The CarbonNet Project

GipNet – Baseline environmental data gathering and measurement technology validation for nearshore marine Carbon Storage

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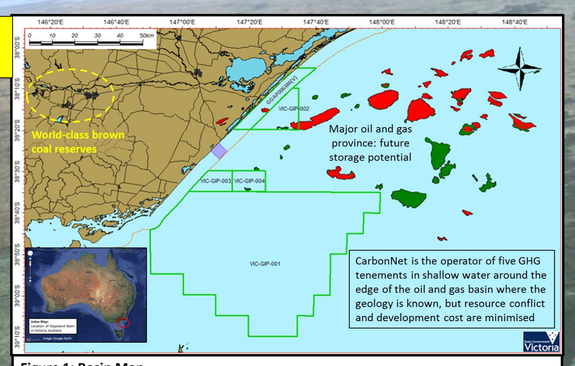

Figure 1: Basin Map.
The CarbonNet area of interest covers the nearshore Gippsland Basin out to approx. 25 km from the coastline, but avoiding major hydrocarbon accumulations. CarbonNet holds five offshore GHG assessment permits in State and commonwealth waters, covering three prioritised potential storage sites

Gippsland Basin Background

The Gippsland Basin is Australia's premier petroleum basin and has been explored for over 50 years. Basin reserves exceed 5 billion barrels of oil and 8 Tcf of gas.

CarbonNet is working-up sites in the nearshore for Carbon Storage and holds five GHG Assessment permits in Commonwealth and State waters (Figure 1). These permits cover several attractive targets , with capacities of up to 125 Mt.

The Gippsland basin has significant oil and gas infrastructure which must be avoided, but this industry activity has also provided a data-rich opportunity with abundant 3D seismic coverage offshore, and supporting 2D seismic in shallow water and onshore. A database of over 1,500 wells demonstrates excellent reservoir quality (Figure 2).

Water depths in the basin range to 500m+ (Figure 3) but in the nearshore area of interest to CarbonNet depths range from 15 to 50m. A Lidar survey was flown in 2008 by another government department for coastal mapping and flood prediction. The marine component offers 5m grids out to 3.5 km offshore and is supplemented by an oil industry LiDAR survey flown in 2004.

The Lidar grid (Figure 4) reveals complex seabed conditions with some mobile sand zones, local outcropping hardgrounds, and large sand waves or channels. Anthropogenic features visible in the LiDAR bathymetry include pipeline trenches, outfall pipelines, and seabed trawl/dredge scars.

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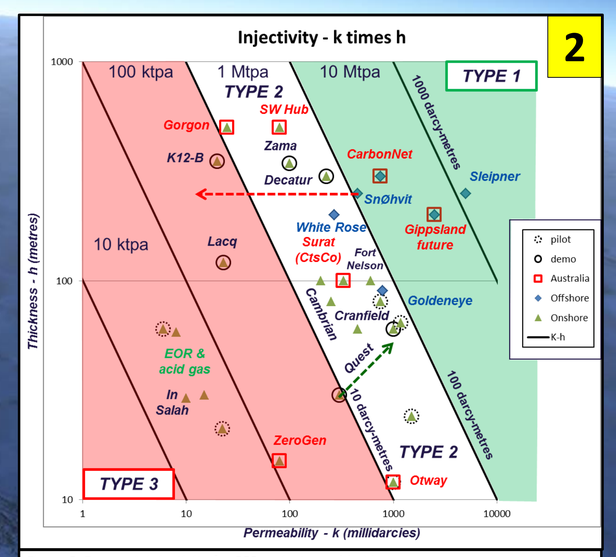

Figure 2: Reservoir injectivity for CCS projects worldwide.
Injectivity is ultimately controlled by reservoir thickness and permeability. Ideal reservoirs (Type 1) are coloured green, and adequate reservoirs (Type 2) are white. Poor reservoirs (type 3) are red and injection is contraindicated because of risk of fracturing (e.g. In Salah)

Image: Google Earth

Summary

The GipNet assets are the foundation to research programs for observations and instrument tests aimed at defining practical and relevant shallow-marine Measurement, Monitoring, and Verification (MMV) programs as the CCS industry considers shallow offshore waters in the Gulf of Mexico and other basins, as well as meeting the specifics of CarbonNet Project options. The CarbonNet Project is investigating large volume storage (nominal 125 million tonnes of CO2 over 25 years) in shallow waters within 20 km of the coastline, offshore Gippsland Australia. GipNet will research the levels of various types of noise and natural variation against which one seeks to detect a positive signal, or confirm a null signal.

