

## ABSTRACTS

in alphabetical order  
by presenting author

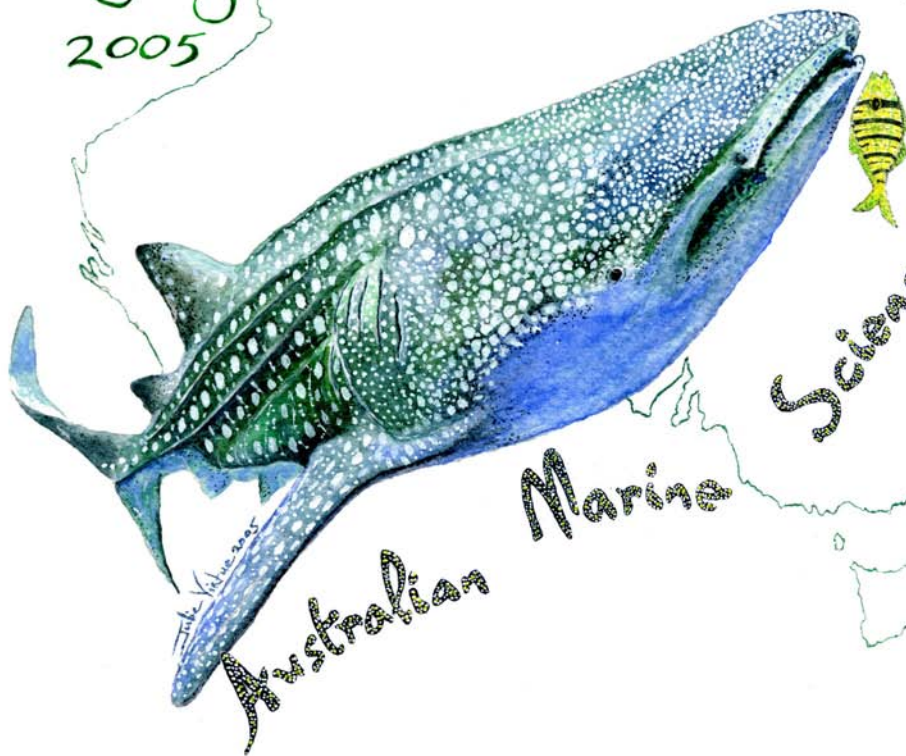
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(in alphabetical order by presenter - presenter is marked with an asterisk if not the first author)

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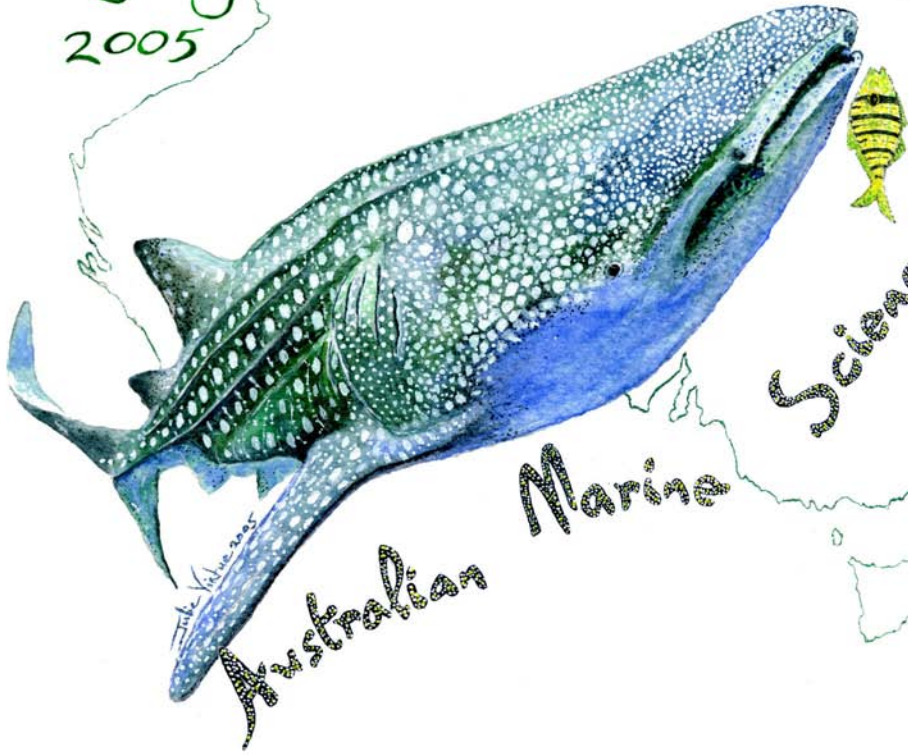


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## Fluctuating asymmetry of seagrass *Zostera capricorni*: method of its measurement and assessment in localities with different heavy metal loading

Stress can be defined as any factor which tends to reduce the efficiency of functioning of physiological processes in the organisms. One of the most important and most difficult tasks is the identification of population subjected to stress before such stress has a detrimental effect. Developmental stability (DS) is one of the stress indices recently used to assess a subtle effect of environmental degradation on organisms. DS is the ability of an organism to resist perturbation and to produce predictable target morphology regardless of developmental noise. Fluctuating asymmetry (random differences between symmetric structures, FA) is a measure of DS and is expected to increase under stress. In this study we developed an original technique of measuring fluctuating asymmetry in *Zostera* leaves as departure from translational symmetry of septae and assessed FA in seven localities of Lake Macquarie (New South Wales, Australia). From each locality we sampled three sites. Our analyses showed that concentration of heavy metals (e.g. Cd, Pb, Se) in seagrass leaves and roots were significantly different between Cockle Bay (the most polluted location) and other locations. At the same time, there was no increased FA in Cockle Bay in comparison with other localities. A possible explanation of such results is that developmental stability, being a general measure of stress, responds to combination of different factors. We may suppose that there are other factors which we do not control which compensate or even surpass effect of heavy metals.

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## Border Biosecurity

The Australian Customs Service has an acknowledged role in border security but what of biosecurity? Through its Coastwatch and National Marine Unit Divisions, Customs undertakes surveillance, patrol and response work in coastal and offshore areas of Australia on behalf of a number of government agencies. We will examine two major operations: the chase of the *Viarsa I* in the Southern Ocean in August 2003 and the targeting of incursions of foreign fishing vessels in northern Australia in April 2005.

In August 2003 after a 21 day, 3900 nautical mile chase, Customs and Fisheries officers boarded the *Viarsa I* and subsequently seized the vessel and its catch of \$1.5m worth of Patagonian toothfish. The vessel was suspected of illegally fishing inside the Australian Fishing Zone adjacent to Heard and McDonald Islands in the Southern Ocean.

The chase of the *Viarsa I* helped to focus world attention on the need for stronger measures to combat illegal, unregulated and unreported fishing. In November 2003 Australia signed a treaty with France that provides for cooperative surveillance, the exchange of information and requests for logistical support. In December 2003 the Prime Minister announced a major upgrading of Australia's Southern Ocean maritime patrol and response efforts.

Illegal fishing in Australia's northern waters has increased dramatically in the last five years and is increasingly being driven by well-organised commercial interests. As of late April 2004, 283 foreign fishing vessels had been apprehended in Australian waters, compared with 217 for the full year 2003-04. Vessels are increasingly being sighted 200-300 kilometres inside Australian waters including deep in the Gulf of Carpentaria, up rivers and on shore.

Illegal fishing seriously threatens important fishing stocks in northern Australian waters, including shark, trepang, trochus and several fin-fish. Additionally, apprehended vessels have been sighted with protected species, including dugongs and dolphins, on board. The vessels often carry pests and/or potential carriers that are a significant threat to Australia's quarantine regime, such as termites, borers, dogs, birds and rats.

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## **Do shallow tropical estuarine nurseries provide small fishes with a refuge from predation?**

The shallow-water refuge paradigm has been globally applied to help explain the high abundances of juvenile fishes that utilise shallow-water estuarine nursery habitats. Despite its wide application and acceptance, there is very little direct evidence that indicates small juvenile fishes benefit from reduced predation pressure in shallow water habitats relative to adjacent deeper waters. The most convincing support for the shallow-water refuge paradigm has come from a few tethering studies in temperate North American estuaries. While tethering studies are not without problems, they provide one of the few approaches to directly assessing the shallow-water refuge paradigm. This study employed chronographic tethering experiments to examine patterns in predation potential across a depth gradient (0.2 - 3 m) in the lower reaches of a tropical estuary. No clear or consistent depth-related patterns in predation pressure emerged during the 6 month study conducting 17 replicate experimental trials deploying a total of 183 tethered fish prey. Despite the widely held views, there was no evidence that the shallow estuarine waters occupied by small juvenile fishes in this region provide them with a refuge from predation. Given the complexity and diversity of the piscivore assemblage it is hardly surprising that no clear patterns emerged. While this study does not provide definitive answers, the findings suggest that the shallow-water refuge paradigm may be too simplistic for diverse and complex tropical estuarine nursery grounds.

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## **Closing the gap to prevent the spread of marine pests**

The introduction of marine pests into the marine environment threatens the biodiversity and ecological processes of marine ecosystems. Their introduction can also pose risks to human health, and may jeopardise the social and economic benefits derived from the marine environment, including aquaculture, recreational and commercial fishing, international and domestic shipping and cultural values. Once established, marine pests often have long lasting impacts, and are usually impossible to eradicate.

Although Australia has managed the risks of International ballast water since 2001, there have not been any permanent measures to deal with Australian domestic ballast water until recently. To deal with this significant regulatory gap (ships from Australian ports account for 75-80% of all ship visits in Victoria), a new policy framework has been developed to manage the risks of domestic ballast water in Victoria. This framework will help minimise the spread of marine pests that have already been introduced in Australia.

In July 2004, EPA Victoria introduced subordinate legislation to manage the risks of domestic ballast water - the Waste management policy (Ships' Ballast Water). These requirements are the first of their kind in Australia and complement requirements for ships coming from overseas.

Victoria is now one of the few places in the world that has effective measures to manage ballast water irrespective of whether a ship is coming from a domestic or international port.

In its first 12 months of implementation there have been over 4000 ship visits into Victoria, with 100% of ships complying with the key policy objectives with no high-risk ballast water being discharged in Victoria.

The success has been achieved through innovative, risk-based approaches to managing ballast water; prior reporting initiatives; use of cost-effective and flexible tools for ships; accreditation agreements to reward ships with good performance and practical measures to deal with non compliance. The success to date may provide a useful model for other jurisdictions dealing with the management of ships' ballast water.

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## **Biodiscovery in Australia's marine estate: conservation to clinic**

Biodiscovery is bioprospecting with the intention to NOT mine the resource. The bright future for Australia into future generations, in generating biochemical leads for medicine and industry, is totally reliant on preservation of biodiversity in its natural context.

Natural biological resources globally were estimated in 1998 to be worth over \$US11 Trillion per year for what they represented in terms of potential leads for biomedicinals, direct harvestable resources and for their intrinsic value in the tourist and recreational industries. One drug is now worth over \$1billion per year in sales, with over 60% of modern drugs still based on a natural lead. The estimations of value for natural products is based on primarily on terrestrial sources as drug companies shy from marine leads due to their inherent complexity and hence difficulty to supply. The sea however, has always represented the best source of novel leads, and Australia arguably remains the richest location for generating these leads. Biodiversity in Australasian seas is unique and high, but like many regions on the planet, this biodiversity is under threat from pollution, sedimentation, invasion. The diversity of species and the biochemical 'defensive' or 'adaptive' responses of each to environmental variation, equates to a rich source of novel chemistry from diverse chemical classes. When screened for biomedical properties, extracts from Australian species display an unusually high proportion of leads, particularly against cancer indications. Australia's relative contribution to anti-tumour active leads globally is high, given the very low level of sampling to date.

A number of Australasian biodiscovery case studies are highlighted to demonstrate the key issues facing ethical and economic elaboration of biodiscovery industry in Australia. The advantages of conducting this science in a rigorous manner from the seafloor up, are detailed to demonstrate how biodiscovery research in the marine estate can deliver benefits to understanding the ecology of marine ecosystems leading to conservation outcomes.

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## **Population dynamics of pocilloporid corals in One Tree Lagoon (2004-2005): consequences of bleaching**

Since the mass coral bleaching event of 1998 there have been a number of smaller events that have affected coral assemblages at One Tree Island Lagoon (southern Great Barrier Reef). The most recent of these occurred in summer 2004. A previous study of the impacts of bleaching at One Tree Lagoon (Booth & Beretta 2002 Mar. Ecol. Prog. Ser 245: 202-212) indicated spatial patchiness in bleaching response for all corals across the lagoon. Here I determine short- and long-term consequences of bleaching on coral populations, by surveying pocilloporid coral distribution, size and bleaching severity at nine locations across the lagoon during a bleaching event (March 2004) and after the event (December 2004 and March 2005).

Bleaching intensity appeared to differ across the lagoon with pocilloporids in central lagoon sites most affected (as indicated by the proportion of colonies bleached in March 2004 and their consequent survivorship). Recovery of bleached pocilloporid corals will also be discussed. Given these corals mainly produce brooded larvae and since self-seeding at the within site level is likely; bleaching may directly affect recruitment at this scale. I will also present results of recruit surveys at these sites during and after the 2004 bleaching episode, and discuss bleaching of other coral taxa relative to the pocilloporids.

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## **Growth trajectories of two species of butterflyfish advected into temperate SE Australia in the East Australian current**

Few coral reef fish larvae return to their natal reefs, but little is known of the fate of larvae advected elsewhere. We are conducting a study of the patterns of recruitment of coral reef fish larvae along the temperate coast of SE Australia, in relation to physical parameters such as East Australian current flow and wind events. Here, we present data on planktonic larval duration and growth, and post settlement growth of 2 species of butterflyfish (*Chaetodon auriga* and *C. flavirostris*) at sites from 23° S to 37° south, using characteristics of their otoliths (earstones). Different patterns of growth and larval duration among locations and among years may be indicative of differences in water temperature and food availability, and may affect persistence of these vagrant fishes in southern waters.

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## **Lipid fraction ratios as an index of condition in hard corals exposed to sediment addition from dredging**

Lipid content has been used as a measure of energetic status and condition in a number of fish and invertebrate species (eg. Hakanson 1993, Harding and Fraser 1999). However common methods for measuring lipid content are time consuming, technically challenging and expensive and these limitations have prohibited the application of lipid content as an impact-monitoring tool. To overcome these limitations, we have developed a rapid low-tech method for determining neutral to polar lipid ratios from hard coral tissue samples. In a preliminary field study, we explore the use of this new method to assess change coral condition in response to anthropogenic sediment addition. Tissue samples were collected from colonies of *Acropora latistella* and *Turbinaria mesenterina* in the Port of Dampier, W.A., prior to, and during, a period of dredge spoil dumping which resulted in these corals being subject to elevated sediment levels. Significant differences in lipid levels were observed between these two species, with the mean lipid ratio of *T. mesenterina* being almost twice that of *A. latistella*. This species difference in lipid energy reserves suggests they could have differing resilience to increased sedimentation and this concurs with the differing distribution patterns of these species along an inshore-offshore turbidity gradient found in the Dampier Archipelago. During dredging, we measured decreases in the lipid ratios of the *T. mesenterina* colonies subject to sediment addition, but this was contradicted by increases in the lipid ratios of *A. latistella* colonies. These results, combined with measures of the percentage of coral cover suggest that the level of sediment they were exposed to may not have significantly stressed these species. This lipid ratio technique has been shown to provide a practical means of investigating natural variation in coral lipid content and with further development to address some limitations highlighted by this initial application, it has the potential to provide a valuable tool for monitoring sub-lethal stress levels in hard corals.

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Centre for Research on Ecological Impact of Coastal Cities, University of Sydney, Sydney, NSW 2006

**Ecology of the small kind: ontogenetic shifts on the rocky shore**

A population of organisms that is partitioned across a resource (e.g. different microhabitats) according to the size of its individuals may indicate a change in behaviour related to the organism's ontogeny. This ontogenetic change in behaviour, however, cannot be simply attributed to the development of a preference by the organism. For example, it may also be (separately or in combination) that the organism is released from previously limiting conditions and is now able to use a different resource. My research is investigating elements of these models using manipulative experiments on the rocky shore.

The population of *Morula marginalba*, a common neogastropod along the NSW coast, is unevenly partitioned across two different habitats; small individuals are more abundant in coralline algae turf than on the open unprotected shore; large ones are equally abundant in both habitats. I used transplant experiments to test if all small individuals behave similarly in their response to the habitat in which they were placed. This model was rejected and the alternate model, that there were sub-populations of small *M. marginalba* that each behave differently, was retained. I am testing this model further by examining movement rates in the different habitats and the ability of individuals to acclimate to new habitats.

A second, but related aspect of the ecology of *M. marginalba* is foraging behaviour. Preliminary experiments on the two size classes indicate that large individuals are attracted to dead gastropods (carrion) on the rocky shore but the small ones appear unaffected regardless of the time of low tide or the habitat where the carrion is placed. Further models examining this difference will involve testing behavioural differences as well as physiological differences.

*M. marginalba* appears to undergo changes in behaviour during its development. Ontogenetic changes in the behaviour of marine invertebrates are not commonly examined after settlement, however, the causes and consequences of later, less conspicuous changes can be particularly relevant to the local ecology.

Brown, Ian<sup>1</sup>, William Sawynok<sup>2</sup>, Mark McLennan<sup>1</sup>, Wayne Sumpton<sup>1</sup>, Adam Butcher<sup>1</sup>, John Kirkwood<sup>1</sup>, Ian Halliday<sup>1</sup>, David Mayer<sup>3</sup>, Gavin Begg<sup>4</sup>, Amos Mapleston<sup>4</sup> and David Welch<sup>4</sup>

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<sup>1</sup> Southern Fisheries Centre, Department of Primary Industries and Fisheries, Deception Bay, Qld 4508<sup>2</sup> Australian National Sportfishing Association, North Rockhampton, Qld 4701<sup>3</sup> Animal Research Institute, Department of Primary Industries and Fisheries, Yeerongpilly, Qld 4105<sup>4</sup> CRC Reef Research Centre, James Cook University, Townsville, Qld 4810**Effects of barotrauma on survival of released reef fish**

Estimation of the impact of cryptic mortality of released line-caught fish requires knowledge of the numbers of fish showing symptoms of hook damage and barotrauma, and the rate of survival of affected fish that are returned to the water. With the assistance of recreational anglers we are collecting data on capture-related injuries and release survival of key tropical reef fish (coral trout, red emperor, small- and large-mouth sea perch, redthroat emperor, spangled emperor and grassy sweetlip). Two barotrauma-relief methods are being tested - venting and shotline releasing. Subsequent tag recapture data are helping to identify the most appropriate release method for each species. Here we examine the susceptibility of red emperor (*Lutjanus sebae*) to barotrauma, and the degree to which its post-release survival is influenced by capture depth. Preliminary results indicate that this species is relatively resilient to the effects of barotrauma and has a good survival rate regardless of relief method. Recapture rates of 12.9%, 8.6% and 10.7% were calculated for untreated, vented, and shotline-released red emperor respectively. For short-term experiments aimed at estimating acute mortality rates we have developed a moored floating vertical enclosure, which overcomes some of the barotrauma-related issues associated with the submerged-cage approach taken in other studies. Initial experiments using this apparatus have been encouraging, although not without some problems, principally relating to operational difficulties in areas of high current flow.

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## **Impacts of land-based abalone aquaculture discharges on adjacent marine communities**

Discharges from land-based abalone farms have the potential to impact adjacent marine benthic communities due to elevated levels of nutrients. Subtidal marine benthic communities were surveyed at three 'non-farm' sites and two 'farm' sites along a 3 km length of rocky coastline on Kangaroo Island off South Australia where two land-based abalone farms have been operating for several years. At each site, three replicate 20m transects were laid out perpendicular to the shoreline from the low tide mark. Along each transect, the benthic community type was described using an LIT method and the number of large (>2 cm) invertebrates was counted in a 1m-wide belt. Counts of invertebrates were also made in five 20x20cm quadrats laid at 5m intervals along each transect, and above-ground biomass of *Posidonia* was harvested from five haphazardly-placed 20x20cm quadrats on each transect. Three artificial seagrass units were placed at each site and left for 3 months to quantify epiphyte accumulation. Triplicate water samples were collected at each site and also from the farm discharge pipes to measure dissolved nitrogen and phosphorous levels.

The benthos at all sites was found to be dominated by macroalgae (*Cystophora*) growing on boulders, with seagrasses (*Posidonia*, *Amphibolis*) growing on sand patches between boulders. The macroalgae and seagrasses appeared healthy at all five sites, however, some subtle differences were detected in the invertebrate communities with significantly greater numbers of gastropods at the farm versus non-farm sites. Elevated levels of nutrients were also detected in the outfalls and at the farm sites. These (and other) results of the subtidal survey are discussed in terms of possible impacts due to the farm discharges.

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## **Effects of shading and nutrient enrichment on seagrass and *Caulerpa taxifolia* interactions**

*Caulerpa taxifolia* gained widespread notoriety as an invasive alga in the Mediterranean, which lead to widespread seagrass loss. *C. taxifolia* is native to Queensland, with Moreton Bay being the southern most extent of its natural distribution. However, benthic surveys conducted over the last 7 years suggest that *C. taxifolia* distribution is increasing and may be replacing seagrass. The aim of the current study was to examine interactions between *Caulerpa taxifolia* and seagrass in relation to changes in water quality. We examined: (1) the growth and expansion rate of *C. taxifolia* and (2) the impact of shade and nutrients on seagrass and *C. taxifolia* growth and interactions. *C. taxifolia* transplants initially grew significantly better at sites with lower water quality; however, after 8 weeks there was 80% transplant mortality at all sites. We also found that *C. taxifolia* growth was stimulated by nutrients; however, shading significantly decreased *C. taxifolia* cover with and without nutrient enrichment. Although previous studies suggest that *C. taxifolia* may be having an ecotoxicological impact on seagrass, the results from the current study suggests that *C. taxifolia* may be opportunistically colonizing sites where seagrass is no longer growing, rather than actively displacing seagrass.

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## **Evo-devo and cryptic species, discovery of a new intertidal sea star from the Great Barrier Reef**

Asterinid sea stars have the greatest range of life histories known for the Asteroidea. Larval form in these sea stars has been modified in association with selection for planktonic, benthic or intergonadal developmental habitats. Investigation of the evolution of development in asterinids revealed a suite of cryptic species from intertidal habitats in tropical Australian and elsewhere in the Indo-Pacific. These are in a new genus, *Cryptasterina*. Several *Cryptasterina* species are unusual in brooding their young in the gonads and giving birth to their young. In addition to the recently described species from central Queensland *C. hystera*, a new species has been discovered from One Tree Island in the southern Great Barrier Reef. These species are sister taxa and are both viviparous. The coastal species releases its young as small stars similar in size to the post-larvae of planktonic developers, while the island species broods its young to the advanced - near mature stage. Intra-uterine growth in the new species is supported by sibling cannibalism. Viviparity in the Asterinidae arose at least three times within the last 0.5-3 Mya. As diverse modes of development are discerned in cryptic species complexes, new species are being discovered and insights into life history evolution are being generated.

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## **Balancing biodiversity protection and fisheries management in the Great Barrier Reef Marine Park**

Trying to achieve a balance between biodiversity protection and fisheries management in the Great Barrier Reef Marine Park (GBRMP) is complex and often controversial; it requires close cooperation between several government agencies and extensive consultation with key stakeholders and the community. The GBRMP is zoned to regulate the types of fishing that can occur in particular areas, recognising that different fishing methods have different ecological impacts. During the past five years, the GBRMP has been rezoned to ensure that representative examples of at least 20% of each bioregion (broad habitat type) are protected in no-fishing zones. The new zoning plan for the GBRMP came into effect on 1 July 2004 and increased the area of no-fishing zones from less than 5% to over 33% of the 344,400 square kilometre GBRMP. The innovative approaches and lessons learnt from the rezoning program (which attracted some 30,000 written submissions from the community) are described. At the same time, substantial changes have occurred in the management regimes for several GBRMP fisheries, including the large-scale trawl and coral reef finfish fisheries and several smaller-scale dive-based fisheries.

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## **Australian government approach to developing the NRSMPA: Combining science input and stakeholder engagement**

This presentation describes how the Australian Government is embracing the challenge of establishing a National Representative System of Marine Protected Areas (NRSMPA) in its jurisdiction (seaward of three nautical miles to the limit of its Exclusive Economic Zone) as part of regional marine planning established under *Australia's Oceans Policy*. A key challenge is the limited availability of detailed ecological information available for offshore marine regions. While some good biological and oceanographic data is available, it is far from comprehensive and it will take many years to advance our knowledge to a finer scale. In developing MPAs the Government is using the best available scientific information and is drawing on a number of scientists to provide guidance and analysis of the available scientific information. However, recognising the limits of existing scientific information, the process also draws on stakeholder expertise and knowledge to assist MPA design. The Government's approach aims to achieve biodiversity conservation while minimising socio-economic costs and maximising long-term stakeholder support for MPAs. While the approach may not lead to a 'perfect' outcome, the peer review at the end of the process will provide the Government with a comprehensive assessment of how the candidate MPAs meet biodiversity conservation objectives. There is also the opportunity through on-going performance assessment to adopt a staged and adaptive approach, increasing levels of protection as more information about the specific economic, cultural and ecological values in the area is gathered and assessed.

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## **Delivering biosecurity in a fluid environment**

Marine bioinvasions have resulted in significant ecological, economic, and social consequences in various regions of the globe. This issue is now considered to be one of the top threats to native biological diversity, equal to the threat posed by human-mediated global climate change. Protecting the marine environment from biological invasions of non-indigenous species, marine biosecurity, has a high profile in both Australia and New Zealand. Both countries are keenly dependent on shipping as the primary mode of trade. Simultaneously, both countries have a strong conservation ethos for their oceans. As a direct result, marine biosecurity has been given a high profile in the development of policy and legislation. Much like the terrestrial environment, multiple vectors and pathways provide ample opportunities for new species to arrive in a region. However, the disparities in baseline knowledge, upstream information, detection ability and fundamental lack of public and sector awareness of impacts and risks require a rigorous strategy of policy and operational development if biosecurity is to succeed.

