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**Environmental flows for estuaries: Trends in method development and application**

In most countries the environmental flow requirements of estuaries have only received recent attention. In the past these requirements were ignored, mostly because of the lack of long-term monitoring data and understanding of the structure and function of estuaries. In some cases it was incorrectly assumed that the minimum flows determined for rivers would protect downstream processes and in others the omission was as a result of the sectoral management of water resources. Current international initiatives are broadly centered on the determination of features such as: runoff and river flow scenarios; definition of key biological indicators and components; identification of interactive processes amongst components and holistic ecosystem approaches. They typically require expertise in hydrodynamic modelling, as well as multidisciplinary knowledge of the structure and function of estuaries. Four main countries have developed environmental flow assessment methods for estuaries i.e. Australia, South Africa, United Kingdom and the USA. Each approach has different advantages and disadvantages but most are data rich and emphasize the need for long term monitoring so that the impacts of freshwater inflow alteration and the variable nature of these systems can be understood. Because of limited financial resources some countries have prioritized estuaries for environmental flow assessment. In other countries legal battles relating to water use have resulted in the funding of detailed modelling and monitoring exercises. However the implementation of environmental flow assessments lags behind the method development mainly because of cost, expertise, adequate institutional and legal arrangements, and effective stakeholder participation. Despite this there is a common understanding among the scientific community that if we want to ensure that environmental flow policies are implemented, allocations must be realistic and results must be communicated in an easily understandable way to the wider community.

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**Wnt and TGF-beta roles in embryonic patterning at the onset of animal evolution**

Little is known about the last common metazoan ancestor (Urmetazoa), a hypothetical and enigmatic marine creature that evolved from unicellular protists over 600 million years ago. An insight into the genetic makeup and developmental mode of this animal can be gained by comparison of developmentally important genes between distantly related extant clades. Conservation of gene function between clades that diverged from the Urmetazoa, namely sponges, cnidarians and bilaterians, would indicate that this pathway had already been utilized by the Urmetazoa. Among these groups, bilaterians with favourite developmental and genetic model systems such as mouse, *Xenopus*, *Drosophila* and *C. elegans* are obviously the best studied basis for comparison. Recently, data on genetic and developmental complexity of cnidarian *Hydra* and *Nematostella* begun to accumulate, making developmental genetics of sponges the last frontier in the quest to understand the Urmetazoa.

We have established a demosponge *Reniera* as a new model system for developmental genetic studies. Here we show that *Reniera* embryos are patterned by two signalling pathways that are known to play key roles in axial determination and germ layer segregation in chordates and cnidarians: Wnt and TGF-Beta. The expression patterns of *wnt* and *tgf-beta* genes in *Reniera* embryos are suggestive of formation of morphogen gradients that can govern cell movement and expression of other genes, and are consistent with specification of germ layers (*tgf-beta*) and anterior-posterior polarity of the embryo (*wnt*). Based on these data, we postulate that the Urmetazoa was a sophisticated animal, with embryonic development utilizing cell signalling mechanisms much alike those used by present day creatures.

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**Tracer – a local genome assembly pipeline and its application to genome of GBR demosponge *Reniera***

The whole genome shotgun sequencing projects generate vast amount of data of immediate interest to geneticists and developmental biologists. Thanks to public repositories such as NCBI Trace Archive, the genomic traces are readily available to researchers long before the genome is finally assembled. However, direct use of the traces is limited due to their not continuous and highly repetitive nature. Complete in-house whole genome assemblies are often infeasible due to insufficient bioinformatics and computer support. In many cases local assemblies limited to regions of interest - e.g. specific genes, are adequate.

We developed a local assembly pipeline named Tracer that is able to build genomic contigs using unassembled traces from shotgun genome projects. Tracer utilizes a set of existing bioinformatics tools and presents user with a biologist friendly web interface. Assembly with Tracer begins with a Blast search of protein or DNA sequence against the genomic traces and ends with genomic contigs containing the sequences found by the search. The resulting contigs can be then automatically extended to cover longer stretches of the genome.

We applied Tracer to genome traces from GBR demosponge *Reniera* to identify and reveal structure of number of genes before the assembled genome becomes available. User friendly nature of the pipeline allows each researcher to work directly on the gene assemblies. Here we present an example assembly process of a selection of developmentally important genes in *Reniera*.