In the well-understood, high quality and thick reservoirs of the Gippsland Basin, plumes are expected to be very predictable, relatively thick, and easily observable with the right techniques such as timelapse 3D seismic imaging and downhole monitoring, but provision must also be made for unexpected outcomes and technologies sought that have low detection thresholds to identify thin or diffuse plume offshoots or early warning of unexpected plume movements in order to provide assurance of storage security.

CarbonNet seeks to validate at this pre-commercial stage, an appropriate, but not excessive, range of technologies to characterise the pre-existing environments. For each proposed technology, the physics of detection was reviewed, as well as the practicalities of deployment in the shallow-water and nearshore environment with multiple sources of 'noise', of initial research and test instruments and later detection systems appropriate for a commercial project. Most importantly, each MMV technology was assessed for its value in monitoring CO2 storage Integrity, Conformance and Assurance and adding to the proven technologies of 3D seismic and downhole monitoring.

Three key technologies were identified for trial deployments and further testing:

1. Natural Seismicity Monitoring Network
2. Atmospheric Monitoring
3. Baseline Marine Monitoring

In determining funding, the physics of detection for each proposed technology was reviewed, as well as the practicalities of deployment in the shallow-water and nearshore environment with multiple sources of 'noise', of initial research and test instruments and later detection systems appropriate for a commercial project. Most importantly, each technology was assessed for their value in monitoring CO2 storage Integrity, Conformance and Assurance.

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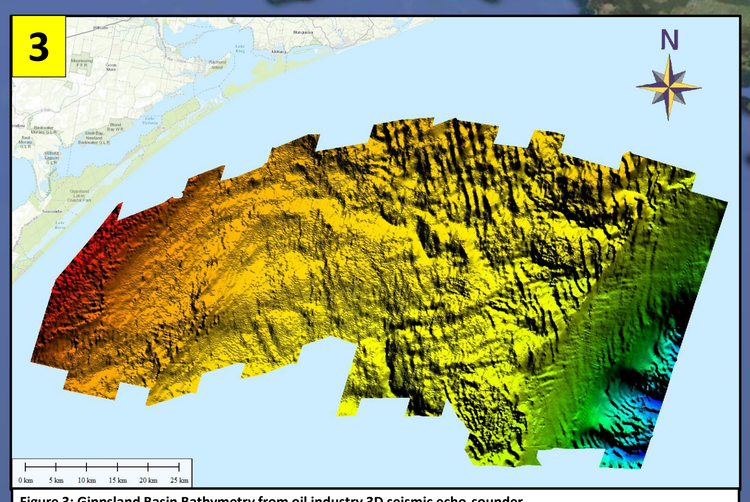

Figure 3: Gippsland Basin Bathymetry from oil industry 3D seismic echo-sounder.
Bathymetry data from marine 3D seismic surveys – Depth scale from 20 m (red) to 580m (blue) – shows a wealth of detail including large (2 km wavelength) sand waves in the north and east of the basin where strong tidal and storm currents impinge on the shelf and the former course of the Latrobe River from the last ice age lowstand meandering across the shelf from top left to centre of the map.