Within New Zealand, government funding has provided the opportunity to begin reducing the knowledge gap through baseline surveys and surveillance activities, increasing risk profiling capacities, and developing public awareness documents about specific target species and risk pathways. Two particularly new initiatives, value and risk mapping, have application beyond a biosecurity focus; being of use and benefit to Maori, the conservation estate, maritime safety, regional councils and industry.

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**How estuaries deal with nitrogen – a scaling approach**

There are many approaches to model the complex transformations and partitioning of nutrients, particularly nitrogen, within estuaries. Complex biogeochemical models consider many types of organism and biologically active material found in the water column and sediments. Many of the interactions in these models involve a conservative flux of material from one state variable to another. For some purposes, the biogeochemistry can be simplified by considering the cumulative effects of many mechanisms and summing over state variables. Thus, for example, several state variables such as phytoplankton, zooplankton, dissolved nitrogen and detritus can be summed to obtain a single variable that represents “the biology” of the water column which is related to light attenuation. Light attenuation is found to scale as the square root of nutrient loading. Increased nutrient load can therefore critically change the distribution and abundance of benthic macrophytes. Nutrient forcing also scales according to catchment area and waterway area so systems that tend to have higher nutrient loading are often better exchanged with the ocean. Similar considerations for other important drivers of estuarine condition such as exchange with the ocean can be scaled to catchment area. The extent to which river flow flushes an estuary/lake scales as the ratio of catchment area to estuary/lake volume. An empirical scaling rule is obtained to determine the fraction of the nutrient load that passes through the estuary too quickly to contribute to biogeochemical cycling. Thus, a suite of scaling rules has been developed that enable the broad characteristics of the catchment and estuary geomorphology to be accounted for in a quantitative determination of the response of an estuary/lake to catchment degradation. The application of these scaling rules to categorise NSW estuaries is explored.

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In October 2004, a joint collaboration was undertaken by the Australian Institute of Marine Science (AIMS), Charles Darwin University (CDU) the National Research Centre for Ecotoxicology (ENTOX) and Department of Infrastructure, Planning & Environment (DIPE) to compliment the existing Water Quality Monitoring Program in Darwin Harbour. Our aim was to assess *in situ* environmental contaminants and their bioavailability at various sites around Darwin Harbour. Time integrated samplers known as semi-permeable membrane devices for polycyclic aromatic hydrocarbons (SPMDs) and diffusive gradients in thin films (DGTs) for labile dissolved metal species were deployed in 4 locations (Sadgroves Creek, Shell Island, Hudson Creek and West Arm) for a period of 10 days. In addition at Sadgroves Creek and West Arm, biomonitoring was conducted using wild caught barramundi (*Lates calcifer*). Several biomarkers, already well established in barramundi, were evaluated and they included bile metabolites, cytochrome P450s and 7-ethoxyresorufin-O-deethylase (EROD). Two other biomarkers were evaluated: vitellogenin in blood to assess potential impact from sewerage into Darwin Harbour, and sorbitol dehydrogenase (SDH) a potential biomarker of liver damage. PAH concentrations measured by SPMDs were relatively low ( $\mu\text{g/L}$ ), however, there was a delineation in PAH concentrations from the eastern to western side of the harbour. PAH concentrations at the West Arm site were below detection whilst PAH concentration at Sadgroves Creek, Hudson Creek and Shell Island were all similar (1.0, 0.674 and 0.729  $\mu\text{g/L}$ , respectively). DGTs labile metals showed no distinctive pattern in concentrations for Ga, Cd, and V, Fe, Cu and U. Al appeared to be higher at Sadgroves Creeks and Mn and Ni were higher at Hudson Creek. Mean concentrations of EROD activity, cytochrome P450, SDH activity, and vitellogenin were not significantly difference ( $p > 0.05$ ) in barramundi from Sadgroves Creek and West Arm and they were comparable to basal levels measured in hatchery-reared barramundi used as a non-exposed reference (courtesy of ABC barramundi farms). These results provided a baseline survey of PAHs and labile dissolved metals at several sites in Darwin Harbour, which compliments the data being generated from the Darwin Harbour Water Quality Monitoring Program. As development of Darwin Harbour progresses, these data provide a framework in which changes in water quality and impact on resident biota can be monitored and assessed.

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## Measuring scales of carbon movement and assimilation by invertebrates in estuaries using stable isotopes

Carbon is generally considered to be more mobile in aquatic than terrestrial systems. It therefore cannot simply be assumed that aquatic animals derive their nutrition from plants in their immediate vicinity. The potential separation of animals and their ultimate autotrophic energy source has implications for the conservation of aquatic fauna, including fisheries resources. We tested the extent of movement and assimilation of carbon among estuarine habitats in subtropical and temperate Australian waters. We measured carbon isotope values of sedentary invertebrates along transects crossing the boundaries of habitats in which the dominant autotrophs had very different carbon isotope values. In the subtropics, we sampled omnivorous shore crabs and snails in several pairs of adjacent areas of saltmarsh grass (mean C isotope value -12‰) and mangrove forest (-28‰). In temperate waters, we sampled carnivorous and detritivorous polychaete worms along transects hundreds of metres long, from the edge of mangroves (C isotope value -28‰), across intertidal mudflats containing benthic microalgae (-21‰), and into subtidal seagrass meadows (-12‰ for both seagrass and epiphytic algae). The extent of carbon movement and assimilation by sedentary invertebrates differed in the two regions. In the subtropical surveys, animal C isotope values matched those of the dominant autotrophs immediately alongside, and therefore changed rapidly across the saltmarsh-mangrove boundary. The animals evidently obtain their carbon from sources in the surrounding few metres. In temperate waters, animal C isotope values were similar at all positions along the transects, and consistently matched values for seagrass and epiphytic algae. Animals here utilise carbon from seagrass meadows regardless of their proximity to the meadows. Further tests in other regions will help to elucidate the underlying factors determining the extent of carbon movement and assimilation.

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## Trophic transfer of carbon, nitrogen, sulfur and fatty acids between detached macrophytes, the amphipod *Allorchestes compressa* Dana and its fish predators in south-western Australia

Detached macrophytes (commonly called wrack) comprise seagrass and macroalgae, which wash into the surf zone from offshore areas and provide food for invertebrates, which in turn are consumed by fish in nearshore areas. The amphipod *Allorchestes compressa* has been shown in past studies to be the dominant macroinvertebrate in south-western Australian wrack, and is one of the main prey of juvenile fish in wrack habitats. The present study examined the role of different types of detached macrophytes in providing the major food source(s) for the amphipod *Allorchestes compressa*, and two species of fish predators in unvegetated nearshore areas in south-western Australia. This was investigated using a combination of stable isotopes ( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$  and  $\delta^{34}\text{S}$ ), together with signature fatty acid profiles, for different species of detached macrophytes, *A. compressa* and fish from three nearshore sites in south-western Australia. Carbon stable isotope analysis showed clear separation between macroalgae and seagrass primary producers, but not between different types of macroalgae. Comparison of fatty acid profiles revealed clear separation of all different plant types, i.e. brown algae, red algae, green algae and seagrasses. Fatty acid compositions of consumer species (amphipods and fish) were most similar to the fatty acid composition of brown algae. The combined stable isotope and fatty acid analyses from all three sites suggest that brown algae makes a greater contribution to the nearshore food web in south-western Australia than other types of benthic primary producers. Results of this study suggest that fatty acid composition provides a valuable tool to clarify ambiguous results from stable isotope analyses.

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## ***Caulerpa taxifolia*: history of spread and control efforts in NSW**

*Caulerpa taxifolia* was first reported in temperate Australian waters in 2000. It is now established in 9 locations in New South Wales. Prior to its discovery in temperate Australia, this species had been classified as a 'marine pest' based on its rapid spread and domination of several subtidal areas in the Mediterranean. In Australia, the situation is complicated because *C. taxifolia* occurs naturally in tropical waters, extending into the subtropical areas of southern Queensland. Never-the-less, the species is classified as a noxious pest in southern states and programs to attempt its eradication in NSW and South Australia have been initiated.

Possible eradication techniques for *C. taxifolia* trialed in NSW included smothering with a range of materials, underwater suction devices, handpicking and the application of salt. Results showed that *C. taxifolia* is readily killed by a layer of salt granules. Applications over large areas can drastically reduce the areal coverage and limit the alga's spread. Results from such large-scale applications have been patchy, however, with good success in Lake Macquarie but only short-term relief in other estuaries. Targetted applications of salt at high risk sites such as boat ramps is continuing in an effort to prevent fragments being inadvertently transferred to other estuaries.

Regular mapping of *C. taxifolia* beds in summer and winter over 4 years has allowed an assessment of spatial and temporal variability in abundance of the seaweed and the identification of new areas requiring treatment with salt or other management responses.

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## **Impact of copper and salinity variation on mobile epifauna associated with the brown alga *Sargassum linearifolium***

The discharge of stormwater into marine and coastal areas poses a major threat to ecosystem biodiversity and function. Standard test procedures and indicator species used to generate stormwater quality guidelines generally have limited applicability to Australian marine systems. Consequently, the actual impacts of stormwater discharge on local assemblages are largely unknown. This study assessed the impacts of two stormwater components, copper and lowered salinity, on a mobile epifaunal assemblage associated with the brown alga *Sargassum linearifolium*. *S. linearifolium* is widely distributed in Australian temperate waters and provides food and habitat for a diverse assemblage of mobile invertebrates. Higher copper and lowered salinity levels decreased species abundance and richness within the algal assemblages. Amphipods were the most sensitive taxonomic group with the Lowest Observable Effect Concentration (LOEC) of 250  $\mu\text{gL}^{-1}$  Cu and 25‰ for salinity. A second experiment aimed at identifying a relevant local indicator species from amongst the amphipod group was undertaken. Salinities were not manipulated and *Peramphithoe parmerong* was identified as the only sensitive amphipod species to copper exposures with an LOEC of 300  $\mu\text{gL}^{-1}$  Cu. This LOEC was reduced to 100  $\mu\text{gL}^{-1}$  Cu when single species tests with higher power were carried out. Additional measures of latent mortality revealed a further 40% decrease in *P. parmerong* survivorship levels, 24 h after individuals were placed in clean seawater. The relatively high sensitivity and abundance of *P. parmerong* within the assemblage suggests it may be a useful indicator species for deriving water quality criteria in temperate Australian waters. Copper concentrations in all the experiments were influenced by the proportion of algal surface area relative to the microcosm size. Thus, it is vital that the impacts of microcosm design and algal surface area be considered when quantifying copper effects on associated marine invertebrates.

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## **Population connectivity in temperate rocky reef fishes: implications for the design of Marine Protected Areas**

Knowledge of connectivity among local populations of fishes is fundamental to the design of MPAs (Marine Protected Areas) and evaluation of their success. Despite this, data on connectivity are few, inconclusive, or have been collected at temporal and spatial scales inappropriate to MPAs. The broad objective of this study was to investigate connectivity among populations of temperate rocky reef fishes at scales of hundreds of metres to hundreds of kilometres along the coast of NSW. Models of connectivity were formulated *a priori* based on knowledge of the biology of fishes examined and habitat continuity. It was predicted that connectivity would be reduced as distance along the coastline increased, and as distance between reef habitats increased, and that this relationship would be influenced by the mobility of adults. These hypotheses were tested using sedentary and highly mobile fish taxa. Different methods for measuring connectivity among populations of marine organisms have inherent limitations that may lead to ambiguous results. A multidisciplinary approach was therefore used including: spatial and temporal measurements of fish abundance, tagging, otolith microchemistry and genetic markers. These data will be used to provide advice on the scale at which local impacts (e.g. fishing) may effect populations, the scale at which local populations should be managed, and the scale that we should expect and test for benefits of MPAs in this region.

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## **Comparison of sand dune migration patterns during the Monsoon and Trade Wind seasons near Turnagain Island, Torres Strait**

Investigations into sediment mobility and its potential impact on seagrass habitats have been undertaken around Turnagain Island as part of the Torres Strait CRC. Repeat high resolution multibeam sonar surveys undertaken during both the monsoon (March 2005) and trade wind seasons (October 2005) have highlighted contrasting patterns of bedform mobility during single spring/neap cycles. During the April survey sand dune crests generally migrated in a westerly direction with the crests of the larger sand dune migrating by up to 16m. During the October survey the migration patterns were much more complex. The overall displacement of the sand dune crests was typically less than two meters but showed a west/east ebb/flood dominant pattern. Between the survey seasons the migration pattern is westward and generally between 5-25m. This is consistent with a dominantly westward flow through Torres Strait.

Although the local migration of the sand dunes was complex only part of the sand bank itself changed position between March and October. The north east portion of the bank moved (by approximately 20m) though elsewhere the bounds of the sand bank remained unchanged. Data from these surveys show that while oceanographic processes are influencing migration and changes in the morphology of sand dunes within the survey area there was little net change in the distribution of the dunes between the survey seasons. These results indicate that migrating sand dunes have the potential to bury seagrass communities that occur within a close proximity to the dunes.

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## **Feedback, fragmentation, and the spread of *Caulerpa taxifolia* in southeastern Australia**

The green alga *Caulerpa taxifolia* was first discovered in temperate Australia in 2000 and now occurs at eleven locations with an estimated cover of almost 800 hectares. One mechanism proposed as important in the invasion of *C. taxifolia* worldwide is the ability of thalli to fragment and consequently reattach. Here, we describe a series of experiments designed to understand the causes of fragmentation and its consequences to the invasion of *C. taxifolia* in temperate Australia. Specifically we, (i) compared fragment abundance in native tropical and subtropical populations to invasive temperate populations, (ii) experimentally assessed the importance of different factors (particularly human-related) in producing fragments in invasive populations, and (iii) experimentally examined the relative importance of fragmentation and stolon growth to the expansion of patches and to local population biomass. Rates of fragmentation were much higher in invasive vs. native populations with over 6000 fragments/m<sup>2</sup> in some invasive sites. Anthropogenic factors (boating and swimming) generated significantly more fragments, compared to non-impacted sites. Significantly, vegetative growth of stolons underpinned patch expansion. Plots with stolons growing into them always had a greater abundance than plots where stolons were removed, even when fragment recruitment was experimentally increased. Greater fragment recruitment only resulted in greater abundance when stolons were absent, a situation analogous to the establishment of new populations. Although post-recruitment processes were more important in determining abundance during patch expansion, there was greater ambient fragment recruitment when stolons were present compared to when they were absent, demonstrating an important feedback between stolon growth, abundance and fragment recruitment. In established patches, greater fragment recruitment over 6 months (six levels of recruitment ranging from 0 to 480 recruits m<sup>-2</sup> mo<sup>-1</sup>) had no effect on biomass. Our experiments demonstrate that the rapid expansion of *C. taxifolia* and its high abundance are underpinned by post-recruitment vegetative growth and, during expansion, by a feedback between vegetative growth and asexual fragmentation.

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## **Remote sensing of estuarine waters, seagrasses and coral reefs**

An overview is presented of the current state-of-the-art of remote sensing in optically complex waters where the colour of water as measured by a remote sensor is either a result of high concentrations of coloured dissolved organic matter, phytoplankton and suspended matter or influenced by bottom visibility (seagrasses, macro-algae, corals, sands etc.).

Examples are presented of applications of remote sensing from aircraft and satellite sensors for a wide range of applications varying from detailed seagrass mapping to coral bleaching detection and bathymetry mapping to water quality compliance monitoring.

The spatial scales at which these information products are becoming available ranges from 2 m pixels to 1 km pixels and the temporal frequency from once a year to twice a day. Examples of possible end-products for relevant Australian and international applications will be presented.

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## **Fisheries and Marine Protected Area management – are we working together?**

In recent years, federal and state governments in Australia have taken significant steps to establish networks of Marine Protected Areas (MPAs), and to substantially increase the area of “no take” zoning in established MPAs such as the Great Barrier Reef Marine Park. Such initiatives inevitably raise long-standing questions regarding the interaction of MPAs and fisheries management arrangements, and whether planning and management regimes designed to meet differing sets of resource management and conservation objectives can be more effectively aligned.

This paper will explore some of the issues around the respective goals and paradigms of fisheries and MPA managers, drawing on examples from Queensland-managed fisheries and fish habitat. Matters for consideration include effort displacement as a result of introducing “no take” areas and the potential biological and socio-economic consequences of concentrating fishing effort outside the MPA closures. Another important challenge where multiple-use MPAs are overlaid on fisheries management, is how to sustainably manage the harvest of species which, because of their biological characteristics, are more suited to rotational rather than permanent fisheries closures.

Reducing potential conflict and achieving enhanced integration of fisheries management and MPAs will require a capacity to identify common goals and recognise how each type of approach can “add value” to the other.

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## **Benthic communities in the Murray “estuary”**

The Murray River connects to the southern ocean in a series of lakes and lagoons. Since the construction of barrages, environmental conditions in this estuary vary considerably, separating the freshwater lakes from a marine to brackish Murray Mouth region and hypersaline conditions in the Coorong lagoon. This extensive wetland area is a Ramsar site, yet shorebird numbers have declined in recent years. We investigated whether benthic communities in this estuary reflect the current environmental conditions and if benthic abundances and biomass provide sufficient food for migratory shorebirds. A total of 51 taxa were distinguished, with species numbers nearly twice as high near the Murray Mouth than further south in the Coorong. Mean abundances near the Murray Mouth (about 26000 ind. m<sup>-2</sup>) were on average four times higher than in the Coorong, where several sampling sites were devoid of benthic macrofauna. Benthic communities at the Murray Mouth and the northern end of the Coorong lagoon were characterised by several polychaete species (*Capitella* sp., *Simplesitia aequisetis*, *Australonereis ehlersi*), amphipods and the micromollusc *Arthritica semen* and differed from the southern Coorong and Lake sites where insect larvae, oligochaetes and amphipods characterised the assemblages. Benthic food availability for waders is confined to mudflats near the Murray Mouth and northern Coorong. The data are discussed in comparison to records from other overwintering as well as stopover sites for migratory shorebirds and possible implications for the water management in this “estuary” will be considered.

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## Great Barrier Reef Seabed Biodiversity Project: a progress report

The Great Barrier Reef Marine Park is the world's largest marine protected area containing >200,000 km<sup>2</sup> of shallow continental shelf. The majority of this space consists of sedimentary environments and shoal bottoms. While the iconic coral reefs and intertidal seagrasses have captured our attention, comparatively little is known about these other submerged habitats.

From 2003 to 2006, the Great Barrier Reef Seabed Biodiversity Project will sample sea floor habitats and their associated life at approximately 1,300 locations in depths to 100m. The information will have two major applications: mapping habitats and biodiversity patterns to support marine conservation planning, and informing risk-assessments to ensure that trawl fisheries within the Marine Park are ecologically sustainable activities.

The Great Barrier Reef Seabed Biodiversity Project is a major collaboration involving two research vessels, four research providers (AIMS, CSIRO, Queensland DPIF, Queensland Museum), and three funding agencies (CRC Reef, Fisheries RDC, National Oceans Office). Biological samples will be sorted in at least six laboratories, and Geosciences Australia will analyse the sediment samples for the national marine sediment database.

The presentation will cover the history, sea-going operations, and progress of the Seabed Project as it enters its third and final year.

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## Water quality and plankton composition of Darwin Harbour

The port of Darwin is Australia's only tropical harbour and is Australia's closest port to SE Asia. The environment within Darwin Harbour is still relatively pristine, with extensive mangrove forests fringing the harbour and a diverse range of ecosystems within the harbour itself, including some coral-dominated communities. The harbour is macro-tidal (7.8m tidal range) and the waters are turbid. During 2002-2004, in collaboration with DIPE, the Australian Institute of Marine Science embarked on a more intensive monitoring program of Darwin Harbour than what had previously been undertaken. This program looked at nine sites throughout the harbour during the wet and dry seasons, with water quality and plankton composition measurements being taken. Standing stocks of nutrients were found to be low (e.g. NO<sub>3</sub> -0.3 µM in the dry season, 1.5 µM in the wet season), as were levels of total chlorophyll. From measurements of zooplankton abundance and distribution within the harbour copepods were found to dominate, with typical small mangrove species being seen.

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## **Mapping the geomorphic habitats of Australia's near-pristine estuaries**

The Coastal CRC recently completed mapping the geomorphic habitats of 158 Australian 'near-pristine' estuaries. These new maps aim to redress a gap in the National Land and Water Resources Audit (NLWRA) mapping, where only 41 of the 537 Australian coastal waterways mapped were in near-pristine condition. When combined with the geomorphic habitat maps completed for the NLWRA, the entire compilation comprises around 700 estuaries ranging in condition from near-pristine to extensively modified. This complete set of maps is now available for download on the OzEstuaries Website ([www.ozestuaries.org](http://www.ozestuaries.org)). The additional near-pristine estuary maps provide important baseline information for comparisons between regions and systems, in terms of water quality, ecology, and geomorphology without the overprint of human impacts. They also allow for geomorphic comparisons between near-pristine and modified estuaries.

The Coastal CRC mapped the spatial extent of different geomorphic habitats within estuaries using high-resolution aerial photographs and Landsat ETM7+ satellite images, which were processed to delineate a range of habitat areas. Our presentation will show examples of completed maps developed using a combination of GIS packages and a more streamlined mapping process compared to that of the NLWRA. The maps presented will demonstrate how the geomorphology of estuaries differs according to geographic location where we will show maps of near-pristine estuaries that typify their geographic region eg. south-east, south-west, north-east and north-west Australia, The Great Australian Bight, and the Gulf of Carpentaria. Some geomorphic mapping limitations will also be discussed.

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## ***Engrailed* is expressed in larval development and in the radial nervous system of *Patiriella* sea stars**

We documented expression of the pan-metazoan neurogenic gene *engrailed* in larval and juvenile *Patiriella* sea stars to determine if this gene patterns bilateral and radial echinoderm nervous systems. *Engrailed* homologues, containing conserved En protein domains, were cloned from the radial nerve cord. During development, *engrailed* was expressed in ectodermal (epithelium, nervous system) and mesodermal (coeloms) derivatives. In larvae, *engrailed* was expressed in the ectoderm and in cells lining the larval and future adult coeloms. *Engrailed* is not expressed in the larval nervous system. As adult-specific developmental programs were switched on during metamorphosis, *engrailed* was expressed in the CNS and PNS, paralleling the pattern of neuropeptide immuno-localisation. *Engrailed* was first seen in the developing nerve ring and appeared to be up regulated as the nervous system developed. Expression of *engrailed* in the nerve plexus of the tube feet, repeated structures along the arm, is similar to the reiterated pattern of expression seen in other animals. *Engrailed* expression in developing nervous tissue reflects its conserved role in neurogenesis. The role of *engrailed* in patterning repeated PNS structures appears separate from its role in CNS development. *Engrailed* may be important in the patterning the 5-fold organisation of the ambulacrae, a defining feature of the Echinodermata.

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## **Who Owns the Sea? – a student research project**

Set on the shores of Tasmania's D'Entrecasteaux Channel the Woodbridge Marine Discovery Centre (WMDC) challenges students of all ages to learn about, discover and care for the marine environment through diverse shore and sea-based programs. In an innovative new program at the Centre Grade 9/10 students from Tasmanian schools have a unique 'authentic learning' opportunity to work with live marine animals and aboard a 13.5m research vessel, Penghana

Students spend the whole week in research teams collecting environmental data and studying the biodiversity of four sites in the D'Entrecasteaux Channel. As well they have the opportunity to meet and work with marine scientists from Australia's premier research facilities including CSIRO, the Australian Antarctic Division, the Tasmanian Aquaculture and Fisheries Institute and IASOS.

As a culminating performance each team prepares a report presenting and analysing the data collected. Students undertake role play exercises and case studies which enable them to develop an appreciation of the roles different stakeholders play in the stewardship of the ocean.

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## **Biogeochemical dynamics of an intermittently open estuary during an open-closed cycle**

A spatially resolved biogeochemical model has been developed to examine biological dynamics of an Intermittently Closed and Open Coastal Lagoon (ICOLL) during an open-closed cycle. This model attempts to use process based, biomechanical descriptions of growth which reduces the need for an extensive calibration of model parameters, by allowing the use of physically defined constants to determine maximum uptake rates of nutrients and light. The model is spatially resolved to 12 homogeneous boxes, corresponding to field sites and catchment and lake characteristics, with mixing co-efficients calibrated from known salinity values. In this study, modelled and field data is used to assess the impact of opening regimes on Smiths Lake, a relatively large, seagrass dominated ICOLL on the mid-north coast of NSW. The model and field data highlights the contrast in the ecology of ICOLL's between open and closed phases as well as following opening phases of different duration.

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## **Maternal provisioning in *O. schayeri* and *O. fasciata*: two brittle stars with contrasting mode of development**

The biogeography of marine invertebrates is highly dependant on their life history traits. Species with small eggs have a high fecundity, a dispersive larval phase and potentially higher death rates. While species with big eggs have a lower fecundity, restricted dispersal and potentially lower mortality. For echinoderms planktotrophic development is considered to be the ancestral state. The evolution of a bigger egg with increased maternal reserves is thought to precede the evolution of non-feeding development. As lipids have been identified as a major energy source for development in other marine invertebrates. It appears that the increase in maternal provisioning in large eggs is achieved by an increase in the lipid content of the egg. In contrast to the assumption that additional energy is needed for development of the non-feeding larva, it is likely that most lipid reserves are retained for the vulnerable postmetamorphic stage. Here I explore the fine-tuning of egg nutritive profiles in two ophiuroid species through documentation of the total lipid/protein content and the abundance of various lipid classes per egg. The two species investigated are *Ophionereis schayeri*, a lecithotrophic developer with a non-feeding vitellaria larva, and *Ophionereis fasciata* with planktotrophic ophiopluteal development.

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## **Hydrodynamics, nutrient status and phytoplankton ecology of a western Victorian salt wedge estuary**

Western Victorian estuaries have been classified as highly stratified “salt wedge” estuaries. Several estuaries in western Victoria, including the Merri River estuary, have been subject to nutrient eutrophication and algal blooms. This study adopted a field based methodology to identify the annual hydrodynamics, nutrient status and phytoplankton communities of the Merri estuary. The study also included whether algae and invertebrates that settle onto artificial substrate could be used as a measure of environmental factors such as nutrient enrichment. The study found that the hydrodynamics of the Merri River estuary was dissimilar from other estuaries in the region. This estuary was found to have very high nutrient levels compared with guidelines specified by ANZECC (2000). Compared with other studies in the region the Merri estuary had a large diversity of phytoplankton with high algal cell concentrations. Rutledges Cutting, a second opening to the river had a much lower number of species which was expected, as the water body becomes hypersaline over the summer dry period. The estuary complex was subject to two algal blooms over the study period which lead to the public closure of the water way. This bloom coincided with the summer low flow period where nutrient enrichment was greatest. There is public concern that high levels of nutrients are being discharged into the newly proclaimed Merri Marine Sanctuary. The study results of the settlement component are not available to date.

