

AUSCEO *news*

REEF SURPRISE

Sounding out
lake beds

Triggers for estuary
plant growth



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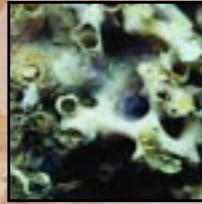
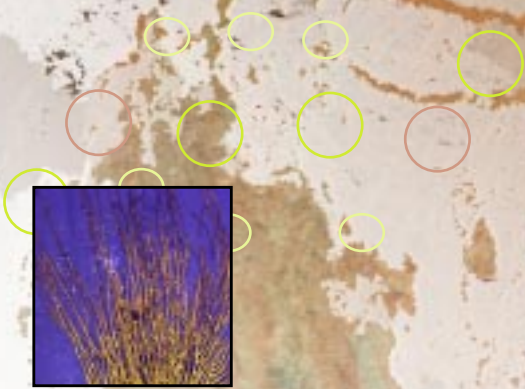


In many Australian coastal waterways plant growth is stimulated by nutrients that come from the catchment. Large increases in plant growth can cause clogged waterways and algal blooms.

But some estuaries and coastal lakes remain 'clean' despite lots of nutrient or sediment.

Something is happening at the bottom of these lakes or in their water that allows them to handle big sediment-nutrient loads without threatening ecosystem health. These factors are discussed in this issue of *AusGeo News*.

Photo: Arthur Mostead



Australia is preparing a bid to host the prestigious International Geological Congress (IGC) in Brisbane in August 2012. The IGC is held every four years and this is the next available slot.

This congress attracts more than 5000 delegates from around the world, so if Australia is successful it will lift the profile of geoscience at home and present some wonderful opportunities internationally.

The 2004 IGC will be in Florence and the 2008 IGC is set for Oslo. Like the Olympics, bidding occurs well in advance and our bid must be submitted in February because a decision will be made at the Florence IGC in August.

Australia's IGC Organising Committee comprises senior Geoscience Australia and State Geological Survey people, academics and representatives of professional geoscience bodies. Two committee positions have been endorsed: Ian Lambert as Secretary General, and I have the honour of being elected President. New Zealand is represented by Alex Malahoff, Chief Executive of the Institute of Geological and Nuclear Sciences. Others will be added at a later stage.

The Australian Geoscience Council will be the incorporated body for the congress so that anticipated profits are channelled into Australian geoscience.

Our theme is: 'Earth dreaming – Unearthing our past and future'. This captures the concept of an ancient land in which geoscience helps to meet societal needs and to look after planet Earth. These needs include effective management of natural resource problems; groundwater supplies; discovering the next generation of mineral and energy resources beneath cover; dealing with greenhouse emissions and climate change; making urban developments more sustainable; and managing and applying geospatial information for an increasing range of stakeholders.

Our bid is an outcome of deliberations leading up to the recent publication of the National Strategic Plan for the Geosciences. It was produced by the National Committee for Earth Sciences, Australian Academy of Science.

A successful bid will give us an enormous opportunity to demonstrate the importance of the earth sciences and provide the geoscience fraternity with a scientifically rewarding and enjoyable international event.

And talking about looking after planet Earth: this issue of *AusGeo News* focuses on our work around Australia's coastline, mapping our seabed and estuaries to help the National Oceans Office, Environment Australia, local councils, and many others better understand ecosystems and manage our natural resources.

The articles illustrate how geological information provides environmental managers with a context and baseline data for the distribution of ecosystems and their biota, and for measuring human impacts. The articles also highlight our recent and ongoing work in a number of Cooperative Research Centre (CRC) projects.

In fact, all this work is done in collaboration with partners from other federal agencies, universities, and state and local government groups that have banded together as the 'Coastal and Marine Environmental Geoscience Group'. This group provides government with advice and products to meet its goals regarding its National Oceans Policy, and the preservation and maintenance of biodiversity, and ecosystem-based management.

Some future work will involve Geoscience Australia in the Torres Strait (through the Reef CRC), as well as in the Gulf of Carpentaria, Recherche Archipelago off south-western Australia, and various bays and estuaries (through the Coastal Zone CRC).

I hope you enjoy reading our December issue, and I'd like to thank you for supporting Geoscience Australia in 2003 and wish you the very best for the festive season.



NEIL WILLIAMS
CEO Geoscience Australia



Reefs found in *murky* Carpentaria depths



Thoughts about reef growth are changing after the discovery of healthy corals in unlikely conditions off far north Queensland.

Geoscience Australia scientists discovered uncharted bryomol reefs and platforms of hard coral in murky, warm water near Mornington Island in the Gulf of Carpentaria on their recent *Southern Surveyor* voyage.

They made the discovery in June using multibeam sonar to map underwater sandstorms and sediment movement from rivers entering the gulf.

Finding living corals was an even bigger surprise because the turbid water and large sediment input would generally smother hard corals, and the surface water temperature of 28–30° C was too warm for coral survival.

Unlikely conditions

The gulf is a shallow sea between York Peninsula and Cape Arnhem. Its deepest point is 65 metres below the surface.

For 10 thousand years, sediment has discharged into it from chenier plains and deltas so that more than half of the sediment in the gulf is from adjacent land.

The southern Gulf of Carpentaria, an area of more than 100 thousand square kilometers, is Australia's largest shelf province of 'terrigenous-dominated' sediments.

The reef depths are unusual because corals typically grow upwards to the surface. The Carpentaria reefs are at depths of 25–30 metres, with the highest point 18 metres down.

Reef age and sea levels over the past 120 thousand years provide some clues (figure 1).

Sea levels are not constant over time. When sea level rises, corals grow upwards. When sea level is stable, corals grow outwards. As sea levels fall, exposed reefs die leaving cliffs of limestone that can be re-colonised when sea level rises again.

Ancient reefs

The Carpentaria reefs were established when sea levels were much lower than present, such as those between 50 and 120 thousand years ago. The climate was cooler and drier, and the gulf was a large lagoon with one entrance via the Arafura Sea. Torres Strait was a land bridge.

During low sea-level phases, reefs built adjacent to the eastern margin of Mornington Island (figure 2, BR). On the *Southern Surveyor* voyage

bryozoans and molluscs were dredged from these reefs, but no live specimens were recovered.

These bryomol reefs are now at 30-metres depth and have a pock-marked surface. There are large, bowl-shaped depressions of weathered limestone up to half a kilometre wide that probably formed at the surface when rainwater dissolved the exposed limestone.

The unusual swirl patterns in the bathymetric image of the area (figure 3) are similar to the comet marks (also called obstacle marks or current crescents) seen in many high-energy, subaqueous environments. They suggest sediment moves northwards, but the marks are probably from fluvial erosion during low sea level rather than from tidal scour or sediment deposition in the past 10 thousand years.

A closer look at the bryomol samples and radiocarbon dates will establish a better history for these reefs, but early results suggest that they are mostly relict.

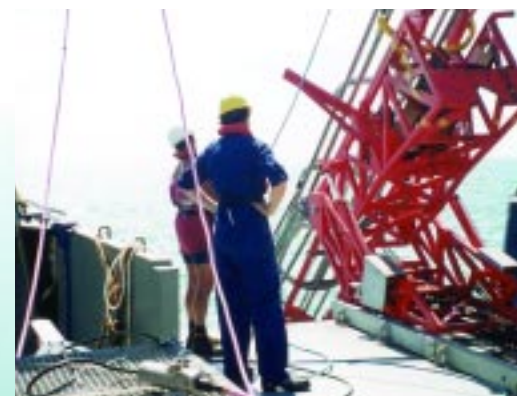
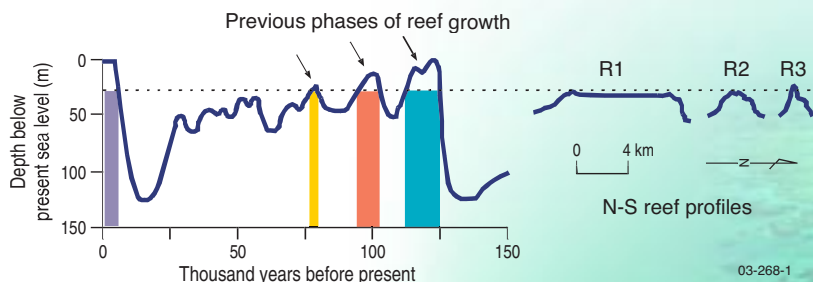
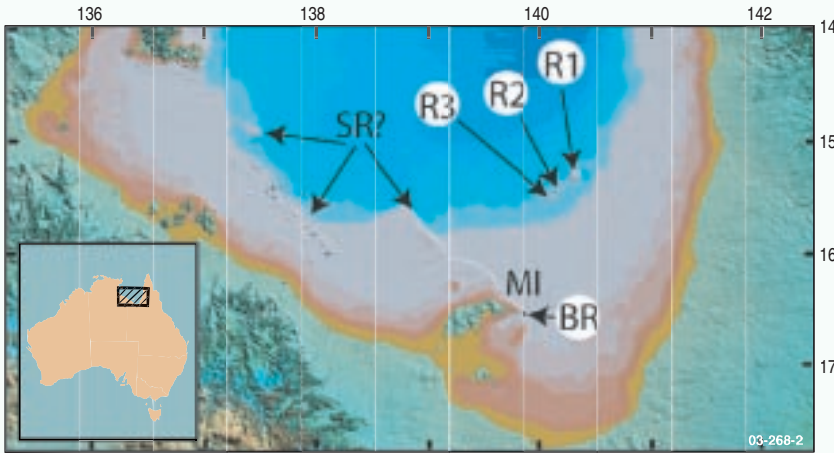


Figure 1. Sea levels for the past 150 thousand years show when the Carpentaria reefs were near the surface. Reef growth and main deposition probably occurred during the three high stands from 50 to 120 thousand years ago.



▲ **Figure 2.** Mornington Island (MI), bryomol reef (BR) and three submerged coral reefs (R1, R2 & R3) are marked on this false-colour bathymetry map of the south-east Gulf of Carpentaria. SR indicates other possible submerged reefs.



Corals may have only recently re-colonised the reefs and so they have not had time to grow upwards.

Whatever the reason for the present-day corals, it could be answered in future sampling expeditions.

More submerged reefs could also be found because shoals about the same depth as these reefs are marked on navigation maps of the southern gulf.

The seed stock for the corals has drifted on currents from warm tropical waters somewhere north of the gulf and when the Carpentaria reefs flourished previously, the Timor or Arafura seas perhaps had abundant reefs.

Submerged reefs at about 30-metres depth have been identified in the Gulf of Papua, Great Barrier Reef, and Indian Ocean.

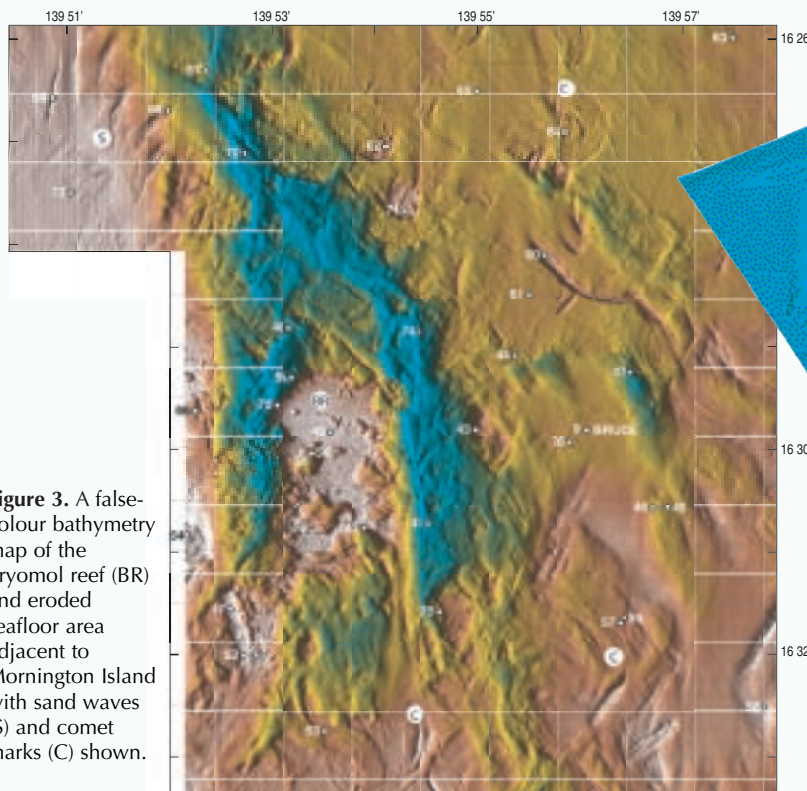
Coral surprise

About 100 kilometres north-east of Mornington Island are three coral reefs that probably formed when sea level was 25 metres lower than today (figure 2). Together they are 80 square kilometres in size (72.5, 5.5 and 1.6 km²). Each is oval-shaped with steep, almost vertical sides.

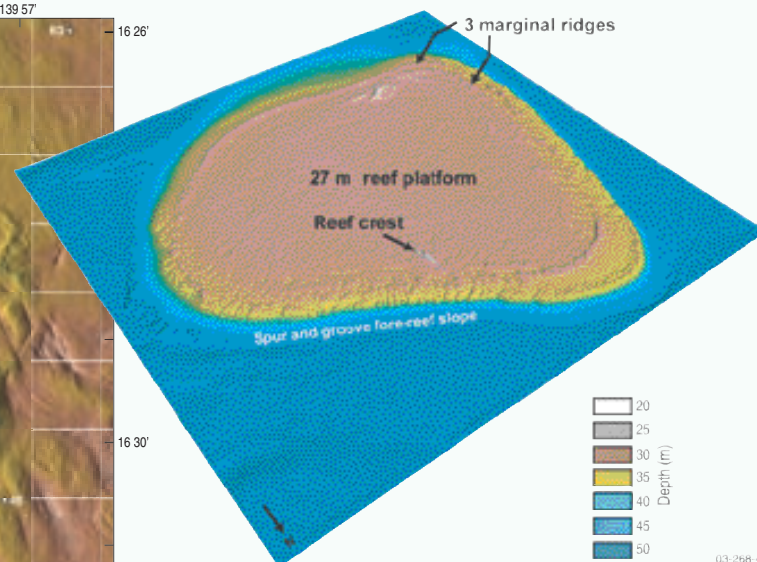
In this area the *Southern Surveyor* dredged a live specimen of plate coral (*Turbinaria*) and hard corals (*Leptoseris*), and videoed fan and barrel sponges, starfish, soft coral, anemones, and many colourful fish.

These reefs are mostly relict even though there are live corals. Only a few small areas of live reef rise above the otherwise flat surfaces, which are platforms (at 27 m depth) and three- to four-metre-high terraces (at 30 m depth) that were shaped by sea-level oscillations (figure 4).

The sluggish growth of corals in the past few thousand years could be due to environmental factors such as temperature, current, turbidity, or nutrient levels. But the live reefs are on a platform and distant from the very cloudy, inshore waters.



▶ **Figure 3.** A false-colour bathymetry map of the bryomol reef (BR) and eroded seafloor area adjacent to Mornington Island with sand waves (S) and comet marks (C) shown.



▲ **Figure 4.** A detailed colour bathymetry map of reef R1, mapped using a 240 kHz multibeam sonar system. Survey lines were spaced at 100–150 metres and adjusted according to water depth.

Future plans

By 2100 global warming is expected to increase sea-surface temperatures by 1–2° C, which will probably kill many coral reefs worldwide. Submerged reefs that are protected from sunlight and hot surface water by a thick, overlying water column could survive and provide important seed stock.

Clearly, more information is needed about the distribution of submerged coral reefs, and why reef growth has not kept pace with sea-level rise in the gulf.

The Carpentaria reefs are too deep to be detected by satellite remote sensing or aerial photographs, but they were identified as reefs by ship-mounted multibeam sonar and confirmed with seabed sampling and underwater video footage.

Geoscience Australia is still analysing data and samples collected in May and June on its month-long voyage that embarked from Cairns and berthed in Darwin.

It plans to map and build a 3D model of the gulf floor. These tools will help local councils and marine agencies better understand the processes that control seagrass growth and coral development, and the fisheries that rely on those habitats for their reproductive cycle.

For more information phone Peter Harris on +61 2 6249 9611 or e-mail peter.harris@ga.gov.au. Also visit www.ga.gov.au/oceans/projects/20010917_12.jsp

Sonar mapper reveals seabed in unprecedented detail

Australia is building amazing images of its seabed since multibeam sonar was added to its research vessel *Southern Surveyor*.