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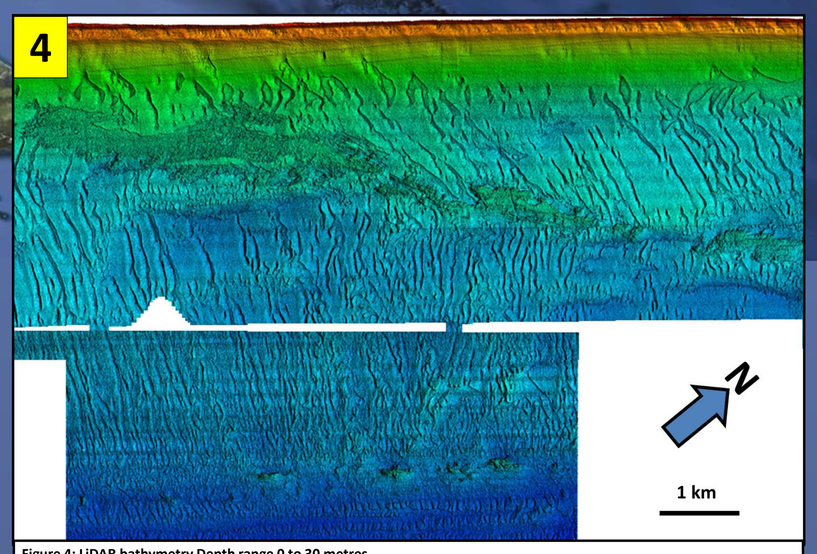

Figure 4: LiDAR bathymetry Depth range 0 to 30 metres.
A rich database of bathymetric textures and associated processes is derived from LiDAR swath mapping of the nearshore. This strip of data is rotated 45 degrees clockwise.

Victoria's State Department of Sustainability and Environment commissioned a Fugro LADS survey over the nearshore in 2008-09 to a nominal 20m water depth or 3.5 km offshore (upper panel of data from orange surf zone to data splice.
2.5 m grids were produced oriented to grid north but original flight grid is only resolved to 5m, in swaths generally parallel to the coast. (Data striping is visible in ~200m swaths)

Fugro LADS also flew a commercial survey in 2004 to delineate seabed obstructions for a 3D seismic survey reaching towards shallower water (lower panel of data, gridded at 5m resolution). Several rocky outcrops and hardgrounds were mapped by LiDAR and safely avoided during the survey.

The CarbonNet Project

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1. Natural Seismicity Monitoring network

The GipNet Seismic Network will involve surface-deployable onshore seismometers and shallow water (<100m) Ocean Bottom Seismometers (OBS). The network will enable monitoring of background seismic activity and other 'noise' sources in the region of prospective storage sites and in the future will enable detection of any induced seismic events that might occur as a consequence of future injection activities. The infrastructure will facilitate research into the state of stress, and controls on seismic energy release in the region, and a variety of associated geophysical properties such as crustal and basin velocity structure, and attenuation properties. An important research objective is to determine protocols for seismic monitoring of CCS in complex, noisy settings such as the nearshore Gippsland Basin.

Nearshore measurements will be strongly affected by surf noise and the ground conditions of soft dune sands. It will be important to characterise that noise and its variability in time and space so that noise floors can be established for different locations and weather conditions. It is also important to investigate methods for equipment installation that minimise noise (e.g. cemented into shallow boreholes, local noise-cancelling arrays, etc.).

Shallow marine seismometers will also be subject to weather and tide/current noise and will have limited time deployments. It is not yet clear whether they will allow a significant catalogue of events to be recorded, and modelling of the probability of useful detection is underway.

2. Atmospheric Sampling

An open-path measurement system will be established for atmospheric trace gases and isotopic composition of CO2. The research programme will characterise the natural variability in atmospheric concentration and isotopic ratios, and characterise the baseline CO2 fluxes for the region. In the future, project MMV can then attribute any changes in local sources or sinks to natural oceanic or biogenic sources or conversely identify whether they are due to the storage infrastructure. The deployment (Figure 7) will test the feasibility of open-path measurement near to and across an active surf beach with salt spray and marine aerosols contaminating the reflectors and atmosphere..