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## **Natural regeneration of the benthic environment: tuna aquaculture as a case study**

Sediments in the vicinity of fish farms are subject to deposition of solid wastes in the form of faeces, uneaten feed and detritus from fouling on the nets. In this study we investigated the ability of the benthic environment to turnover these additional nutrient inputs. Sediments under two commercial pontoons used for the farming of southern bluefin tuna in Port Lincoln, South Australia, were compared to two control sites during a full growout period from February to August 2004. Sedimentation rates varied with feeding, peaking at the beginning of fish stocking in March, when values were up to 4 times those at controls, but decreasing after April. Concentrations of phosphate, and to a lesser extent ammonia, in porewaters increased two weeks after stocking, and continued increasing to the end of the season. Higher values in these transient reserves that are available to diffuse into the overlying water column were reflected in higher benthic fluxes. However, these porewater reserves were small in comparison to the total nitrogen and phosphorus reserves in the sediments, and increased values of the latter only became evident towards the end of the stocking period. Although the metabolic response of the benthos was gradual, with organic matter remineralisation increasing throughout the season, it showed an extraordinary ability to process the organic matter reaching the seafloor. Towards the end of the season, there was more material being remineralized at the sediment-water interface than reaching the seafloor. Three to four months after the end of the stocking period, sediment nutrient stores and fluxes were only marginally higher than the natural background. Given that sites are left to fallow for two years, one would expect complete recovery provided that there is no interference from nearby farms or lease rotations.

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## **Expatriation of tropical fishes into temperate SE Australia**

Dispersal of larval organisms is the major mechanism facilitating connectivity of marine populations. However, only a tiny fraction of dispersed larvae return to suitable habitat. For coral reef fishes, larvae are advected away from coral reefs despite strong behavioural mechanisms (inc. swimming) and some may travel long distances away from the tropics. Understanding how these processes occur and the exact nature of their species specificity will add greatly to our ability to describe the large scale population biology of these fishes. Here we study the recruitment of tropical fishes into the temperate waters of south-eastern Australia using three years of visual survey data. We document recruitment patterns and look for synchrony amongst species. We also use water temperature data to study the influence of the East Australian Current as a transport/delivery mechanism and as a factor in determining the ultimate long-term persistence of these warm water species. Results indicate complex patterns of recruitment but provide some evidence for synchronous settlement, especially for *Chaetodontids*. The relationship between water temperature and recruitment seems to be quite complex and while there is some evidence for a straightforward link between spikes in water temperature and recruitment, there are other factors such as supply and certainly wind forcing that will need to be accounted for.

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## **A risk-based predictive tool to prevent accidental introductions of non-indigenous marine species**

Preventing the introduction of non-indigenous species (NIS) is the most efficient way to avoid the costs and impacts of biological invasions. The transport of fouling species on ship hulls is an important vector for the introduction of marine NIS. We use quantitative risk screening techniques to develop a predictive tool of the abundance and variety of organisms being transported by ocean-going yachts. We developed and calibrated an ordinal rank scale of the abundance of fouling assemblages on the hulls of international yacht hulls arriving in New Zealand. Fouling ranks were allocated to 783 international yachts that arrived in New Zealand between 2002 and 2004. Classification tree analysis was used to identify relationships between the fouling ranks and predictor variables that described the maintenance and travel history of the yachts. The fouling ranks provided reliable indications of the actual abundance and variety of fouling assemblages on the yachts and identified most (60 %) yachts that had fouling on their hulls. However, classification tree models explained comparatively little of the variation in the distribution of fouling ranks (22.1 %), had high misclassification rates (~43 %) and low predictive power. In agreement with other studies, the best model selected the age of the toxic antifouling paint on yacht hulls as the principal risk factor for hull fouling. Our study shows that the transport probability of fouling organisms is the result of a complex suite of interacting factors and that large sample sizes will be needed for calibration of robust risk models.

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<sup>2</sup> Aquatic Zoology, Australian Museum, Sydney NSW 2010

## **Long-term changes in polychaete assemblages of Botany Bay (NSW) following a dredging event**

Little is known about the long-term effects of marine aggregate dredging on benthic invertebrates in the Southern Hemisphere. Few studies have followed dredged sites to complete recovery. From late 1992 until late November 1993 areas of the seafloor in Botany Bay (NSW, Australia) were dredged to provide infill for a third parallel runway at Sydney Airport. The Australian Museum was commissioned to assess the recolonisation and recovery of these sites from April 1994 until October 1995. Reference sites in Pittwater and Port Hacking were studied for comparison during this time. Abundance, species richness and biomass of the macrofauna were monitored at all sites, as well as sedimentary characteristics and depths. By the end of the study, in late 1995, the benthic assemblages of the impact sites had not fully recovered. A new study revisited all sites, impact and reference, in September and December 2004. The primary aim of the new study was to assess the long-term recovery of polychaetes in the impact sites. The study followed the methods employed during the previous study as closely as possible. Fifty-six grab samples were collected in total, and polychaetes were identified to species. Data on polychaetes from this and the previous study were analysed, using univariate and multivariate statistical methods, to assess the state of recovery at the impact sites. Analyses were carried out at species, genus and family levels to gauge the effectiveness of the study at different taxonomic resolutions. Although the present study could not address any changes in the benthos during the years between the two studies, it was possible to document and quantify changes after this period, and to speculate how these changes may be related to the dredging events of 1992 and 1993.

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## Effects of spearfishing in the Great Barrier Reef Marine Park

The legitimacy of recreational spearfishing in the Great Barrier Reef Marine Park (GBRMP) has been debated for many years. Unfortunately, however, there is no objective information on the effects of spearfishing, nor on the efficiency of spearfishing in relation to other, more socially-acceptable forms of fishing. The objectives of this project, therefore, were to assess the effects of spearfishing on a fringing reef in the GBRMP, and (2) compare the catch per unit effort (CPUE) of spearfishing to that of linefishing.

The size and (or) abundance of several target and non-target species was assessed before Palm Island reef was opened to spearfishing (as part of the rezoning process of the Representative Areas Program). Preliminary results obtained one year later indicate little change in the size and (or) abundance of fish stocks, even when compared to those on a nearby reef which remained closed to spearfishing. There was however, a decline in the abundance of painted crayfish (*Panulirus versicolor*) after the introduction of spearfishing, but only in shallow-water habitats, presumably because deepwater habitats are not accessible to spearfishers.

When fishing activities were standardized across time, space and skill level (via a structured fishing program), spearfishers caught fewer and larger fish than linefishers, but the difference was small when bycatch was excluded. Other differences between the two fishing techniques included (1) catch composition, (2) quantity of bycatch, (3) gear loss, (4) depth limitation, and (5) the frequency of "hangs" (moves). These results do not support the popular contention that spearfishing is more destructive (and thus less sustainable) than linefishing, particularly when the effort invested in each fishing technique is considered on a reef-wide basis.

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## Professional development for marine educators

Australia has few formal opportunities for non-tertiary marine educators to develop their marine science knowledge and skills, or to network with marine scientists. This presentation will propose a national formal professional development program that will not only provide professional development but will create strong links between the education and marine science sectors by involving educators in marine science research in situ. There are some international programs that may act as models for such a proposal, and one Australian program that is beginning to undertake this role on a small scale. Such a program would require interagency partnerships and the support of many organisations and stakeholders. An overview of the many benefits of the proposed program for scientists, educators and school students will be provided.

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## **Amphiboloidean diversity (Gastropoda, Pulmonata); anatomy and systematics**

The systematics of the pulmonate superfamily Amphiboloidea (Mollusca, Gastropoda) are investigated using morphological information and cladistic analysis. Two new Australian families (Phallomedusidae fam. n. and Maningrididae fam. n.) and four new genera (*Lactiforis* gen. n., *Naranjia* gen. n., *Maningrida* gen. n. and *Phallomedusa* gen. n.) are described. Characters of the shell, operculum, radula, reproductive system and nervous system are described and compared between taxa. In particular, the reproductive system demonstrates remarkable morphological diversity. All amphiboloidean species possess an operculum, unlike other pulmonate groups. The number of recognised Australian amphiboloidean species has increased considerably from two species to eight, with an estuarine/mudflat distribution across most of Australia's coastline. The results of a cladistic analysis (119 characters, 26 taxa) show Amphiboloidea as a monophyletic clade basal to other pulmonate taxa.

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## **The distribution of foraging effort of Australian sea lions at Dangerous Reef**

Australian sea lions (*Neophoca cinerea*) are Australia's only endemic pinniped, and have a unique life-history strategy that sets them apart from most other pinnipeds. In addition very little is known about the species foraging habits. The largest population of the species is at Dangerous Reef, southern Spencer Gulf. We investigated the at-sea movements of 45 Australian sea lions at Dangerous Reef between 2003-2005, using satellite telemetry. In general, foraging could be described as heterogeneous and highly individualistic, with most seals utilising individually unique foraging spaces that differed with respect to distance and direction from the colony. Comparison of the foraging space of adult females (33), adult males (4) and juveniles (8), indicated extensive overlap, with juveniles tending to forage in shallower waters. Among the adult females tracked, the maximum distance that seals foraged from Dangerous Reef ranged from as little as 9.8km to 94.6 km (mean 45.6km). Most seals (73%) used at least one additional haul-out location, although three seals used more than two sites (19%), and one used three (6%). Four adult females were also fitted with time-depth recorders that indicated that seals foraged on the benthos with decent and ascent rates maximised to enable greater bottom (foraging) time. Most foraging occurred in 30-45m of water, with seals spending approximately equal proportions of time on land and at sea (51 and 49%, respectively). A total of 82 foraging trips were recorded for the four seals, averaging 0.89 days (21.4 hrs) in duration, the longest lasting 2.4 days. 72 shore attendance bouts were recorded for the four seals, these averaged 0.94 days (22.6hrs) in duration, the longest being 4.5 days. Departures for foraging trips occurred mostly at night (between 6-8pm), returning the following morning (most between 5-7 am), suggesting preference for nocturnal foraging.

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## **Coral percent of habitat cover monitoring at Garig Gunag Barlu National Park (Cobourg Peninsula, Northern Territory, Australia)**

Sixteen permanently marked permanent bottom plots each containing four 1 m<sup>2</sup> quadrats were set up at different Park sites in 2001 to monitor changes in live coral cover. During baseline data collection still photo images of each 1 m<sup>2</sup> quadrat were taken using a Sony® TRV 120E video camera in an Amphibico® Dive Buddy housing equipped with 80 degree wide-angle wet lens and a 52 mm internal URPro® filter for optimum colour correction. Live coral cover area values within each 1 m<sup>2</sup> quadrat were then assessed using Image-Pro® Express software. Data was imported to MS Excel and percent live coral cover was calculated for each of 64 quadrats within 16 permanent plots for further statistical analysis.

Statistical power vs. *group sample size* analysis revealed that four 4 m<sup>2</sup> permanent plots at any site are enough to detect changes in live coral cover with sufficient statistical power (close to 0.8). The chosen monitoring design is able to detect less than 5% changes in live coral cover with statistical power of 0.8 for both positive and negative trends.

Established arrangement of monitoring stations allowed for the assessment of the impact from a coral bleaching event that happened in November 2001. This bleaching resulted from local “hot spot” that has emerged in the area. It lasted for about a week. Impact from this coral bleaching was measurable, but relatively small. No significant changes in live coral percent cover have been found. A destructive coral bleaching resulting from a combination of both a series of low spring tides during mid-day hours and “hot spot” was recorded in November 2002- mid January 2003. Surface water temperature in mid December 2002 reached coral bleaching threshold (31°C) and stayed at this level until mid January 2003. As a result coral cover losses assessed 4 months after bleaching were very high, from 44 to 90% at different sites.

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## **Invasive alga provides a habitat refuge for a post-settlement infaunal bivalve**

The invasive green macro-alga *Caulerpa taxifolia* now occurs at 11 populations in temperate Australia. Studies investigating the effects of *C. taxifolia* have mainly considered the interactions between the alga and native species such as seagrasses. Virtually nothing is known of the effects of *C. taxifolia* on native infauna. In this study, we investigated the distribution, habitat selection and predation of new recruits of the Sydney cockle, *Anadara trapezia*, at two sites invaded by *C. taxifolia* in Lake Conjola, NSW. Recruitment of *A. trapezia* was higher in *C. taxifolia* (both sparse - 30% cover, and dense - 100% cover) compared to *Zostera capricorni* and bare sediment. Up to 680 recruits/m<sup>2</sup> were observed in *C. taxifolia*. However, in laboratory experiments, recruits showed no preference (all p-values>0.05) for *C. taxifolia* over seagrasses (e.g. *Z. capricorni* and *Halophila ovalis*). When a live *A. trapezia* adult was included, recruits showed a significant preference for adults over all macrophytes (all p values<0.05). Field data showed that adults in bare sediments had very few recruits (<0.07 recruits/adult at each site) attached to them compared to adults found within *C. taxifolia* (0.95 ±0.25 and 1.23 ±0.31 recruits/adult at each site). Given that recruits displayed a strong preference for adults but were rare on adults in bare sediments, we hypothesized that *C. taxifolia* acted as a habitat refuge from predation for juvenile *A. trapezia*. We tested this hypothesis by creating paired habitats (n=15) of bare sediment and *C. taxifolia*, placing adults with attached recruits into each habitat and observing predation. All recruits on adults in the bare habitat were consumed by predatory fish within 5 mins, whereas no recruits on adults in the *C. taxifolia* habitat were eaten. This data suggests that predation pressure on juveniles is an important process in structuring populations of *A. trapezia* and that *C. taxifolia* acts as a refuge from predation enhancing recruit numbers.

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## **The interplay between temperature, survival and Hsp expression during development in *Haliotis***

Temperature has a profound impact on gene expression during development, and ultimately adult phenotype. Heat shock proteins (Hsps) including Hsp70, Hsp90 and the Heat Shock transcription Factor (HSF) are strongly upregulated in response to thermal stress, imparting protection through prevention of apoptosis. Protection however occurs at the expense of the diverse and extensive roles of Hsps in early development. We studied the impact of heat shock during the development of the gastropod *Haliotis* and the interplay between timing of exposure, survival, larval morphology and heat shock gene expression. Subtle differences in temperature and timing of exposure impacted profoundly on embryo morphology. In particular, the early cleavage stages were the most sensitive to heat shock, whereas less severe abnormalities were present in treatments of the mid gastrula phase, as has been demonstrated in urchins, ascidians and vertebrates. The most strongly affected tissues exhibited the highest constitutive expression of Hsp70 and 90 during the heat shock period, including the prototroch, foot and mantle. Despite dramatically impacting on the formation of these tissues, heat shock did not appear to affect expression of the Hsps and other gene markers. Thus, Hsps are regulated in a dynamic developmental pattern regardless of culture temperature.

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## **Reproductive biology and larval development of the feather star *Aporometra wilsoni* (Echinodermata: Crinoidea)**

*Aporometra wilsoni* is a small ovoviviparous comatulid crinoid with internal fertilisation and is likely to live for one year. The reproductive and larval biology of *A. wilsoni* from Christies Beach, Adelaide, was investigated. Sampling occurred fortnightly between February 2004 and February 2005. *Aporometra wilsoni* increased in size till June, at which point females were bearing larval stages. Juveniles were found from November onwards. All specimens were examined under light microscopy to determine sex and stage of development. The sex ratio for the population was 1:1. *Aporometra wilsoni* females display intragonadal development within the pinnules so internal fertilisation is likely for this species. Males were found to be reproductive for most of the sampling period and contained spherical-headed sperm (a morphology thought to occur in externally fertilising species). Scanning electron microscopy was used to determine surface features of doliolaria and pentacrinoid larval stages. Larval stages in *A. wilsoni* differ from other crinoids in that the doliolaria larvae are without ciliated bands and an apical tuft. This is the first study of a crinoid lifespan and the only in-depth reproductive study for a brooding crinoid.

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## **Coastal lagoon processes and the influence of entrance management**

Coastal lagoons are relatively common on the south-east Australian coastline, where they are mostly known as Intermittently Closed and Open Lakes or Lagoons (ICOLLS). Environmental processes within these coastal lagoon systems have evolved to accommodate the natural variability in water level that results from periodic and sustained entrance closure. ICOLLS within NSW contain a diverse range of physical, chemical and biological environments, which to a large degree, is a function of the behaviour and characteristics of their entrances. When closed, water levels in ICOLLS can vary by up to 3 metres depending on catchment runoff, which has significant impacts on fringing riparian lands and associated vegetation communities. When closed, ICOLLS also receive and store 100% of catchment-derived inputs (including all volumetric, sediment and contaminant loads). Rural and/or urban development has occurred around most NSW ICOLLS, and has generally occurred with little consideration of the natural variability of the lagoon. Consequently, infrastructure and other assets have been positioned around ICOLLS at levels that become inundated when water levels in the lagoons are high (which can occur when the entrance is closed). The typical response to this situation has been to artificially open the lagoon entrance and drain the system, thus removing the inundation threat. Approximately 50% of ICOLLS in NSW are artificially opened from time to time for this purpose. Truncation of the natural hydrodynamic regime of these ICOLLS is resulting in a series of changes that permeate through the whole physical, chemical and biological spectra of ecosystem processes. Key changes include exacerbated shoaling of the flood tide delta, and 'terrestrialisation' of fringing wetland habitats.

At present, entrance management of NSW ICOLLS is carried out in an uncoordinated and inconsistent manner. Few ICOLLS have a formal entrance management policy or plan, while the legislative basis for the opening works is also unclear. Results of a survey of NSW ICOLL entrance managers will be presented, along with a discussion of the expected impacts of current entrance management practices on the physical, chemical and biological environment of the lagoons.

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## **When the going gets rough, the tough get going: community response to oceanographic disturbance**

Physical disturbance can contribute to the pattern or structure of a benthic community where different aggregations are shaped by different disturbance levels. Response of algal communities was explored at two sites of differing wave action and current on the Southern Australian coast. Settlement plates were deployed at the two sites, and aggregations from translocation experiments were monitored over a 3 month period. Field observations indicate that the northern site experiences higher wave action and swell than the more protected southern site. Community structure was quantified with time-series photographs; and analysed using a functional group approach. The north site (exposed) hosted a less diverse community ( $H' = 1.04 \pm 0.08$ ) with higher dominance than the more sheltered southern site ( $H' = 1.37 \pm 0.08$ ). Translocation also indicated asymmetrical recovery response between sites, where communities translocated from sheltered to exposed moved more rapidly toward resident functional group structure than those from exposed to sheltered. Dominance of a particular functional group may therefore be an important indirect effect of oceanographic disturbance in shaping community structure.

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## **The embryonic development of the brown-banded bamboo shark, *Chiloscyllium punctatum***

*Chiloscyllium punctatum* is a small, oviparous reef shark found throughout the Indo-West Pacific. Due to its small size, resilience, and unique striped pattern at hatching, it is a common aquarium fish. *C. punctatum* deposits rectangular (14.5 cm by 6.5 cm) eggs between August and February, each containing a single embryo connected via an umbilical cord to a large yolk sac. The embryological development of *C. punctatum* was monitored from the time of egg deposition until four months post-hatching at temperatures between 21 and 25 °C. Embryos were observed *in situ* through a “window” made in the keratinous outer layer of the egg case and *in vitro* for closer observation of the embryo. *C. punctatum* embryos are first observed unaided around 18 days post deposition (dpd), and captive-bred animals hatch out as miniature adults around 160 dpd. At hatching, the embryos average 191 mm total length and grow steadily over the next couple of months. The hatchlings first show signs of active feeding at 26 days post hatching (dph) and begin swimming by 32 dph.

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## **Decision Support for estuarine and marine management**

Making management decisions within estuarine and marine environments can be extremely challenging. Decision makers need to consider a range of scientific, social and economic issues. And the science about these systems is often complex and ever-evolving. It is increasingly expected that decision-making be carried out in a consultative and transparent manner, often in situations where there is inadequate information, limited resources and insufficient time. Organisations often have in-efficient knowledge management systems, and struggle with losing extensive knowledge when people change jobs or retire. One solution to assist with these challenges is to develop decision support systems (DSS).

Decision-making about activities in the coastal zone is generally underpinned by information from monitoring and modelling. Modelling is a highly technical field and communicating modelling concepts and uncertainty is challenging, particularly to a non-expert audience. In addition, modelling expertise often lies outside Government departments, and can be scarce, with modellers often limited to particular software or applications. Although water quality monitoring is better established than modelling, there are still many areas of monitoring that need to be optimised.

A DSS is being developed to aid regulatory decision-making about activities that potentially affect the water quality, biodiversity and aquatic ecosystem health of coastal waters. The DSS is built on knowledge bases containing information elicited from experts on monitoring and modelling approaches. The knowledge bases provide “metadata” information such as approaches, typical uses, specific data and resource requirements, quality assurance considerations, examples and links to further information. The DSS and associated help system will be a valuable training tool but will also assist non-experts in reviewing the monitoring or modelling done as part of regulatory applications. The generic design of the DSS will also lend itself to assisting decision-making on other issues such as catchment effects on water quality.

The presentation will describe the knowledge bases being developed for the DSS and include a brief demonstration of a prototype.

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## **Newly revealed active submerged coral reef province in southern Gulf of Carpentaria**

A 400 km-wide active submerged coral reef province in southern Gulf of Carpentaria has been revealed by a Geoscience Australia marine survey. The survey, completed in April 2005, indicates that there are probably as many as 50 individual submerged coral reefs in the southern Gulf located on a region of submerged bathymetric highs. A detailed sampling program of six reefs, including shallow cores (<3 m long), revealed that they are comprised of framework corals and reef lagoon deposits. Longer cores show that the reefs have undergone several phases of growth and occur atop older reef deposits and indurated mudstones of the underlying bedrock. Underwater video footage shows that the reefs comprise abundant corals with coverage in places equal to that of patch reefs in the Great Barrier Reef (GBR). Ages for the reefs are not yet available. However, the cores and reef geomorphology indicate that the reefs are quite old, with most growth probably occurring during sea level high stands throughout the last 125,000 years. Modern corals form only a thin (<1 m) mantle over the older deposits. Key questions remain as to the exact age(s) of the reefs and timing of reef development, and why the reefs have not reached present sea level. A widespread submerged active coral reef province in the southern Gulf of Carpentaria will need to be considered in the northern region regional marine plan and for the selection of marine protected areas.

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## **Bio-available nutrients in sediments: a stoichiometric model of sediment-nutrient pool sizes in estuaries.**

The benthic TCO<sub>2</sub> flux (a measure of the rate of organic carbon degradation in sediments) was found to be approximately seven times the benthic silicate flux in about three hundred measurements from several Australian temperate estuaries. This result indicates two important features of carbon and nutrient cycling processes. First, diatomaceous organic carbon is probably the most predominant form of organic matter in estuaries. Second, silicate is a proxy for organic carbon and (because of Redfield stoichiometry) also a proxy for nitrogen and phosphorus. TCO<sub>2</sub>, DIN (dissolved inorganic nitrogen) & DIP (dissolved inorganic phosphorus) concentrations in pore waters increase from bottom water concentrations to near asymptotic levels at depths near 20-40 cm and indicate organic carbon degradation, nutrient (DIN, DIP) release and a flux of metabolites to overlying bottom waters which has been measured in benthic chambers. The results from the benthic chamber experiments have been rewritten in terms of pore water metabolite concentrations to develop a series of stoichiometric equations, which use silicate as a proxy for carbon, nitrogen and phosphorus, to describe the down core distributions of TCO<sub>2</sub>, DIN and DIP in sediments. The predicted TCO<sub>2</sub> concentrations with depth in the sediments were found to be in very good agreement with the measured TCO<sub>2</sub> concentrations and confirm silicate as a proxy for organic carbon. The measured DIN concentrations down-core were generally less than the predicted concentrations and the 'missing nitrogen' has probably been lost via denitrification-a microbial process which helps maintain low DIN concentrations in the water column and inhibits eutrophication. A comparison of the N-loss from sediments via denitrification, from both benthic chamber results and pore water modelling are in good agreement. The measured DIP concentrations down-core were always less than the predicted DIP concentrations, a result which indicates that 50-90% of the P-input to sediments is generally trapped and buried.

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## Water quality for all stakeholders

The eutrophication process is the enrichment of coastal waterways with nutrients. Eutrophication manifests itself in many ways including nuisance and toxic algal blooms, frequent occurrences of hypoxic and anoxic events with fish-kills and clogged waterways all of which result in a general deterioration of water quality. Visible changes in the ecology are preceded by biogeochemical imbalances in the cycles of key nutrients nitrogen, phosphorus and silicate. These processes are complex. We have developed a series of animations, for stakeholders, which illustrate (in a simple way) the key processes of photosynthesis and respiration (O<sub>2</sub> and C cycling), nutrient (N, P & Si) cycling and methods to study sediment-nutrient inputs and these are included in an electronic book produced by Geoscience Australia. The cartoons run for 20 to 30 seconds and illustrate the complex interactions and feedback loops in C, N, P & Si cycling. Key metabolites are depicted as labelled moving icons. We have also developed a simple model of nitrogen cycling in estuaries which is in EXCEL and easy to use and illustrates in a quantitative and visual format the key processes controlling nitrogen budgets, computes sustainable N-loads and water quality parameters TN (total nitrogen) and chlorophyll-a for a range of N-inputs, flushing times and denitrification efficiencies. Animations depicting N-cycling illustrate the differences between 'healthy' and 'unhealthy' estuaries. This teaching and learning tool is suitable for a wide range of stakeholders.

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## Seasonal variability of bed shear stresses on the Australian continental shelf

Surface ocean waves, tidal currents, wind and density driven currents are all capable of impacting upon the seabed; mobilising sediment and physically disturbing benthic communities. Each of these processes operate at different timescales, and of these only tidal currents have no seasonal signal in Australian shelf waters. Geoscience Australia's sediment mobility package, GEOMACS, has been developed to make use of results from a suite of models predicting these oceanic processes, to compute the combined wave-current bed shear stresses over the entire Australian continental shelf for a 7-year period (March 1997 - Feb 2004, inclusive).