This imaging technology is allowing Geoscience Australia to create bathymetry models of the seafloor in detail never before possible, and recently helped it discover uncharted reefs in the Gulf of Carpentaria (figure 1).

The image quality and resolution depend on sea conditions and the depth in which the multibeam sonar is operating.

Topographic features smaller than 10 centimetres were discernable from the *Southern Surveyor* in ideal conditions in the gulf's shallow water (20–50 m).

As the *Southern Surveyor* traverses the sea surface, a fan (or swath) of sonar beams bounce off the sea bottom like echoes, to produce an image of the seabed.

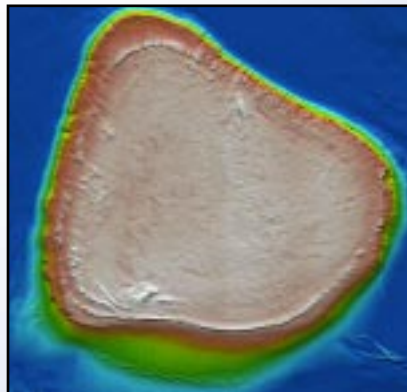
The beams (orientated port/starboard across the survey track) generate near-immediate, accurate, seafloor bathymetry maps.

Raw data from the beams are combined with data from other equipment (gyrocompass, motion sensor, GPS, sound-velocity profiles, and tide models) to accurately position bathymetry soundings on the seafloor. The soundings are 'cleaned and gridded' to produce a seafloor model.

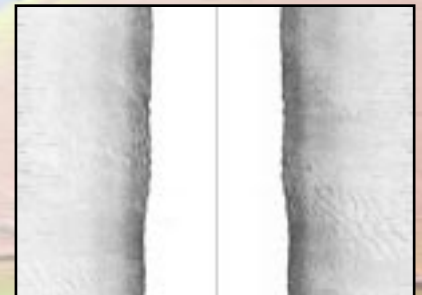
Sonar energy

As the multibeam unit processes bathymetry data, the returned energy of the sonar beam (acoustic reflectivity) is recorded. The image of the returned energy, known as sidescan or backscatter, is also gridded.

Sidescan is used with bathymetry to identify changes in benthic habitats, rock types, or topography, such as that caused by tidal currents and transported sediment (figure 2). It is often logged at a much higher resolution than the bathymetry to identify small-scale features.



▲ **Figure 1.** A coral reef in the south-east Gulf of Carpentaria was uncharted until multibeam sonar was added to the *Southern Surveyor*. The reef is approximately 120 square kilometres. It lies at 40 metres depth and rises to 19 meters below the surface.



▲ **Figure 2.** A sidescan reveals a rippled seabed east of Mornington Island in the Gulf of Carpentaria. The ripples suggest that tidal currents are transporting sediment in the area.

Wide use

Multibeam sonar technology is being applied in resource and waterways management, regional marine planning, habitat mapping, and mapping sediment distributions and mobility. At present Geoscience Australia is using multibeam sonar data to:

- update bathymetry grids for the Australian exclusive economic zone;
- 'characterise' the seabed by mapping areas of similar acoustic response or geomorphological shape;
- map sediment facies and benthic habitats for Regional Marine Planning;
- generate maps and 3D displays for scientific and educational purposes; and
- produce environmental assessments.

In December additional multibeam sonar equipment will be installed on the *Southern Surveyor* by Geoscience Australia, National Oceans Office and CSIRO Marine Research for mapping the bathymetry and seabed character in deeper water.

The Simrad EM300 will map in water as deep as 3000 metres with a swath width of up to 7000 metres and 1x1 degree beam-widths for maximum resolution in ideal surveying conditions.

This state-of-the-art mapping technology is available to all research institutes in Australia, which should boost the scope of research happening in Australian waters.

For more information
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james.daniell@ga.gov.au

Census of tiny marine species in Torres Strait

The waters of the Torres Strait–Gulf of Papua region are very energetic and difficult for tiny marine life.

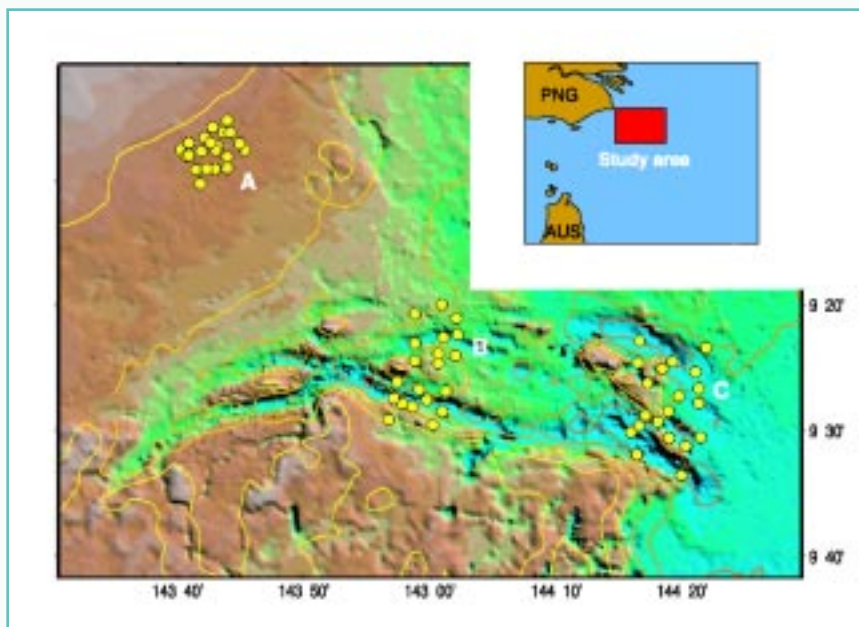
Warm, salty water is diluted by heavy, equatorial rain, and Papua New Guinea's Fly River flushes about 120 million tonnes of sediment annually into the strait. Much of this sediment is swept through the strait by strong tidal currents that scour the seafloor.

Some tiny marine organisms float in deep water; others cling to the rocky bottom for stability, or burrow in the muddy sand. But just how abundant are these organisms in the tough conditions?

Early last year on the *Franklin* voyage, Geoscience Australia collected more than 60 grab samples from the Fly River delta, Torres Strait and Gulf of Papua (figure 1, A–C) to determine their distribution.

Fifteen different groups of organisms in the classic micropalaeontological size fraction (150 μm –2 mm) were quantified (figure 2).

Two of these groups live in the water column (planktonic foraminifera and pteropods). The others live on the seafloor and/or within a few centimetres of sediment.



▲ **Figure 1.** On the *Franklin* voyage, Geoscience Australia collected more than 60 grab samples from the Fly River delta (A), Torres Strait (B) and Gulf of Papua (C) to determine the distribution of tiny marine organisms.

Organism distribution

The bottom-dwelling foraminifera are by far the most abundant group sampled (figure 2), but they decrease towards the inner shelf (Areas B and C). Bivalves, ostracods and porifera also steadily decrease from Area A to C.

Only fragments of bryozoa, halimeda and corals (including soft corals) were in the sizes analysed, but they increase in abundance towards the shelf edge.

In the water column, planktonic forams show a marked and constant increase towards the greater depths of Area C, while pteropods are abundant in all areas.

Various factors influence abundance patterns. In the region sampled, water depth has the strongest influence overall, followed by water temperature, salinity and mud content and, lastly, calcium carbonate content.

Water depth

Numbers of bottom-dwelling forams (e.g. *Amphistegina*, *Elphidium* and *Ammonia* spp) that like brackish and shallow water rapidly decline as water deepens. *Amphistegina lessonii*, for example, is commonly found at water depths of five–40 metres, which is typical of Area A.

This water-depth trend is opposite for the other tiny marine organisms, which also respond negatively to salinity increases.

The planktonic foraminifera are more abundant in deeper water as many species descend to considerable depths during their life cycle—a process that is difficult in the shallower parts of Areas A and B.

Condition changes

Small changes in water temperature and salinity, which are mostly driven by bathymetry changes, cause strong variations in the distribution and abundance of organisms.

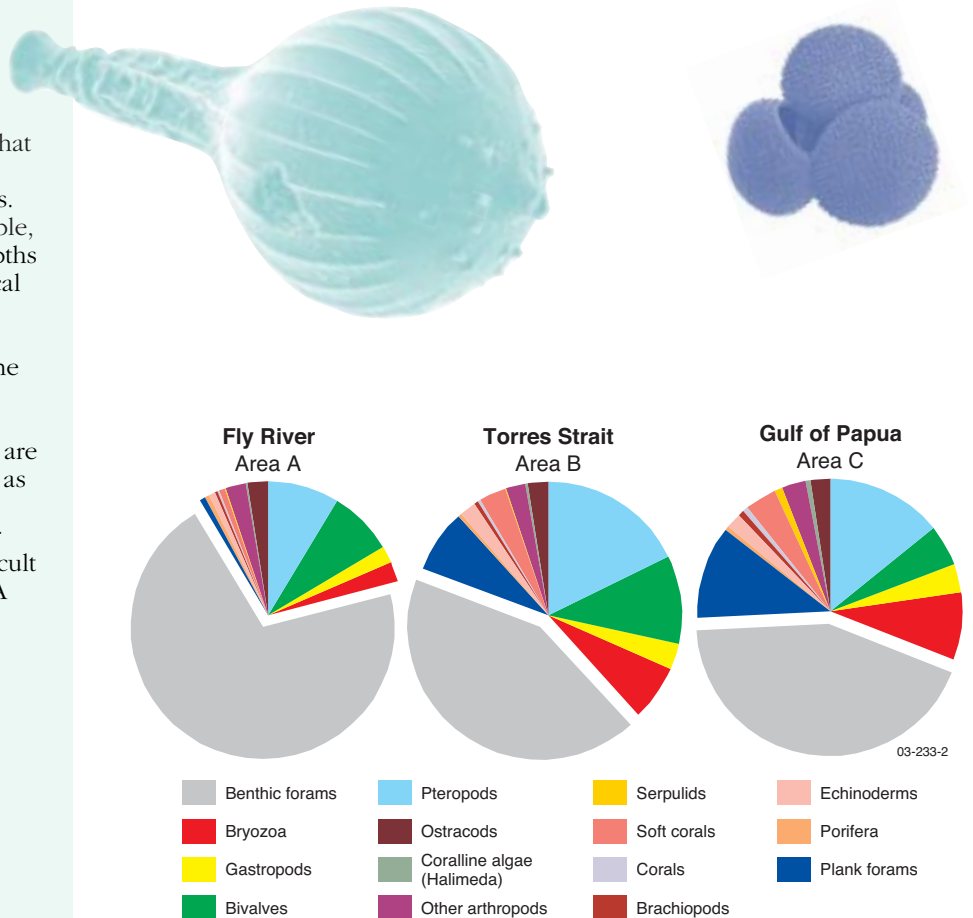
The bryozoa and corals are the most sensitive, favouring stable environments with well-defined ranges in temperature and salinity. As brackish and very shallow water inhibit coral growth, any fragments counted in innermost areas were probably transported and reworked by currents and wave scour.

Bivalves and ostracods are the least sensitive, their prevalence only weakly associated with the sedimentary mud content. They are filter feeders consuming detritus stirred up by their antennae or mandibles, and thrive best in muddy sands and silts. Very high percentages of mud, however, can prevent their full development.

Pteropods and planktonic forams are affected by salinity, temperature and water depth. Pteropods react less strongly to these factors, and adapt better than forams to shallow-water environments.

The tiny marine organisms of the Torres Strait–Gulf of Papua region provide useful information about their adaptability to ecosystem variations. Quantifying their response to different conditions provides reference data for monitoring ecological changes, even though the region's complex sedimentary and oceanographic dynamics are not yet completely understood.

For more information phone Alix King on +61 2 6249 9127 or e-mail alix.king@ga.gov.au



▲ **Figure 2.** The distribution of 15 groups of marine organisms (150 μm –2 mm in size) from three areas, expressed as percentages based on the number of specimens/gram.



Bottom life *quite rich in gulf*

The Gulf of Carpentaria seabed was considered flat and muddy and home to prawns and mud burrowers until the recent *Southern Surveyor* voyage, despite fisher reports of rough ground at 20–40 metre depths.

Geoscience Australia's 3D mapping on the voyage targeted prawn-trawl grounds as well as uncharted rough seabed, providing an opportunity to explore unknown parts of the gulf floor.

It allowed CSIRO Marine Research to systematically sample areas passed over by biological researchers in the past 25 years.

Biological samples were collected from muddy-sand seabed, steep rock cliffs, gorges and plateaux using a short tow with a benthic sled, rock dredge or sediment sampler (table 1).

Diverse fauna were collected with a total of 569 taxa (species groups) identified within 64 major taxonomic groups (family level or higher).

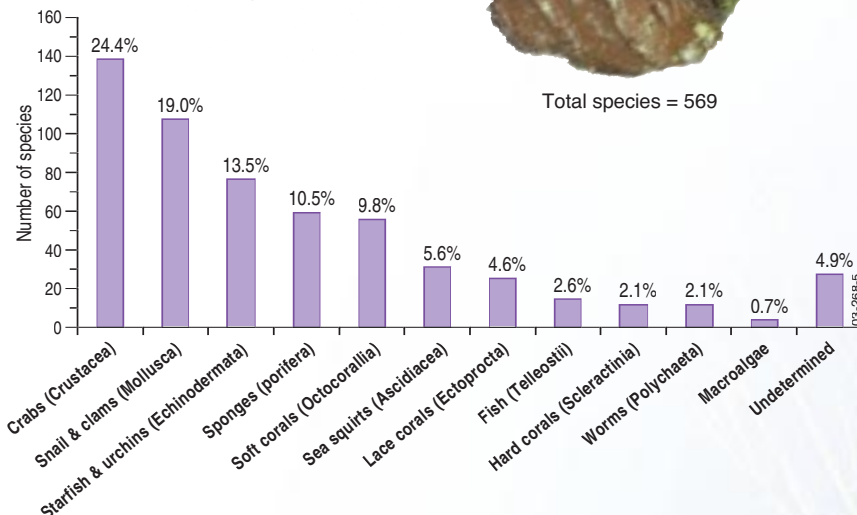
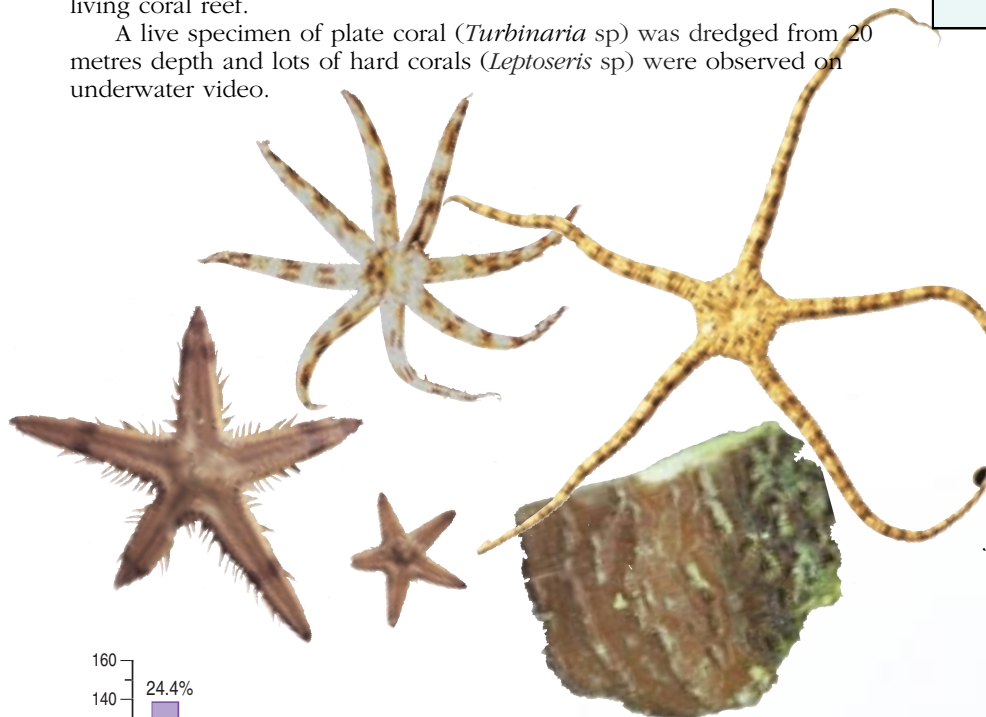
Crustaceans provided the greatest variety (139 species), followed by the bivalves (64), sponges (60), and soft corals (56). Gastropods (39), tunicates (32), starfish (28), bryozoans (26), sea cucumbers (24), hydroids (19) and fish (15) were also plentiful. There was also a variety of hard corals (12) and worms (12), and five algal species (figure 1).