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**Effects of human trampling on central Victoria's rocky intertidal reefs**

Central Victoria's rocky intertidal reefs support a diverse array of plants and animals, which when exposed at low tide are subject to trampling by humans. Rocky intertidal communities are most susceptible to trampling during the summer months, when the impact of trampling is compounded by a combination of high visitation rates, fine weather and very low tides during the day. One of the most notable impacts of human trampling in the rocky intertidal is on the brown alga, *Hormosira banksii*. Trampling causes an alteration of the canopy structure of *H. banksii* which indirectly impacts the invertebrates and algae which are associated with *H. banksii*. An investigation into the response of *H. banksii*, and its associated species, to trampling in Central Victoria was conducted through surveys of four paired control and impact intertidal reefs both before and after summer. More specifically the effect of continuous (across a platform) and discrete (along a walking path) human trampling were assessed within *H. banksii* beds on the intertidal platforms. A natural reduction in the canopy structure of *H. banksii* was observed at control reefs after summer. There were spatially variable effects of continuous human trampling on *H. banksii* and its associated species on the impact platforms from before to after summer. There was a clear effect of discrete human trampling along a walking path through *H. banksii* beds at an impact reef after summer. The implications of this research will be discussed in relation to successful management and protection of Victoria's rocky intertidal reefs.

**Aller, Josephine Y<sup>1</sup>, Daniel M Alongi<sup>2</sup> and Robert C Aller<sup>3</sup>**

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<sup>1</sup> Marine Sciences Research Center, Stony Brook University, Stony Brook NY 11794-5000<sup>2</sup> Australian Institute of Marine Science, PMB No.3, Townsville M.C., Qld 4810 dalongi@aims.gov.au<sup>3</sup> Marine Sciences Research Center, Stony Brook University, Stony Brook NY 11794-5000. raller@notes.cc.sunysb.edu**Benthic biological indicators of seasonal sedimentary dynamics in the Gulf of Papua**

Distributions of benthos and organic particles in Gulf of Papua sediments suggest shelf-wide seasonal variations in transport, deposition, and physical disturbance. Chlorophyll- *a* and total phaeopigment concentrations in surface sediments varied spatially by an order of magnitude, with highest values in water depth bands between ~10 - 20 m (inner topset) and 40 - 50 m (topset - foreset transition). Temporal patterns demonstrate Chl- *a* higher during the SE Trades (Sept.-Dec.) and phaeophytin higher during NW Monsoon (Jan.-Feb.) periods. Concentrations of residual particulate plant debris (> 0.062mm) comprised mainly of macerated palm and mangrove fragments were highest over the top 30 cm at inshore stations from the Fly River to Central Gulf, particularly during the SE Trades. At stations between 10 and ~40 m water depth concentrations were highest during seasonal transition periods (May-June) and lowest during monsoons. During all seasons, debris concentrations dropped sharply by 30 m and continued to decrease with increasing water depth. Measurable concentrations of macro debris found at depths of > 600 cm in a piston core taken along a central Gulf transect provide evidence of deep physical reworking and are consistent with the presence of active bacterial assemblages. Densities of macrofauna also reflect seasonal differences with highest densities occurring during transitional periods when deep burrowing crustaceans and tubicolous polychaetes are abundant. Lowest faunal densities occur during monsoon periods with large individuals absent, and opportunistic polychaetes and crustaceans dominant. Unlike most of the year when physical disturbance keeps organic matter suspended and inhibits development of benthic communities, the apparent relatively quiescent transition periods allows suspended organic matter to settle out and accumulate in sediments, and benthos to become established.

**Aller, Robert C<sup>1</sup>, Vasso Alexandratos<sup>1</sup>, Gregg Brunskill<sup>2</sup>**

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<sup>1</sup> Marine Sciences Research Center, Stony Brook University, Stony Brook, NY, 11794-5000, USA<sup>2</sup> Australian Institute of Marine Science, PMB 3, Townsville, 4810. g.brunskill@aims.gov.au**Reverse weathering in the Gulf of Papua subaqueous delta**