The spatial distribution of the long-term mean and the maximum bed shear stress obtained, enable a regional estimation of the natural physical disturbance of the seabed. Maximum shear stresses of up to 10 Nm<sup>-2</sup> (capable of mobilising a ~2 cm diameter quartz pebble) are predicted in several regions on the Australian shelf in response to combined forcing mechanisms. Results of time-series analyses of the bed shear stresses will be presented indicating the dominant ocean processes impacting on the seabed at each location. Strong seasonal variation of bed shear stress values is evident at many locations on the Australian shelf, corresponding to either strong seasonal wave action, i.e., southern ocean swell variability along the southern margin, or variability of wind and density driven ocean currents on the shelf.

Long term mean bed shear stress estimates have applications towards characterisation of seabed properties. Similarly, temporal variability of these stresses has applications towards the prediction of physical disturbance of the seabed in response to storm and/or extreme events.

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## **Has there been a change in the Antarctic marine ecosystem?**

Significant changes in zooplankton composition have occurred in various ocean systems in recent years. These changes can be quite dramatic, occurring within one or two seasons, as happened with the regime shift in the North Sea and North Atlantic in the late 1980s. Substantial shifts also occurred in the far North Pacific in 1976/77 and more recently in 1998/98. These regime shifts have had impacts on higher trophic levels, particularly commercial fish stocks. Antarctica and surrounding waters are speculated to be particularly sensitive and vulnerable to climate change and Antarctic zooplankton may respond to climatic forcing in the same fashion as demonstrated elsewhere. The effect of global warming on cold water plankton and sea-ice patterns, plus UV impact may also trigger a sudden change in Southern Ocean plankton with subsequent impacts through the rest of the ecosystem. Prof. Kawamura provided some evidence of a significant decline in herbivorous copepod abundances between the 1930's and the 1980's caused by an excess of Antarctic krill. A possible decline in krill numbers in favour of salps has since been identified. These indications of change have been based primarily on the comparison of abundances of individual species between years. Caution is required in the interpretation of such analysis due to the inherent problems of estimating plankton abundance and high variation associated with abundances estimates. This presentation reports on detailed analyses of zooplankton species composition and associations in the Antarctic sea-ice zone (SIZ) using data collected by continuous plankton recorders between 1991 and 2004, in order to determine if any substantial changes have occurred at a community level. The SIZ showed a marked change in species composition in the late 199's from a krill dominated community to one comprising smaller zooplankton in higher abundance more typical of the open ocean north of the SIZ. Changes in SIZ primary production may be the cause of the change, which in turn may affect the survival of krill dependent higher predators.

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## **Planning the Biodiversity Cruise: shelf overview and gaps**

Recent reviews of our knowledge of Australia's marine fauna reveals major gaps in our knowledge of this fauna on the shelf and beyond. Extensive systematic collecting is required by well planned biodiversity cruises which ensure that a good representation of the fauna is collected using a range of gear and extraction techniques. Replicate sampling may be required in order to monitor temporal scales. While ship time is expensive, it is imperative that sufficient funds are made available to ensure that all material collected is worked up by the appropriate systematists and data based. This material will almost certainly consist of numerous groups and a suite of systematists will be needed to work up this material which will certainly include many new species or records. Various models as to how these collections can be dealt with will be proposed, including having one Institution acting as the host and responsible for organizing the relevant specialists to identify and describe where necessary this material and database it. As such cruises are expensive it is imperative that preliminary reports with good photographic coverage are provided to the media and the public and made widely available through the web as it will take time to identify the material and document this fauna in scientific publications.

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## Linking science and culture to improve understanding of marine biodiversity in northern Australian waters

A recent survey of northern Australian coastal waters involving marine scientists and Indigenous communities has greatly improved our understanding of marine biodiversity across the Top End and established a solid foundation for future collaborative work. Co-funded by the NT Government, the National Oceans Office, Director of National Parks and the Northern Land Council (NLC), the North Australia Marine Biodiversity Survey investigated inshore waters off the Arnhem Land and Van Diemen Gulf coasts which were last explored by scientists around 160 years ago on the *Mermaid* and the *Beagle*. The North Australia Marine Biodiversity Survey has been built on collaboration between local Indigenous people who have an intimate understanding of local natural systems and species, and scientists who have built on this local knowledge through scientific analysis of biodiversity. The central tenets of the project are 'building knowledge, building relationships and building capacity' reflecting the desire of all participants to improve understanding of the marine environment, build sound, respectful working relationships between governments, researchers and Indigenous organizations and communities, while at the same time strengthening the foundations for good marine research across northern Australia.

The project has been successful in achieving its aims through the involvement of Indigenous communities in many aspects of the project's design and implementation, development of communication protocols, and genuine sharing of information and expertise between Indigenous people and scientists. The project has also established a strong foundation for developing good working relationships between researchers, governments and Indigenous people in the future.

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## The pros and cons of *in situ* algal productivity measurements – it's hard to go natural...

Mathematical representations of the relationship between photosynthesis and light ( $P$  vs.  $E$  curves) are often used to relate short term, small scale photosynthetic rates to long term, large scale processes. Net primary production can be calculated from a  $P$  vs.  $E$  relationship by extrapolating measurements of photosynthesis at fixed irradiance levels. The calculation of net primary production is dependent upon a good estimation of the photokinetic parameters  $Pm_{gross}$ ,  $E_k$  and  $R_d$ , which are derived by fitting non-linear models to observed data.

*In situ* studies on algal productivity have the advantage that the spectral quality and the variations in irradiance are natural, which is largely ignored in laboratory orientated experiments. However the maximum daily irradiance experienced by the plant/alga *in situ* does not always exceed a level for light saturated photosynthesis to occur. This is particularly relevant to seasonal experiments where winter irradiance measurements are often below saturation. Regardless, the assumption is made that  $Pm_{gross}$  is always accurately estimated. It is important to be able to validate this assumption. A series of models were created from a dataset obtained from *in situ* measurements to explore this question; firstly to determine the maximum irradiance required to accurately predict  $Pm_{gross}$  based on fixed values of  $Pm_{gross}$ ,  $E_k$  and  $R_d$ , and secondly to determine whether sample size (the number of measurements taken to create the  $P$  vs.  $E$  curve) influences the estimation of the parameters. Results are presented to support the argument that  $Pm_{gross}$  and  $E_k$  can be accurately estimated if light does not reach saturating intensities, although this is dependent upon the number of observations obtained for the  $P$  vs.  $E$  curve.



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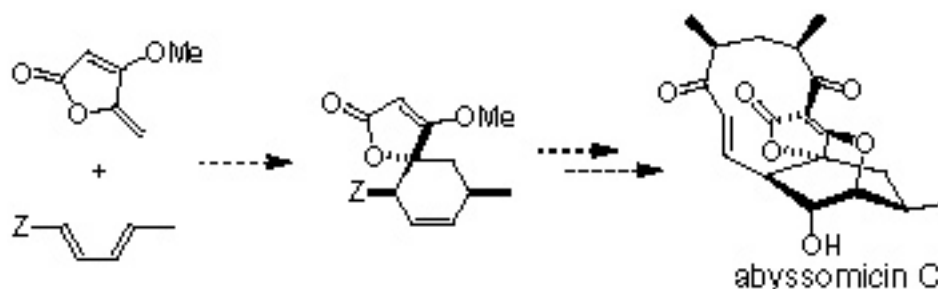
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## A Diels-Alder approach to the synthesis of the Spirobicyclic core of Abyssomicin C

Novel antibiotics inhibiting the biosynthesis of *para*-aminobenzoic acid (*pAba*) are an attractive target, as the biological pathway for synthesising folate is restricted to plants, fungi, parasites of the apicomplexa group and prokaryotes. A direct precursor in the synthesis of folic acid, *pAba* is derived from chorismate and is essential for microorganisms. Screening of marine and terrestrial organisms that produce metabolites inhibiting *pAba* biosynthesis revealed a single actinomycete, *Verrucosipora* strain AB 18-032, isolated from marine sediment extracts collected at 289 m depth in the Sea of Japan. A family of three novel polycyclic polyketides were isolated from the *Verrucosipora* strain, aptly named abyssomicins B, C and D.<sup>1</sup> Only abyssomicin C was found to be active against multi-resistant strains of gram-positive bacteria.



The work presented here concentrates on studies toward the synthesis of the spirobicyclic core of abyssomicin C. To establish the spirobicyclic tetronate core, we envisage using a Diels-Alder reaction between the electron-rich alkene methyl 5-methylenetetronate and an electron-rich diene.

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## Developmental genes in the tropical sponge *Reniera*: Another tile in the mosaic of the first multicellular animal

As the most ancient metazoan lineage, sponges can shed light on the transition to a multicellular grade of organisation in animals. A fundamental step in this process would have been the emergence of an inheritable developmental program. We have investigated the development of the tropical demosponge, *Reniera*, and the presence of genes that have conserved roles in the development of other metazoans. Based on phylogenetic analyses of *Reniera* genes, certain important transcription factor (TF) gene classes (such as Sox or Lim-HD) appear to have arisen and diversified prior to the evolution of the last common ancestor to all animals. Traditionally, sponges have been set apart from the rest of Metazoa, based on their alleged lack of symmetry, tissues, nerve cells, and other supposed cardinal metazoan features. For the first time, we show spatial gene expression patterns during sponge development. As is the case in other metazoans, the expression of these TF genes is localised to certain domains and they are probably involved in determination and differentiation of cells. Thus, we show that sponges are not as different from other metazoans as once thought, and that the last common ancestor of all extant metazoans probably used the same genetic tools for fundamental developmental processes as are used in all other animals. We postulate that the origin and diversification of these TF classes during the period of transition to the first multicellular animal may have paved the way for the elaboration of a fundamental metazoan developmental program, whose key features have been conserved in all animals.

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## **Plume front dynamics and phytoplankton activity in the Strait of Georgia, Canada**

The Strait of Georgia is a semi-enclosed estuary on the southern coast of British Columbia dominated by seasonal patterns of the Fraser River plume. The river plume forms a buoyant layer covering up to ~30% of the southern strait and is able to entrain substantial quantities of nutrient rich oceanic water from below to maintain high productivity. However with the onset of freshet in late spring, the ~ ten-fold increase in discharge can herald the demise of the spring bloom. During summer, production is maintained with episodic blooms that have been observed in tandem with spring-neap cycling. These are considered to be correlated to spring-neap pulsing of the deepwater intrusions to the strait, but are perhaps more sensitive the location and intensity of the plume front. The bio-physical coupling of this ecosystem has recently been investigated by the STRait Of Georgia EcosysteM (STRATOGEM) program. High-resolution physico-chemical data are obtained from a series of instrumented ferries that operate up to 21hrs/day across this plume-dominated region. In conjunction, a series of transects undertaken along the ferry tracks have targeted the spring and summer bloom periods. Data indicate strong fronts during spring and summer routinely locate phytoplankton maximums outside the plume's leading edge. While significant entrainment of nutrients is evident at the plume front, the chlorophyll maxima correspond to an exhausted nutrient regime. Frontal excursions of 10-20kms often correlate with spring-neap cycles but show sensitivity to weather band forcing. The importance of frontal structure to enhance phytoplankton populations at the plume edge is discussed in relation to physical forcing.

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## **Low levels of metal contamination affect predatory and reproductive behaviour of a mobile invertebrate**

The free living flatworm *Stylochus* sp. is an important and abundant mobile predator of young barnacles on natural and artificial substrata in Botany Bay, New South Wales. Laboratory experiments were carried out to assess the influence of sublethal concentrations of copper, range from 0 to 50 µg/L, on the predatory and reproductive behaviour of *Stylochus* sp. *Stylochus* sp. was sensitive to low levels of copper contamination. Response of *Stylochus* sp. to stimulation was reduced at 25µg/L. Besides, hatching success of flatworm eggs was reduced at 10µg/L and the number of egg patches laid was also significantly less at 25µg/L. Brooding behaviour was observed regardless of the copper concentrations tested. The predation rate of *Stylochus* sp. on barnacles was not affected by copper although the feeding rate of the prey was affected by both copper and the presence of predatory flatworms. Overall, the findings suggested that community structure would be affected by low levels of copper contamination through the alteration of predatory and reproductive behaviour of flatworms and predator-avoidance behaviour of barnacles.

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## **Report on the stock assessment of burrowing blackfish and recent advances in the management of the East Coast Queensland beche-de-mer fishery**

The Queensland Sea Cucumber Association (QSCA) has recently implemented a system of management involving rotational harvesting and precautionary catch trigger points for the East Coast Queensland Beche-de-mer Fishery. The system, initiated by industry, has been formalised into a memorandum of understanding between the QSCA, the Great Barrier Reef Marine Park Authority and the Department of Primary Industries and Fisheries. This type of validated self-management is an Australian first. The system aims to reduce the impact of fishing on the sea cucumber stock by spreading effort both spatially and temporally. Precautionary trigger points on catch levels for each individual species require that once a trigger has been set off, a review of catch and effort pattern is conducted and if warranted, a full stock assessment will be undertaken for that species. The first two stock assessments have just been completed for the burrowing blackfish species. These stock assessments are likely to be the most extensive deep water; diver operated stock assessments ever completed in Australia. The fishery, which is operated within the Great Barrier Reef Marine Park, aims to be at the cutting edge of sustainable fisheries management.

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## **Aliens on ice: marine biosecurity in the Southern Ocean**

The spread of non-indigenous species in the marine environment is a process causing significant impacts to coastal biodiversity across the globe including remote regions. This study examines the extent to which human activities in the sub-antarctic islands and Antarctica act as a transport mechanism to introduce temperate species into this unique environment. An examination of national science vessels highlights hull fouling as a significant vector for the transport of non-indigenous and shows that entrained organisms are able to survive prolonged voyages to high-latitude coastlines. Surveys were conducted at both Macquarie Island and the New Zealand Auckland islands aimed at highlighting existing introductions, and to establish a base-line data set that can be used to identify and respond to future introductions. The extent of genetic transfer enabled by human transport mechanisms has also been addressed through a study of the population genetics of *Mytilus galloprovincialis* in the Southern Hemisphere. A further investigation will examine the tolerance of temperate fouling species to high-latitude thermal conditions. Management solutions and future research requirements are discussed.

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## **Australia's response to introduced marine pests: a National System**

Australia is responding to the threat posed by introduced marine pests by developing a comprehensive *National System for the Prevention and Management of Marine Pest Incursions* (the National System). Marine pest risks from ballast water, biofouling and other potential vectors will be addressed under the National System. Development of the National System is being achieved through collaboration between the Australian and state and territory governments, marine industries, conservationists and researchers. Implementation of the National System is planned for October 2006. Mandatory management requirements for internationally sourced ballast water are in place and arrangements to manage ballast water movements between Australian ports are under development. Australia has made a significant contribution to the International Convention for the Control and Management of Ships' Ballast Water and Sediments which it signed, subject to ratification, in May. Guidelines are being developed to address biofouling risks for a range of sectors including fishing, aquaculture, petroleum, recreational vessels and international yachts. To support the finalisation of these guidelines, risk assessment projects are being undertaken along with ongoing sector consultation.

A species and location targeted ongoing monitoring strategy is being developed to support the National System. Clear quality assurance and quality control standards for marine pest monitoring will be integral to this Strategy. A monitoring manual is being developed in collaboration with New Zealand to describe procedures for setting up monitoring programs and the minimum monitoring standards.

A national communications strategy, evaluation and review framework are being developed and the research and development strategy for the National System is being revised.

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## **Observation systems for detecting non-indigenous marine species (NIMS) in Australia and New Zealand**

Australia and New Zealand have developed a joint approach to monitoring our coastlines for the presence of non-indigenous marine species (NIMS). Part of this approach has involved preparation of a Marine Pest Monitoring Manual, which was discussed at a technical workshop (discussed elsewhere at this conference). Kingett Mitchell were contracted to prepare the Observation Systems for the manual, outlining the methods to be used for detecting target species in different locations. This presentation summarises the approach used in preparing the Observation Systems Methods (OSMs), provides some sample OSMs for discussion, and discusses the challenges and opportunities faced in detecting non-indigenous marine species in biologically and morphologically diverse habitats. Conference participants are invited to provide comment on the suitability/applicability of individual OSMs in order to improve the overall programme prior to adoption by the Australian Government and Biosecurity New Zealand.

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## **Relating the distribution of a semi-demersal fish, *Macruronus novaezelandiae*, to their pelagic food supply**

The Chatham Rise to the east of New Zealand underlies the Subtropical Front and is an important region for deepwater fisheries, as well as being a nursery region for hoki, *Macruronus novaezelandiae*, the species that supports New Zealand's largest fishery. The spatial distribution and abundance of mesopelagic fish, which are a major food resource for hoki, are influenced by the location of banks on the western and eastern Chatham Rise. Analysis of three austral summer fisheries surveys allowed us to relate the spatial distribution of mesopelagic fish to the distribution and condition of hoki. The highest biomass of mesopelagic fish on the Chatham Rise was associated with the banks at its western and eastern ends. The intensity of the hotspots was strongest in 2002-03 and weakest in 2001-02. Concentrations of hoki occurred on the western banks in 2001-02 and 2002-03, but the western intensification was strongest in 2002-03, as was the case for mesopelagic fish. There were significant regional differences in the length-weight relations for hoki across the Chatham Rise and year 3++ hoki (65 cm) were approx 3-5% heavier for a given length on the western Chatham Rise. The catch rate of hoki was correlated with the abundance of vertically migrating mesopelagic fish, especially on the western Chatham Rise. We infer that the greater weight at length of year 3++ hoki on the western Chatham Rise was due to the greater abundance of the mesopelagic fish that they prey upon.

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## **Are grapsid crabs keystone species in tropical mangroves?**

Grapsid crabs have been referred to as "keystone species" in the mangrove forests of tropical Australia and south-east Asia. We used experiments and sampling studies to test the effects of grapsids, primarily *Neosarmatium meinerti*, on ecological processes in the mangrove forests around Darwin Harbour. Although information on other grapsids is limited, there was clear evidence that *N. meinerti*, as a consumer, did have significant effects. It selectively attacks propagules of particular mangrove species, reduces the survival of seedlings in some assemblages and appears to reduce the amount of litter on the forest floor. Thus, *N. meinerti* appears to influence key ecological processes structuring these mangrove ecosystems, but the question of whether or not it is a "keystone species" requires more information regarding the strength of the interactions and effects, and determination of the necessity of the species to the ecological organization of the system.

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## **Planning for environmentally sustainable tropical finfish cage culture**

The nations of the S.E. Asian region share concerns in maintaining appropriate environmental standards for the rapidly developing finfish cage culture industry. However, the environmental effects of fish cage culture are poorly understood in the tropics. Tropical environments used for cage culture are dissimilar to the better-known northern hemisphere systems in a number of ways (e.g. biological turnover rates, tidal regimes, sediment types, water chemistry and rainfall regimes). In addition, aquaculture target species in the tropics also differ greatly in biology from those grown in temperate northern hemisphere environments. Cage technology used in Indonesia, and much of Asia, comprises small-scale pens or floating cages, usually moored in sheltered water - and this most often means semi-confined bodies of water such as estuaries and bays where wastes do not rapidly disperse. Moreover, fish farmers are risk-averse and reduce perceived risk by 'clustering' cage farms very close together. Consequently, there tend to be concentrations of numerous small cage farms in small areas. There is an urgent need both for better understanding of the environmental effects of fish cage farming in the tropics, and for better planning tools to mitigate any adverse environmental impact.

This presentation will review environmental effects of sea cages in the tropics, and will profile a new ACIAR-funded project to develop planning tools to regulate the expansion of sea cage culture in South Sulawesi, Indonesia.

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## **How big an MPA for whale sharks?**

Whale sharks (*Rhincodon typus*) occur at Ningaloo Reef each year from March to June. They form an important resource for ecotourism, but the future and status of this population is uncertain. Our research examines population size and trends in this species using photo-identification and historical records. We use archival and satellite tags on sharks to follow their movement and diving patterns near the reef on temporal scales from days to months. Long term tracking (months) of sharks showed that some individuals migrate towards Indonesia where they may be subject to fishing once they have departed from Ningaloo.

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## **The effect of introduced bryozoans on the plankton community in Sydney Harbour**

A majority of the carbon and nitrogen in the ocean is in the form of plankton  $<5\mu\text{m}$ , and thought to be retained in the microbial loop. Recent studies have shown that the major benthic suspension-feeding invertebrates such as sponges, ascidians and soft corals feed at the base of the microbial loop, resulting in a shift in carbon in the food web. Bryozoans are an abundant group of active marine suspension-feeders, however, as their diet has never been quantified, it is unknown what effect they have on the plankton community. We first determined the ultraplankton community and the biomass of bryozoans in Sydney Harbour. We surveyed the bryozoan communities at four sites around the harbour. From these surveys, we found that the most dominant bryozoan species in Sydney Harbour are invasive species, inhabiting urban structures. Next, we qualified then quantified what bryozoans remove from the water column both through capture and ingestion. We first confirmed that phytoplankton is actually ingested by the bryozoans, as opposed to just being captured, using confocal microscopy. We then conducted feeding studies, both diurnally and seasonally, and using flow cytometry, found that the natural diet of the three most common bryozoans includes ultraplankton (plankton  $<5\mu\text{m}$ ). Using these integrated set of measurements, we quantified the organism-mediated flux of the plankton community due to bryozoans (annual mean is  $37.475 \text{ mg Cm}^{-2} \text{ day}^{-1}$ ). As these bryozoans inhabit urban structures, and not the benthos, they have access to a greater portion of the water column. It is highly likely that they have had a dramatic impact on the composition of the plankton community of Sydney Harbour since their introduction with European settlement. Ultimately, this study determined for the first time the effects any bryozoans on the plankton community, and measured the carbon and nitrogen fluxes, by introduced bryozoans in Sydney Harbour.

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## **Nutrient release from sediments in a highly eutrophic estuary, south-western Australia**

The severely modified Torbay Inlet/Lake Powell drainage system, located 25 km west of Albany, is considered to have the poorest estuarine water quality in Western Australia. Progressive nutrient enrichment over several decades from agricultural and industrial land use, and a wastewater treatment plant has contributed to water quality problems and frequent toxic blue-green algal blooms. Most of the time, concentrations of nutrient species such as ammonium ( $\text{NH}_4$ ) and phosphate ( $\text{PO}_4$ ) in surface waters are above ANZECC guidelines trigger values.

In April this year, Geoscience Australia (GA) measured benthic fluxes in the Torbay Inlet/Lake Powell drainage system to determine the importance of sediments as a source of nutrients to the water column. These benthic fluxes were the highest GA has ever measured. Rates of carbon dioxide ( $\text{TCO}_2$ ) release were up to  $1100 \text{ mmol m}^{-2} \text{ day}^{-1}$ . This is extremely high compared to all other temperate Australian estuaries sampled by GA ( $n=17$ ), where average  $\text{TCO}_2$  fluxes were all below  $70 \text{ mmol m}^{-2} \text{ day}^{-1}$ .  $\text{NH}_4$ , silicate ( $\text{SiO}_4$ ), and  $\text{PO}_4$  fluxes were also extreme, up to 123, 37, and 20  $\text{mmol m}^{-2} \text{ day}^{-1}$  respectively, compared to an average for other temperate Australian estuaries of less than 6, 6, and 1  $\text{mmol m}^{-2} \text{ day}^{-1}$ .

Sites with the highest benthic fluxes also had very low denitrification efficiencies and evidence for nitrogen fixation. Therefore, very little N is lost as  $\text{N}_2$  gas at these sites, leading to an ever increasing pool of N in the sediments. The magnitude of benthic fluxes, combined with low denitrification efficiencies and N-fixation indicate that sediments are a significant source of nutrients to the water column.

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## **Australia's near-pristine estuaries: current knowledge and management**

Near-pristine estuaries provide important reference sites from both a scientific and management perspective. Natural variability observed in these systems can guide in distinguishing between changes caused by human activity and changes associated with natural cycles of disturbance and change. Scientifically, near-pristine estuaries allow for comparisons between regions and estuary types without the overprint of post-European settlement impacts, and for management, they provide a benchmark for measuring the degree of change in more modified estuaries concerning water quality, ecology, and geomorphology. Near-pristine estuaries themselves are also valuable as undisturbed habitat for native plants and animals, for biodiversity conservation, for tourism and wilderness experiences, and for fisheries. Baseline data on these systems can assist in protective management and detection of changes resulting from human activity. Australia is fortunate in that a large proportion of estuaries remain in near-pristine condition (the NLWRA classified ~ 50% as *near-pristine*). Recently, the Coastal CRC collated all the biophysical data and information it could find on Australia's near-pristine estuaries and looked at how each State and Territory manages these systems. This presentation outlines some key findings, including: (1) in southern Australia, there remain no near-pristine examples of some estuarine types (based on size and geomorphology), especially large, open estuaries; (2) in contrast, most estuaries in northern Australia are relatively undisturbed (only 42 of the 536 estuaries north of the Tropic of Capricorn are *extensively modified* or *modified*, the remainder are either *largely unmodified* or *near-pristine*) and there are near-pristine examples of all estuary types, however, grazing impacts in the catchments of these are a concern; (3); in southern Australia most near-pristine estuaries are small with catchments entirely within National Parks and managed for conservation by state agencies, whereas; (4) in northern Australia most near-pristine estuaries are on indigenous, private, or crown land, and not managed specifically for conservation.

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## **Partitioning of nutrients in *Posidonia* and *Amphibolis* beds along the Adelaide metropolitan coastline.**

This ongoing study measures seasonal and diel partitioning of nutrients using benthic chambers on *Posidonia* and *Amphibolis* beds found along the Adelaide metropolitan coast. Water contained in the chamber is spiked with a known concentration of stable isotopes of  $^{15}\text{NH}_3$  and  $^{15}\text{NO}_3$  to simulate a land run off. Compartmentalisation of these nutrients in seagrass leaf tissue, shoots, below ground biomass, epiphytes and suspended particulate material in the water column will be measured from the uptake of the nutrient stable isotope after a 2 hour incubation in situ. Preliminary results from this study will be presented.