Some animals collected from very rough seabed were indicative of a living coral reef.

A live specimen of plate coral (*Turbinaria* sp) was dredged from 20 metres depth and lots of hard corals (*Leptoseris* sp) were observed on underwater video.

Area	Samples	Species	Av number species
Area B	dredge		
	x 5	78	16
Area B	grab		
	x 35	83	2
Area B	sled		
	x 18	553	31
Area C	dredge		
	x 6	79	13
Area C	grab		
	x 25	20	<1
Area C	sled		
	x 12	347	29
Area D	grab		
	x 5	8	2
Area E	grab		
	x 6	2	<1
Central east gulf	grab		
	x 9	4	<1
Central east gulf	sled		
	x 8	237	34
South-east gulf	grab		
	x 28	35	1
South-east gulf	sled		
	x 23	589	26

Table 1. Summary of samples collected by each device, the number of species collected and the average number of species per sample for six regions in the eastern Gulf of Carpentaria



The coral species recovered, which are typical of an inner-shelf reef, comprised three species of hard corals, seven species of gorgonians (sea ferns), and one species of soft coral. Four species of sponge and a starfish species (*Linkia* sp) commonly found on coral reefs were also collected.

Two species of fan sponge (*Ianthella basta* and *I. flabelliformis*), a barrel sponge (*Xestospongia* sp) and the sea ferns that were recovered are found on seabed channels in Torres Strait and the Great Barrier Reef.

Animals generally live on the seabed in the gulf's rough ground, and it seems to be a refuge for many mobile seabed animals. In the muddy trawl-grounds animals mostly live within the seabed.

The *Southern Surveyor* voyage led by Geoscience Australia was sponsored by the National Oceans Office and the Department of Environment and Heritage.

For more information about Carpentaria benthic habitats and fauna phone Ted Wassenberg on +61 7 3826 7217 or e-mail Theodore.Wassenberg@csiro.au

Figure 1. Species collected by the *Southern Surveyor* in the eastern Gulf of Carpentaria using three sampling devices.

Why *estuaries are green or clean*

In Australian coastal waterways plant growth is stimulated by nutrients such as nitrogen and phosphorus that come from the catchment. How prolifically plants grow because of these nutrients and whether ecosystem health is threatened depend on a number of factors.



The physical characteristics of the waterway are important including how often water flushes through the system and how sediments and nutrients are trapped, buried and washed to sea.

Sunlight is a big influence. If the water is turbid, not much sunlight penetrates the water for plant photosynthesis.

Also important is how much nutrient is processed by microbes in the sediment and dissolved in the water or released as nitrogen (N_2) gas into the atmosphere.

Eutrophic waterway

Large increases in plant growth can cause clogged waterways and nuisance or toxic algal blooms, indicating the waterway is eutrophic.

When large quantities of plants die and decay, oxygen is depleted from the water column and without enough oxygen fish and other marine animals die. Sometimes the waterway smells of rotten egg gas (hydrogen sulphide).

Geoscience Australia has developed some generalisations for environmental managers to show how prone seven types of coastal waterways are to eutrophication (figure 1).

Eutrophication in any system is determined by the balance between nutrient (particularly nitrogen) inputs and exports (flushing to the sea, burial in the sediments, and transformed to N_2 gas).

Once a waterway becomes eutrophic, it is difficult to re-establish its original conditions.

Tidal systems

In northern Australia there are many tide-dominated deltas, estuaries and tidal flats. They have a low-to-moderate susceptibility to eutrophication because they are naturally turbid and not much sunlight penetrates the water column for plant growth. Mangroves are the most abundant plants in the large intertidal areas.

Estuaries are more susceptible than the deltas and tidal flats. They have the capacity to trap more nutrients and they are flushed less frequently—roughly every few weeks.

Tide-dominated systems, particularly the deltas, tend to export much of their sediment–nutrient loads to the near-shore shelf in northern Australia. This has ecological implications for adjacent shallow continental-shelf areas that support seagrass and coral reef ecosystems.

These areas off northern Australia include the inner Great Barrier Reef lagoon, the Gulf of Carpentaria and the Arafura Sea.

Microbial processes in sediments and dissolved nutrients (particularly

nitrogen) in the water can change the ecosystem. Nutrient-poor waters that support seagrasses and coral reef growth could become nutrient-rich waters that encourage nuisance algae.

The susceptible offshore areas are most likely adjacent to catchments with intensive agriculture.








Wave systems

In the temperate climates of south-west and south-east Australia, there are many wave-dominated deltas, estuaries, coastal lakes, strand plains and lagoons. Some estuaries, lagoons and strand plains are referred to as ICOLLS (intermittently closed and open lakes and lagoons), and as a group are moderately to highly susceptible to eutrophication.

Wave-dominated estuaries accumulate river and catchment runoff. They have a central basin to accommodate a lot of sediment and nutrients. The nutrient-laden water stays in the system for weeks to months and sometimes years, because the estuaries are poorly flushed.

Plant growth occurs in the water column (phytoplankton) and on the sediment surface in the shallow areas. Plants formed in situ and their debris stay in the sediments where sunlight, dissolved nutrients and low turbidity encourage algae and macrophyte growth.

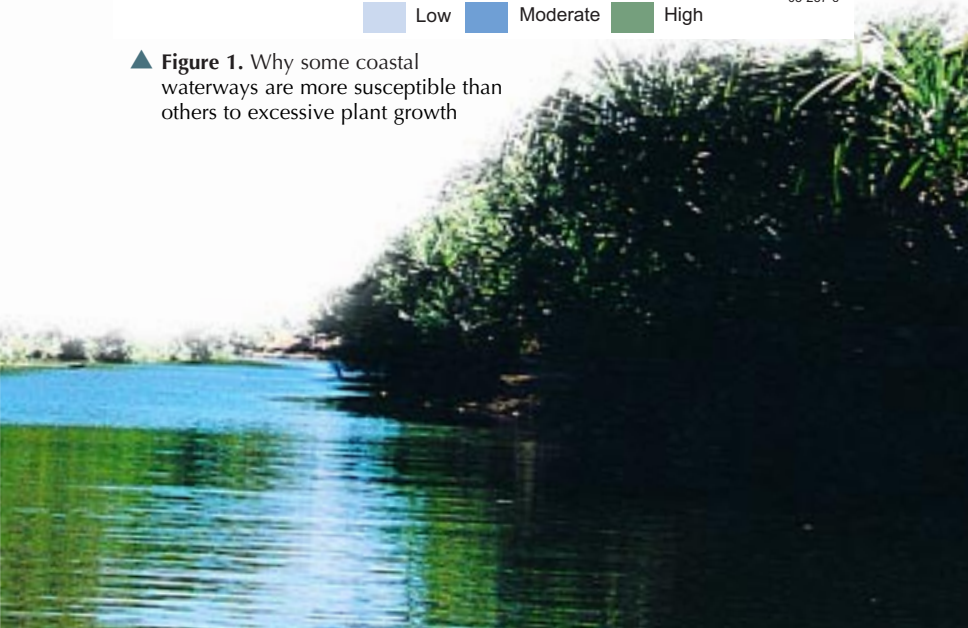


Waterway type	Particulate retention	Turbidity	Flushing	Eutrophication susceptibility
 Tide-dominated delta	Low	High	High	Low
 Wave-dominated delta	Low	Low	High	Moderate
 Tide-dominated estuary	Moderate	High	Moderate	Moderate
 Wave-dominated estuary & coastal lake*	High	Low	Low	very high*
 Tidal flats	Low	High	High	Low
 Strand plains	Low	Low	Low	Moderate
 Lagoon	High	Low	Low	High

Low
 Moderate
 High

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▲ **Figure 1.** Why some coastal waterways are more susceptible than others to excessive plant growth



Coastal lakes

Coastal lakes are a type of wave-dominated estuary, but the entrance to the sea has closed. They are highly susceptible to eutrophication.

Flushing is negligible so water and other material remain in the lake for years, waiting for a large rainfall event to breach the barrier and flush accumulated organic debris and nutrients to the sea.

Lagoons

Lagoons do not receive fluvial discharges. Sediment–nutrient retention is high because they are not flushed very often.

Nutrient loads to lagoons are generally low because most sediment is from the sea and it comprises mineral grains that are usually low in organic carbon and nutrients.

Unless they receive local surface runoff that is high in dissolved nutrients, lagoons are moderately susceptible to eutrophication.

Strand plains

Strand plains are ‘ponds’ of water trapped between beach ridges. They are usually very shallow, poorly flushed and receive only local runoff.

Because they are small, there is little space for sediment–nutrient retention. They are moderately susceptible to eutrophication unless local runoff is rich in nutrients.

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Trapped nitrogen throws out estuary balance

Toxic algal blooms, anoxic water, fish kills and the smell of rotten egg gas in an estuary suggest something is out of balance, and the most likely culprit is nitrogen.

Yet some environments seem to have the capacity to handle more nitrogen than others.

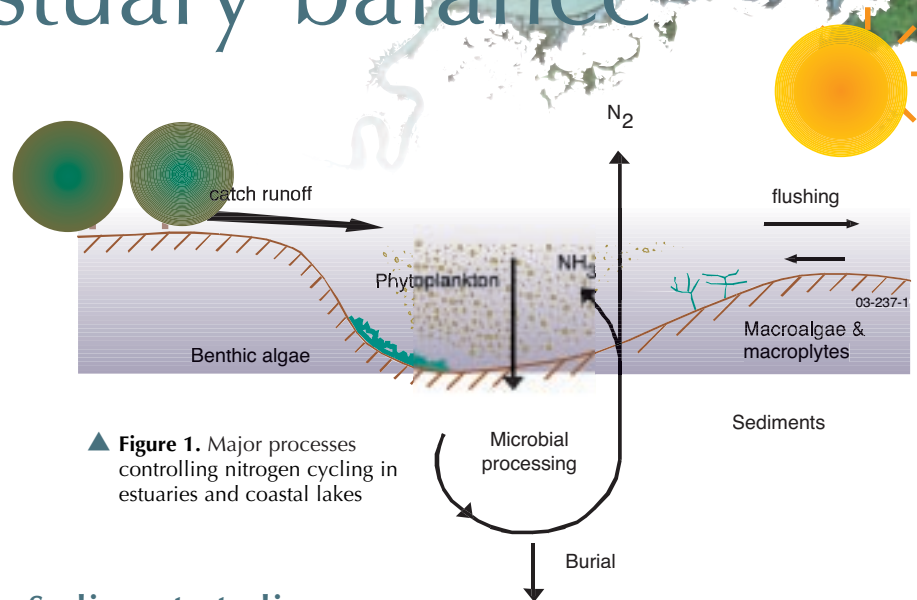
Nitrogen trap

Most nitrogen added to an estuary is from land-use practices and urban runoff into the catchment. Some is flushed to sea but quite a lot is trapped in estuaries and coastal lakes in temperate Australia.

Some of the trapped nitrogen is buried in the sediment, but most bolsters plant growth including phytoplankton, macroalgae, macrophytes and mangroves. The plants eventually die and sink to the bottom to be degraded by bacteria (figure 1).

Sediment reactions are important. Microbial processes in the sediments recycle nitrogen principally as either N_2 gas (by a reaction known as denitrification) which is lost to the atmosphere, or as ammonia (NH_3) which is recycled to the overlying water.

Some estuaries and lakes will eventually choke on their plant life if they are too enriched in nitrogen.



▲ Figure 1. Major processes controlling nitrogen cycling in estuaries and coastal lakes

Sediment studies

Geoscience Australia has been using benthic chambers to study the degradation of plant material in coastal sediments. These chambers capture a parcel of seawater overlying the sediments and measure the organic carbon being degraded during 'incubation' (<24 hours).

The microbes consume oxygen from the water and liberate carbon dioxide, nitrate, ammonia, nitrogen gas, phosphate and silicate into the chambers.

The chambers have been deployed about 350 times in various Australian estuaries and coastal waterways.

In about half of the sampling, phytoplankton was the major organic source being degraded in the sediments. It seems to be the main plant biomass forming in estuaries and coastal lakes in temperate Australia.

Benthic fluxes

The nitrogen recycled in sediments and into the overlying water is measured as a flux. Plots of the ammonia (NH_3) versus carbon dioxide (CO_2) fluxes from various Australian waterways are shown in figure 2.

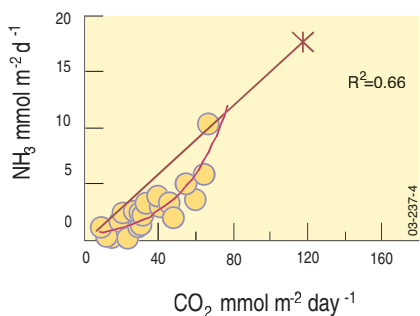
Because carbon and nitrogen in phytoplankton are in the proportion of C:N::106:16, the maximum nitrogen released per unit of CO_2 can be predicted and this is shown as the Redfield line in figure 2. Four things are evident in the data.

1. All measured ammonia fluxes fall below the Redfield line indicating that some nitrogen is missing. In the benthic chambers N_2 gas was forming in the sediments.
2. The ammonia fluxes for Myall Lakes and the Swan River estuary show that denitrification is not very efficient (<50%) at carbon oxidation rates <60 $mmol\ m^{-2}\ day^{-1}$.
3. In Port Phillip Bay and Moreton Bay denitrification efficiency is high at carbon oxidation rates below 40 $mmol\ m^{-2}\ day^{-1}$ and <50% at carbon oxidation rates >80 $mmol\ m^{-2}\ day^{-1}$.
4. Most nitrogen is lost by denitrification in Wilson Inlet, at carbon oxidation rates <150 $mmol\ m^{-2}\ day^{-1}$, and only at higher oxidation rates is ammonia release important.

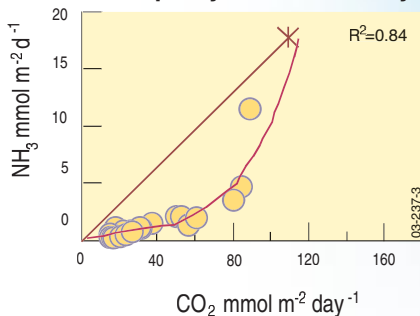
These results show that some environments such as Wilson Inlet have a greater natural capacity to handle more nitrogen than others.

The burrowing of animals, which ventilates the sediments with oxygenated bottom waters, is important for high rates of nitrogen loss to the atmosphere. An active benthos is probably a good indicator of high denitrification rates.

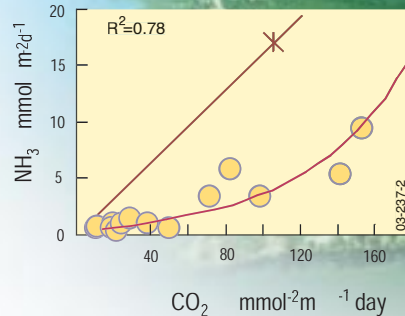
Swan River Estuary & Myall Lakes



Port Phillip Bay & Moreton Bay



Wilson Inlet



▲ **Figure 2.** Data from the Swan River estuary (WA) and Myall Lakes (NSW), Port Phillip Bay (Vic) and Moreton Bay (Qld), and Wilson Inlet (WA) showing ammonia released from the sediments and organic carbon degradation rates. The straight line is the Redfield line.

Efficiency gauge

Geoscience Australia has developed a 12-zone classification to describe how susceptible sites are to changes in nitrogen levels and how efficiently they get rid of it. (See figure 3: The trophic state refers to the organic carbon recorded in benthic CO₂ fluxes).

Sites in zones one to four are quite robust to nitrogen loading and 'stable' trophically. Those in zones nine to 12 recycle significant amounts of ammonia back into the overlying waters and are potentially 'unstable' or more susceptible to nutrient enrichment and more likely to change ecologically.

Some sites in Wilson Inlet are in zone one because they efficiently rid the system of nitrogen when carbon input rates are high.

Wilson Inlet has not had nuisance algal blooms and apparently remains in good condition even though it experiences a lot of microphytobenthos growth in autumn and supports abundant *Ruppia* production.

Sites from the Swan estuary and from the Bombah Broadwater of Myall Lakes (zones seven to 12) though have problems, even with low carbon input. These waterways had nuisance algal blooms when the measurements were taken.