Wide ranges of lithogenic and terrestrial organic particles are delivered by rivers to the Gulf of Papua subaqueous delta. A portion of the lithogenic debris is highly weathered and enriched in metal oxides. The reactive Fe, Al -oxides are mixed with labile terrestrial and marine organic matter, biogenic silica, and seawater in mobile deltaic topset deposits, which act as sedimentary batch reactors. These diagenetic conditions result in efficient suboxic remineralization of terrestrial and marine organic matter, the reductive mobilization of metals, and the rapid reconstitution and neoformation of clay minerals. Sedimentary dynamics are critical to maintaining suboxic, nonsulfidic properties, episodically entraining reactants, and promoting clay formation. Pore water distributions, solid phase compositions, and laboratory incubation experiments demonstrate that early diagenetic clay formation can be major sinks for K<sup>+</sup>, Li<sup>+</sup>, F<sup>-</sup>, and biogenic Si. Depending on the exact assumptions, for example, ~ 60% of the dissolved riverine delivery of Li<sup>+</sup> is taken up in the subaqueous delta. Overlying water is sufficiently well mixed that relationships between Li<sup>+</sup>, F<sup>-</sup>, and salinity appear conservative despite extensive uptake of Li<sup>+</sup> and F<sup>-</sup> by the seafloor. Over the last ~20 years, a broad spectrum of field measurements, experiments, and diagenetic models has demonstrated that rapid formation of authigenic clays takes place in the major tropical deltaic systems of S. America and Oceania (Gulf of Papua deltaic complex). Authigenic aluminosilicates in these deposits are typically Fe-rich and form in suboxic, nonsulfidic muds underlying oxygenated water over periods of months to years. Rapid authigenic Fe-rich clay formation in many high sedimentation rate nearshore regions, particularly tropical deltas, confirms that reverse weathering as hypothesized by Mackenzie and Garrels in the mid-1960's is a very general and important early diagenetic process, and a significant component of elemental cycling in the oceans.

## **Arrowsmith, Naomi<sup>1</sup> and Louise Duxbury<sup>2</sup>**

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### **Watershed Torbay – Using science to facilitate learnings for community and government from a catchments to coast national demonstration catchment**

Watershed Torbay commenced 5 years ago as a national demonstration catchment funded by the National Rivers Consortium (NRC). Its aim was to develop and demonstrate a whole of catchment to coast restoration program, using two major principles: best practice community involvement and change, leading to comprehensive adoption; and a strong science base to inform decision making. In establishing the national demonstration catchment, the NRC also sought to document and share learnings from the process, and to develop principles and approaches for achieving community change leading to the protection of rivers, wetlands and estuaries at a whole catchment scale. Therefore, the process and learnings of change have been documented in detail to provide guidance to other catchments embarking on such work, and to add to the knowledge and literature about community change processes. Torbay is a small (300 square kilometre) catchment just to the west of Albany on the South Coast of Western Australia. Not only does it provide important ecosystems services to the City of Albany - fresh water supplies, and sewerage disposal - it also has many of its own issues including the most frequent toxic blue-green algae blooms in any waterways in Western Australia, significant riparian and estuarine degradation, acid sulphate soils, deep drainage impacts, and conflicts over water availability. Torbay also has very low landcare adoption rates, small farm size and low-income levels, which makes community change and adoption more challenging. This presentation will explain the project, give an overview of the environmental and social issues in the catchment, describe the community involvement and change processes in detail, and describe the learnings and principles that have emerged. It will particularly focus on the science program, and how this was used to facilitate and promote community change, as well as informing the restoration planning. There are major learnings for government agencies, communities, and scientists from this project, which will be shared.

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## **Arundel, Helen, John Sherwood, Julie Mondon**

### **EEMSS: A database for managers of intermittently closed estuaries**

The need for managers to balance seemingly competing socioeconomic, cultural and environmental values is characteristics of many natural resource management decisions. This requirement and community concern about the lack of clear, consistent guidelines were the impetus for the development of the Estuary Entrance Management Support System (EEMSS).

The three major components of the EEMSS database are:

- An impact assessment, based on an assets-threats model, this ensures a consistent process is used when making the decision whether or not to open an estuary;
- A checklist that ensures a consistent protocol is followed when the mouth is opened;
- A data storage section that stores physicochemical information thereby allowing managers to better monitor their management decisions

Technical advisory groups and consultants were engaged to develop the 'rules' for scoring assets, and the threat to those assets, under various water levels and conditions. Community input via a series of workshops was an integral stage in the development and implementation of the EEMSS.