The coastal region is a low-density populated region with established agricultural and local industrial uses, but hosts significant summer vacation activity on lakes, beaches, and adjacent campgrounds and holiday homes. This activity which may represent a disturbance threat to installed equipment and lines of sight. Atmospheric impacts of open fireplaces, vehicle exhausts, and recreational activities need to be considered, as well as atmospheric drift from the nearby hydrocarbon processing plant and industrial sources further afield. The open-path network will trial measurement over both onshore and marine paths, with strategically-placed retroreflectors and establish whether shore-based marine atmospheric measurements are practicable in the presence of marine aerosols.

3. Marine Monitoring

This project aims to utilise marine monitoring assets relevant to promising monitoring technologies, develop their use, and test in the marine environment.

The shallow coastal waters containing the GHG exploration permits are well-mixed throughout the year due to tidal stirring (Figure 8), thus changes in water properties near the seabed should be reflected throughout the water column which will have advantages for monitoring (Figure 9). Records from nearby buoys show that the current direction is oscillatory with a range of timescales. The area is also subject to seasonal intrusions of water from the Tasman Sea with quite different properties to Bass Strait waters, increasing environmental variability substantially.

While Sleipner and SnØvit have tested and implemented several aspects of monitoring, these sites are located in deeper waters (>100m), and so the proposed research is aimed at shallow water sites such as exist in many nearshore basins worldwide, including Gippsland and the Gulf of Mexico. Outputs will include a reference dataset from which to select appropriate measurable parameters and fixed locations or schedules for mobile measurements in the future, including reference to physical features such as wellheads and subsurface discontinuities, including faults.
Preliminary marine habitat surveys indicate a relatively barren sea floor with sand ripples. In the area of the downslope channels, larger shore-parallel sand waves occur with coarser material compatible with downslope higher energy flows (Figure 10).

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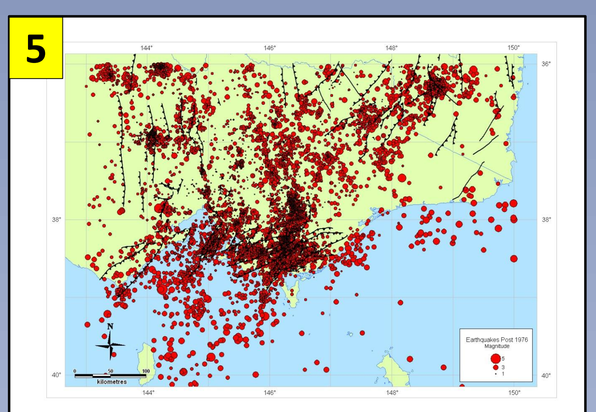

Figure 5: Earthquakes since the start of 1976 in SE Australia..
The onshore area is moderately seismically active, with events to a maximum just over 5 recorded. Offshore seismicity is low and has not interfered with oil production over 50 years. The onshore-offshore differences will be investigated further in this study

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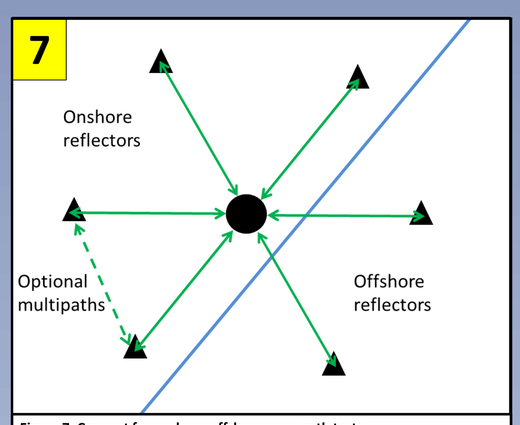

Figure 7: Concept for onshore-offshore open path tests.
Open path atmospheric monitoring allows improved assurance monitoring of the successful storage of CO2 over a wide area of observation. It will also allow overall monitoring of the local natural carbon cycle to demonstrate that it has not been perturbed by the project. The research phase will test the practicality of such measurements across an active surf beach