Nitrogen model

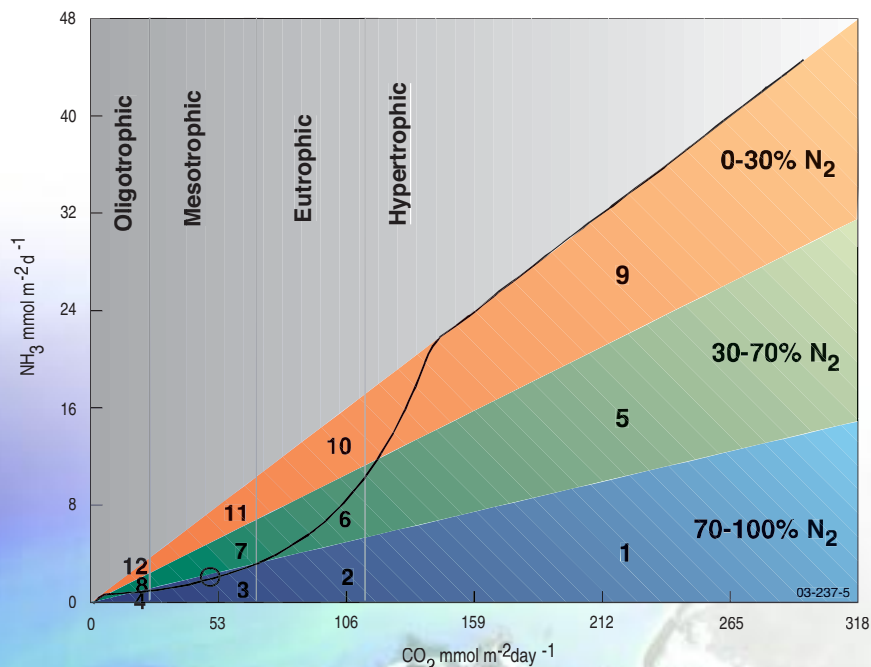
Geoscience Australia has developed a model that can be used to investigate whether nitrogen in an estuary will remain in steady state (inputs balance outputs) or increase (be assimilated into macro-plants) as a result of different nitrogen loads.

Consider a bogus site in zone three (the solid dot in figure 3), which has a high capacity for denitrification.

If 10 per cent of the nitrogen load was flushed to the sea and buried in the sediments, this site would remain in near steady state even with a 20 per cent increase in nitrogen. However, the net nitrogen flux would rise rapidly—promoting additional plant growth—if the nitrogen load increased 50 per cent.

Excess nutrients, sedimentation and declining water quality are serious issues affecting Australian coastal waterways. Geoscience Australia's work on nitrogen recycling provides valuable data and new insights on how to better manage them.

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▲ **Figure 3.** A classification of estuarine sites based on ammonia release rates from the sediments and organic carbon degradation rates. The various states are shown with the 0–30%, 40–60% and 70–100% denitrification efficiency boundaries. The solid dot shows a hypothetical site with a nitrogen loading of 7 mmol m² day⁻¹ and a denitrification efficiency of 70%.

Fitzroy under scrutiny for catchment loads

With major fisheries relying on a healthy estuary and the Great Barrier Reef offshore, the Fitzroy River in central Queensland is under the scrutiny of environmental managers and local stakeholders.

In September the Coastal Cooperative Research Centre began a series of studies into how nutrients, fine sediment and agricultural chemicals are transported, stored and transformed in the Fitzroy estuary, and perhaps carried to the reef.

The study collaborators (called the Fitzroy Contaminants Dynamics project) are Geoscience Australia, CSIRO, Griffith University, Central Queensland University and Queensland Department of Natural Resources and Mines.

Samples and other data collected in the first surveys are currently being assessed by project members.

Water and bottom sediment

Geoscience Australia and CSIRO Land and Water chartered a local vessel from September 5–12 to survey the Fitzroy estuary and Keppel Bay. Seventy-two stations were sampled to assess dry-season water column and bottom sediment properties (figure 1).

At each station, various combinations of the following were targeted:

- bottom sediments;
- water-column nutrients (total and dissolved), organic carbon (total and dissolved), and phaeophytin and chlorophyll a;
- total suspended matter and its grain size;
- water clarity; and
- algal pigments and dissolved organic matter.

At some stations a vertical profile of the water column was undertaken to assess dissolved oxygen, turbidity, light absorption and conductivity.

Floodplain

In the same period, the floodplain was cored to determine what sort of sediment has been transported from the catchment into the estuary over the past 5000 years.

Cores were taken from billabongs along the Fitzroy River and from a small tidal creek, using a small boat and a push corer (a hand-operated device that can retrieve two-metre cores from soft sediments).

Sites included Crescent Lagoon and Frogmore Lagoon near the town of Rockhampton. Local reports suggest that these lagoons never completely dry out, providing a continuous and undisturbed sedimentary record.

Soft sediment cores were also taken from Casuarina Creek, a large tidal creek fringed by mangrove forest (figure 2).

In the hard, clay-rich areas of the floodplain a Geoprobe percussion corer was used.

Geoscience Australia and CSIRO are currently analysing the geochemistry and grain-size distribution of the cores, mainly to determine the sediment ages and accumulation rates.

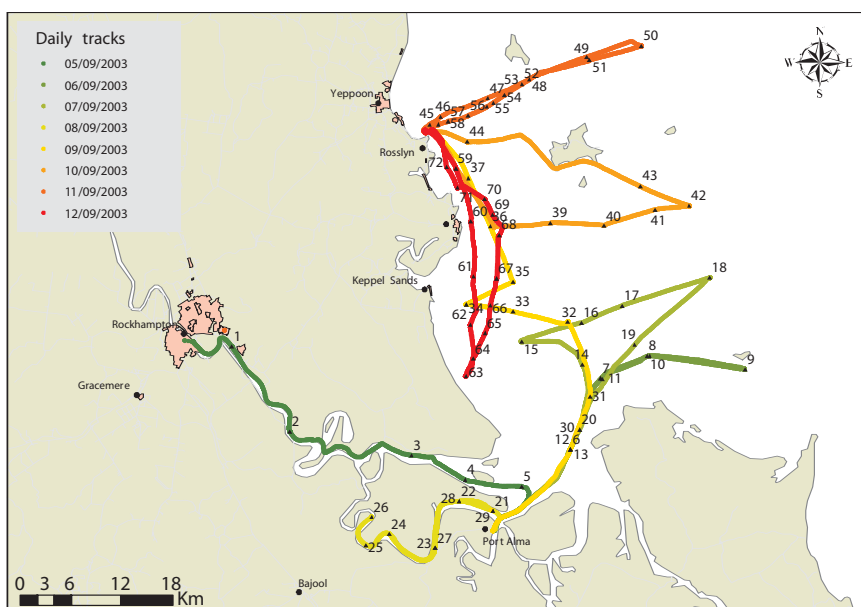
Beach ridges

Adjacent to the river mouth is a series of beach ridges (figure 2). These ridges show that Long Beach is prograding towards the sea, and probably because of Fitzroy River and Keppel Bay sediments.

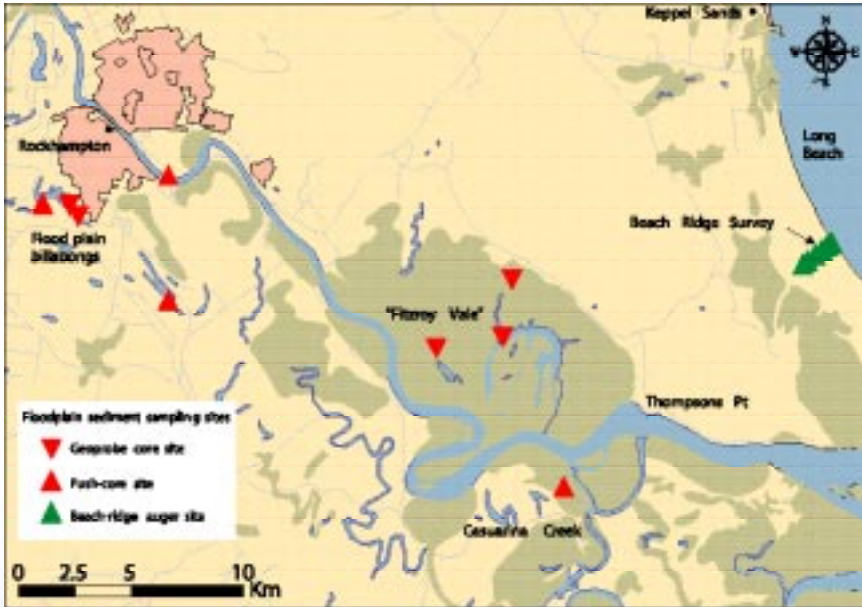
Sediment was collected from the first 11 major ridges landward from the beach (figure 3), using a hand-auger.

The sediment samples are being dated to find out the rate of shoreline progradation. Trace elements will be analysed to determine any changes in the source and character of sediments over time.

The elevation and shape of the ridges and swales (shallow depressions between ridges) that



▲ Figure 1. Daily ship tracks and the station locations for the water-column survey



▲ **Figure 2.** Location of the floodplain sediment core sites and beach-ridge auger sites

Surface sediment samples were collected along the mudflats of the Fitzroy River and major creeks. At each site, multiple samples were collected for chlorophyll and biomarker analysis, and nitrogen fixation experiments.

Determining species composition is important because cyanobacteria and eukaryotic algae play a significant role in the mudflats and when one dominates, the nitrogen levels (and chlorophyll production) differ.

Samples are being analysed at CSIRO Marine's Hobart laboratory: chlorophyll as a basic measure of primary production; sterol and fatty acid biomarkers and algal pigments to quantify broad classes of eukaryotic algae (diatoms, dinoflagellates and green algae) from cyanobacteria.

Nitrogen fixation was measured using the acetylene reduction technique. This involves incubating a small (about 20 gm) of surface sediment in a gas-tight glass bottle and injecting acetylene into the head-space. If nitrogen-fixing bacteria are present in the sediments, some of the acetylene should be reduced to ethylene.

Ethylene will show that biological nitrogen fixation occurs at sites where these sediments were taken.

extend inland from Long Beach were also measured. This information indicates the rates at which sediment was delivered to the shoreline (e.g. low-amplitude, well-spaced ridges = rapid sediment accumulation; high-amplitude, closely spaced ridges = slow accumulation).

Intertidal zone

In October, the intertidal areas and mangrove wetlands were assessed for their role in estuarine productivity and nutrient cycling (particularly nitrogen). The nitrogen from the intertidal mudflats is thought to be a significant component of the overall biogeochemical nutrient budget in the Fitzroy.

▼ **Figure 3.** A vertically exaggerated representation of the surveyed beach ridges (see figure 2 for location). Survey measurement sites are represented by red triangles. Sediment auger sample sites are shown as black arrows.



For more information phone Brendan Brooke on + 61 2 6249 9434 or e-mail brendan.brook@ga.gov.au. Also see: www.coastal.crc.org.au/fitzroy/index.html



Visualisation EDGE

Geoscience Australia has the edge on others exploring Australia's geology with a new theatre and a state-of-the-art stereo visualisation system that allows people to 'experience' data in true 3D.

The EDGE 3D theatre (for Enhanced Discovery of Geosciences) is a work room for scientists to view and analyse models of the subsurface, as well as a display venue for visitors.

The 3D visualisation adds reality to subsurface models and helps scientists discuss their ideas about natural hazards and resource potential and communicate them to non-scientists.

For example, a slice of the Earth can be rotated and layers of data can be added or removed for discussions about mineral and petroleum exploration, earthquake monitoring and problems such as salinity.

The EDGE has already been used to fine tune a preliminary 3D model of the Yilgarn geology, a major gold mining region in Western Australia.

3D images and digital movies are projected onto a 2 x 2.4 metre screen, and viewed using passive polarising glasses. The viewing system incorporates a PC, a signal splitter, and two projectors with polarising filters.

The EDGE was officially opened on November 26 by the Australian Government Minister for Industry, Tourism and Resources, Ian Macfarlane.

Geoscience Australia plans to develop the EDGE so that data can be manipulated virtually and people can simultaneously interact with the same model in a teleconference. 📍



◀ **Left to right:** ITR Secretary Mark Paterson, Minister Ian Macfarlane, and Geoscience Australia CEO Neil Williams.

MARine Sediment database

Geoscience Australia is creating the MARS database so that researchers have a secure, central repository of sediment data from Australia's marine jurisdiction.

All sorts of data will be stored in MARS, ranging from ship-deck descriptions of grab samples to the latest underwater video footage.

MARS data will be used to map seafloor properties and build what is known about marine ecosystems and benthic habitats in different regions of Australia. The data will be vital to regional marine planning.

The National Oceans Office has provided funds to fast-track MARS development.

Some marine sediment data may have research, commercial or security restrictions. However all open-file data, including Geoscience Australia's extensive datasets, will be promoted as the 'National Fundamental Marine Dataset' which can be viewed and downloaded from the web next year.

The database is being developed in line with ANZLIC data standards. 📍

Marine science meeting

A French–Australian science meeting was held in Geoscience Australia headquarters in Canberra on October 15 to discuss marine research priorities for the next five years.

Presently there are more than 100 cooperative research projects involving scientists from both nations in coral reef, geoscience, climate, fisheries and aquaculture studies.

Australia and France share sea borders in the New Caledonian and Kerguelen Plateau regions, and have interests in Antarctica.

France has superb blue-water research vessels with cutting-edge geophysical systems, submersibles, remotely operated vehicles and long coring equipment.

Australia has the vast marine jurisdiction that extends from the tropics to the poles, in which many global scientific problems can be researched.

Together French and Australian researchers and marine management agencies can ensure that a large part of the world's oceans are better understood and properly managed.

All major French and Australian government marine agencies were present including Geoscience Australia, the Australian Antarctic Division, National Oceans Office, CSIRO, the largest French marine research agency (IFREMER) and the French Polar Institute (IPEV). 📍

Reference database

All major Australian geoscience publications are being added to the international GeoRef database. This should be good news for those who have struggled to find relevant reference material since AESIS (Australian Earth Sciences Information Service) folded in 2001.

GeoRef contains 2.4 million references to geoscience journals, books, maps, conference proceedings and reports, making it the world's best geoscience database. References can be found by searching for title, author, subject, or publication date.

Users will be able to subscribe to the full GeoRef database, the Australian content only (AusGeoRef), or to a customised alert service via the web or on CD. Subscription details are available at www.geoscience.gov.au

GeoRef was established in 1966 by the American Geological Institute. 📍

Mutant pollen

Mutations found recently in prehistoric conifer tree pollen are the same as those in modern pines suffering environmental stress.

Some 250 million years ago, it is thought that gas and dust from massive volcanic eruptions damaged Earth's ozone layer and changed its atmosphere, causing mass extinction.

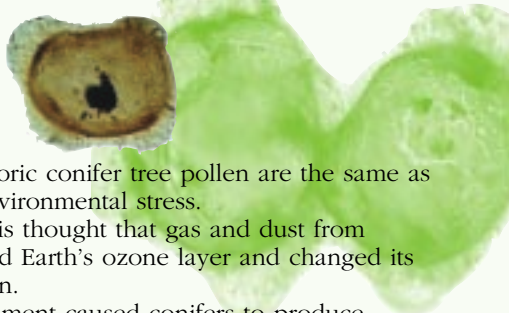
The extreme change in environment caused conifers to produce mutant pollen.

Instead of the usual two-wing sacks that help the pollen drift through the air, the stressed prehistoric conifers produced pollen with one, none or three or more wing sacks.

Modern pines show these mutations in response to such stresses as extreme cold, dryness and fallout from the Chernobyl nuclear power plant disaster.

The prehistoric mutant pollen was found in ancient lake sediments in China and Russia and is being studied by a team of international scientists including Geoscience Australia's Clinton Foster and Sergey Afoin from the Palaeontological Institute of Moscow.

It is speculated that similar mutant pollens will be found in sediments dating back to the dinosaur-extinction event about 65 million years ago. 🗒



SHIP UPGRADE

A major refit of the 66-metre-long research vessel *Southern Surveyor* in December will improve its capability, particularly for marine geoscience.

A Simrad EM300 multibeam sonar swath mapper will be installed for detailed mapping of the seabed in water depths of 15 to 3000 metres. Soon afterwards a Simrad Topas PS18 sub-bottom profiler will be added for high-resolution images of seabed strata down to about 80 metres. This technology will help scientists better target seabed coring.

Geoscience Australia, the National Oceans Office and CSIRO purchased the new equipment.