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## **Planning the cruise: Slope overview and gaps**

There are significant gaps in our knowledge about biological communities of Australia's continental slope. Existing collections vary considerably in their spatial, temporal and taxonomic coverage. Major spatial gaps for all groups include NE Qld/Coral Sea and the Northern Coast (between Australia and Indonesia). There are very few samples from Australia's EEZ from under 3000 m. Nevertheless, there is sufficient coverage of some taxonomic groups for large scale bioregional analyses and some areas have been sampled consistently enough to delineate habitats. Determining patterns of seamount endemism is problematic because of the probable occurrence of cryptic species. The taxa with the most extensive spatial coverage are fish and some echinoderms (ophiuroids, holothurians), with sponges, some crustaceans (especially decapods) and octocorals well covered in some areas. Large, consistently identified taxonomic datasets take 3-10 years to compile. Post-voyage taxonomic funding is required for the prompt completion of identifications.



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## The National Marine Bioregionalisation of Australia

The National Marine Bioregionalisation is a spatial framework that divides the Australian marine environment into bioregions that make sense ecologically and are at spatial scales useful for broad marine planning and management. It is based on the most comprehensive national marine biophysical data available using novel analysis and visualisation techniques. Extensive collaboration (multi-jurisdictional and multi-disciplinary) has been required to develop it. The result is a comprehensive national set of bioregions that cover both the benthic and pelagic environments of the Australian Exclusive Economic Zone (EEZ). The benthic bioregionalisation is based on distributions of demersal fish and geophysical data. It identifies provinces, representing areas of endemism in Australia's fauna; biomes, representing depth structuring of fauna on the continental slope; and geomorphic units - areas of similar geomorphology that are assumed to reflect habitat distribution. Additional layers of information on sponge biogeography, geomorphic features and sediment characteristics provide information on finer-scale patterns in the benthic environment.

The pelagic regionalisation is based on physical properties of the water column and defines water masses, circulation regimes and fields of oceanographic features in Australia's oceans based on innovative analyses of oceanographic data at 56 depths from the surface to more than 4km depth. At the sea surface, the biological significance of these patterns are corroborated by biogeographic patterns of phytoplankton communities and satellite imagery of ocean colour.

The National Marine Bioregionalisation provides the best available national spatial framework for Australia's regional marine planning, development of a national representative system of marine protected areas and State of the Environment reporting and may be used for other planning and management applications.

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## Comparison of *Caulerpa taxifolia* and *Zostera capricorni* as habitat for mobile epifauna

The spread of the invasive green alga *Caulerpa taxifolia* in Australian coastal waters raises concerns about potential reduction in abundance and diversity of invertebrate assemblages in affected estuaries. *C. taxifolia* is generally perceived as habitat of poor quality, largely because it is unpalatable for some grazers and usually has little epiphytic growth on its fronds. A comparative study was conducted at Mannering Park (Lake Macquarie, New South Wales, Australia), where *C. taxifolia* was first found in 2001 and now occurs in patches within beds of the native seagrass *Zostera capricorni*. We tested a general hypothesis that the abundance and diversity of epifauna in patches of *C. taxifolia* would be smaller than in the surrounding beds of *Z. capricorni*. Epifauna associated with *C. taxifolia* and *Z. capricorni* were sampled in June and August 2003 when *C. taxifolia* was abundant.

Samples of *C. taxifolia* and *Z. capricorni* and associated epifauna were taken at two sites approximately 50 metres apart. No significant differences in abundances of epifaunal taxa on *C. taxifolia* and *Z. capricorni* were detected. The structure and composition of epifaunal assemblages associated with both macrophyte species was also similar. However, because patches of *C. taxifolia* and *Z. capricorni* at Mannering Park occur in close proximity to each other, it is possible that mobile invertebrates collected within *C. taxifolia* patches originated from *Z. capricorni* beds. Suggestions for further study to examine epifaunal assemblages and the effects of *C. taxifolia* patch size, and proximity to *Z. capricorni* beds, will be presented.

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## Microzooplankton from South Western Australia; their community structure and impact on phytoplankton

This is the first study of the microzooplankton community and its impact on phytoplankton in the lower west coast of Western Australia, and is a component of a larger regional scale project, the Strategic Research Fund for the Marine Environment (SRFME).

The microzooplankton community was found to be highly variable in terms of its abundance and impact on phytoplankton. The abundance of microzooplankton varied from 550 cell l<sup>-1</sup> to blooms reaching 10 000 cell l<sup>-1</sup>, with an average of 2000 cell l<sup>-1</sup>. The main contributors in general were ciliates and heterotrophic dinoflagellates; the most abundant were ciliates from the genera *Strombidium* and *Strobilidium*. Carbon derived from microzooplankton ranged from 0.34 µg C l<sup>-1</sup> to over 1000 µg C l<sup>-1</sup>, with an average of 40 µg C l<sup>-1</sup>, reflecting findings from other studies. The large ciliate *Tontonia* sp. and dinoflagellate *Ceratium furca* contributed most to biomass. 30 % of the variability within the microzooplankton assemblage is attributed to salinity and nitrate.

I determined the percentage of primary production grazed by microzooplankton using the dilution method (Landry and Hassett 1982) at three stations across a cross-shelf transects on 9 occasions. Analysis included chlorophyll *a* estimates for grazing impact on the whole phytoplankton assemblage, and flow cytometry to estimate the impact on specific phytoplankton species. The results from Chlorophyll *a* analysis show the average impact increases from 38 % inshore to 60% offshore, however the data are highly variable and this trend is not significant. Flow cytometry data showed that 100 % of the production of *Synechococcus* sp. and *Prochlorococcus* sp. was grazed and the impact on a species of cryptophyte increased from approximately 40 % in winter to over 80% during the summer across all station.

This investigation shows that the microzooplankton assemblage is highly dynamic and able to effectively graze small phytoplankton cells.

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## Diet of an ommastrephid squid, *Todarodes filippovae* from east and south Tasmania: stomach content and signature lipid analysis

This is the first reported dietary study of *Todarodes filippovae*, an abundant ommastrephid squid with a circumpolar distribution in the Southern Ocean. The diet of *T. filippovae* was assessed using stomach contents and signature fatty acid analyses as complementary dietary techniques. The contents of 503 stomachs collected opportunistically from waters off eastern and southern Tasmania between 2000 and 2004 were examined. 53 prey taxa were identified, including fish, cephalopods and crustaceans, demonstrating the opportunistic feeding strategy of this high-order predator. Teleost fish remains were found in 68% of stomachs with myctophid fish dominating numerically and taxonomically. Common fish genera were *Electrona*, *Gymnoscopelus*, *Bathylagus* and *Lampanyctus*. The most common cephalopod genus in the diet was *Histioteuthis*. Natant decapods and amphipods made up the crustacean portion of the diet. The lipid class and fatty acid profiles of the digestive gland and mantle tissue were analysed for 43 squid from three sites. Mantle tissue was low in lipid (0.8±0.5%), and contained high levels of phospholipids and polyunsaturated fatty acids (PUFA). In contrast the digestive gland tissue had a moderate lipid content, mean value of 14.8±7.9% wet mass and was rich in triacylglycerol (TAG) and monounsaturated fatty acids (MUFA). Using multidimensional scaling (MDS) analysis, the signature fatty acid profiles of the digestive gland of *T. filippovae* grouped with profiles of Southern Ocean myctophids and squid, thus supporting the findings obtained in stomach content analysis. Neither technique showed evidence to support size, maturity, spatial or temporal differences in the diet of *T. filippovae* during 2000-2004.

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## **Understanding the spatial and temporal patterns and processes in macroalgal assemblage structure in south-western Australia – what are the driving forces?**

Benthic algal assemblages are a key component of coastal productivity, provide habitat and food for marine invertebrates and fish, contribute to biogeochemical cycles, and can exert influence over nearby habitats. Despite their recognised importance, comparatively little is known of the ecology of the algal habitats in south-western Australia. The goal of the present study was to characterise and understand the mechanisms underlying natural variability in macroalgal assemblages on reef habitats, and was achieved by sampling at different scales in space and time within three biogeographic regions (Jurien, Perth and Geographe Bay) along a 600 km stretch of coastline. To date, over 400 taxa of algae and seagrasses have been recorded. At the greatest spatial scale, that of region, a latitudinal shift in assemblage structure was evident despite a degree of overlap between northern regions. However, this broad trend overlies significant variability at smaller spatial scales (ie. locality, and sites within localities), where the spatial distribution of macroalgal assemblages was relatively patchy. Analysis of environmental correlates of assemblage structure indicates that reef topography as well as orbital velocity at the reef surface are likely to play important roles in this variation. Seasonal trends were apparent in assemblage structure and resulted from both seasonal changes in the physical environment (eg. light penetration, storm activity) and intrinsic life history attributes of some key brown algal species. This study is continuing but these preliminary results hold significant prospect for informing our understanding of factors important to macroalgal assemblage structure, and allowing us to better predict their response to disturbance.

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## **Differential tolerance to heavy metals between two source populations of the introduced bryozoan *Bugula neritina***

Resistance to heavy metals is a potentially important trait for introduced marine organisms, facilitating their successful invasion of disturbed natural communities. We conducted laboratory- and field-based experiments to examine differential resistance to a heavy metal (Cu) between two source populations of the introduced bryozoan *Bugula neritina*, originating from a polluted (Port Kembla Harbour, NSW, Australia) and an unpolluted (Botany Bay, NSW, Australia) environment. A laboratory toxicity test was conducted to assess the relative resistance of *B. neritina* recruits from the two sources, by measuring the attachment success, survival and growth of individuals exposed to a range of Cu concentrations (0, 25, 50 and 100  $\mu\text{g l}^{-1}$  Cu). Upon completion, reciprocal transplantation of the colonies to the original polluted and unpolluted locations was conducted to assess ongoing survival and growth of colonies under realistic environmental conditions. *Bugula neritina* colonies originating from the polluted Port Kembla Harbour had increased resistance to Cu relative to populations from the unpolluted Botany Bay. There appeared to be a cost associated with increased metal tolerance. In the laboratory, Botany Bay recruits displayed significantly higher growth in control treatments and significantly poorer growth at 100  $\mu\text{g l}^{-1}$  Cu with respect to Port Kembla Harbour individuals, which showed unusually uniform and low growth irrespective of Cu concentration. Field transplantation showed copper resistance in Port Kembla Harbour colonies constituted an advantage in polluted but not benign environments. The findings of this study provide evidence of the benefits to invasive species of pollution tolerance and suggest that human disturbance may play a role in facilitating the establishment and spread of invasive species in marine systems.

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## **Guidance for planning seabed biodiversity surveys from analysis of a previous series of habitat and biotic sampling surveys on a tropical shelf: Phase 1 of the GBR Seabed Biodiversity Project**

Prior to embarking on extensive sampling for the GBR Seabed Project, a first phase involved examining the sampling design guidance provided from re-analyses of the datasets from the earlier GBR Effects of Trawling Study. These included:

- (a) Comparisons of assemblage information content of different gear types
- (b) Dependence of information content on taxonomic resolution & abundance
- (c) Reliability of bio-physical relationships for prediction
- (d) Reliability of physical covariates for mapping and stratification
- (e) Spatial auto-correlation considerations

The key messages from these analyses will be presented, as will the strategy for stratification and sampling design developed for Phase 2 of the project.

These assessments will be re-visited later in 2006, using all the available data from the Seabed Project, as one of the objectives is to develop transferable scientific methods and tools to facilitate regional marine management planning elsewhere. This includes: knowledge of bio-physical relationships between assemblages and the physical environment (surrogates), cost-effective survey designs & techniques (including performance of rapid assessment tools video & acoustics), spatial-statistical classification & prediction methods, and sustainability risk indicators for seabed species, assemblages and communities.

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## **Stable isotopes distinguish the trophic pathways of azooxanthellate and zooxanthellate rhizostome jellyfish**

Carbon and nitrogen stable isotopes were used to compare the trophic ecology of the azooxanthellate *Catostylus mosaicus* and zooxanthellate *Phyllorhiza punctata* at Smiths Lake, NSW, during December 2004 and March 2005. Isotopic signatures were obtained for medusae, zooxanthellae of *P. punctata* and nocturnal and diurnal zooplankton. During December and March, *C. mosaicus* were enriched in <sup>13</sup>C by more than 3 delta units compared to diurnal mollusc larvae and copepods but were only 1.5 delta units more enriched than nocturnal copepods, indicating that *C. mosaicus* derives its carbon from copepods it captures at night rather than zooplankton available during the day. The delta <sup>13</sup>C signatures of *P. punctata* were more than two units greater than that of diurnal and nocturnal zooplankton and its zooxanthellae and the source of carbon for *P. punctata* was not confirmed. Modelling of <sup>15</sup>N signatures shows that *P. punctata* derives its nitrogen from a combination of heterotrophic feeding on nocturnal and diurnal zooplankton and translocation of photosynthetic products from its zooxanthellae.

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CoML, International Scientific Steering Committee (SSC), Washington**Census of Marine Life (CoML)**

In a world characterized by crowded shorelines, oceanic pollution, and exhausted fisheries, a global marine census will probe the realities of the declines or global changes in ocean resources and the extent of our ignorance. Archives spanning centuries, technologies empowering exploration, and communications connecting scientists open opportunities for such a census. In the year 2000, the Census of Marine Life (CoML) began, led by an International Scientific Steering Committee of experts in diverse forms of life, habitats, and technologies.

The goal is to assess and explain the changing diversity, distribution, and abundance of marine species from the past to the present, and project future marine life. Global marine life since fishing became ecologically important, from icy polar to warm tropical waters, from tidal zones shared by humans to trenches 10,000 meters deep, from microscopic plankton in the light and sea lions plunging into the dark to worms in abyssal sediments, from organisms shifting on the slopes of seamounts to ones tolerating fiery oceanic vents, the 5 percent of the ocean that is fairly regularly visited and the 95 percent of the ocean whose life is largely unexplored.

Through 2010, scientists worldwide will exploit and organize what is known, shrink the unknown, and minimize diversion into the unknowable. Three large questions define the tasks of the Census: What did live in the oceans? What does live in the oceans? What will live in the oceans? Globally, scientists collaborating in CoML are mining historical and environmental archives, typically since about the year 1500, to write a History of Marine Animal Populations (HMAP), quantifying how fishing and environmental fluctuations changed what lived in the oceans. Fourteen cooperative international Ocean Realm Field Projects as well as affiliated national efforts are exploring the diversity, distribution, and abundance of what lives in six ocean realms from tidal zones to deep trenches.

The observers in the field projects, as well as HMAP, deposit their data in the Ocean Biogeographic Information System (OBIS), a global georeferenced database about marine species, accessible on the web with tools for visualizing relations among species and environments. The Future of Marine Animal Populations (FMAP) network integrates the extensive Census-generated data in mathematical models to predict how environmental and human influences will change what will live in the oceans. The legacies of the CoML will be improved methods for biological sensing for the Global Ocean Observing System, access to data on marine life in OBIS, information for wise management of marine resources, and a better informed public.

For more information, visit: [www.coml.org](http://www.coml.org)

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**Examining the role of species as habitats on intertidal rocky shore ecosystems**

Victoria's intertidal rocky shore is home to a variety of plant and animal species that create potential habitat for other co-occurring species through their physical structure. These sorts of species have been suggested by current ecological theory to function as primary facilitators, dominant competitors or ecosystem engineers to name a few. Several species have been identified that can alter reef conditions by changing wave and sun exposure and at a smaller scale creating microclimates which provide refuge habitats for other intertidal species exposed during low tide. This study will compare the utilisation of these biotic habitats by species in comparison to the utilisation of abiotic habitats across shores that range in structure, exposure and habitat availability. Determining the importance of these habitat-forming species will allow a greater understanding of the potential repercussions of their loss to intertidal communities and overall ecosystem health. This study serves to examine current marine ecological theory across a large spatial scale and a variety of conditions to establish its breadth, and most especially its applicability to Southern temperate rocky shores.

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## **Sources of variation in herbivore preference: among individual and past diet effects on amphipod host choice**

Understanding which factors affect the feeding preferences of herbivores is essential for predicting the effects of herbivores on plant assemblages and the evolution of plant-herbivore interactions. Most studies of marine herbivory have focussed on which plant traits (e.g, chemical defences) determine preferences, while few studies have considered how preferences may vary among individual herbivores due to genetic or environmental sources of variation. Such intraspecific variation is essential for evolutionary change in preference behaviour. We examined how preferences of the herbivorous amphipod *Peramphithoe parmerong* vary among individuals and the degree to which preferences are altered by environmental factors (past diet and condition). Preferences among three species of brown algae did not vary significantly among individual amphipods, thus constraining the ability of natural selection to promote increased specialisation on high quality hosts. Amphipod preferences were strongly influenced by past diet, with increased tendencies to feed upon hosts that were not recently used. Such past diet effects indicate that herbivore preferences are a function of herbivore history in addition to plant traits, and provide a mechanism for the continued persistence of this herbivore on poor quality hosts in the field.

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## **Capturing the distribution and diversity of benthic macrofauna from physical datasets: A case study from the Gulf of Carpentaria, Australia**

Mapping the distribution of marine benthic fauna over broad areas of the seabed is both time-consuming and costly. For this reason, there has been a growing interest in the characterisation of habitats based on their abiotic (physical and chemical) attributes. The characterisation of habitats should, in theory, allow the identification and monitoring of the biotic components of the system. However, this link between the abiotic and biotic elements of marine ecosystems remains poorly tested. The aim of this study was to investigate the relationship between the distribution of benthic macrofauna in the southern Gulf of Carpentaria and physical factors such as sediment composition (grain size and carbonate content), sediment mobility, water depth and organic carbon flux. We also tested the correlation between these physical parameters and the macrofaunal diversity. A strong correlation ( $R^2 = 0.79$ ) was obtained between macrofaunal diversity and a combination of sediment mobility due to wave power, the percent modern vs relict sediment, the percent very fine sand, skew in the grain size distribution and the organic carbon flux. Analysis of the physical conditions at low diversity sites indicated that high sediment input suppresses biological diversity.

Biogenic material preserved in seafloor sediments is also a rich source of biological and environmental information in both space and time. In this study we tested the potential for benthic foraminiferal diversity to act as a surrogate for benthic macrofaunal diversity and distribution in the Gulf of Carpentaria. Preliminary results from this analysis are promising, suggesting that analysis of benthic foraminifera preserved in seafloor sediments may allow assessment of macrofaunal diversity and the ecosystem response to environmental change through time.

Prowse, Thomas

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## **Fuels for development: maternal provisioning in Asterinid sea stars**

The larval development of free-spawning marine invertebrates is inseparably linked to the size and energy content of their eggs. With this in mind, eggs and larvae of closely related Asterinid sea stars with divergent modes of development were collected for lipid analysis. Energetic lipids known as triglycerides were the most abundant energy source present in the eggs of these species. There was some relationship between egg lipid content and life history strategy. In contrast to sea urchins, however, it appears that these sea stars do not furnish their eggs with wax esters, another class of energetic lipid. This may reflect the lack of these lipids in the diets of the asteroids studied. Furthermore, while lecithotrophic larvae of the cushion star *Meridiastra calcar* did use triglycerides during their lifetime, a significant portion of the initial store was still present at the juvenile stage. This result parallels those for sea urchins, demonstrating that *M. calcar* females provide more reserves in their eggs than is required to complete metamorphosis, the remainder presumably being used for juvenile growth and development.

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## **Burnt out snails: effects of desiccation and sunlight on the development of rocky shore gastropods**

Intertidal encapsulated embryos may be synchronously exposed to many environmental stressors, but interactions between some of these factors remain poorly understood. Here, the effects of solar radiation and desiccation on embryonic mortality and developmental rates were assessed using laboratory and field experiments. Egg masses of three intertidal gastropod species were exposed for 72 hours to combinations of spectral (full spectrum, UV-blocked, dark) and daily emersion treatments (control, 15-, 30-, 60-minutes). *Siphonaria denticulata* and *Bembicium nanum* embryos were expected to be tolerant to emersion and UVR as they are routinely deposited on exposed rock platforms. In contrast, *Dolabrifera brazieri* embryos were predicted to be vulnerable to these stressors as they are deposited in shaded, submerged habitats. Lab experiments revealed that light treatments and desiccation negatively affected the mortality and developmental rate of *D. brazieri*. The mortality of *B. nanum* did not significantly increase after UVR-exposure or emersion, and the developmental rate was significantly faster in light treatments than dark. Surprisingly, embryonic mortality of *S. denticulata* was significantly higher in UV-blocked treatments than full spectrum treatments after 60-minute emersion periods, but neither spectral treatments nor desiccation periods affected developmental rates. Field observations were also conducted to investigate the natural effects of desiccation on the embryonic mortality of *S. denticulata* and *B. nanum*. Despite the apparent resistance of these embryos to UVR and desiccation in the laboratory, mortality was significantly higher in desiccated habitats than in submerged habitats in the field, thus suggesting that selection of these spawning sites may not be optimal for embryos, particularly in light of global change.

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## Biogeochemical processes inferred from two dry season surveys in Keppel Bay and nearby coastal environments

The biogeochemical functioning of tide-dominated estuaries is not well understood in Australia, and there is a pressing need to identify sediment, nutrient and agrochemical pathways, sinks and accumulation rates. This is particularly the case in coastal northern Queensland where the impact of water quality changes in rivers resulting from vegetation clearing, changes in land-use and modern agricultural practices are the single greatest threat to the Great Barrier Reef Marine Park. The Fitzroy River, together with the Burdekin River, is responsible for major inputs of sediment and nutrients to the coastal zone, including the Great Barrier Reef lagoon. Although the Fitzroy catchment was targeted for a research and development program in the most recent *Reef Water Quality Protection Plan* (<http://www.deh.gov.au/coasts/pollution/reef/>), comparatively little attention has been given to the important estuary and coastal zone areas within this plan and other regional planning processes. The strategic imperative of the Fitzroy Contaminants project in the Coastal CRC was thus to develop better systems understanding and predictive capability in terms of water quality in the Fitzroy Estuary and Keppel Bay. This talk will highlight some interesting biogeochemical findings from two dry-season surveys of the Fitzroy Estuary and Keppel Bay conducted as part of the project (in September 2003 and August 2004). These preliminary findings include evidence for: (i) the biological utilisation of organic nutrients; and (ii) an important role for iron in the breakdown of organic matter and in the utilisation of N<sub>2</sub> by (potentially) heterotrophic bacteria. Importantly, these findings will feed into development of a predictive model for the system (see abstract and talk by Ian Webster).

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Centre for Research on Ecological Impacts of Coastal Cities, Marine Ecology Laboratories A11, University of Sydney, NSW 2006

## Changing diversity in an interaction web of intertidal mollusc grazers and epilithic biofilms: are there functional effects?

Traditionally, scientists have focused on biodiversity as a response variable to natural variation or experimental manipulation of ecological systems. In recent years, however, interest about how diversity affects, rather than responds to, ecological processes (or functions) has emerged and developed. As a paradigm for this new field of research, generally labeled Biodiversity and Ecological Functioning (BEF), is the concept that the loss of biodiversity causes decreases in the average intensity and stability of ecological processes. Several models about the effects of diversity at the level of consumers and resources have been formulated in the context of BEF research. Most authors propose a negative relation between the number of species of consumers and the aggregate biomass of resources. A positive relation between the diversity of resources and their resistance to consumption has also been proposed. In this experiment, an interaction web of intertidal mollusc grazers and the epilithic biofilm that they feed on, was manipulated to test specific hypotheses from those models. The experiment was done in enclosures, with species diversity of grazers orthogonally arranged against distinct levels of biofilm, obtained by leaving sandstone tiles to colonize on the shore for different amounts of time. Three common species of grazers, the limpet *Cellana tramoserica* and the snails *Nerita atramentosa* and *Bembicium nanum*, were used to establish seven levels of diversity, that were distinct in terms of species richness and/or composition. Preliminary results show an increase in the relative abundance of microalgae containing phycobilins on the assemblages that included *N. atramentosa*. No clear effect of the number of species of grazers on the aggregate biomass of epilithic biofilm has emerged so far. Artefacts caused by the enclosures and colonization by macroalgae have confounded the first results about resistance of biofilms to consumption. Further experiments are currently underway to help clarify some of these issues.



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## Seasonal sources of carbon and nitrogen to the inter tidal mudflats of a sub-tropical macrotidal estuary

During 2004, four seasonal surveys were undertaken along mud flats of the Fitzroy estuary, QLD. Samples of surface mud (top 1cm) were collected at 24 sites from just downstream of the tidal barrage at Rockhampton to the estuary mouth. These samples were analysed for bulk stable isotopes ( $^{15}\text{N}$  and  $^{13}\text{C}$ ), lipid biomarkers (Fatty acids and sterols) and pigments with a view to assessing the dominant sources of carbon and nitrogen to the mud flats and the relative importance of microphytobenthos in a highly turbid macro tidal estuary.

During the year the estuary was characterised by large changes in salinity, for example sites close to the barrage ranged from 0‰ to almost full salinity. Water temperature ranged from around 20 °C in winter to 28 °C in summer along the length of the estuary and at all times the water column remained well mixed.

Primary productivity on the mudflats was characterized by a high but seasonally consistent spatial variability, indicating an influence from the physical environment, and by significantly increased productivity in the “cooler” winter months. Nitrogen content of the sediments exhibited large but inconsistent variation over the length of the estuary, however the  $\delta^{15}\text{N}$  values were largely consistent, around 5-6‰, except in the upper part of the estuary where elevated values possibly indicate a contribution from sewage effluent.

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## Copper contaminated macroalgae reduces epifaunal colonisation and alters habitat and feeding preferences in an abundant gammarid amphipod

Conventional toxicity testing generally assesses the effects of contaminants in their dissolved state. On introduction to the marine environment contaminants, such as heavy metals, are known to readily chelate to sediments, bind within organic matrices or accumulate in marine organisms such as macroalgae. Marine macroalgae are recognized as effective and efficient bioaccumulators of heavy metals, with algal contamination common in industrialized regions. However, the potential ecological impacts of macroalgal contamination upon algal epifauna are yet to be considered. In this study the brown algae *Sargassum linearifolium* was experimentally spiked with copper and used to assess the effects of contamination of macroalgae upon epifaunal colonisation, habitat preferences and feeding rates. A combination of field experimentation and laboratory assays using the locally abundant gammarid *Peramphithoe parmerong* were employed. Algal spiking produced copper concentrations that would be expected in contaminated macroalgae in the field. The field experiment examining colonisation patterns identified reduced colonisation of a range of epifaunal taxa to contaminated macroalgae. In laboratory assays *P. parmerong* was shown to feed and nest less on spiked macroalgae. Heavy metal contamination of macroalgae is potentially a widespread phenomenon and must be considered an important source of heavy metals to many marine invertebrates.