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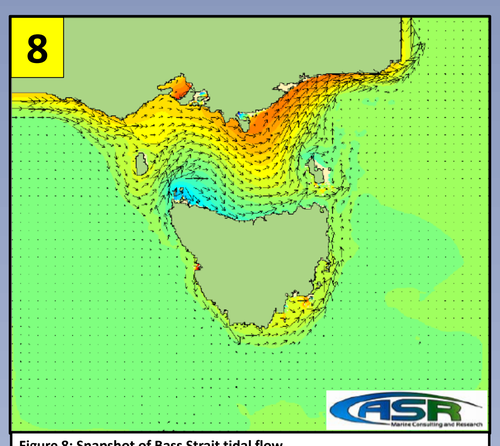

Figure 8: Snapshot of Bass Strait tidal flow.
Tidal flows in the Bass Strait are strong and oscillatory, parallel to the shoreline along Ninety Mile Beach. The SEA hydrodynamic model was developed by ASR Ltd for GHD, visualising currents through Bass Strait generated by low-frequency oscillations and wind events.

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Figure 10: Seabed video survey.
The seabed is generally composed of fine sand with ripples (top) and little infauna except on localised hardgrounds and mounds. The downslope channels contain a distinct seabed facies of coarse-grained material formed into metre-scale waves oriented cross-slope (below). This is consistent with downslope currents of relatively high energy

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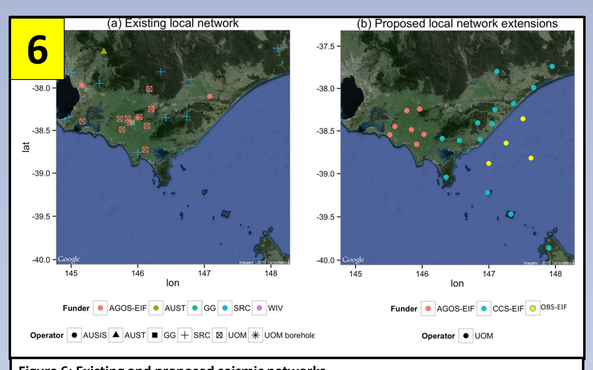

Figure 6: Existing and proposed seismic networks.
(a) Existing local seismic network in the Gippsland Basin, along with (b) the candidate sites for the proposed local network onshore component of the GipNet deployment shown in green and proposed extensions of the AGOS network

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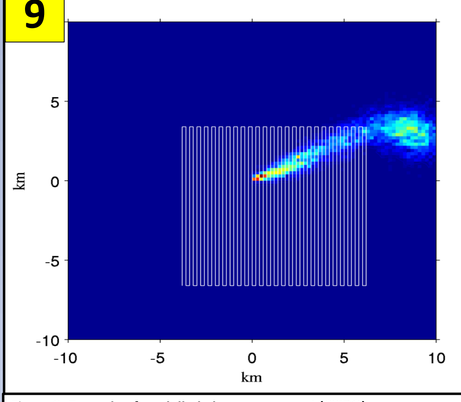

Figure 9: Example of modelled plume movement (CSIRO).
The plume washes back and forth with the tide and other currents and is dispersed parallel to the shore. A nominal search grid for an autonomous waveglider is overlain showing how multiple transects of the plume would occur. The present study will investigate whether it is operationally simpler to have a single sentinel array of sensors perpendicular to the coast and allow the tides to bring the plume to the sensors.

About the Authors

Dr. Nick Hoffman has over 25 years' international oil industry experience, including substantial time with BP in Europe, and with BHP in Australia and worldwide.

He joined CarbonNet in 2011 as part of the start-up technical team to lead the geoscience evaluation over CarbonNet's portfolio of nearshore CO2 sequestration targets.

Nick integrates a wide range of basin data to understand the implications for long-term safe CO2 storage.

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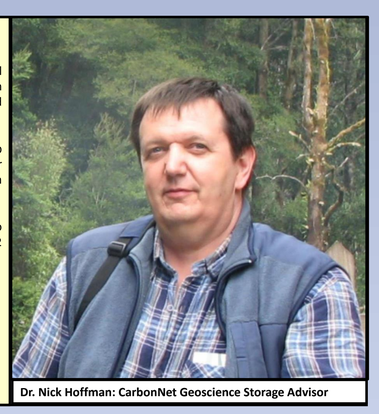

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