The mid-range swath mapper will be used for the first time in February–March next year by Geoscience Australia in the Bremer Basin, a frontier area off Albany. The voyage will run seismic profiles on the first leg and then dredge rocks from submarine canyon walls on the second leg, aiming to understand the geological history of the basin and assess its petroleum potential.

In May both the swath mapper and sub-bottom profiler will be used by Geoscience Australia to survey the deep-water Kenn Plateau north-east of Brisbane.

The survey aims to assess the geological history of this continental fragment which separated from mainland Australia about 95 million years ago, and what this means for the region's petroleum prospects. 🗒



Topo map *check*

Most topographic mapping nowadays is done by satellite. The position of big features like hills, lakes and reserves are confirmed by government and the private sector.

Local knowledge is needed for the small landmarks and easily overlooked changes such as a road being sealed.

Geoscience Australia's Rachele Nevin and Matt Barwick are talking with local map users such as councils, Rural Fire Services, and National Parks and Wildlife Services, and checking some changes first hand.

They use a car navigation system and digital software (OziExplorer and NATMAP Raster 250K) to track their location and identify inaccuracies in the position of local features such as mines, towers, homesteads and landing strips.

The pair spent two weeks in the Armidale region of New South Wales at the end of October and in mid-November travelled around the Kalgoorlie district in Western Australia. Generally each district is visited about every five years.

In September, Geoscience Australia completed the topographic mapping of the entire Australian continent (all 7.66 million km²) at 1:250 000 scale.

The field work to date verifies the maps are accurate and easy to use. They are available from the Geoscience Australia web site. 🗒



SEASON'S GREETINGS

Best wishes for the festive season.

Thank you for your interest in Geoscience Australia and your readership of *AusGeo News*. We look forward to your support in 2004.

Land clearing swells sediment loads in WA estuaries

Just months before his passing in 1998, Ernest Hodgkin suggested that increased sedimentation from land clearing was the main long-term threat to estuaries and tributaries in south Western Australia

He called for research into the effects of catchment clearing on estuaries and on sediment transport.

Geoscience Australia in collaboration with Western Australia's Waters and Rivers Commission collected surface sediment samples from the central basins of 12 estuaries in south Western Australia (figure 1).

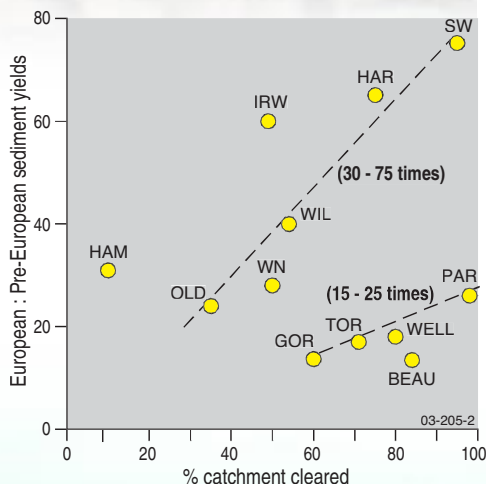
The two water-quality monitoring surveys conducted in 1997 and 2002 were part of a broader initiative to develop geochemical indicators of sediment condition for monitoring Australia's coastal waterway health.

The sediment was analysed for grain size, total nitrogen (TN) and total phosphorus (TP), total organic carbon (TOC) and major element oxides (including total sulphur, TS).

Some of the Commission's long-term water quality data (TN, TP and dissolved nutrients), and CSIRO sediment-yield data were also used.

From the data, Geoscience Australia calculated the sediment load, carbon and nitrogen accumulation rates, TOC:TS ratio, and a weathering index for each estuary.

► **Figure 1.** Surface sediment samples were collected from 12 estuaries in Western Australia.



▲ **Figure 2.** The National Land and Water Resources Audit found that land clearing has changed the amount of sediment in estuaries in south Western Australia over the past 200 years. In the estuaries investigated, it is now 15–75 times higher than prior to European settlement.

Huge sediment increase

Since European settlement, the amount of sediment in the estuaries investigated has increased 15–70 times because of land clearing (figure 2).

It is estimated that up to seven kilograms of sediment per square metre of estuary are added yearly to some Western Australian estuaries (sediment loads range from 0.1 to 7.8 kg m⁻² y⁻¹).

In the Swan Canning estuary, Hardy Inlet and Oldfield Inlet in particular, land clearing practices in their catchments have added a lot of sediment to the waterway. Organic debris, nutrients such as nitrogen and phosphorus, and other contaminants travel with sediments into the estuaries.

Oldfield and Hardy inlets have high levels of carbon and nitrogen accumulation that could affect ecosystem health (figure 3). The nutrient loads of a couple of others are also a concern particularly as some of these carbon accumulation rates would be lower than actual carbon loads because they do not account for carbon oxidised at the sediment–water interface.



▶ **Figure 3.** Median inorganic (nitrogen):organic (carbon) ratios in estuarine sediment loads, which provide insights into estuarine health

Poor water quality

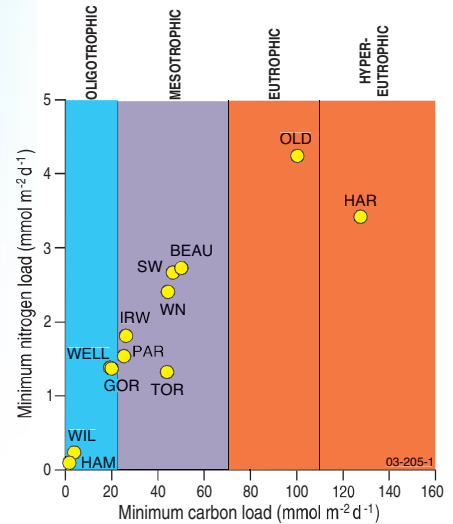
There is a distinct relationship between the weathering index and sediment loads (curve in figure 4).

Soil erosion probably explains the rising phase of the curve. The declining phase that occurs when sediment loads are even higher is probably bedrock erosion (i.e. the transport of more primary minerals and less clay).

Overall, eroded soil contributes to poor water quality in south Western Australia's estuaries.

Nutrient concentrations (TN and TP) in the water column tend to be more than double levels recommended by the Australian and New Zealand Water Quality Guidelines, when sediment loads are in the range 2–4 kg m⁻² y⁻¹ and weathering indices are higher than 67 (figure 3). In these situations minerals in the soil have helped transport organic matter and nutrients.

Chlorophyll a levels and algal blooms are also typically higher in estuaries with these sediment loads (figure 4).



Water quality surprise

The inlets with the highest sediment loads (Oldfield and Hardy inlets) have good water quality based on total nutrients and chlorophyll, but their sediment quality is poor from their TOC:TS ratios.

These ratios are at their lowest in the estuaries with higher sediment loads (figure 3: higher than 3 kg m⁻² y⁻¹).

The TS in sediment shows that organic matter has been decomposed by sulphate-reducing bacteria. The bacteria oxidise organic matter under anoxic (no oxygen) conditions and in the process produce hydrogen sulphide. Some hydrogen sulphide converts to sulphides (TS) upon reaction with iron minerals in the sediment.

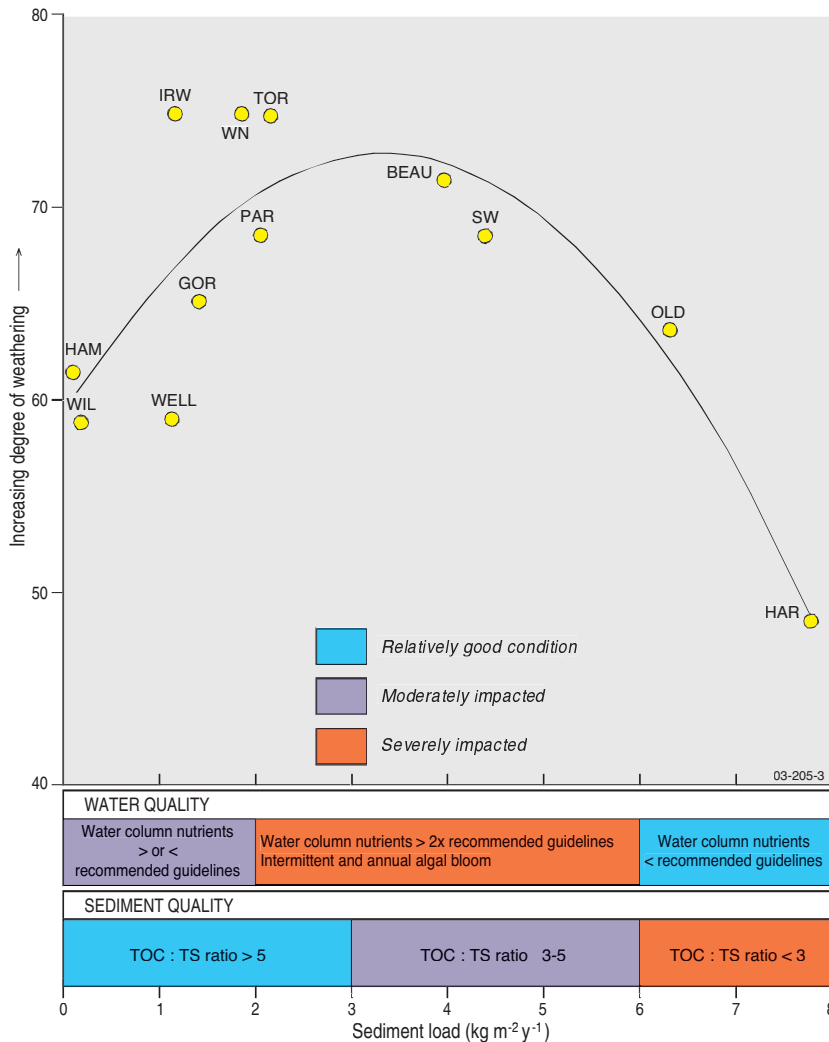
Hydrogen sulphide can be toxic. It can also inhibit the waterway's ability to transform and get rid of nitrogen.

Rapid burial seems to reduce the time available for organic matter to be oxidised in the water column so it builds in the sediment, allowing bacteria to decompose it. The bacteria use the oxygen, causing sediment anoxia.

Geoscience Australia continues its work on the impacts of sedimentation on coastal waterways, at present in south-east Australia.

Ernest Hodgkin was a marine ecologist who pioneered research into Western Australian estuaries. He continued his work long after retirement and until his death.

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▶ **Figure 4.** Changes in the weathering index with sediment loads. Changes in water and sediment quality are displayed as horizontal bars.

Figure abbreviations: HAM = Hamersley Inlet, WI = Wilson Inlet, IRW = Irwin Inlet, WELL = Wellstead Inlet, WN = Walepole-Nornalup Inlet, GOR = Gordon Inlet, PAR = Parry Inlet, TOR = Torbay Inlet, BEAU = Beaufort Inlet, SW = Swan Canning estuary, OLD = Oldfield Inlet, and HAR = Hardy Inlet

Habitat maps of shallow marine environments are in demand for environmental planning and managing Australia's natural resources. But good-quality maps are scarce.

The Coastal Cooperative Research Centre is addressing the problem with the latest sonar mapping technology: a SeaBat swath mapping system mounted on a survey boat.

After trials in known areas like Sydney Harbour, the Reson SeaBat 8125 will move to other coastal waters around Australia over the next three years.

This Coastal CRC work, called the Coastal Water Habitat Mapping project, heavily involves Geoscience Australia.

Sonar mapping

A swath mapper uses sonar to map large areas of seabed underneath and on both sides of the survey boat.

SeaBat 8125 is capable of mapping the depth of the seabed up to 60 metres below the water surface.

It emits 455 kHz pulses of sonar energy, which echo from the seabed. The returning echo signals are resolved into 240 narrow beams, in a 120° arc under the boat. The arc allows a swath or strip of seabed approximately 3.5 times the water depth to be mapped.

Seabed features can be resolved to about six-millimetre accuracy.

SeaBat 8125 also records the properties of sound waves that bounce back from the seabed (acoustic backscatter information), which highlight different textures on the seafloor. This data can be used later to classify sediment types and define seafloor habitats.

By using 3D technology with the system, images of the seabed can be viewed in near real-time as the boat carries out the survey.

SeaBat trial echoed from coast to coast

Sydney Harbour trial

SeaBat 8125 was tested in Sydney Harbour during August. The harbour was ideal because it has been surveyed with numerous other techniques and results could be compared with SeaBat 8125 data.

The main test site was an area of high seabed diversity in the outer section of Sydney Harbour known as Sow and Pigs Reef (figure 1). The reef is exposed during low tide and can be a shipping hazard.

An area of approximately one square kilometre (one-third the survey area) was mapped (figure 1). Survey lines were spaced so that beams overlapped to get total seabed coverage and to minimise outer-beam distortion.

A 3D bathymetry image from SeaBat data shows there is a shoal around Sow and Pigs Reef (figure 2, red area to the left) that comprises a small bedrock outcrop surrounded predominantly by sand. The sand is from landward-migrating continental shelf sediments and is mixed with river mud.

The deepest point in the survey area was 24 metres (blue area at the bottom left of figure 2). This area borders the dredged Western shipping channel. The channel allows safe access to Sydney Harbour, and cuts through the region from the north-west to the south-east.

Another dredged area, the Deviation Cut, appears as rough areas in the 3D image, at about 12 metres water depth.

Ground-truth work

The acoustic diversity in the SeaBat echoes can be used to form proxy maps of the seafloor and its habitats, such as the location of seagrasses, reef, sponge gardens, sand and mud.

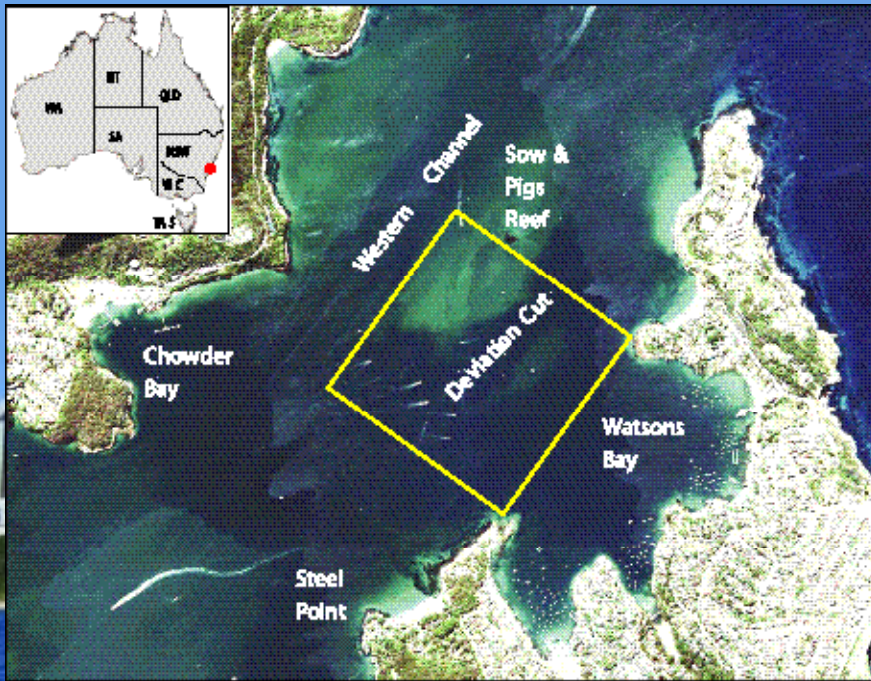
These maps are validated through 'ground truthing', generally by grabbing sediment samples from the seabed and taking underwater video footage.

Video transects were recorded of the Sydney Harbour study area, and seabed samples were collected from 21 sites. The primary sampling tool was a 60 kilogram Smith-Mackintyre grab sampler that returns large, relatively undisturbed sand and muddy sand samples. A box-corer collected undisturbed samples from muddier areas.

Samples from the deeper 'holes' (blue area in figure 2) comprise soft black mud, whereas the shoal areas typically had sands with molluscs and other invertebrate fauna. Samples from the harbour's dredged areas typically comprised a mixture of sands and gravels.

The grab samples are undergoing sediment and geochemical analysis at Geoscience Australia and will be compared with video footage and backscatter data to improve interpretation of SeaBat data and seabed models.





