach. These platforms were equipped with a suite of 30 geochemical sensors (e.g. CO_2, pH, oxygen, methane, temperature and salinity) and six acoustic sensors (to monitor for bubbles). The platforms were located within a 750 m radius to minimise the footprint of research activity.

The objective of the 2018 six month deployment was to test the performance of these platforms in a highly dynamic shallow-water environment. Results from the 2018 field experiment provided vital information on the performance of a number of elements including, the sensors, data transmission and how the equipment withstood the physical conditions. This information has enabled improvements to monitoring network design to be implemented including configuration considerations and likely servicing requirements to ensure the platforms are able to function effectively in this harsh environment. The additional environmental data collected from the sensors is also helping to further characterise the area.

A modified configuration was redeployed to site in May 2019 and was removed in August 2020.

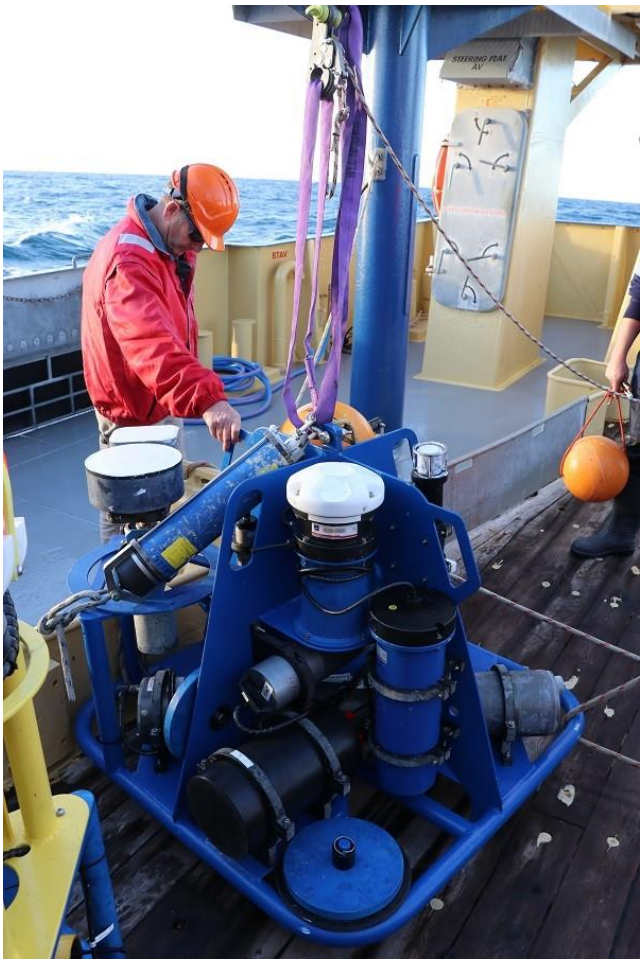
Autonomy is likely to be a critical component underpinning ocean monitoring operations in the future and may offer opportunities in sustained observations and broader spatial coverage when compared to sensors on fixed moorings.

CSIRO has tested the use of a Saildrone (a type of unmanned surface vehicle, or USV) equipped with a number of sensors to determine its suitability of mobile platforms as potential tools for monitoring a CCS site. Initial testing has been completed and the both the sensor performance and quality of the data looks promising. Further field trials are anticipated during 2020.

Using numerical models

Numerical models of ocean circulation and CO_2 dynamics have been developed alongside the collection of field measurements to help understand the drivers of natural chemical variability, and to test different marine monitoring approaches for the study region. By

introducing artificial additions of CO_2 at the seabed, the models provide insight into how theoretical leak signatures can be reliably separated from the natural background conditions observed at fixed or mobile platforms, in order to minimise false alarms or incorrect attribution of CO_2.



Preparation of a lander (with a range of sensors attached) for deployment onto the seabed at Golden Beach.

Findings from this research will enable methods for MMV of subsea CO_2 storage in the marine environment to be advanced. This research will also help to provide necessary assurances to government, business and the community that shallow-coastal CCS operations are able to be monitored effectively and accurately.

The outcomes will not only be relevant to Australia but also internationally, informing best practice for monitoring CCS in shallow marine environments globally. Data collected will become publicly available upon publication in the scientific literature. This research will provide insights into the dynamic processes shaping the nearshore Gippsland region, enabling characterisation of the sediment and biological communities present.

By understanding the variability of such natural signals, false alarms arising during monitoring of stored CO_2 can be reduced.

Saildrone

Unmanned surface vehicles (USV) are a cutting-edge technology platform that can collect a range of oceanic data. CSIRO is partnering with *Saildrone* (USA) to test this technology in the Australian marine environment. Saildrone is a wind-powered craft approximately 7 m in length and 4 m in height. With average speed of around 3 knots (max 8 knots), it is controlled through satellite communications and able to provide real-near-time data transfer. These platforms are also equipped with an Automated Identification System (AIS).

Saildrone is an unmanned surface vehicle equipped with sensor technology to measure the marine environment.

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