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## **A survey of coastal seagrass habitats, marine biodiversity and marine debris across northern Australia**

There are significant gaps in our knowledge of seagrass distribution and marine biodiversity across northern Australia's marine habitats. To address this knowledge gap, the North Australian Marine Biodiversity Survey, involving marine scientists and local Indigenous communities, assessed coastal habitats across Kakadu, Western Arnhem Land and the Gulf of Carpentaria. Collaboration between Indigenous communities and scientists and the sharing of knowledge were pivotal in achieving the overall aims and goals of the survey.

The survey had three components; consultation with Indigenous people to develop a baseline of traditional ecological knowledge, a helicopter based survey of intertidal seagrass communities, and a vessel based assessment of marine biodiversity in the Arnhem coastal region. We report on the helicopter and vessel based survey components in this paper.

The helicopter survey mapped intertidal seagrass habitat from Kakadu to Cape York in November 2004. The survey area represents almost 10% of Australia's mainland coastline. This paper describes the distribution, structure and composition of intertidal and shallow sub-tidal seagrass communities from the region. The location of marine debris (discarded fishing net and crab traps) recorded during the helicopter survey is also presented. We outline the benefits and limitations of using helicopters to rapidly survey tropical coastal habitats. Results from the helicopter survey assisted with site selection for the ensuing vessel based survey.

The vessel based survey was undertaken in November-December 2004. Samples from seagrass habitats adjacent to Kakadu National Park and Western Arnhem Land were obtained by gill net, beam trawl, grab and dredge. Over 2000 specimens, comprising at least 800 taxonomic units, were collected from 391 sites. Although very few new species were recorded, the range of many species was extended into previously unknown areas. Preliminary analysis indicates low endemism and variable species diversity.

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## **Facilitating access to estuary and coastal information**

A lot of effort has been put into collecting scientific and spatial data within the coastal zone and estuaries, and at improving the state of understanding of these complex ecosystems and the interactions that occur within them. However, little effort has been extended toward making that "understanding" an integrated, shared and common resource readily available to all. The *OzCoast* ([www.coastal.crc.org.au/ozcoast](http://www.coastal.crc.org.au/ozcoast)) web site is being developed by the Coastal Zone CRC to facilitate the better utilisation of coastal resource data, dynamic conceptual and ecosystem models, decision support tools, process facilitation, local knowledge and aspirations, and expert judgements.

The development of the web site is being guided by the results of a literature review on the behaviours and constraints of natural resource decision-makers, and a more focussed survey of how these decision-makers find online data, information or knowledge that they need to make decisions quickly. The survey found that the web was one of the most popular sources of information for decision-makers. The literature review emphasised the importance of the human dimensions of knowledge exchange, and was supported by the survey, which found that most decision-makers used their own experience and networks to source information. Both studies found that trust and confidence in the source of information, and the need for knowledge as well as information, were also important issues for decision-makers.

The presentation will expand on some of the results of the literature review and survey, and will describe the development of the *OzCoast* web site to date.

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## Seasonal circulation in the Torres Strait marine ecosystem

A model of Torres Strait has been developed by Geoscience Australia and CSIRO Marine research to investigate the interactions of currents and sediment movements with the ecosystem, with a view to better understand the significant dieback of sea-grasses in northern parts.

The most recent atmospheric and oceanographic reanalysis products have been used to force the latest release of the hydrodynamic code. This model has been calibrated to obtain the best quality correlations with available data, including temperature and salinity profiles, tidal predictions, and long term tide gauge records.

The resulting 5-year simulation provides time series sufficient to investigate the seasonal variability of the circulation. The results reveal that seasonal currents are typically around 10% of the tidal current magnitude, with westward flow prevailing for more than 9 months of the year and producing a net inflow into the Gulf of Carpentaria. The seasonal flow across the strait is southward during the monsoon and northward during the trade, with a potential "stagnation zone" in the north of the Strait near Kai reef. This zone is likely to define the southernmost latitude reached by turbid waters encroaching along the coast of Papua New Guinea. This hypothesis appears to be supported by field measurements and remote sensing observations, and will be further tested using a sediment transport model currently under development.

Future work will focus on analysing the variability of modelled suspended sediment in northern Torres Strait to assess the potential for sustained encroachment of high turbidity water and its likely impact on the light environment and seagrass health.

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## What does water quality really say about estuarine condition?

The hypothesis that "the values of indicators of estuarine condition measured in coastal lakes will reflect patterns in the external stress on the estuary" is commonly assumed in many monitoring programs. Typically sampled estuarine indicators (water quality, chlorophyll, seagrass, sediment characteristics) were measured in 18 coastal lakes in NSW. Replicated samples were collected in central basins and along margins. Data were compared to determine differences within and among estuaries. Independent information on the characteristics of associated catchments was also determined (size, nutrient loads, difference from pre-development nutrient loads, proportion of catchment under various types of development). Regression analyses were done to determine if the measured data from lakes corresponded to any of the patterns in catchment characteristics. The only indicators which showed any correlation with catchment condition were chlorophyll, turbidity and seagrass epiphytes. Reasons why water quality variables seem to have more utility overseas than in Australia will be discussed.

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## **Techniques for discriminating stocks of blue mackerel (*Scomber australasicus*): a pilot study**

This pilot study confirmed the suitability of three complementary techniques for discriminating stocks of blue mackerel (*Scomber australasicus*). The study addressed three specific aims: to assess the feasibility of each technique for studying blue mackerel stock structure; to establish protocols for the use of each technique; and, to determine the variability within and between putative stocks across the geographic distribution, and thus conduct power analyses for a finer scale stock structure study. A total sample size of 75 fish was taken from four locations across the geographical distribution of blue mackerel in Australasian waters (SE Queensland, South Australia, SE Western Australia and New Zealand). Whole frozen fish were dissected and Australian fish were subjected to each of three stock discrimination techniques, which were: analysis of parasite assemblage, genetic analysis and otolith microchemistry. Parasite analysis revealed several parasite taxa suitable for use as biological tags and additionally was able to discriminate between the four locations. Genetic techniques were developed to extract and amplify a segment of the mtDNA control region. This region showed significant heterogeneity between WA and Queensland fish. Otolith microchemistry using LA-ICPMS was technically and practically feasible, with manganese and barium discriminating between the three locations. Power analyses revealed that for the effect sizes shown in this pilot study, to investigate stock structure with a high degree of power will require minimum sample sizes between 20 and 100 fish per location depending on the technique used.

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## **Effects of marine and lacustrine larval development on maternal investment in *Galaxias maculatus***

Classical models of optimal offspring size assert that at any given time an individual has a set finite amount of resources available to invest in reproduction. This leads to a trade off between the effort that can be invested per-offspring and the number of offspring that can be produced. Importantly, these models often predict that the fitness of a parent is highest when that parent allocates their resources equally to all their offspring. Equal allocation is generally not observed in nature and several authors have extended classical models to account for variability in investment by invoking environmental heterogeneity. In variable environments parents may adopt a “bet-hedging” strategy and allocate their resources unevenly. There is also growing evidence that investment in offspring is plastic, and parents may modify their resource allocation according to their expectations of the environment their offspring will experience. Parents would allocate unequally to guard against incorrect predictions of the offspring environment. The native fish *Galaxias maculatus* spawns on spring tides amongst flooded vegetation on the banks of estuaries. The eggs become stranded when spring tide waters recede and remain exposed to the air until they are induced to hatch by a subsequent spring tide. Newly hatched larvae are washed out to sea where they complete larval development. Interestingly, there are also populations of *G. maculatus* that have become landlocked. In landlocked populations all life history stages are found within a single lake. Therefore, females spawning in lakes potentially have more accurate expectations of the environment their offspring will experience. Here we discuss differences in egg size, egg size variability and energetic content between populations of *G. maculatus* occurring in lakes and rivers.

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## **Improving microbiological parameters in coastal models**

Marine ecological models often lack the ability to capture ecological/ biogeochemical mechanisms as they assume that processes are largely independent within the marine ecosystem. Fundamental processes overlooked by present models include the roles of bacteria, zooplankton and light in algal bloom formation and decay. In particular, algal mortality rates and terms are unknown and have not been addressed in models despite both modellers and biologists regarding these rates as significant. An approach to some of these issues is to imitate the parameters of a simple model with biological experiments. For our biological experiments we used a mesocosm model designed to simplify a particular biogeochemical process. Significant in the model is the dark phase where the nutrients are depleted after an algal bloom and light is removed in order to identify mortality terms of the algae. Biological experiments with various toxic and non toxic algae and algicidal bacteria demonstrate a diverse range of results when algae are exposed to darkness. They highlight the importance of mixotrophy and demonstrate that darkness for extended periods does not necessarily result in algal mortality.

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## **Large scale biodiversity assessment techniques applied to Bynoe Harbour-Fog Bay region, a region of conservation, recreational and Indigenous importance**

Recent planning documents, such as the Integrated Natural Resource Management Plan and the Parks Master Plan, have all identified that there is insufficient data for managers to make informed management decisions on issues concerning the protection and management of marine biodiversity in northern Australian waters. In particular, baseline information, such as the distribution of marine and coastal habitats and the flora and fauna they contain, are unknown. Funded by the Northern Territory Government and NHT, the Marine Biodiversity and Conservation Unit in collaboration with the Museum & Art Gallery of the Northern Territory have applied a wide range of techniques to map marine habitats and conduct an assessment of fish biodiversity for the Fog Bay - Bynoe Harbour region, an area which is considered to be of conservation, recreational and Indigenous importance.

This poster outlines the rationale behind the choice of techniques; how analyses of satellite images, aerial photography, acoustic data and underwater video were used to efficiently map broad habitats; and describes how these data can assist managers in making more informed management decisions.

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## Understanding the habitat requirements of two harvested gastropods

Harvesting of invertebrates for food and bait is a widespread phenomenon in coastal areas world-wide. Along the coast of New South Wales, many intertidal and subtidal invertebrates are harvested for recreational and/or commercial use, often with little knowledge of their ecology. *Turbo undulatus* is an intertidal gastropod often harvested recreationally for food; *Turbo torquatus* is predominantly found subtidally, where it is the target of a small-scale commercial fishery. Before these species can be effectively managed in an ecologically sustainable way, a comprehensive understanding of the mechanisms that influence their distribution and abundance is desirable. One mechanism widely recognised to influence the abundances of organisms is that of structural complexity of habitat, with greater abundances of organisms in structurally complex habitats than in structurally simple habitats. After extensive sampling of intertidal rock-platforms along the coast of NSW, it was shown that *T. undulatus* were more abundant in structurally complex habitats (such as mats of *Hormosira banksii*, beds of *Pyura stolonifera* and coralline turf) than in an adjacent simple habitat ('bare rock'). The generality of these patterns was evaluated by sampling the distribution of *T. torquatus* in subtidal habitats (such as kelp, 'fringe', turf and barrens). Similarly, more *T. torquatus* were found in structurally complex habitats (such as Kelp, 'fringe' and turf) than in a simple habitat (barrens). Therefore, irrespective of the species' for intertidal and subtidal habitats, similar associations occur between complexity of habitat and density of animals. To understand some of the mechanisms generating these patterns (intertidally and subtidally) models about the importance of structure of habitat, place of the habitat and/or type of the habitat, were evaluated by testing relevant hypotheses using manipulative experimentation.

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## Evolution of a novel biomechanical model of plankton rates and distribution

Physical processes such as size and shape can limit the rate at which ecological processes occur. For example, the encounter rate of planktonic predators and prey limits the rate of ingestion of prey. A coupled biological model which considers a number of physical limits has been developed and coupled to the Princeton Ocean Model. Our initial approach involved the use of the physical limits in a Nutrients-Phytoplankton-Zooplankton model applied to an idealized ocean basin (representative of the Tasman Sea), driven by upwelling or downwelling winds. This model gives a realistic chlorophyll response at depth, when compared with a common NPZ model that does not use physical limits when parameterising planktonic processes. When coupled to a configuration of the East Australian Current, the biomechanical NPZ model represents nutrient and chlorophyll distributions of actual upwelling events observed off the NSW coast. But an inevitable compromise of the trophic level approach is the necessity to specify one or a few plankton sizes. Presently we are developing a model that contains a continuous size spectrum. When discretised for numerical solution, the present version has 16 size classes of phytoplankton, 11 size-classes of protozoan and 45 size-classes of metazoan. Ultimately, production estimates from the size-resolved model will be compared to empirical estimates from the Tasman Front in Sept. 2004. Using an optical plankton counter we have production from the slope of the zooplankton size frequency distribution (the size spectrum), and from daily growth increments in the earstone of larval fish.

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## Pragmatic use of the zooplankton biomass size distribution – trends over 27 years

Zooplankton collections made with a standard bongo net (0.3 and 0.5 mm mesh) were made across a standardised grid from 1972 to 1998 off southwestern Nova Scotia, where the geographic persistence of larval herring in a well mixed region is observed. Plankton samples from eight stations were analysed for size frequency composition with a lab-based optical plankton counter, and converted to a normalised biomass size distribution (“spectrum”). Multivariate analysis of ten taxonomic categories correlated with an identical analysis of the biomass of size categories. After accounting for within year, between day-night and among station variation, we found the slopes of the normalised size spectra - an index of secondary production - fluctuated around a theoretically derived value of -1. The slope will be compared with the year class estimates of the annual herring assessments.

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## Lagoonal circulation and the supply of coral reef fish larvae to Lord Howe Island

Larval supply in reef fish populations is often highly variable in both space and time and such variation plays an important role in the population dynamics of reef fishes. In lagoon environments, water flux is strongly influenced by the dynamics of water exchange over the reef crest and through reef passages. To determine the importance the physical exchange processes to the supply of larval reef fishes to the lagoon of Lord Howe Island, we conducted contemporaneous measurements of daily larval supply using light traps and ocean circulation using a diversity of instrumentation. The observed temporal patterns in larval supply were strongly influenced by both lunar cycles in availability of settlement-stage larvae and oceanographic features which facilitated onshore transport of larvae. With increasing focus on active larval control over dispersal and settlement, this study re-emphasizes the importance of incorporating physically mediated transport into studies of recruitment in marine populations.

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## Edge effects in temperate seagrass meadows

While the study of landscape ecology has become common in terrestrial systems, there has been relatively little attention paid to processes operating at this scale in marine systems. Landscape ecology examines the role of habitat configuration, and one of the major areas of research in this field is determining whether and why edge effects exist. I demonstrate here that clear edge effects exist in biomass for the seagrass *Zostera muelleri*, but that these effects are not so clear in *Posidonia australis*. *Zostera* biomass increases from the edge of a patch up to 2 m from the edge, whereas *Posidonia* decreases over the same spatial scale. A more detailed investigation of *Posidonia* shows that the number of leaves per shoot declines from an average of 3.5 at the edge of a patch, to 2.5 in the centre. This is not influenced by whether the patch is surrounded by bare sand, or the seagrass *Heterozostera tasmanica*. This difference is not accounted for by seagrass growth rates, as growth is the same at the edge of a patch and in the centre. I also examine patterns of light availability, photosynthesis and epiphytism to see how they vary with the distance from the edge of a patch.

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## **Marine National Parks and Marine Sanctuaries: is there potential for community based monitoring to collect useful data?**

Marine Protected Areas (MPAs) require monitoring programs to protect ecological values. The Victorian system of Marine National Parks (MNPs) and Marine Sanctuaries (MSs) management planning has identified through best practice risk assessment the need to monitor ecological threats. Marine pests, intertidal trampling, and visitor disturbance were some of the significant risks highlighted by the assessment and requiring frequent monitoring. Local community groups are often first to notice changes in their local marine environment and seek opportunities to participate in MPA management. Therefore potential exists for community based monitoring (CBM) to assist in the collection of ecological data to assist in MPA planning and management. Parks Victoria is evaluating this potential. *Sea Search* is a cooperative community/agency/industry project that has developed methods for monitoring marine habitats by community groups. Along with research partners Deakin University, pilot sites were established at Merri MS (subtidal reefs), Ricketts Point MS (intertidal reefs), and Corner Inlet MNP (seagrass beds). Data collected by volunteers was assessed and compared to data collected by scientists to understand relative data quality. The data quality from volunteers varied with level of training and habitat types. Volunteer monitoring was more accurate on intertidal reef habitats compared to subtidal reefs and seagrass beds, but further assessment is required. Future monitoring programs can be designed with these differences in mind. The project also investigated volunteer attitudes to identify a monitoring regime that may act as a model to encourage sustainability of CBM projects and avoid volunteer burn-out.

The *Sea Search* methods can also be applied to other CBM projects including *Reefwatch*. There is potential for data from these CBM projects to be recorded in Parks Victoria's Environmental Information System to provide baseline ecological information to fill knowledge gaps, identify impacts, and assist in planning and management.

CBM programs including *Sea Search* and *Reefwatch* need to consider the level of community interest, compatibility of community skills to monitoring tasks, address management and planning questions, and compliment data collected by scientists. Community participation in the monitoring of Victorian MNPs and MSs is valuable from both an ecological and social perspective.

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## **Determining the mechanisms of self-recruitment in coral reef fishes**

Populations of endemic reef fishes are, by definition, self-replenishing. In contrast, populations of more widespread species are likely to be replenished by dispersal of planktonic larvae from other sources. The early life-history characteristics of related pairs of endemic (to Lord Howe Island) and wider ranging species whose range encompasses that of the endemics were compared. This comparison allowed us to determine which characteristics are important in maintaining self-replenishing populations while controlling for differences in evolutionary history. Comparisons of egg size, hatchling size and planktonic larval duration of endemic and non-endemic con-generics across a range of reef fish families were made. Preliminary results of the comparative study are presented and the testing of assumptions of this study using population genetics and phylogenetics are discussed.



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## **Changes to macroalgal dominated reefs following a sedimentary disturbance**

Macroalgae are abundant organisms on shallow temperate reefs and are important as both primary producers, and in providing habitat to other reef biota. In South Australia, members of the orders Laminariales and Fucales are canopy-forming dominants and often create dense stands. The structure of these stands is rarely uniform, with many studies identifying large amounts of both spatial and temporal heterogeneity.

In this study, stands of canopy forming macroalgae at ten reef sites along Adelaide's southern metropolitan coastline were followed over a four-year period. The study was commissioned following the accidental creation of a large sediment plume that smothered several of the sites.

On a broader scale, unfavourable environmental conditions prior to the plume appear to have had a negative effect on the dominant taxa, meaning that at the time of the plume, assemblages were already in a state of recovery.

Elevated levels of sediment deposition on the plume-impacted reefs created a further level of disturbance and caused recruitment failure in a number of species. This additional impact retarded the broader recovery process and led to further degradation several sites.

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## **Primary productivity in the Eastern Great Australian Bight during the summer/autumn upwelling season.**

Data presented here form part of a study designed to examine the influence of seasonal coastal upwelling on primary and secondary productivity in the Eastern Great Australian Bight (EGAB), an area that supports an economically important sardine fishery. Results relate to research cruises conducted during the upwelling seasons of 2004 and 2005. The euphotic depth ranged from 31m to 90m and the surface mixed layer from 30m to 65m with a deep-water chlorophyll maxima associated with the thermocline. Surface chlorophyll concentrations ranged from 0-2.2  $\mu\text{g L}^{-1}$ . Maximum rates of photosynthesis saturated between 69-99  $\text{umol m}^{-2} \text{s}^{-1}$  but both  $P_{\text{max}}^{\text{b}}$  (0.178-0.237  $\text{mg C (mg chl)}^{-1} \text{hr}^{-1}$ ) and photosynthetic efficiencies ( $\alpha$ , 0.0024-0.0026  $\text{mg C (mg chl)}^{-1} \text{hr}^{-1} (\text{umol m}^{-2} \text{s}^{-1})^{-1}$ ) measured via  $^{14}\text{C}$  uptake were low compared with global estimates. Zooplankton grazing pressure was also generally low, suggesting something other than grazing was causing the low chlorophyll concentrations. Upwelling areas of the EGAB were rich in nitrogen and phosphorus (4-85  $\mu\text{g N L}^{-1}$ , 1-50  $\mu\text{g P L}^{-1}$ ), and the addition of N and P did not stimulate the algal growth potential suggesting that something other than N and P may be limiting phytoplankton productivity in the area. Silica concentrations in the EGAB were well below levels that would be expected to limit phytoplankton growth ( $<1\text{mg Si L}^{-1}$ ), and it appears that an inadequate supply of silica is the most likely cause of low diatom productivity in the region.

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## Management of sea turtle hatchlings that do not emerge from hatchery nests in Peninsular Malaysia

In Peninsular Malaysia, green sea turtles (*Chelonia mydas*) have declined by more than 80% in the last 50 years, mainly due to the collection of their eggs for human consumption. In recent years, hatcheries have been implemented to protect the eggs from this threat. During hatchery operation, it is common practice to excavate the nests approximately 1 week after hatchling emergence to determine the hatch success of each nest. During this procedure, hatchlings are found still alive in these nests, although they have been observed to be extremely slow moving and dehydrated. This study investigated whether excavating nests sooner after emergence increases the quality of these hatchlings to be released. In a treatment that represented normal operating procedures of sea turtle hatcheries in Peninsular Malaysia, hatchlings that were excavated 5 days after the primary emergence ran nearly two times slower and had significantly reduced mass:length ratios. Conversely, in a treatment that excavated nests 1 hour after the primary emergence hatchling running speed was only slightly reduced and mass:length ratio remained unchanged. This study provides evidence that there may be benefit in excavating nests immediately after the primary emergence of each nest. Faster running speed and release of these hatchlings with the main group will reduce exposure to nearshore predators. Preventing a reduction in mass:length ratio also maximises the energy reserves for offshore dispersal and stops dehydration from occurring. These factors potentially increase likelihood of survivorship of sea turtle hatchlings in these first few critical hours of existence.

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## Predators and predation intensity in a temperate marine reserve

The 126 ha Kingston Reefs sanctuary at Rottneest Island is one of the longest-established reserves of its kind in Western Australia, being established in 1988. We surveyed the densities of predators and large invertebrate prey at sites inside and outside the reserve, and estimated predation intensity by measuring mortality of tethered sea urchins of two species (*Heliocidaris erythrogramma* and *Centrostephanus tenuispinus*). The densities of all fishes combined, of fish species retained by anglers, and of fishes that prey on sea urchins was higher inside the reserve than outside; however, the difference was significant only for species that were retained by anglers. Mortality of tethered urchins was significantly higher in the reserve for both species. Video of the tethers showed that five fish species successfully preyed on the urchins inside the reserve, while two species successfully preyed on urchins outside the reserve. The diversity of scavengers (fishes that fed upon urchins that had been opened) was also higher inside the reserve (12 species) than outside the reserve (7 species), although the number of fish that fed on each urchin showed no difference. However, while the densities of *H. erythrogramma* and turbinid gastropods were significantly higher outside the reserve, the densities of *C. tenuispinus* were significantly higher inside the reserve. So, although predator density and predation intensity are higher inside the reserve, this does not lead to simple gradients in prey density.

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## **The development of an International Antarctic Institute**

The International Antarctic Institute is a consortium being developed by leading global Antarctic educational and research-intensive institutes. Its purpose is to facilitate cooperation and collaboration between member universities in undergraduate and postgraduate multi disciplinary education with a major emphasis on marine science in Antarctica and the Southern Ocean. As has been seen over the past half-century, international cooperation is the key to the success of large-scale research programs in Antarctica and the Southern Ocean. By sharing teaching resources between international partner universities we can create educational opportunities on a scale unattainable by any one institute or through traditional bilateral alliances.

The International Antarctic Institute will work towards establishing multi-institute degrees whereby students will enrol in their home institutions (an International Antarctic Institute -affiliated university) and take up to an agreed proportion of their course units at other member institutions. The units taken during this exchange will be credited through their home university. The International Antarctic Institute is planning to offer both a BSc and MSc. The MSc will be available in 2007. Degrees would be “jointly badged” by the participating institutions of the International Antarctic Institute.

Members and associated members presently include institutes from: Australia, Brazil, Chile, France, Germany, Japan, Malaysia, New Zealand, Norway, United Kingdom and the United States of America. The International Antarctic Institute is open to institutes who presently or potentially have an Antarctic educational mandate.

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## **The Census of Antarctic Marine Life - an initiative for the International Polar Year in 2007/08**

The Census of Antarctic Marine Life (CAML [www.caml.aq](http://www.caml.aq)) is a new project among the 14 field projects in the international Census of Marine Life. CAML will investigate the distribution and abundance of Antarctica’s marine biodiversity, how it is affected by environmental change, and whether change will alter the nature of the ecosystem services currently provided by the Southern Ocean.

In the collaborative ethos of the International Polar Year, CAML has become a major initiative, adopted by the Scientific Committee on Antarctic Research (SCAR) as a central component of its program “Evolution and Biodiversity in Antarctica”. The SCAR Scientific Steering Committee, with 20 invited experts, met in Brussels in May 2005 to prepare a comprehensive science plan for the five-year CAML project. Funds to SCAR from the Sloan Foundation will cover the project management, database, workshops, education and outreach activities. In addition to traditional taxonomy, the use of powerful new genetic and molecular tools will determine the extent to which the circum-Antarctic marine fauna and flora is responding to change. Research will be conducted in the pelagic, sea-ice, and benthic realms. Australian scientists have established a lead role in CAML, offering exciting opportunities to increase our capacity in taxonomy, molecular biology and integrated databases such as SCAR-MarBIN and OBIS. This paper reports the progress to date in the fledgling CAML project and addresses the significant challenges for the future.