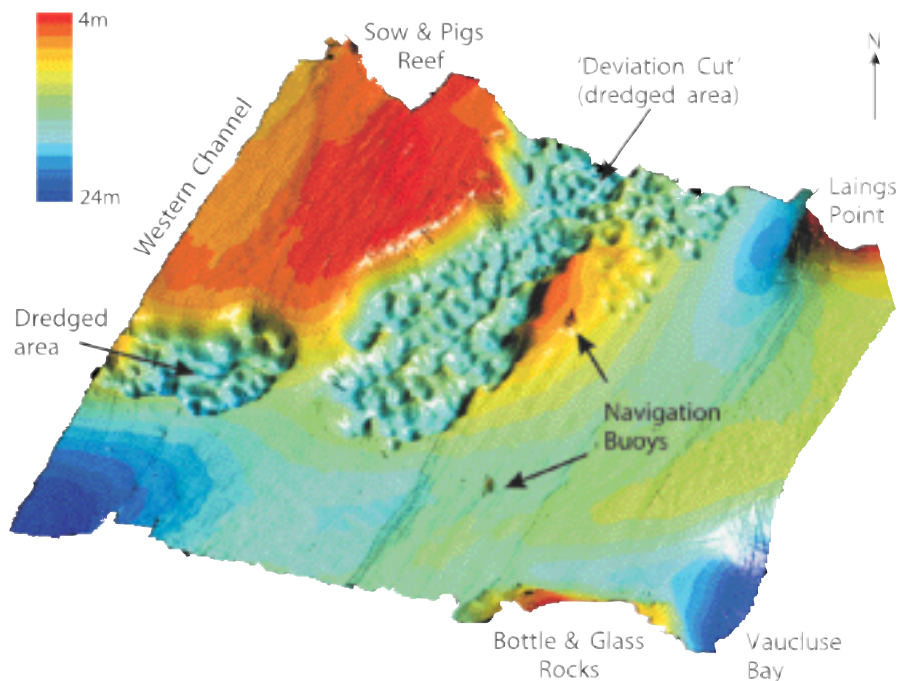
▲ **Figure 1.** The trial swath mapping area for SeaBat 8125 in Sydney Harbour is indicated by the yellow box. Sow and Pigs Reef is also shown.



Futher seabed mapping

In mid-November, SeaBat 8125 moved to the Recherche Archipelago, south of Esperance in Western Australia, to be tested in different conditions outside of shallow harbours and estuaries.

In deep water near the Woody and Remark Island groups, the mapping and sampling work found the seafloor comprises a mix of calcium-carbonate-based sand, reef with algae and sponges, and massive granite boulders.



▲ **Figure 2.** A 3D image from SeaBat 8125 data collected over the Sow and Pigs Reef area in Sydney Harbour

Plans are under way to use SeaBat 8125 for seafloor habitat mapping again in Sydney Harbour, as well as Cockburn Sound in Western Australia, Keppel Bay and Moreton Bay in Queensland, and possibly the Derwent River in Tasmania.

Others involved with Geoscience Australia in the Coastal Water Habitat Mapping project are Curtin University, the University of Western Australia, Defence Science and Technology Organisation, Reson, Fugro, Sonardata and GeoReality.

For more information
phone Brendan Brooke on
+ 61 2 6249 9434 or e-mail
brendan.brooke@ga.gov.au ☐

Sounding out lake bed *habitats*

Many parts of Wallis Lake, a large estuary on the central New South Wales coast, are turbid and difficult to map so new echo-sounder equipment was trialled last year.

Large areas of the lake were rapidly mapped by Geoscience Australia using Quester-Tangent single-beam acoustic equipment (figure 1). The results were then field tested.

Geoscience Australia found that the lake bed produced six distinctive acoustic responses to the echo-sounder signal. These were 'ground truthed' to find out what features in different areas of the lake floor influenced the acoustic response.

The track of the echo-sounder was combined with a GIS of the lake (figure 2) so that a range of habitats would be sampled. Once in the field, the sampling sites were located using a very accurate global positioning system (DGPS).

Bottom sediment was collected from more than 100 sites using a push-corer. At most sites, divers provided extra information about the lake bed, such as the density of seagrass and animal burrows. Underwater photographs were also taken.

Back in the laboratory, each sample was measured for grain size, wet bulk density, total organic carbon, CaCO₃ content, and coarse shell material (>2 mm diameter).

There were four predominant sediment types: organic-rich sandy mud with a lot of shell, organic-rich mud, medium-grained sand, or fine- to medium-muddy sand.

Other features of the lake bed had to influence the acoustic signal to produce six distinctive responses.

Muddied

Both sediment and biophysical (morphology and biota) features have affected acoustic signals. Bottom types and even similar sites were not necessarily associated with one acoustic class. For example:

- Acoustic classes 1 and 6 are related to muddy basins, which comprise fine, low-density muds and abundant animal burrows but no seagrass.
- Acoustic classes 2 and 5 generally represent shell-rich sandy muds, and occur mostly in deeper channels.
- Acoustic class 3 is indicative of coarse sediments with low organic carbon and seagrass beds, typically the marine-derived sands in the main inlet channels.
- Acoustic class 4 generally represents shelly muds with patches of seagrass, although this class was sedimentologically similar to classes 1 and 6.

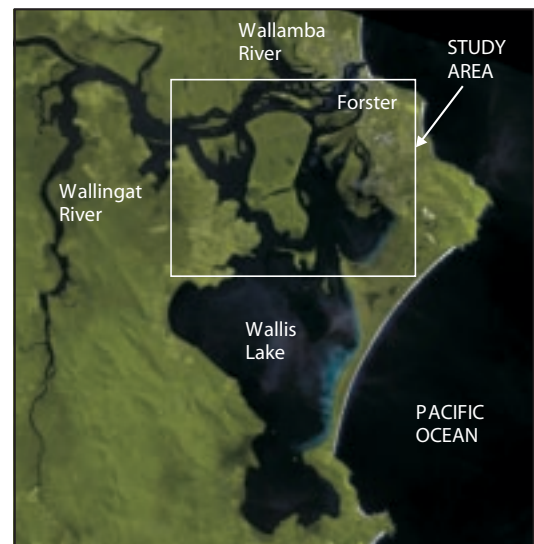
The extensive muddy environments, although acoustically different from sandy areas, were particularly hard to differentiate by acoustic class. Burrow size and density might better differentiate the muddy habitats and show why they produce a range of acoustic responses. Also, other unmeasured features of the lake bed may have influenced the echograms, such as gas bubbles produced by plants or evolved from within the organic-rich muds.

The seagrass areas are largely restricted to the shallow margins of the basins and the inlet channels. There are also dense beds in the marine tidal

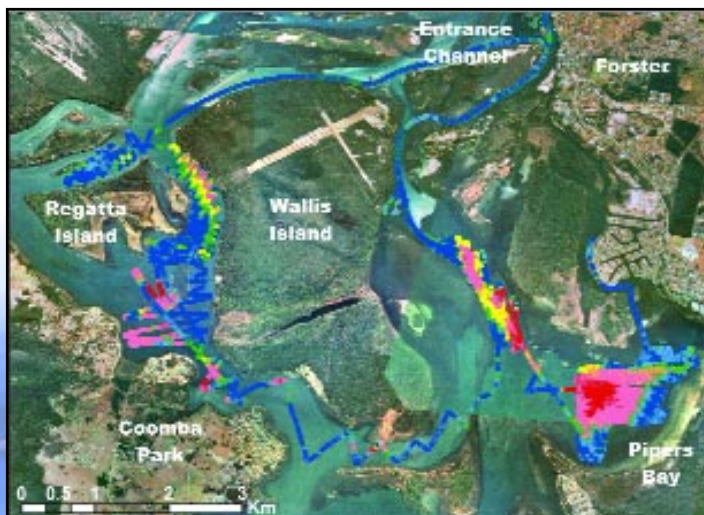
delta which consists of clean, well-sorted sand.

Most of the broad basins such as Pipers Bay and the area west of Wallis Island are dominated by very fine sediments with varying concentrations of shell material often densely populated by various infaunal organisms (ones that live within the sediments).

The intricate network of channels in the northern section of Wallis Lake are the deepest parts (up to 8 m), and they comprise relatively dense sandy mud and muddy sand, often with a relatively high concentration of shell material.



▲ **Figure 1.** An Aster satellite image of Wallis Lake estuary, northern New South Wales, shows the estuary shape with the study area marked by a white box.



Acoustic class 1 2 3 4 5 6

▲ Figure 2. Colour-coded acoustic responses are plotted on an aerial photograph of Wallis Lake supplied by Land and Property Information, NSW.

Potential

Single-beam acoustic mapping in very shallow water such as estuaries still has some challenges, but it also has much potential.

Large areas of Wallis Lake were rapidly mapped and sampled with this technology and the results indicate the diversity and abundance of habitats in areas of the lake that are difficult to map using traditional techniques.

This survey is the first quantification of non-seagrass habitats in the deeper, often highly turbid areas of the lake.

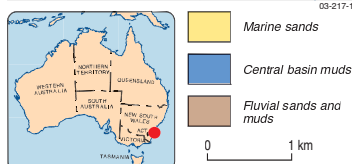
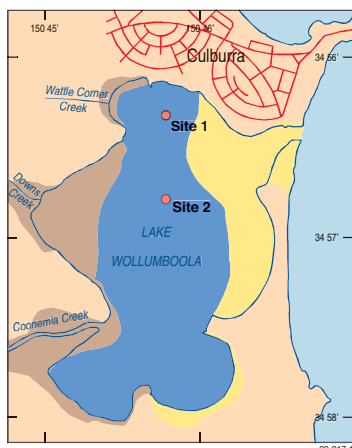
For more information phone David Ryan on +61 2 62499257 or e-mail david.ryan@ga.gov.au. Details of the survey can soon be viewed on the web at www.ozestuaries.org/

Smelly conditions perfect for estuary work

Geoscience Australia has been probing the bottom sediments of a smelly, saline lagoon on the New South Wales south coast.

Lake Wollumboola has high concentrations of hydrogen sulphide, or rotten egg gas, in the sediment porewaters and lake-bottom waters. Periodically the hydrogen sulphide escapes to the atmosphere making it unpleasant for the residents of Culburra (figure 1).

This pristine but sometimes smelly lake provides the ideal environment for finding out about nutrient cycling and nitrogen release in hydrogen sulphide-rich estuaries.



Bacteria at work

When organic matter settles to the bottom of an estuary, it is broken down in several ways (figure 2). If there is enough oxygen in the water, aerobic bacteria in the sediment go to work. These nitrifying bacteria use oxygen to break down organic matter, producing carbon dioxide, phosphate and nitrate (table 1, equation 1).

The nitrate produced is then used by denitrifying bacteria to breakdown organic matter and produce carbon dioxide, phosphate and most importantly, nitrogen gas (table 1, equation 2). The nitrogen gas subsequently escapes to the atmosphere (figure 2).

Nitrogen is an essential nutrient of life. But too much of a good thing can have negative consequences such as excessive plant growth or algal blooms, which can deplete oxygen levels and result in poor water quality.

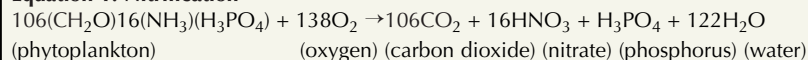
Denitrification is one way estuaries can get rid of some nitrogen and limit excessive plant growth. Water exchange with the ocean is another means of losing nutrients (figure 2).

But if excessive amounts of organic matter are deposited, the aerobic bacteria will use up the oxygen in the water and so anaerobic bacteria, such as sulphate-reducing bacteria, take over the work of breaking down organic matter.

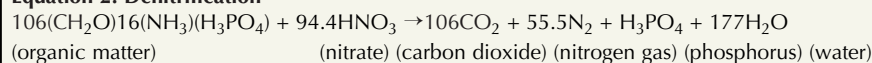
Sulphate-reducing bacteria produce hydrogen sulphide, which smells like rotten eggs, and in the process carbon dioxide, phosphate, and ammonium (equation 3). Ammonium is a form of nitrogen which remains in the system (figure 2), perpetuating cycles of excessive plant growth and depleted oxygen levels.

Table 1. Bacteria at work

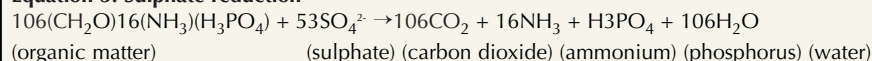
Equation 1: Nitrification



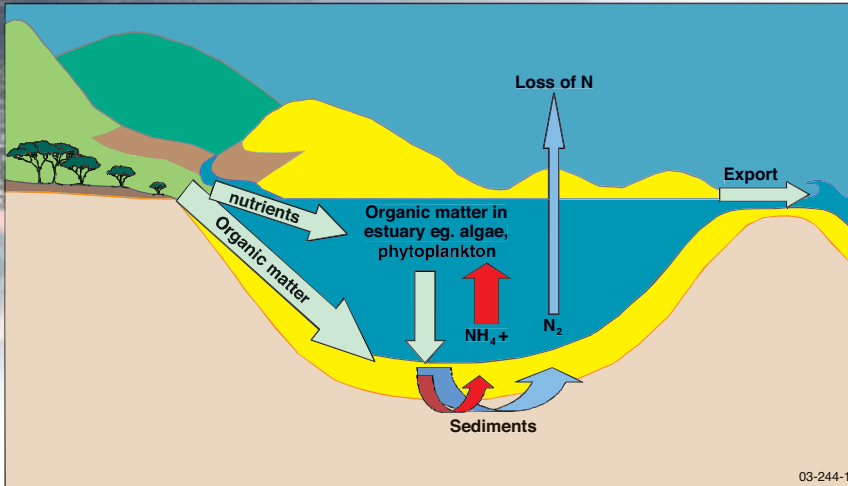
Equation 2: Denitrification



Equation 3: Sulphate reduction



▲ Figure 1. Map of Lake Wollumboola and the benthic-chamber sampling sites



▲ **Figure 2.** Diagram showing how nitrogen is lost or recycled in the waterway

Organic source

Benthic chambers were dropped at two sites in the central basin of Lake Wollumboola in November 2002 to determine how nutrients are cycled in the lake (figure 1).

Benthic chambers isolate a volume of water in contact with the sediment. Changes in oxygen, carbon dioxide, and nutrient concentrations inside the chamber are measured over time.

At first glance, 'weeds' (that are really macroalgae) appeared to provide most of the organic matter for bottom sediments of Lake Wollumboola. The macroalgae looks like green hair and forms a one-metre-thick layer across most of the lake's central basin.

The benthic chamber data revealed, however, that phytoplankton (microscopic algae) was the major source of organic matter at the time of the survey.

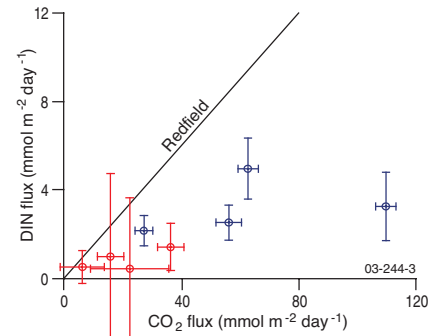
Missing nitrogen

Two methods were used to determine what was happening to the nitrogen in Lake Wollumboola. The first measured ammonia and nitrate in the benthic chambers (figure 3) and the second measured the increase in nitrogen gas over time.

Denitrification rates could be measured because phytoplankton has a carbon: nitrogen: phosphorus ratio of 106:16:1 (Redfield line, figure 3). The 'missing nitrogen', or the difference between the measured dissolved inorganic nitrogen flux and the expected nitrogen flux (Redfield line), is assumed to be nitrogen gas produced via denitrification.

Denitrification efficiencies calculated using the two different methods were comparable for most chambers. The average denitrification efficiencies for sites 1 and 2 were 61 per cent and 65 per cent respectively.

In Lake Wollumboola more than 60 per cent of nitrogen is being lost as nitrogen gas and around 40 per cent is being recycled into the water column and available for plant growth.



▲ **Figure 3.** Graph of dissolved inorganic nitrogen (DIN) flux, against carbon dioxide (CO₂) flux. The difference between the DIN flux and the expected total nitrogen flux (Redfield line) is the nitrogen gas flux (denitrification). Violet data points are for site 1 and orange data points are for site 2.

High concentrations

Average hydrogen sulphide concentrations in the surface sediment porewaters were 412 μm at site 1 and 44 μm at site 2.

Despite these high concentrations, denitrification occurs in Lake Wollumboola. This is surprising as research elsewhere reports that hydrogen sulphide concentrations above 100 μm inhibit nitrification/denitrification.

Perhaps the bottom sediments of Lake Wollumboola are heterogeneous—that is, made up of hydrogen sulphide-rich patches where denitrification *does not* occur and hydrogen sulphide-free patches where denitrification *does* occur. Such patches may be due to the activity of organisms living in the sediment.

Burrows, for example, can take oxygen deeper into the sediment, allowing nitrification/denitrification to occur immediately around the burrow. Sulphate reduction could be occurring in anoxic sediment away from the burrow.

For more information
 phone Emma Murray on
 +61 2 6249 9019 or e-mail
 emma.murray@ga.gov.au

Inaugural SPATIAL CONFERENCE well attended

For five days in September, Canberra hosted the inaugural Spatial Sciences Conference which was an amalgam of the conferences of five professional associations (AURISA, IEMSA, ISA, MSIA and RSPAA).

Leading experts from around the world were among the 830 registrants. They included the UK Ordnance Survey Director-General, Dr Vanessa Lawrence, the US Geological Survey's Associate Director for Geography, Barbara Ryan, and Australia's Chief Scientist, Dr Robin Batterham.

Geoscience Australia supported the conference with speakers and presenters, as well as a display that exhibited a new Raster mosaic product.

This product was launched at the conference by Geoscience Australia CEO Dr Neil Williams.

Many delegates took the opportunity to visit Geoscience Australia's headquarters and the Australian Centre for Remote Sensing (ACRES) to check out the latest mapping and visualisation activities. 📍



Marine research forum *a big success*

This year COGS (Consortium for Ocean Geosciences for Australian Universities) held its three-day conference in conjunction with the Australian Sedimentologists Group and it was jam-packed with presentations.

The COGS conference is a major forum for presenting the research of marine geoscientists and students in Australia. It was held at the Kioloa field research station on the New South Wales south coast from July 7–9.

Most of Australia's leading ocean and coastal geoscientists attended and there were 19 presentations from Geoscience Australia.

Some research outlined in this issue of *AusGeo News* was presented, including estuary habitat mapping, the production of a geomorphic features map for the entire Australian margin, and riverine sediment loads in estuaries in southern Western Australia.



Other Geoscience Australia work presented at COGS 2003 involved:

- A geophysical survey of the seafloor east of Norfolk Island, across the Three Kings Ridge and northwards to the Cook Fracture Zone, which revealed a series of broad plateaux separated by depressions and a trench-like feature west of the ridge.
- High-quality deep seismic of the western Antarctic margin that provides details about the continental–ocean boundary, and the break-up of Australia and Antarctica and subsequent slow seafloor spreading.
- Swath mapping the Murray Canyons system off South Australia to determine sedimentation patterns, sea-level fluctuations and environmental changes in the Murray–Darling Basin.
- Sediment transport studies in the northern Great Barrier Reef which show that Fly River sediment is not being transported to the reef because of tidal current scour and channels.

The 38 presentations and six posters delivered over the three days were testament to the exceptional quality of marine geoscience research happening in Australia. COGS 2005 conference in Townsville should be equally successful.

For more information phone Andrew Heap on +61 2 6249 9111 or e-mail andrew.heap@ga.gov.au 📍

Call for *research proposals* for
EXPERIMENTS
in **2004** &
beyond

Submissions by February 16, 2004

The Australian National Seismic Imaging Resource (ANSIR), a major national research facility, seeks bids for research projects for experiments in 2004 and beyond.

ANSIR operates a pool of state-of-the-art seismic equipment suitable for experiments designed to investigate geological structures. ANSIR is operated jointly by Geoscience Australia and the Australian National University.

ANSIR equipment is available to all researchers on the basis of merit, as judged by an Access Committee.

Demand for broad-band equipment is very high. This should be taken into consideration in the design of experiments. ANSIR provides training in the use of its portable equipment, and a field crew to operate its seismic reflection profiling systems. Researchers have to meet project operating costs.

Applicants should consult the web (<http://rses.anu.edu.au/seismology/ANSIR/ansir.html>) for details of the equipment available, access costs, likely field project costs, and the procedure for submitting bids. This site includes an indicative schedule of equipment for projects that arose from previous calls for proposals.

Researchers seeking to use ANSIR equipment from mid-2004 should submit research proposals to the ANSIR Director by February 16, 2004.

Enquiries should be directed to:

**Prof Brian Kennett, ANSIR
Director, Research School of
Earth Sciences, Australian
National University,
Canberra ACT 0200.
Tel. +61 2 6215 4621 or
e-mail ANSIR@anu.edu.au**

EVENTS calendar

compiled by Steve Ross

**North American Prospects
Exhibition 2004**

American Association of
Professional Landmen
5 & 6 February, Houston, Texas
Contact: AAPL, 4100 Fossil Creek
Boulevard, Fort Worth, Texas 76137
USA

phone +1 817 847 7700
fax +1 817 847 7704
e-mail nape@landman.com
www.napeonline.com

NZSEE Annual Conference 2004

New Zealand Society for
Earthquake Engineering
19 to 21 March, Rotorua, New
Zealand

Contact: Derek Wilshere, NZSEE,
PO Box 2193, Wellington, New
Zealand

phone +64 4 562 7920
fax +64 4 562 7920
www.nzsee.org.nz/EVENTS/events.html

**17th Australian Geological
Convention**

Geological Society of Australia
8 to 13 February, Hobart
Contact: Conference Design, PO
Box 342, Sandy Bay, Tas 7005

phone +61 3 6224 3773
fax +61 3 6224 3774
e-mail 17thagc@gsa.org.au
www.17thagc.gsa.org.au

APPEA 2004

Australian Petroleum Production &
Exploration Association
28 to 31 March, Canberra
Contact: Julie Hood, APPEA Ltd,
GPO Box 2201, Canberra ACT 2601

phone +61 2 6267 0907
fax +61 2 6247 0548
e-mail jhood@appea.com.au
www.appea.com.au

PDAC 2004

Prospectors & Developers
Association of Canada
7 to 10 March, Toronto, Canada
Contact: Prospectors & Developers
Association of Canada, 34 King
Street East, Suite 900, Toronto,
Ontario M5C 2X8, Canada

phone +1 416 362 1969
fax +1 416 362 0101
e-mail info@pdac.ca
www.pdac.ca

AAPG 2004

American Association of Petroleum
Geologists
18 to 21 April, Dallas, Texas
Contact: AAPG Convention,
PO Box 979, Tulsa Oklahoma
74101-0979 USA

phone +1 918 560 2679
fax +1 918 560 2684
e-mail convene@aapg.org
www.aapg.org

**Petroleum
Open Day**

Canberra April 1

e-mail jenny.maher@ga.gov.au

The Petroleum Open Day gives you the chance to discuss Geoscience Australia's program over the next four years with petroleum researchers and government decision makers.

This event immediately follows APPEA 2004 in Canberra and is held at Geoscience Australia's headquarters.

The Open Day costs \$33, which includes lunch and morning and afternoon tea, and it must be paid by March 12.

The proposed program is available at www.ga.gov.au

Regional-scale seabed map *a first*

For the first time, the 'landscape' of Australia's seabed has been mapped at a large scale in a Geoscience Australia–National Oceans Office project.

The geomorphic map for a major part of Australia's exclusive economic zone is crucial for proper management of offshore resources, as each feature is home to very different ecosystems and marine life.

The map is a major reference for regional marine planning and is held in a geographic information system for updating.

Map construction

Geoscience Australia added approximately 289 million soundings from swath surveys, ship echo sounders, and Navy fair-sheets to its existing bathymetric database. From these data, it generated a bathymetric grid (250 metre horizontal cell size) for defining seabed features.

Published information and bathymetry were used to determine features, which are based on the International Hydrographic Office definitions. They include major geomorphic provinces (continental shelf, slope, rise and abyssal plain), as well as individual features (e.g. reef, canyon, fan and terrace). Sandwaves/sand banks were added even though they are not in the IHO scheme, because they are a major feature of the continental shelf.

Boundaries separating the shelf, slope, rise and abyssal plains were determined by changes in slope.

The geomorphic map was constructed at a scale of 1:5 million, so the smallest unit size that could be reliably resolved was about 10 square kilometres. Some features that are even larger could not be mapped because no data are available.

The boundaries of the features were digitised and stored in a GIS and their surface areas were calculated from the GIS polygons.

Different composition

Australia's seabed is quite varied even on a regional scale (figure 1). The northern margin is more than 70 per cent continental shelf, whereas the eastern margin and the island regions are more than 80 per cent abyssal plain environments.

The continental rise along the western margin is better developed than along the southern and south-east margins.

The most abundant feature are plateaus (about 22% of the area mapped, see table 1), but they are not uniformly distributed. The largest are the carbonate-dominated Queensland and Marion plateaus in the north-east.

The second most abundant feature is basins (657 600 km²; 9.1%) and there are two types: shallow basins on the continental shelf in the Gulf of Carpentaria, Bass Strait and Bonaparte Gulf, and deeper ocean basins such as the Coral Sea Basin. Knowing the distribution and abundance of shallow shelf basins is important because these are principal repositories for river-borne nutrients and contaminants.

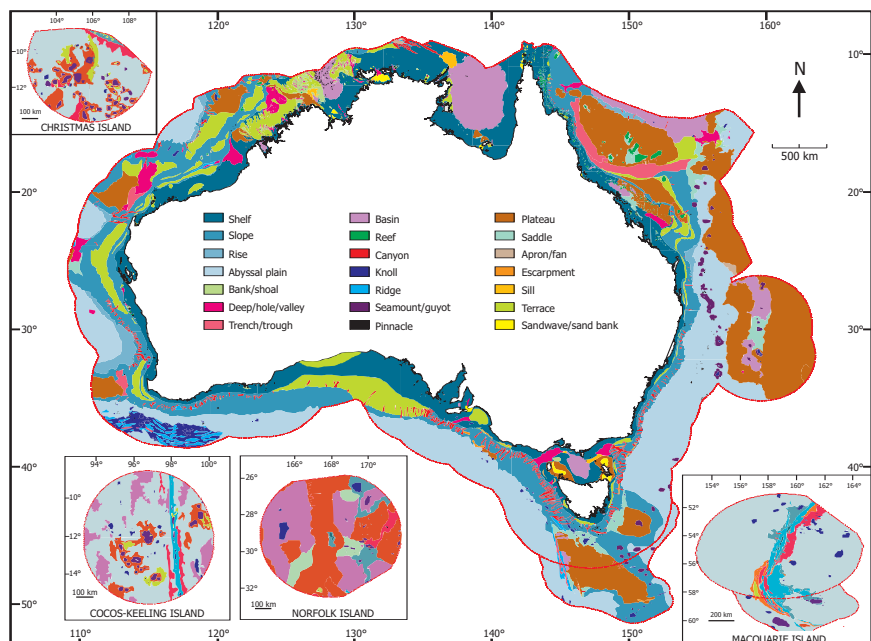
Shallow sills separate basins from the deeper ocean. The sills profoundly influence basin habitats. They have regulated the transfer of water and sediments between the basins and adjacent oceans over many sea-level cycles.

Terraces are the third most abundant feature (591 500 km²; 8.2%), particularly in the west and southern margins where they comprise extensive low-gradient mid-slope surfaces.

Habitats on these margins will be more affected by depositional processes than the rest of the mid-slope which is characterised by gravity flows and submarine canyons and their dynamic habitats.

Submarine canyons are numerous and occur in all regions except for Cocos-Keeling Islands. They are most extensive on the south-east margin (50 536 km²), followed by the west (23 232 km²), south (21 227 km²), north (15 873 km²), north-east (6798 km²) and east (5116 km²) margins.

The relationship between the distribution of submarine canyons and onshore drainage and regional rainfall patterns (i.e. river discharge) is not straightforward. The canyons occur where the slope is steepest. But the geomorphic map data could be biased, so questions about canyons will need to wait until there are more high-resolution bathymetric data (e.g. from multibeam swath surveys).



▲ Figure 1. The first geomorphic map for a large part of Australia's exclusive economic zone mapped at 1:5 million scale

Management framework

Based on the distribution and abundance of seabed geomorphic features, Geoscience Australia divided the mapped area into eight regions (figure 2).

For example, the north-east margin is defined by an abundance of marginal plateaus, coral reefs, and large submarine troughs. In contrast, the eastern margin has seamounts and a relatively narrow shelf cut by numerous small but steep submarine canyons.

This breakdown is useful for identifying unique seafloor regions that may require protection. It has already been used to define Broad Areas of Interest, or candidates for marine protected areas, on the south-east margin.

The information also allows quantitative comparisons of features. For example, coral reefs in the north-east margin, which are an extremely valuable resource are in area only about three per cent of the region.

Future work

High-quality multibeam swath data are not available for most of Australia's offshore jurisdiction. The areas with high-quality data coverage are mostly along the upper slope of the southern margins. Sensitive management areas such as the Great Barrier Reef have not been comprehensively swath mapped.

Geoscience Australia is creating a national repository for multibeam survey data, and has contributed to a new sonar mapping system that will be installed on the research vessel *Southern Surveyor* in December.

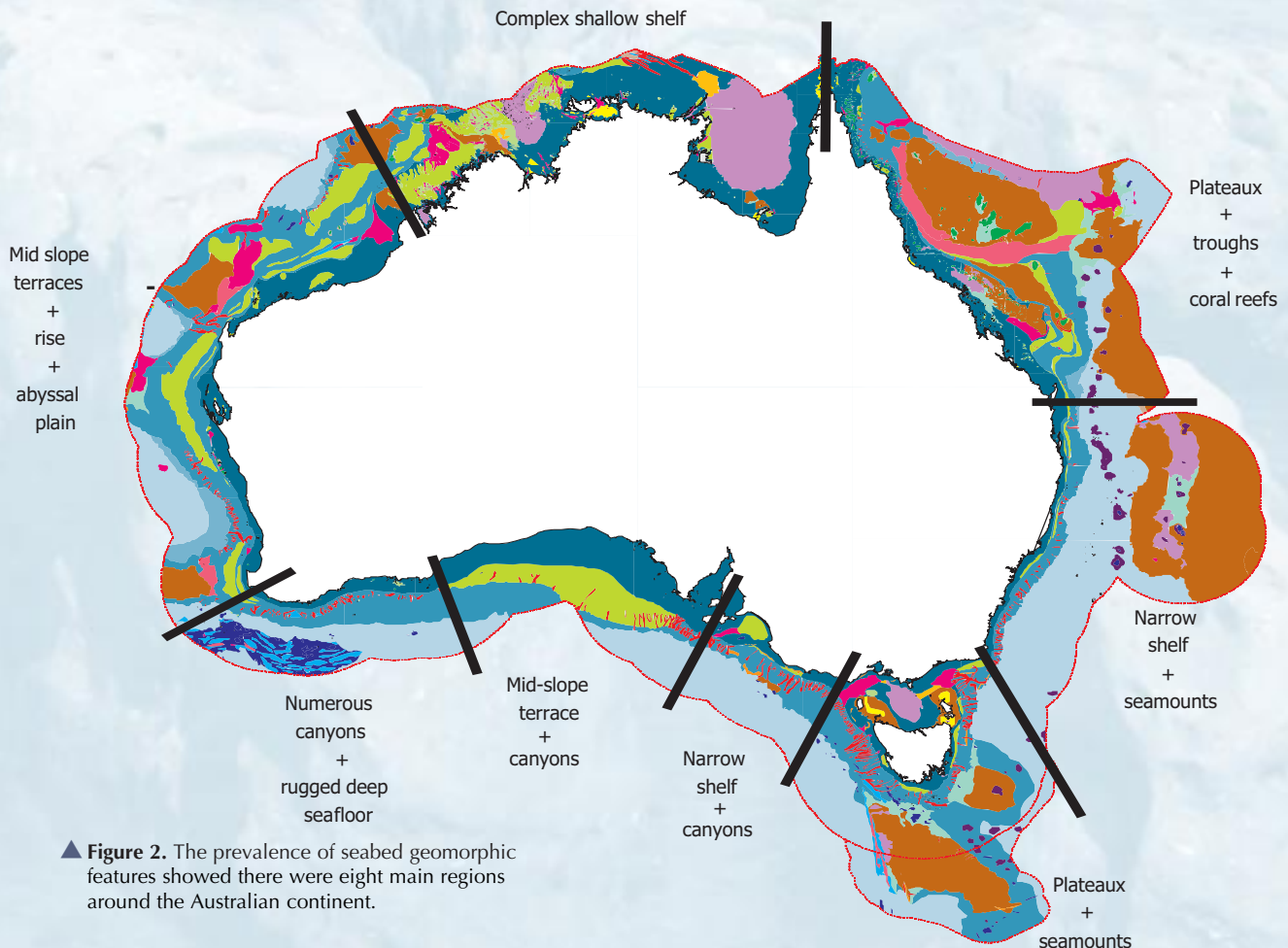
Early next year, Geoscience Australia will use the equipment to collect detailed bathymetric data in the Bremer Basin on the south-west margin and Kenn Plateau on the north-east margin.