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## **Facilitating natural seagrass recruitment: a means of rehabilitation?**

During the past few decades it has been estimated that more than 5,200 ha of seagrass habitat has been lost from Adelaide's metropolitan coastline as a result of anthropogenic disturbances. Improvements to wastewater management, particularly in terms of nutrient loads, have prompted the notion of seagrass rehabilitation in areas of loss. Seagrass rehabilitation in Adelaide through the transplantation of cores and sprigs of mature plants has had variable to low success and proved to be extremely time consuming. An alternative to transplantation is to facilitate recruitment via the provision of suitable substrate. Such methods avoid impacting on donor seagrass beds and are less time consuming than transplanting mature seagrass or culturing seedlings. Hessian substrates were used to enhance recruitment of *Amphibolis* seedlings, which are released from the parent plant with a 'grappling apparatus' for attachment. A range of bags and strips made out of different hessian types were deployed at two sites along the Adelaide coastline in September 2004. There have been significant differences in the effectiveness of the varying types of bags and strips to recruit seedlings as well as maintain seedling numbers over time. Three months after the deployment of the bags and strips, seedling numbers averaged up to 156 m<sup>-1</sup> on strips and 344 m<sup>-2</sup> on bags. Ongoing monitoring has identified that seedling numbers have declined over time, however, after seven months survival is still high (up to 52 seedlings m<sup>-1</sup> on strips and 262 seedlings m<sup>-2</sup> on bags). In contrast, no recruitment was observed on adjacent sandy areas. Our experiments have shown that hessian appears to be effective at recruiting *Amphibolis* seedlings, and may prove to be an effective method of rehabilitation.

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## **The Fitzroy Project – a study of the dynamics of an Australian tropical estuary**

After the Burdekin, the Fitzroy River supplies the second largest load of sediments and nutrients to the lagoon of the Great Barrier Reef. Over the last 6 years, we have been undertaking a study of the hydrodynamics, fine-sediment dynamics and biogeochemistry of the Fitzroy Estuary and adjacent Keppel Bay. The aim of the project is to assess the both the impact that catchment loads have on the Fitzroy Estuary itself and the role that the estuary plays in mediating the delivery of material from the river to the reef. The discharge of the Fitzroy is highly episodic - its discharge usually occurs as a series of high-flow events during the summer months with virtually no discharge occurring during the rest of the year. Interannual variability is also very high with annual discharges varying by a factor of 100 from year to year. The variability in the discharge poses significant challenges for studies of its dynamics and we have chosen a combined measurement, remote sensing, and modelling approach to address this issue. In my talk, I will present an overview of the project together with some of the significant results achieved so far.

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## **The role of jellyfish in the trophic ecology and nutrient dynamics of Smiths Lake, a coastal lake in New South Wales, Australia**

Understanding the trophic ecology and nutrient dynamics in coastal lake ecosystems is a major step towards establishing baseline data, monitoring the state of the lakes and identifying problem situations. The large biomass and the stochastic temporal variation of jellyfish suggest that they may have important direct and indirect influences on the ecology of coastal lakes and estuaries but there have been few studies in Australia or indeed worldwide that quantitatively assess their role.

The aim of this study was to compare the influence of *Phyllorhiza punctata* (a zooxanthellate species) and *Catostylus mosaicus* (an azooxanthellate species) on the nutrient dynamics and plankton communities of Smiths Lake, which is a coastal lake in New South Wales, Australia. Results indicate that while *P. punctata* consumes plankton, it also obtains nutrition from photosynthetic products that are produced and transferred from the zooxanthellae to the host jellyfish. *P. punctata* retains nutrients for extended periods of time and competes with other primary producers. By comparison, *C. mosaicus* derives nutrition by consuming plankton and rapidly excretes excess nutrients back into the water, and therefore encourages primary producers. In addition to these processes, a large percentage of available nutrients in coastal lakes may be locked up in the biomass of either species, particularly during blooms, and these nutrients are released when the jellyfish numbers crash and the biomass decomposes. Overall, jellyfish appear to have an important yet contrasting influences on the plankton communities and nutrient dynamics of coastal lakes.

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## **The effects of an prolonged estuary entrance closure on Mangroves in a NSW barrier estuary - an explanation of the distribution of mangroves throughout NSW barrier estuaries and coastal lakes and lagoons**

This research investigates the effects of a prolonged entrance closure on Mangrove populations in Deep Creek at Valla on the NSW mid north coast in 2000. Over 370 mangroves were tagged and numbered at 3 locations within Deep Creek. Control sites were located in 3 other permanently open estuaries. The height of individual Mangroves from the substrate was recorded and placed in a size class for comparison. The results show that many mangroves die due to long term inundation of pneumatophores caused by lack of tidal exchange during entrance closure. The highest mortality and stress occurred in the shortest mangroves with the most least affected being in the tallest size class. There was no indication of mangroves stress at the control sites in all size classes. The die back of mangroves in Deep Creek has important management implications for artificial estuary entrance opening and the management of ICOLLS in general. This study shows morphological adaptations and zonation of mangroves differ in artificially open estuaries to those with natural opening and closing regimes. Inference from this study suggests all barrier estuaries and coastal lakes and lagoons would naturally have limited mangrove communities if natural hydrological regimes were reinstated in NSW estuaries. Furthermore this research shows that entrance dynamics and associated freshwater flows is a major determinant of mangrove distribution in NSW barrier estuaries.

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Curtin University of Technology

## **The Ningaloo Ocean and Earth Research Centre**

Ningaloo Reef is the largest fringing reef in Australia, forming a discontinuous barrier enclosing a lagoon, which varies from 200 m to over 6 km in width. The reef extends from Bundegi Reef in the north, around the tip of North West Cape and continues south some 260 km to Gnaraloo Bay. It hosts more than 500 species of fish including the world-renowned whaleshark, and more than 300 species of coral. It is widely recognised that Ningaloo Reef has significant conservational, recreational, commercial, educational, historical and research values. On the Cape Range peninsula, unique geological features and climatic influences have created an extraordinary range of underground habitats. At least 16 genera are endemic to the Cape Range. Troglobites have evolved to be totally dependent on cave environments. They occur mostly in Tulki Limestone in the Cape Range; recent work has identified more than 31 species of troglobites endemic to the area. Stygofauna inhabit a range of freshwater and brackish caverns and fissures in the limestones of the coastal plain; more than 12 endemic taxa in the stygofauna have been identified. Relevant information on Ningaloo Reef is limited and further studies are required to provide sufficient baseline data to support appropriate decision making and management. In 2002 the Shire of Exmouth, in collaboration with the Gascoyne Development Commission, proposed the establishment of the Ningaloo Ocean and Earth Research Centre (NOERC) in Exmouth's new marina development. The conceptual Plan was developed in 2004 and the process garnering stakeholder involvement has begun with the development of a business planning brief. Information will be presented on the current status of the NOERC project - outlining particular needs and potential uses - while seeking support for such a research facility on the west coast of Australia.

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## **Ocean acidification: implications for the marine ecosystem**

The industrial nations of the World currently depend on the combustion of fossil fuel for the provision of energy. With World primary energy demand projected to rise at an average of 1.7% annually over the next 30 years this means an increase in the release of CO<sub>2</sub>. Of all the predicted impacts attributed to this inevitable rise in atmospheric CO<sub>2</sub> concentration and the associated rise in temperature, one of the most pressing is the acidification of surface waters through the absorption of the atmospheric CO<sub>2</sub> and its reaction with seawater to form carbonic acid. It is predicted that this process may lead to a surface ocean pH reduction of 0.7 units by the end of the century. It is clear therefore that the growing emissions of CO<sub>2</sub> from anthropogenic processes could pose a distinct threat to the global environment. However quantifying the consequences of CO<sub>2</sub> release is problematic as many physical and biogeochemical processes combine to create a complex set of interactions. This presentation will introduce the process of ocean acidification, highlight some of the key environmental concerns and discuss some of the mitigation strategies that have been suggested.

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## **Ongoing research at the Plymouth Marine Laboratory (UK): Assessing the impact of ocean acidification on the biodiversity, function and health of coastal marine sediment systems**

The observed rise in atmospheric CO<sub>2</sub> concentrations as a result of burning fossil fuels has been associated with a rise in mean global temperatures which in turn could have a number environmental effects (e.g. suppression of the North Atlantic circulation, large-scale melting of ice sheets, destabilisation of methane hydrates and sea level rise). However, one of the most pressing and least studied effects of increased atmospheric CO<sub>2</sub> concentrations is the continued acidification of surface ocean waters. Over recent years, ocean pH has fallen by 0.1 units and it is predicted that the continued release of fossil-fuel CO<sub>2</sub> into the atmosphere could lead to a surface ocean pH reduction of 0.7 units by the end of the century.

The oceans harbour tremendous biological diversity and it is considered that the majority of this diversity is made up of animals living in or on the seafloor. Marine sediments and the organisms that live in them also play a crucial role in maintaining a healthy marine ecosystem. Changes in ocean acidity will almost certainly affect both the sediment and the animals that live in it. Impacts on key organisms acting as 'ecosystem engineers' may exacerbate the effects of falling pH on sediment processes (e.g. nitrate flux) and the whole marine ecosystem. This talk presents the work currently being undertaken at the Plymouth Marine Laboratory (UK) which addresses the potential impact of decreasing seawater pH on the coastal sediment ecosystem; its processes, biodiversity and health of key organisms. The work consists of controlled laboratory experiments coupled with marine ecosystem modelling.

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Wiebkin, Annelise<sup>1,2</sup>, Brad Page<sup>1</sup>, Simon Goldsworthy<sup>1</sup>, Tim Ward<sup>1</sup> and David Paton<sup>2</sup>

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## **Satellite tracking Little penguins (*Eudyptula minor*) in South Australia**

Little Penguins (*Eudyptula minor*) are key predators on small pelagic fishes in the shelf waters of the eastern Great Australian Bight (EGAB) and gulfs of South Australia. Investigation into the diet and foraging ecology of Little Penguins in South Australia is an essential part of understanding the trophodynamics of the ecosystem supporting Australia's largest volume fishery, the South Australian Pilchard fishery (TAC for 2005 51,100 t). Satellite trackers were attached to breeding Little Penguins in July 2004 to track fishing trips. The aim of the study was to establish whether local waters surrounding breeding colonies were able to provide sufficient fish feed for penguins in the height of the breeding season. Results from island colonies in the EGAB, the Spencer Gulf and the Gulf St Vincent showed distinct differences in foraging trip lengths and distances travelled. Birds from an offshore island in the EGAB travelled up to 118km away and trip lengths extended to 12 days. All birds foraged east, towards the mainland. This compared with penguins in the Gulf St Vincent where most foraging trips lasted one day and birds only travelled up to 16km from the colony, generally in a northerly direction. Birds from the Spencer Gulf travelled 25km to the North East. Penguins from the EGAB were significantly smaller than birds from other colonies and differences also existed in their diving behaviour, breeding and diet. The need for long foraging trips suggests that sufficient food was lacking in the near vicinity of the EGAB colony and that the colony may be affected by small pelagic fish availability in the entire EGAB shelf off South Western Eyre Peninsula.

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## Hydrodynamics of Darwin Harbour

Darwin Harbour is undergoing rapid development and yet the physical properties that govern the biophysical processes are not well understood. While Darwin Harbour remains in a healthy condition there is an opportunity for science to provide solutions for assisting resource development and urban expansion without compromising the sustainability of living resources and the quality of urban and traditional life. This discussion describes the water circulation in Darwin Harbour, focusing on its flushing properties and the fate of sand and mud. It is shown that (1) the wet season runoff is important to flush the harbour and to redistribute fine sediment, (2) that the upper reaches of the harbour are very poorly flushed during the eight-month long dry season with a residence time estimated to be at least twenty days, (3) that the harbour traps most of the fine sediment from runoff and redirects it into mud banks in embayments and mangroves wetlands, (4) that eddies shed by the complex bathymetry maintain sand shoals, (5) the harbour is an inverse estuary that imports oceanic water during the dry season, and (6) the harbour is a stratified estuary for a few days to a few weeks during the wet season, and a vertically well-mixed estuary the rest of the time. These findings may have profound implications on development strategies for ecologically sustainable development.

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## Oceanography of the Arafura Sea: a biological survey

The Arafura Sea is an important seaway between the Pacific and Indian Oceans that influences climate, oceanography and biological features of both oceans. Despite this importance, the benthos of the sea has received little study, other than for fisheries research by vessels from Australia and other nations. Because this region has potential for oil and gas extraction as well as ongoing fisheries, knowledge of species richness and distribution of its currently unknown sea floor fauna is urgently needed. A collaboration between the Australian Museum (Sydney), the Northern Territory Museum, CSIRO Hobart and the National Oceans Office led to two biologists participating in a Geosciences Australia cruise in the Western Arafura Sea. Grab, epibenthic sled and rock dredge samples captured a broad range of benthos, ranging from hard substrate filter feeder-dominated assemblages in high energy regions to primarily infaunal assemblages in more quiescent hemipelagic ooze habitats. Although the macrofaunal-sized organisms are not yet analysed, approximately 245 species of larger organisms from 107 samples were catalogued and photographed on the cruise. A species accumulation curve of these organisms provides evidence for an even larger number of undiscovered species in this region.

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## **How thirsty is your estuary? – using science to manage freshwater extraction in coastal rivers**

As populations in coastal centres continue to rise, water supply for domestic and industrial sectors is emerging as one of the biggest issues facing local and state governments. In NSW, many dams and weirs are located just above the freshwater limit of estuaries. With increasing demand and changes to management frameworks and legislation, scientific information is needed to answer questions like ‘How much water does an estuary need?’ and ‘When is the best time to release pulsed flows?’. One of the hurdles to providing this type of information is the lack of even basic information on the biology and ecology relevant to the questions, particularly for upper estuaries. However, information is needed quickly and must be useful in a management and operational context. A case study is presented where these issues were addressed. The Seaham Weir is one of the main sources of drinking water for Newcastle and the Lower Hunter. This paper outlines the approach used to develop a program of scientific investigations to determine the impact of operation of, and extraction from, the Seaham Weir on the estuary downstream. Importantly, this program will inform operational decisions, was agreed to by industry, regulators and scientists, and included a short, medium and long term strategy to collect scientific information.

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## **CSIRO Wealth from Oceans Flagship program**

Wealth from Oceans is one of Australia’s six National Research Flagships. This initiative, led by CSIRO, is one of the largest scientific undertakings in Australia’s history, bringing together the scientific and commercial communities to tackle major issues facing the nation such as climate change, farm yields, resource management, national security and the environment. Scientists from the Wealth from Oceans Flagship will ensure the value of Australia’s oceans, which span from the chilly Antarctic waters to our northern tropical seas, is identified and unlocked responsibly. The Flagship will form the core of an industry sector specialising in the export of marine products, knowledge and technology. Our aim is to position Australia as an international leader in ocean ecology and to derive economic, social and environmental wealth from research and commercial applications.

Early successes from the Wealth from Oceans Flagship Program will be discussed. One such highlight is development of an ocean model, integrating data capture, assimilation and analysis to provide operational forecasts of ocean conditions (Bluelink). Other highlights derive from field studies by WfO scientists and collaborators on the impacts of climate change on the marine environment. For example, work in the Southern Ocean has revealed that deep waters are cooler and show reduced salinity compared to 10 years ago. WfO scientists are also developing and integrating the suite of scientific expertise needed to measure, predict and evaluate strategies for multiple-use management of Australia’s marine resources. One tool being developed in support of this goal, linked to the Census of Marine Life, is use of molecular sequence data to identify Australian fish species using the so-called barcode of life. This technique will be applied to specimens collected during the upcoming Wealth from Oceans Voyage of Discovery in Australia’s southwest oceans.

The overall research portfolio of the Flagship will also be described, together with a brief discussion of the recently announced collaboration fund which will enable scientists from outside CSIRO to carry out projects that contribute to the flagship’s overall goal.

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## **Using Marine Protected Areas as ecological research tools: monitoring the effects of a no-take zone in an estuarine tidal flat**

Recent development of Marine Protected Areas has proven a valuable tool for ecological research. They provide an opportunity to demonstrate the effects of human predation or disturbance by removing it. Concurrently, monitoring and management of MPAs benefit from a better understanding of the impact of conservation efforts. Here, I examine the effect of human foraging (bait suction pumping and trampling) on estuarine tidal flat macrofauna within a no-take sanctuary zone. Rather than focus on target species alone, I determined effects on a whole assemblages using a Beyond-BACI design, analysing both univariate and multivariate data. In contrast to previous studies, this study looks at effects on taxa at a low trophic level that are responsible for secondary production. I sampled macrofauna from a 'no-take' tidal flat and two reference locations. Flats were sampled before and for two years after the declaration of the sanctuary zone in the Jervis Bay Marine Park, NSW, Australia. The experimental design included both nested spatial and temporal scales as well as interactions. I found that the spatial distributions of discrete assemblage types during the first year were maintained throughout the three years. This provides strong evidence to support the existence of different sub-habitats, at scales of 100s meters, within a habitat generally considered biologically homogeneous. Importantly, of the 80 taxa identified over three years, one bivalve, *Eumarcia fumigata*, showed a significant six fold increase in numbers. A similar pattern was apparent for another bivalve, *Soletellina alba*. Most of the other taxa demonstrated minor fluctuations that could not be distinguished from natural variation. One important factor to consider specific to this habitat, is that many of the species have evolved to tolerate high levels of natural sediment disturbance by fish predation. I conclude that the effects of human exclusion in certain habitats may be specific to non target species, and may be a consequence of secondary impacts such as trampling.

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## **UV-induced mortality in encapsulated intertidal embryos: are MAAs an effective sunscreen?**

Mycosporine-like amino acids (MAAs) are believed to protect a variety of marine organisms against the negative effects of ultraviolet radiation (UVR), but their role in protecting developing intertidal encapsulated embryos remains unknown. In the present study, we focused on the UV protective role of natural concentrations of MAAs for 2 intertidal gastropod species, *Bembicium nanum* and *Siphonaria denticulata*, which spawn in habitats completely exposed to sunlight. We predicted that in both species, higher concentrations of MAAs within the egg masses increases the likelihood of embryonic survivorship in the presence of UVR. Egg masses from both species were collected along the rocky shores of south-eastern New South Wales. A portion from each egg mass was subjected to one of three separate spectral treatments: full spectrum, UV-B block, and full UV block. After 72 hours, proportions of surviving embryos were recorded for each spectral treatment. MAA composition was quantified for each egg mass using a portion of the egg mass not subjected to any treatment. Levels of variation in MAA concentration were striking, with *S. denticulata* egg masses showing more intraspecific variation than those of *B. nanum*. As predicted, survivorship and total MAA concentration were significantly and positively correlated for *B. nanum* under full spectrum treatments, suggesting that MAAs in this species play a significant photo-protective role during development. In contrast, we found no evidence that MAA concentration was correlated with survivorship in *S. denticulata* and conclude that this species may possess alternative mechanisms that minimise the negative effects of UVR.

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## **Spatial and temporal variation in grazing of two temperate fishes, *Meuschenia freycineti* and *M. trachylepis* (Monacanthidae) on the seagrass *Posidonia australis***

Juveniles of *Meuschenia freycineti* and *M. trachylepis* (Monacanthidae) live in estuarine seagrass meadows along the eastern and southern coast of Australia. They are omnivorous, consuming mainly seagrass (*Posidonia australis*) and its epiphytes and epifauna. We measured the biomass, abundance and seagrass grazing rates of both species over 16 months in three estuaries in the Sydney region, namely Pittwater, Botany Bay and Port Hacking. Results showed within-year and interannual variability in both biomass and abundance of both species and between all sites. In Botany Bay and Port Hacking biomass was highest between February and July (up to 2.2 gm<sup>-2</sup> for *M. freycineti* and 1.9 gm<sup>-2</sup> for *M. trachylepis*) while in Pittwater biomass was greatest in between May and September for *M. freycineti* (up to 0.2 gm<sup>-2</sup>) and between July and September for *M. trachylepis* (up to 1.1 gm<sup>-2</sup>).

The quantity of *P. australis*, consumed daily by the two species was established by using the daily variation in complete intestinal tract contents of individual fish and an estimation of the evacuation rate. By combining these results with monthly biomass estimates for each species, we calculated seagrass removal values throughout the year. In addition we tested the feeding preferences of fish for various parts of the seagrass shoot under controlled laboratory conditions, confirming the general assumption that these species prefer blades covered with epiphytes over any other part of the seagrass shoot accessible to them.

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## **High and dry in the intertidal: linking stress, individual performance and population dynamics**

Intertidal species are thought to suffer high levels of “stress” because of daily fluctuations in exposure to the air. Because individuals in high-zones are exposed to the air for longer, they are likely to suffer greater stress than individuals in lower zones. Here, we use several different measures of performance combined with matrix modelling to examine the individual and population-level consequences of intertidal stress for an abundant seaweed in high and mid intertidal zones. Against our expectations, high-zone thalli did not consistently perform worse than mid-zone thalli. There were some months when thalli in the high zone performed better, and some months when thalli in the mid zone performed better. Periodic matrix models based on monthly transitions revealed that over the entire year, high and mid-zone populations also had similar stable population growth rates and elasticities (contribution of different life-cycle stages to population growth), suggesting no population level-effects of stress. However, using periodic models allowed us to examine the demographic response in different zones each month of the year. Elasticities of juvenile stages in the high zone were highest in the months following extensive daytime exposure in summer, when temperature and humidity extremes occur, indicating population growth during this stressful time-period depended most on juvenile growth and survivorship. Elasticities of large adults in the high zone were highest before the most stressful time-period. These responses were largely absent in the mid zone where elasticities were relatively stable throughout the year. Thus, stable population growth in the different zones is maintained by different demographic strategies. Our study highlights the complex way in which small-scale variation in stressful conditions can affect life-histories and dynamics of intertidal species.

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## Science and information to underpin ecosystem based management of the marine environment in northern Australia

Regional marine planning seeks to encourage an ecosystem based approach to marine planning and management which requires substantial information and data. Science and information are a key component of regional marine plans, because they support the identification of measurable sustainability objectives and inform potential management responses, such as the development of MPAs. This paper describes a number of projects for northern Australia that have improved the state and accessibility of data and knowledge about biophysical components of the marine environment, and key social and economic drivers of change. The National Oceans Office has reviewed the state of knowledge of key marine species and habitats of ecological, commercial and cultural significance in northern Australian waters. To address identified knowledge gaps, the Office has facilitated a number of projects in the Northern Planning Area, including studies of poorly-known species groups and a series of regional biological surveys which have extended our knowledge of the distribution of key species in northern waters. For example, these surveys have revealed a previously unknown system of coral reefs in the southern Gulf of Carpentaria and explored the biota of related to hydrocarbon seeps in the Arafura Sea. In addition to biophysical data, the Office has collated social, economic and fisheries data, and undertaken literature reviews of socio-economic information in the Northern Planning Area and Aboriginal interests in, and responsibility for, sea country in the region. This information allows us to develop a systems understanding of human-ecosystem interdependencies in this relatively poorly known region.

The research and information collation undertaken through the Northern Regional Marine Planning process is greatly improving our understanding of the region and is providing a holistic information base incorporating biophysical, social and economic data that is accessible to marine industries, researchers and managers to support planning for future marine uses in the region.

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<sup>2</sup> New South Wales Department of Primary Industries, Port Stephens Fisheries Centre, Private Bag 1, Nelson Bay NSW 2315, Australia

## Aquarium weed threatens fish diversity in estuaries: the story of *Caulerpa taxifolia* in NSW

Seagrass beds in estuaries are important habitats and nursery grounds for a great variety of fishes, including many economically important species. The introduction of the invasive green alga *Caulerpa taxifolia* could potentially threaten the seagrasses of south-eastern Australia. This seminar examines the implications of the spread of *C. taxifolia* on ichthyofauna in two estuaries in central New South Wales. In a recently completed study, fish assemblages were compared among adjacent habitats of *C. taxifolia* and two seagrass species (*Posidonia australis* and *Zostera capricorni*). Fish were sampled using a small beam trawl to test for differences among habitats in (1); the species composition of the fish assemblages, (2); total abundance and species richness of fishes, and (3); abundances of major fish families. Fish assemblages separated into 3 significantly distinct groupings based on habitat. Total abundances of fishes were similar among habitats, however species richness was lower in *C. taxifolia*. The fish assemblages in *C. taxifolia* were largely characterised by high abundances of gobiid fishes, similar to those in *Z. capricorni*, and few or no syngnathid and monacanthid species when compared to seagrass fish assemblages. This suggests that if *C. taxifolia* competitively replaces native seagrass beds, the resulting change in habitat may cause a change in fish assemblages, and possibly reduce the abundances of some protected and economically important fish species.