The geomorphic map will be updated as new data become available. Geoscience Australia is seeking the science community's input into newer versions of the map.

Feature	Km ²	Area%
1. Shelf	1 973 879	27.40
2. Slope	2 636 416	36.59
3. Rise	97 099	1.35
4. Abyssal plain	2 496 205	34.65
<i>Total</i>	<i>7 202 700</i>	<i>100</i>
5. Bank/shoals	51 600	0.72
6. Deep/hole/valley	176 300	2.45
7. Trench/trough	189 000	2.63
8. Basin	657 600	9.13
9. Reef	58 700	0.82
10. Canyon	125 100	1.74
11. Knoll/hill/peak/mountain	120 800	1.68
12. Ridge	111 200	1.54
13. Seamount/guyot	103 700	1.44
14. Pinnacle	5600	0.08
15. Plateau	1 603 600	22.26
16. Saddle	160 200	2.23
17. Apron/fan	17 700	0.25
18. Escarpment	22 900	0.32
19. Sill	17 400	0.24
20. Terrace	591 500	8.22
21. Tidal sandwave	25 200	0.35

Table 1. Surface areas of major geomorphic features on Australia's seabed

For more details or if you would like to contribute data for the map contact Andrew Heap on +61 2 6249 9790 or e-mail andrew.heap@ga.gov.au



▲ Figure 2. The prevalence of seabed geomorphic features showed there were eight main regions around the Australian continent.

Geochemical plotting *on-line*

Geoscience Australia has redeveloped its Geochemical Data Analysis (GDA) system and released it as an on-line package for retrieving and plotting geochemistry data it holds in a corporate database.

Originally programmed in FORTRAN, the application has been rewritten in Java to run on a standard web browser.

The current version allows users to retrieve data from Geoscience Australia's OZCHEM database as well as files from a local file system via the web. The retrieved data can be filtered and grouped, and plotted as X-Y graphs, Ternary diagrams, spidergrams and histograms. Overlays can be added to the X-Y and Ternary diagrams.

Other features include: lines of best fit, stacked plotting, logarithmic scales, zoom in/out of selected parts of a graph, enlarge/reduce graph size, modify symbol colours, and retrieve sample information from individual graph points.

Filtered and grouped data and plotted graphs can be saved to a PC.

Java Runtime Environment (Version 1.4.2 or above) is needed to take advantage of all the features. But if users do not have this software, a simplified (html only version) provides access to the same data.

Although the GDA redevelopment deals specifically with the extraction and display of geochemical data, the application is sufficiently generic to be used for the retrieval and plotting of data types from other data sources.

For more information phone Neal Evans on +61 2 6249 9698 or e-mail neal.evans@ga.gov.au. Also visit the Plot-It web site at www.ga.gov.au/gda/

Web delivery of airborne survey data *streamlined*

Data from Geoscience Australia's airborne geophysics and gravity databases are now delivered using a new system called GADDS (Geophysical Archive Data Delivery System).

To access these databases enter the address www.ga.gov.au/gadds into a standard web-browser and follow four simple steps:

1. Define the area of interest on a map of Australia.
2. Choose the data types (magnetics, radiometrics, elevation or gravity), and the format (ASCII columns or Intrepid Database).
3. Choose the dataset of interest and the dataset columns.
4. Supply your e-mail address for data delivery.

You will receive only the required data. Both vector (line and point) and raster (grid) datasets are available.

For raster data files either the entire dataset or a sub-sample (every 2nd or every 10th cell) dataset can be supplied. You can preview a colour image of the dataset prior to downloading.

Vector data files are supplied at the full dataset resolution. The columns required from each vector dataset are selected by clicking on the corresponding check box. All check boxes are left unchecked if all fields are required.

An estimate is given for how much of the chosen dataset is in the region of interest. The 'survey extents' and 'survey metadata' links are also a feature of the data delivery.

The 'survey extents' link displays a map of the full extent of the chosen survey relative to the extent of the interest area entered by the user. The 'survey metadata' link queries the airborne metadata database and displays all available survey metadata relating to the chosen survey.

An estimate of the unzipped file size and the time to complete the request is also displayed—with a warning about download time if the file size is greater than 200 Mb.

Data for individual surveys usually cover one or more 1:250 000 sheet areas. Most surveys prior to 1990 in the databases have flight-line spacings of 1500 metres or more. From 1990 they usually have flight-line spacings of 400 metres or less.

For more information phone Murray Richardson on +61 2 6249 9229 or e-mail murray.richardson@ga.gov.au



Long lines of seismic data *refreshed*

Geoscience Australia has re-processed seismic data from two large regional-scale reflection surveys that were carried out in Queensland in the early 80s. This is more than 2100 kilometres of seismic data acquired for crustal structure studies.

Data were recorded to 20-seconds two-way time on a 48-channel DFS IV system. The group interval was generally set at 83 metres with a shot interval of 333 metres. Dynamite was used as the energy source (drill holes 40 m deep and a charge size of 8 kg).

Eromanga Basin (L115, 116 & 118): Over three years (from 1980 to 1982), 1382 kilometres of data were acquired from 13 traverses in the central Eromanga Basin to investigate the basin's structure with a view to future hydrocarbon exploration.

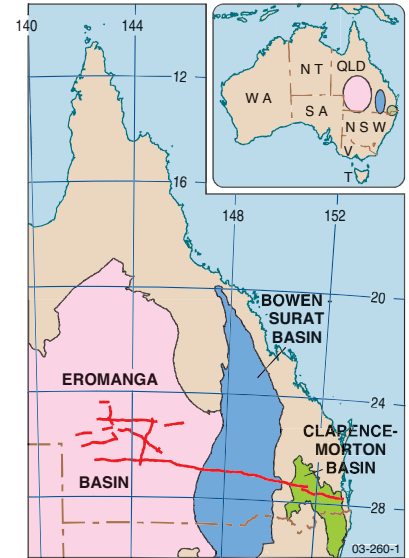
South-east Queensland (L120): Eight hundred kilometres of six- or 12-fold CDP reflection data were recorded over eight months in 1984 from a line near Charleville in south-west Queensland to Ipswich in the east. This was the first of the Australian Continental Reflection Profiling (ACORP) initiatives to study critical transects of the Australian lithosphere.

Generally speaking data quality was good to fair and has been used in detailed stratigraphic and structural studies of the sedimentary basins as well as deep crustal studies.

Long line: A continuous traverse is available from Mt Howitt, in the western part of the Eromanga Basin, to Ipswich in the Clarence-Moreton Basin (figure 1). This traverse is 1067 kilometres long and comprises approximately 3200 drill holes (figure 1).

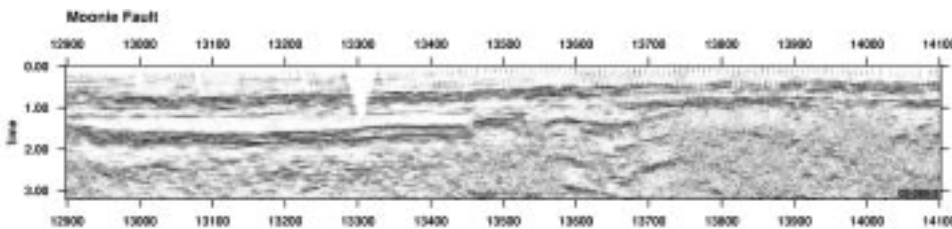
The data are available in SEG Y format, as 'shot' records or enhanced 'final stack' records, and are easily read on any seismic viewing package and plotted/viewed/interpreted at any required scale. They have been considerably improved with the recent re-processing (figure 2).

Ancillary data, including drill-hole logs, operations reports and potential field profiles are also available.



▲ **Figure 1.** Location map of recently re-processed seismic data

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◀ **Figure 2.** Example of improved data from Moonie area, Surat Basin

Pristine estuaries being mapped

The National Land and Water Resources Audit says that about half of Australia's 1048 estuaries are 'near-pristine'—that is, they have had little or no apparent human impact.

These estuaries are mostly along the remote and least-explored coastline, such as far northern Australia and south-west Tasmania, so little is known about them.

A new Coastal CRC project aims to increase knowledge of Australia's pristine and near-pristine estuaries. The two-year 'Near-pristine Estuaries' project is collating existing information, and mapping the sedimentary environments and habitats of some using satellite images and aerial photos.

The characteristics of near-pristine estuaries are needed for comparison with modified estuaries—as an environmental benchmark to assess the degree of alteration that has occurred.

Much of what is known about Australian estuaries comes from studies done in more accessible areas, such as along the south-east and south-west coasts. These estuaries are often quite altered due to human activities like native vegetation clearing.

If you have worked in or studied a near-pristine estuary, the Coastal CRC would like to know about your findings.

Maps, information and management tools from this work will eventually be available on the OzEstuaries database (www.ozestuaries.org). In the meantime, you can receive updates via e-mail on project progress, and maps which invite feedback.

Geoscience Australia is managing the Near-pristine Estuaries project in collaboration with CSIRO Land and Water and the Queensland Environmental Protection Authority.

For more details, or to contribute to the project or receive e-mail updates,
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Yilgarn *exposed*

A new on-line GIS uncovers one of Australia's key mineral provinces, the Yilgarn Craton in Western Australia (N Lat 32°; S Lat 36°; W Long 114°; E Long 126°).

The Yilgarn attracts more than half the mineral exploration expenditure, and produces two-thirds of the gold and most of the nickel mined in Australia.

The problem is bedrock exposure is extremely poor throughout the Yilgarn and most known mineral deposits occur within or adjacent to sparse outcrop.

The on-line GIS allows users to display all deposits in the region or just the gold or nickel deposits. Mineral deposit distributions can be compared to other data layers such as geology.

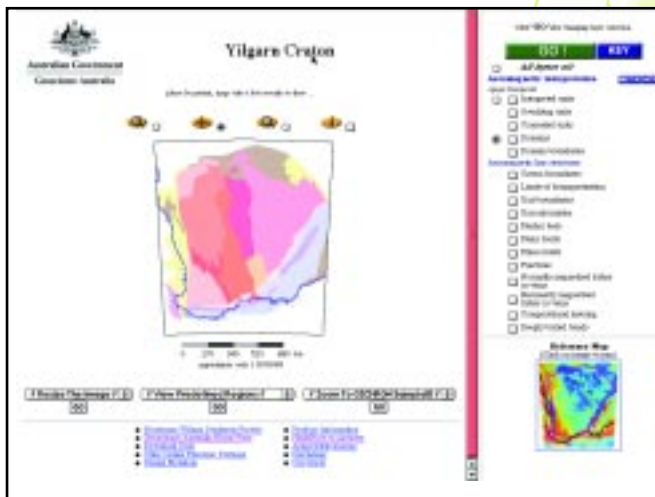
The GIS uses standard browser technology with in-built pan, zoom, query and select tools. Dataset themes include geology, topography,

potential field geophysics, seismic traverses, whole-rock geochemistry, and geochronology.

One of the main features is the craton-wide aeromagnetic interpretation (lithology distribution and structure), revealing the prospective Archaean bedrock distribution under the relatively thin regolith cover. Interpreted structural elements include lithological layering, faults, and dyke swarms. Also presented are several surrounding and partially overlying Proterozoic and Phanerozoic basins and provinces.

There is also a detailed solid geology interpretation of the Leonora–Neale Transect from seismic reflection profiles acquired in 2001 (01AGS-NY1 and NY3).

This GIS is a product of the Norseman–Wiluna Synthesis project, a National Mapping Agreement project involving Geoscience Australia and the Geological Survey of Western Australia.



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 visit ww.ga.gov.au/map/yilgarn

Coastal GIS proceedings *released*

The proceedings of the Coastal GIS 2003 Workshop held at Wollongong University on July 7–8 have just been published.

Australia is very actively involved in numerous issues in its coastal zone, and this workshop explored what spatial information technology has to offer for the rapid dissemination and effective use of geographical data.

Papers included in the proceedings examine such topics as: Coastal data—hydrography, data conversion and marine cadastre; Near-shore mapping; Coastal assessment and databases; Coastal morphology and hydrodynamics; Estuarine mapping; and Coastal management.

The proceedings show that Australia is well placed to become an international leader in the development and adoption of GIS as an effective coastal research and management tool.

The workshop was sponsored by Geoscience Australia, the National Oceans Office, HSA Systems and ESRI Australia. Participants were from a wide range of Australian research institutes, including leading Australian federal, state and local government agencies, and from New Zealand and South Korea. It was organised by Colin Woodroffe, from the School of

Geosciences at Wollongong University, and Ron Furness, a former director with the Australian Hydrographic Office.

Copies of *Coastal GIS 2003: An integrated approach to Australian coastal issues* are available from Myree Mitchell at the Centre for Maritime Policy, University of Wollongong, e-mail myree_mitchell@uow.edu.au



Lots more in *estuaries database*



OzEstuaries is a national repository for information about Australian estuaries and coastal waterways, which Geoscience Australia has been improving with new geographical and geochemical data, and models of estuary function and ecosystem health.

'Function' models

Geomorphic conceptual models for the seven types of Australian estuaries and coastal waterways (e.g. wave- and tide-dominated estuaries, deltas, and lagoons) have been added. The models provide insights into estuarine function, particularly the estuary's capacity to trap sediments and process pollutants.

Each model comprises a 3D block diagram that summarises the estuary's physical form, hydrology, and sediment and nutrient dynamics.

These diagrams are useful tools for assessing relationships among components in an ecosystem. They will be improved over time through testing and user review. A report on estuary models can be downloaded at www.ozestuaries.org/oracle/ozestuaries/document/.

Fact sheets

Biophysical indicators, coastal issues and human pressures on the coastal zone are summarised as fact sheets in the module 'Coastal Indicator Knowledge and Information System'. There are also fact sheets to describe the economic and social consequences (or impact) of changed ecosystem health and how these may be managed.

The sheets are linked to other indicator fact sheets and to the estuarine function models to show the interconnectedness of different measures and, where possible, the coastal settings where they best apply.

There are also external links to web information such as Catchment Condition On-line Maps and Water Quality Targets On-line.

On-line GIS

An on-line GIS allows users to check the location of individual estuaries on a Landsat satellite mosaic, and to pan and zoom at different scales. The Landsat image has a spatial resolution of 25 metres and shows the details of most estuaries. For some estuaries the geomorphic habitat mapping can be displayed along with cadastral features.

A variety of other imagery is also available, from regional overviews of ocean condition and properties to aerial photography and other satellite images. The attributes of estuaries held in the database, such as geometry or habitat type, can be queried from the on-line GIS.

Other features

In OzEstuaries there is now a 'condition assessment' for most Australian estuaries, which was compiled as part of the National Land and Water Resources Audit. It provides information about physical, chemical and biological aspects of the estuaries.

There is also a link to CSIRO's Simple Estuarine Response Model (SERM). This model predicts an estuary's response to changes from varying input. SERM is particularly useful for gaining a better understanding of the interconnectedness of estuary processes.

The 'Links' page enable users to locate other relevant information and documentation about Australia's estuaries and coastal waterways.

OzEstuaries represents the collaborative efforts of more than 100 coastal scientists from a range of government agencies and universities.

For more information phone Craig Smith on + 61 2 6249 9650 or e-mail craig.smith@ga.gov.au. Also visit www.ozestuaries.org

SEE AUSTRALIA FOR \$99 Mosaic of Australia now on DVD



The Landsat 7 Mosaic of Australia was released on DVD in November. It is derived from the ACRES Landsat 7 Y2K Mosaic data produced by the Australian Greenhouse Office in 2000.

This beautiful but inexpensive satellite image of Australia displays ground features in photographic-like perspective. It is particularly useful as digital background information for GIS applications.

The mosaic contains two different 3-band image combinations that have been compressed to reduce image size yet retain high quality. The first image combines spectral bands 2, 4 and 7 (blue, near infrared, middle infrared) which results in a pseudo-natural colour image. The second image is a combination of spectral bands 1, 2 and 3 (blue, green, and red) which results in a natural colour image.

Pixel size is an impressive 25 metres using GDA94 datum and Lambert Conformal Conic projection. The image is ortho-corrected.

The product comes with ER Viewer software that allows the user to load, open, display, view and save images into a wide range of formats including tiff, jpg and Windows bmp.

The Landsat 7 Mosaic of Australia on DVD costs \$99 through ACRES Landsat data distributors (www.ga.gov.au/acres/distributor/landdis.htm) or phone the Geoscience Australia Sales Centre on 1800 800 173 (Freecall in Australia) or +61 2 6249 9966, or e-mail sales@ga.gov.au