# **Poster Abstracts**

1	<b>Annese, Danielle</b> , Ron West and Martine Jones	The impact of the introduced green alga <i>Caulerpa taxifolia</i> on fish communities in a southern NSW coastal lake
2	Johnston, Emma L and <b>Graeme F Clark</b>	Experimental establishment of endemic sponge for the restoration of a degraded port
3	<b>Costa, Trudy</b> &, Tim O'Hara and Mick Keough	Human impacts on rocky intertidal organisms along the coast of Victoria
4	<b>Cribb, Helen</b> and Andria Marshall	The black-striped mussel legacy - protecting Territory waters
5	<b>Duckworth, Alan</b> , Carsten Wolff, Elisabeth Evans-Illidge and Steve Whalan	Spatial variability of Dictyoceratid sponges across Torres Strait
6	<b>Heller, Martin</b> , Tom Vigilante and Phil Palmer	The Kimberley Saltwater Country Project
7	<b>Heller, Martin</b> , Cheryl Parker, Neville Marchant	Providing on-line information on Western Australia's marine plants
8	<b>Hill, Nicole</b> , Stuart Simpson, Emma J Johnston	The effect of heavy metal contaminated sediments on hard substrate assemblages in temperate and polar regions
9	<b>Hoschke, Alexandra</b> and Glen Whisson	Utilising GIS to monitor Ningaloo Reef, Western Australia
10	<b>Lee, Jessica</b> , Maria Byrne and Sven Uthicke	To split or not to split? A study of fission in tropical holothuriids and the carrying capacity of the environment
11	<b>McClary, Dan</b> and Mike Stuart	Hitchhikers delight: Five star translocation of non-indigenous marine species by cruise ships
12	Arundel, Helen, John Sherwood, <b>Julie Mondon</b>	When should an estuary be opened? An Estuary Entrance Decision Framework to inform manager's decisions
13	<b>Pedder, Adele</b>	Australia's oceans under threat - the solution lies with you and me
14	<b>Razak, Nurhidayah</b> and Edwina Tanner	Modelling ocean nourishment in Morocco using the GIS system EASY
15	<b>Suthers, Iain</b> , David Booth and Jane Williamson	Sydney Harbour Institute of Marine Science (SHIMS)
16	<b>van Keulen, Mike</b> , Eric Paling, Peter Ridd, Douglas Fotheringham and Jennifer Verduin,	Seagrass rehabilitation and sediment dynamics
17	<b>Virtue, Patti</b> , Toshi Yoshida, Wilhelm Hagen, So Kawaguchi, Kerrie Swadling, Stephen Nicol, Peter Nichols	Does carnivory improve the fitness/condition of Antarctic krill?
18	<b>Whisson, Glen</b>	The Ningaloo Ocean and Earth Research Centre
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20	<b>Whisson, Glen</b> , Christopher Tomlinson, Alexandra Hoschke and Prayadt Wangpen	Comparing the catch composition of two designs of 'samplers' deployed on the Ningaloo Reef, Western Australia, with an emphasis on crustaceans
21	<b>Wressnig Anna</b> , Cameron McIntyre and Christopher McRae	Gut content analysis of fish by thermochemolysis with tetramethylammonium hydroxide (TMAH) and gas chromatography-mass spectrometry (GC-MS)
22	<b>Yunupingu, Djawa</b> and Richard Barkley	Carpentaria Ghost Net Programme: Saltwater people working together

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## The impact of the introduced green alga *Caulerpa taxifolia* on fish communities in a southern NSW coastal lake

*Caulerpa taxifolia* is a marine alga that is endemic to tropical regions around the world. However, since 2000, it has been found displacing native seagrasses in nine waterways in temperate NSW. The objective of this study was to compare the composition of fish assemblages before and after colonisation by *C. taxifolia* in Lake Conjola on the NSW south coast. Fish communities were sampled in Lake Illawarra, St Georges Basin, Burrill Lake, and Lake Conjola. Data obtained in 2004, following extensive colonisation by *C. taxifolia* in Lake Conjola, was compared to data previously collected between 1998 and 2000. Cluster analysis revealed a 20 % similarity in assemblages across all sampling occasions between 1998 and 2004, however, species diversity was variable at all lakes among years of sampling. Despite the clustering of samples obtained from Lake Conjola in 1998, 1999 and 2004, these assemblages were found to be significantly different among all years sampled, both before and after *C. taxifolia* colonisation, indicating that species composition, and the proportion of the total catch that they represent, are highly variable from year to year. In contrast, a notable decline in fish abundances was evident in Lake Conjola following colonisation by the alga. This research suggests that *C. taxifolia* may be having an effect on fish communities in Lake Conjola, but that there is no simple relationship between the colonisation of native habitat by *C. taxifolia* and the composition of fish assemblages.

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## Experimental establishment of endemic sponge for the restoration of a degraded port

Restoration ecology has emerged as a growing discipline that aims to return ecosystems to their natural state. This involves the remediation of both physical (habitat structure and quality, disturbance regime) and biological (species identity and biodiversity) components of an ecosystem, and projects must often consider potential interactions between these components. Ports and urban estuaries are among the most modified of all marine environments, and may be considered a priority for restoration efforts. We assessed the relative importance of a) water quality, and b) community composition on the success of experimental reintroductions of an endemic sponge into a degraded port. We grew hard-substrate marine communities at various sites throughout Port Kembla Harbour, NSW. Water quality varied between sites, as did the dominant fauna and community composition. A reciprocal transplant was then conducted in which communities from each site were transferred to each other site, such that the factors of community composition and water quality were fully-crossed. An endemic sponge was then inserted into each community, and we quantified the survival, growth and metal bioaccumulation of the sponge over a given period. By comparing the effect of the initial site (where communities originated) to the final site (where communities were transplanted to) on sponge growth, we could gauge whether community composition or water quality was the primary determinant of sponge establishment. The survival of sponges transplanted into the less polluted sites was almost double (~75%) that transplanted to the polluted sites (~40%). We did not detect effects of the initial community composition on live sponge tissue area or wet weight, which suggests that the characteristics of the initial community did not affect sponge growth or survival. Bioaccumulation of metals in sponges was correlated with survival, however other factors such as turbidity may be required to explain sponge mortality at some sites. This study suggests that remediation of the physical environment may be a prerequisite for biological remediation, and demonstrates the utility of experimental transplants in assessing restoration potential.

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## Human impacts on rocky intertidal organisms along the coast of Victoria

Anthropogenic activities have a diverse array of ecological consequences on rocky intertidal reef habitats. These consequences can include a reduction in species richness and diversity, changes in the size-class distribution of some species and increased competition with invasive species. A number of studies have sought to elucidate the various anthropogenic effects on rocky intertidal organisms by conducting small-scale experimentation at a small number of sites; however few have assessed these effects over large spatial scales. Victoria's intertidal rocky reefs support a diverse suite of animals and plants, many of which only occur in south eastern Australia. Many of these reefs are subject to human induced pressures, particularly those within bays, which are susceptible to trampling by visitors, over-harvesting of some shellfish and bait species and exposure to domestic and industrial pollution. The aim of this project is to evaluate the effect of human impacts on the patterns of species richness and diversity within Victoria's rocky intertidal bay habitats. More specifically, to observe distribution patterns of species with a limited capacity for dispersal (i.e. direct developers and brooders) and assess how these correlate with the magnitude of human impacts. This data will further our understanding of these unique habitats and provide coastal managers with information critical for the sustainable management of Victoria's rocky intertidal reefs.

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## The black-striped mussel legacy - protecting Territory waters

The threat posed to native ecosystems by the introduction of exotic species via biofouling on the hulls of recreational cruising yachts gained national recognition following the detection of an established marine pest in Darwin in April 1999. The successful eradication of the black-striped mussel (*Mytilopsis sallei*) demonstrated the necessity of early detection and a rapid response.

Only a year later *Mytilopsis sallei* was again detected within Darwin Harbour. In this instance the mussels were found in clusters amongst fouling on the hulls of apprehended Indonesian fishing vessels.

In response to these threats, the NT Fisheries Group Aquatic Pest Management Unit (APMU) implemented a program aimed at managing biofouling vectors and monitoring communities of fouling organisms in Darwin and along the NT coastline.

Biofouling on the hull or in the seawater piping of recreational and apprehended vessels as a vector for species introductions is managed through vessel inspection and treatment protocols. The vessels' voyage history and anti-fouling details are assessed to determine the level of risk posed by that vessel.

An environmental surveillance program provides for ongoing monitoring of fouling communities within areas of high vessel traffic, and for water quality monitoring within Darwin Harbour and marinas.

Historically focussed in Darwin Harbour and marinas, monitoring has recently expanded to include a number of locations along the NT coastline. The use of artificial settlement surfaces allows for species within the natural fouling communities to be monitored, seasonal trends in species abundance to be identified, and provides an 'early warning system' in the event of a species introduction.

Monitoring of water quality has identified high risk periods when Wet Season runoff results in highly stratified marina water bodies. Unable to survive the extreme variations in temperature and salinity, native fouling species are therefore less able to compete should new species be introduced. At these times, artificial marina environments are most susceptible to invasion by marine pests.



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## **Spatial variability of Dictyoceratid sponges across Torres Strait**

Spatial variability of dictyoceratid sponges was examined in Torres Strait, an archipelago of islands and reefs between northern Queensland and Papua New Guinea. Surveys were done at 4 locations, each separated by 50-220 km, with each location subdivided into 5-7 sites, each  $\geq 2$  km apart. At each site four 50x2 m belt transects were quantitatively surveyed for dictyoceratids. In addition, several environmental factors were also recorded including substrate type (rock, rubble and sand), water clarity, and reef slope and depth. Dictyoceratid abundance was similar among locations, averaging 15.5 individuals per 100 m<sup>2</sup>, but varied significantly among sites. Twenty five dictyoceratid species were recorded in Torres Strait, with approximately half (12/25) found in only one location. Canonical Correspondence Analysis determined that the measured environmental factors explained only 26% of the spatial variation. Cluster analysis indicated that the dictyoceratid community could be similar among neighbouring sites and among sites separated by hundreds of kilometres. Conversely the dictyoceratid community could vary greatly between neighbouring sites 2 km apart and on the same reef complex. In addition to environmental and biological factors, such as reef slope and reproductive dispersal, it appears that stochastic processes influence spatial variation of dictyoceratids in Torres Strait.

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## **The Kimberley Saltwater Country Project**

In 2004 the Kimberley Land Council, through the Rangelands NRM Group Inc. successfully applied for Natural Heritage Trust funding to undertake the Saltwater Country Project. The project is intended to conserve traditional knowledge relating to the use and future management of the Kimberley coastline from the Buccaneer Archipelago (north of Derby) to Cambridge Gulf. The project targets coastline culturally significant to the traditional owners of the Kimberley coast and will compliment and effectively integrate into the larger NRM planning process currently underway in the Kimberley. This will be achieved by providing a better definition of indigenous coastal country and its assets and documenting their associated values. The impact that current and future threats/uses have or may have on these assets and values will also be defined. A series of suggested management actions to reduce the impacts of the threats on the assets will be detailed. The project and its associated final document will significantly assist the traditional owners of the Kimberley coast in expressing their natural and cultural resource management planning aspirations and concerns to the wider community and current and future NRM processes in the Kimberley region that the State or Commonwealth may undertake.

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## **Providing on-line information on Western Australia's marine plants**

Funded in 2004-05 this Natural Heritage Trust project is the second phase of a much larger project to support conservation of the state's biota by providing on-line access to critical marine plant data. A readily available web-based information system will facilitate easy access by managers, researchers, community and other marine stakeholders to marine plant species inventories and up-to-date names. The project will initiate a training program to ensure that marine studies efficiently collect and document new collections of marine flora to extend the information base.

On-line access on the state's marine plants will be provided via the Department of Conservation and Land Management's information system FloraBase.

FloraBase is available on CALM's website at <http://florabase.calm.wa.gov.au>

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## **The effect of heavy metal contaminated sediments on hard substrate assemblages in temperate and polar regions**

Many anthropogenic disturbances to the marine environment have large and persistent impacts on a variety of benthic communities. In urban areas, heavy metal pollution from sources such as industrial discharges, leachates from reclaimed land, stormwater drains and metal based antifouling paints are of environmental concern. These contaminant sources have led to widespread enrichment of metal concentrations in sediments, often to several orders of magnitude greater than natural background concentrations. Numerous studies have shown heavy metal contamination affects the structure of soft sediment communities. Disturbance to contaminated sediments provides a mechanism for the resuspension of these sediments and the release of metals into the water column. Both of these processes may affect the hard substrate assemblages that live immediately above areas of contaminated sediment. To date there have been no assessments of the potential for heavy metal contaminated sediments to impact on hard substrate communities. Using a combination of field and laboratory based experiments this study will determine whether sediments contaminated with copper, lead and zinc affect the recruitment, growth and survival of hard substrate marine organisms. The second aim of this study is to compare the response of temperate and polar hard substrate assemblages to contaminated sediments. The proposed experiments will be conducted in Sydney Harbour and around Casey Station, Antarctica.

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## Utilising GIS to monitor Ningaloo Reef, Western Australia

Ningaloo Marine Park (NMP) has been established to protect the biodiversity of Ningaloo Reef, Western Australia, which is widely recognised as possessing significant conservational, recreational and commercial values. The 2005 Management Plan for NMP includes a zoning scheme that has placed 34% in Sanctuary Zones, and has outlined research and monitoring programs to improve the knowledge base of the marine environment and assess anthropogenic impacts. A Geographic Information System (GIS) was used to facilitate two such research projects initiated by Curtin University: 1. A comparative assessment of crustacean sampling devices at Ningaloo Reef; and 2. An assessment of sediments in designated mooring and anchoring areas of NMP. In both cases GIS was used to identify sites from a Landsat TM / Orthophotography mosaic according to specific spatial criteria. Information will be presented on the significance of GIS as a support system to the successful implementation of marine bio-monitoring projects, as well as its critical role as a tool in the accurate gathering, recording and interpretation of multi-faceted databases.

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## To split or not to split? A study of fission in tropical holothurioids and the carrying capacity of the environment

Asexual reproduction by transverse fission of four species of aspidochirotida holothuroids (*Holothuria atra*, *H. hilla*, *H. difficillis* and *Stichopus chloronotus*) will be monitored in One Tree Island on the Great Barrier Reef and fission products will be surveyed for the duration of the study (March-September). *Holothuria atra* were translocated to patch reefs (micro-atolls) within the lagoon at 2 density treatments (low density and high density) with unmanipulated patch reefs as controls. The *H. atra* were measured and weighed before being placed into the patch reefs. Their weight, length and reproductive response (fission) will be monitored throughout the study. These experiments will test the hypothesis that holothuroids can adjust their reproductive strategy in response to the carrying capacity of their environment. Aspidochirotids are deposit feeders and ingest the top 5mm of the substratum. The nutritional value of the sediment in all treatments will be assessed during this study and analysed for any nutritional changes potentially resulting from the presence of holothuroids. Presently the demand for holothuroids as beche-de-mer has increased drastically and has led to the overharvesting of species of high market value. There is now an urgent need for better management strategies for fisheries to maintain sustainable populations of holothuroids as a food resource whilst maintaining their role in coral reef ecology. This depends on an increased understanding of the biology and ecology of holothuroids.

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## **Hitchhikers delight: Five star translocation of non-indigenous marine species by cruise ships**

Much study has been made of the relative risks of ballast water as a vector of non indigenous marine species (NIMS), but hull fouling as a vector for the translocations of NIMS is relatively poorly understood. Biosecurity New Zealand (BNZ) has commissioned a multi-year study aimed at characterising the nature and extent of fouling communities present on a variety of vessel types arriving in New Zealand from overseas. BNZ is managing this large and complex project by assigning the sampling of different vessel types to different research providers (reported in other presentations at this conference), and by adopting a 'taxonomic clearinghouse' approach, whereby a single research provider is responsible for all identifications of material supplied from different sources. We have been contracted to survey fouling communities on cruise ships and fishing vessels arriving in New Zealand. We report here the interim results of the first season of cruise ship sampling, including consideration of vector pathways and general fouling assemblages.

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## **When should an estuary be opened? An Estuary Entrance Decision Framework to inform manager's decisions**

Many estuaries in south west Victoria intermittently close following the formation of a sand bar at the mouth of the estuary. The resultant increase in water level within the estuary has an environmental benefit as adjoining wetlands and littoral fringes are inundated, however, there are also economic costs associated with flooding of infrastructure and agricultural land. A history of unlicensed river mouth openings and community concern about the lack of clear, consistent guidelines were the impetus for the development of the Estuary Entrance Management Decision Framework

Community input via a series of workshops was an integral stage in the development of the Framework. The workshops identified the range of socioeconomic, cultural and environmental assets to be considered when deciding whether or not to open an estuary. The Framework is a computer program, which will have the capacity to store physicochemical data, biological information and digital images. An impact assessment, based on an assets-threats model, will compare opening with not opening an estuary at a range of water levels. The Framework also allows the user to vary water level, time of the year, periods of inundation and time since last inundation. Technical advisory groups were established to provide expert input into describing the impact of various water regimes on environmental values, particularly birds, fish and plants. Community members, associated with specific estuaries, will be involved in scoring assets and threats for their estuary. The Framework also provides a platform for ongoing monitoring of key estuarine physicochemical characteristics and identifies assets, most at risk from artificial mouth openings, to target in monitoring programs.

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## **Australia's oceans under threat - the solution lies with you and me**

For 40 years the Australian Marine Conservation Society has been working to protect the health and vitality of Australia's coast and oceans. To this day, AMCS and its branches remains a consistent and persuasive voice for the seas. Increasingly, Australians from all walks of life are becoming passionate and active members and supporters of AMCS and its campaigns. These include Marine Protected Areas, Species at Risk such as whales, sharks and rays, Habitats at Risk such as Darwin Harbour and Glyde point in the NT, and Sustainable Fisheries. This poster will illustrate some of the current conservation challenges facing Australia and provide solutions through community action. The most trusted and experienced sectors within the community who can best address these challenges are scientists and conservationists. It is these two groups who can find the best way forward.

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## **Modelling ocean nourishment in Morocco using the GIS system EASY**

The technology involved in ocean nourishment is the construction of factories to deliver nutrient to the ocean. The factories use natural gas as feed stock and pump the nutrient created in low concentration into barren areas adjacent to pelagic fisheries. The nutrient stimulates the growth of phytoplankton in a replication of the natural process of photosynthesis termed bio-mimicry. Phytoplanktons are the basis of the food chain in the ocean and their increased growth leads to increased fish production. The carbon dioxide becomes locked up in the tissue of plankton and fish, and falls into the deep ocean as detritus.

Developed by a team lead by Professor Dale Kiefer's of Department of Biological Sciences, University of Southern California, L.A., Environmental Analysis System (EASy) is a geographic information system that is designed specifically for the usage in marine and coastal area with the capabilities to view, analyzes and store a diverse environmental data.

This system has been used to provide information and visualization options involving overlaying numerous environmental and ecosystem data layers in the Morocco region. Satellite data including chlorophyll-a and sea surface temperature together with in situ measurement have been assimilated in EASy to produce images for analyzing the trend of pelagic fisheries in Morocco. In particular the physical properties of the Moroccan exclusive economic zone have been presented along with a model for small pelagic fish biomass. The resulting trend shows that the fish production is concentrated to the south of Morocco. This is supported by layering fish egg concentration, actual fish production and chlorophyll-a data on the same interface as shown by the poster presentation.

The observed trend will later be used to study the impact of various levels of Ocean Nourishment process on the sustainable fish stocks for Morocco pelagic fisheries.

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## **Sydney Harbour Institute of Marine Science (SHIMS)**

The Sydney Harbour Institute of Marine Science (SHIMS) is a joint venture research facility based at a former Royal Australian Navy site at Chowder Bay on the foreshore of Sydney Harbour. The cornerstone of SHIMS will be a high quality flow-through seawater system for inter-disciplinary, marine research in what was Building 18, the Engineers' workshop. It will offer safe and convenient access to drive research in one of the most spectacular and intensively used ports in the world. Through studies of the East Australian Current it will also provide an important logistical link in the oceanography and bio-geography between the Great Barrier Reef and Bass Strait. Key research areas will be the ecology of ports and harbours; coastal oceanography; biotechnology and bio-prospecting; and urban fisheries science.

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## **Seagrass rehabilitation and sediment dynamics**

One of the key factors influencing the success of seagrass transplantation work appears to be the stability of the surrounding sediment, and therefore an understanding of the dynamism of the sediments is crucial to further progress in this field. This project will examine the dynamics of sediments around seagrass meadows across a range of wave energies in Cockburn Sound, Western Australia and Adelaide, South Australia. A series of automated sediment height loggers will be deployed in seagrass meadows, as well as locations where seagrass meadows have been lost. Detailed studies of the sediments and environmental conditions will be undertaken at the same time, permitting comparisons between different locations.

Over 1 hectare of seagrass has been transplanted to date in Cockburn Sound, in areas where seagrasses have been lost, which is an outstanding achievement in seagrass rehabilitation terms. Monitoring studies show a ~78% survival rate of the most recent seagrass transplantation effort. Construction of the sediment loggers is almost complete with first deployment in Adelaide anticipated in June-August 2005, followed by alternate deployments in Perth and Adelaide.

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## Does carnivory improve the fitness/condition of Antarctic krill?

Experimental studies using different feeding regimes were conducted over 9 months to examine changes in the lipid content, lipid class and fatty acid composition of *Euphausia superba*. Since growth and maturation are closely linked to the quality and quantity of food supply, experiments were undertaken to elucidate the influence of different dietary conditions on the lipid composition in various organs/body parts (hepatopancreas, abdomen, etc.). Krill were either kept on a diet of low or high diatom concentrations or on a mixture of diatoms and minced bivalves, and were analysed at selected time intervals. Lipid class and fatty acid profiles of krill organs/body parts are discussed with regard to the impact of their diets on the physiological condition of krill. These profiles reflect processes associated with lipid metabolism and verify the use of lipid analysis as a powerful tool for both trophodynamic and metabolic studies.

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## The Ningaloo Ocean and Earth Research Centre

Ningaloo Reef is the largest fringing reef in Australia, forming a discontinuous barrier enclosing a lagoon, which varies from 200 m to over 6 km in width. The reef extends from Bundegi Reef in the north, around the tip of North West Cape and continues south some 260 km to Gnaraloo Bay. It hosts more than 500 species of fish including the world-renowned whaleshark, and more than 300 species of coral. It is widely recognised that Ningaloo Reef has significant conservational, recreational, commercial, educational, historical and research values. On the Cape Range peninsula, unique geological features and climatic influences have created an extraordinary range of underground habitats. At least 16 genera are endemic to the Cape Range. Troglobites have evolved to be totally dependent on cave environments. They occur mostly in Tulki Limestone in the Cape Range; recent work has identified more than 31 species of troglobites endemic to the area. Stygofauna inhabit a range of freshwater and brackish caverns and fissures in the limestones of the coastal plain; more than 12 endemic taxa in the stygofauna have been identified. Relevant information on Ningaloo Reef is limited and further studies are required to provide sufficient baseline data to support appropriate decision making and management. In 2002 the Shire of Exmouth, in collaboration with the Gascoyne Development Commission, proposed the establishment of the Ningaloo Ocean and Earth Research Centre (NOERC) in Exmouth's new marina development. The conceptual Plan was developed in 2004 and the process garnering stakeholder involvement has begun with the development of a business planning brief. Information will be presented on the current status of the NOERC project - outlining particular needs and potential uses - while seeking support for such a research facility on the west coast of Australia.

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## **PierCam: a flexible teaching tool for multi-species aquatic ecology**

A recent initiative of the Department of Applied Biosciences at Curtin University of Technology has involved the placement of two video cameras underwater at the Exmouth Navy Pier, one of the world's top shore-based dive sites. The biodiversity at the Navy Pier is remarkable with over 150 species of finfish frequenting the area, representing a large complex underwater habitat protected by a marine sanctuary zone. The cameras send analogue images back to a subsystem, which converts them to a digital signal. This signal is sent over 14km, via a radio link, to the Exmouth town centre where a receiver is located, enabling live images to be uploaded via web-based software. Aquatic ecology students at Curtin then access the images and participate in identification and behavioural practical classes in computer laboratories. Piercam delivers significant teaching efficiencies within the Department and allows single datasets to be viewed simultaneously by a large number of students. Piercam can be accessed at: <http://muresk.curtin.edu.au/campus/bentley/piercam.html>

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## **Comparing the catch composition of two designs of 'samplers' deployed on the Ningaloo Reef, Western Australia, with an emphasis on crustaceans**

This project aims to record and compare the catch composition of two types of artificial samplers, with emphasis on crustaceans. A way of providing representative samples of the Ningaloo Reef ecology would be of particular interest to managers of the Ningaloo Marine Park (NMP); or to aquaculturists considering the cultivation of crustaceans, like spiny rock lobsters, for human consumption; or smaller crustaceans, such as ornamental shrimp for the aquarium trade. The eventual aquaculture of these species could also benefit re-stocking practices should the Reef require replenishment due to over-fishing. This project has seen the development, design, construction, deployment and sampling of two types of artificial samplers: one comprising a hard mesh material (bioblock material) and the second being constructed from a soft mesh material (Tanikalon™). Samplers were placed on the Ningaloo Reef at locations satisfying several criteria: 3 - 5m water depth; 500m - 2km from shore; and, located on sand substrate no more than 100m from living reef. Samplers have been inspected monthly with diversity indices being developed to compare the catch composition of each design. Further, additional replicates of each sampler design have had an attractant (fish pellet) added in order to evaluate the interactive effect of sampler design and chemo-attractant. Results will be discussed in terms of species composition and abundance for each sampler design.

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## **Gut content analysis of fish by thermochemolysis with tetramethylammonium hydroxide (TMAH) and gas chromatography-mass spectrometry (GC-MS)**

Gut content analysis of fish are typically conducted using methods based on visual identification. These can lead to inconsistent results because of their subjective nature, especially when sample sizes are limited or food items are not resolvable. New approaches are required to increase the accuracy of gut content analysis by reducing their subjectiveness. In this study we investigate whether thermochemolysis with TMAH and GC-MS detection can qualitatively and quantitatively analyse the gut contents of two monacanthid fishes fed seagrass, epiflora and epifauna under controlled conditions. Our results showed that the three food categories could be readily differentiated when analysed individually, that seagrass could be distinguished from epifauna and epiflora in the gut and that quantitative data could be obtained using marker compounds unique to a food item. We conclude that thermochemolysis with TMAH and GC-MS represents a useful new technique for the gut content analysis of fish which can complement traditional techniques and be applied to samples that are very small (0.5-2 mg) and contain items difficult to separate.

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## **Carpentaria Ghost Net Programme: Saltwater people working together**

'Ghost Nets' is a term used to describe marine sourced abandoned or derelict fishing gear that continues to fish long after being separated from the original vessel. Fishing debris tends to be the most widely reported type of debris and the debris type of greatest concern to coastal communities of Northern Australia (Finding Solutions. Kiessling, 2003). Many of the nets recovered through the day to day activities performed by local Aboriginal Land and Sea rangers also have turtles or fish often dead or entangled within them.

In 2004 the Carpentaria Ghost Nets Programme obtained funding of \$2M by the Natural Heritage Trust for a three year project currently underway. Through the Carpentaria Ghost Net Programme, Traditional Owners, conservationists, scientists and government representatives from all parts of the Gulf of Carpentaria come together to try and address an issue of common concern: Ghost Nets. Ghost Nets are recognised throughout the world as a menace to all marine wildlife however, in the Gulf region they are a real threat to sea turtles in particular.

The programme is managed by the Northern Gulf Resource Management Group and aims to remove the Ghost Nets from the coastline, thereby reducing the number finding their way back into the water. The collected nets will be recorded in a variety of ways by the community groups involved in the project so that important information about the nets: where they come from?, how many?, and what type of turtles or marine life are trapped etc?; can assist in negotiations with Australia's northern neighbours to assist in dealing with the issue at its source, as most data collated to date indicates a high level of internationally borne debris.

The Programme has a Steering Committee comprises of a number of Traditional Owner groups from both sides of the Gulf of Carpentaria. The rest of the committee includes six non-government organisations: Cleanup Australia, Northern Gulf Resource Management Group (NGRMG), Northern Land Council, Seagnet, Northern Australian Indigenous Land and Sea Management Alliance and World Wildlife Fund and is open to more members on request. This Steering Committee makes all the decisions on how the programme functions, however, the local communities make their own choices regarding how to cleanup their sea country with the assistance of a project officer based in each state.