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**Conservation genetics of marine turtles-- ten years later**

One decade ago, Bowen and Avise (1996) reviewed genetic data and their conservation relevance for marine turtles, all species of which are listed as threatened or endangered. Here I update that review by considering studies published in the past decade using molecular markers such as microsatellites and DNA sequences. The newer data confirm and extend earlier genetic findings about several aspects of sea turtle behavior, population demography, and phylogeny that remain difficult to assess by traditional field studies and non-molecular evidence. Topics uniquely illuminated by molecular markers include: features of the genetic mating system such as the frequency of multiple paternity within clutches; population demography, inter-rookery gene flow, and phylogeographic structures at local, regional, and global scales; movement patterns as deduced by identifying the natal sources of juveniles and adults at non-nesting times, such as on feeding grounds or migrational corridors; and phylogenetic relationships germane to taxonomic assignments and species boundaries. Overall, the genetic findings on marine turtles provide paradigm examples of how molecular markers can offer basic biological information, often of conservation relevance, on species that are otherwise difficult to monitor in the wild.

**Bainbridge, Zoe<sup>1</sup> and Jon Brodie<sup>2</sup>**

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<sup>1</sup> Australian Centre for Tropical Freshwater Research, James Cook University, Townsville 4811<sup>2</sup> Australian Centre for Tropical Freshwater Research, James Cook University, Townsville 4811 jon.brodie@jcu.edu.au**Water quality monitoring of sediments and nutrients in the Burdekin region, north Queensland**

A community-assisted water quality monitoring project was established in 2003 for the Burdekin Dry Tropics Natural Resource Management body (BDTNRM) to investigate suspended sediment (SS) and nutrient concentrations in waterways throughout the Burdekin region. It will also assist in the development of a regional Water Quality Improvement Plan. The project targets wet season rainfall flow events, which comprise approximately 80% of the annual discharge from the Burdekin River. During these flow events community volunteers (predominately graziers) collect grab samples from waterways to capture changes in SS and nutrient concentrations over the flow hydrograph. The catchment's large size (133 510km<sup>2</sup>), steep upper catchments and dry tropical environment exacerbated by widespread grazing all combine to form a system that is highly efficient in transporting freshwater runoff and associated SS and nutrients off the landscape into downstream environments, including wetlands and the Great Barrier Reef lagoon. The loss of SS from the landscape is one of the largest water quality management issues for BDTNRM, with SS concentrations significantly higher than those of neighbouring regions. Sediment and nutrient concentrations from the last three wet seasons display considerable variability across the Burdekin sub-catchments. For instance, the Bowen-Broken sub-catchment has peak SS concentrations (□8000mg/L) that are an order of magnitude greater than the Cape River sub-catchment (□300mg/L). The Upper Burdekin is another sub-catchment that has relatively high SS concentrations (peaking at □2000mg/L) and contributes up to 50% of the average annual Burdekin River discharge. Monitoring of waterways in the Lower Burdekin floodplain has also identified relatively high nitrate concentrations during initial first flush conditions. These concentrations were similar to neighbouring regions (e.g. Mackay Whitsunday) where intensive cropping are also a prominent feature of the coastal floodplains. The monitoring results largely agree with the latest models that predict the sediment and nutrient loads transported from the Burdekin region. The data from this project will assist to refine these current models.



**Baker, Ron<sup>1,2</sup> and Marcus Sheaves<sup>1,2</sup>**

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**Refugees or ravenous predators: Detecting the impacts of predation in an inherently patchy environment**

Shallow water estuarine habitats are considered to provide small juvenile fishes with refuge from predation due, in part, to the apparent low numbers of piscivorous fishes. However, many of the most abundant small and juvenile fishes that utilise these habitats consume other fish to some degree. Because of the low average occurrence of fish in the diets of these 'minor' piscivores, they have rarely been considered as potentially important predators in estuarine systems. However, the occasional predation by minor piscivores on new recruits when they first enter the nursery may create a significant bottleneck at this critical life-history stage. To determine the potential importance of minor piscivores as predators on new recruits, the diets of minor piscivores were examined in fishes sampled over 6 yr from shallow (<1.5 m) sandy habitats in the lower reaches of 17 tropical estuaries. The spatial patchiness of new recruits at scales which can be feasibly sampled made it impossible to correlate the abundance of new recruits with their consumption by minor piscivores. However, examination of spatio-temporal variability in the consumption of fish prey by minor piscivores revealed that the low average occurrence of fish in their diet was a poor reflection of the spatial and temporal patterns in predation pressure by these on fish prey. Most of the time, minor piscivores did not consume fish prey, occasionally a large proportion of them did so. When minor piscivores consumed fish prey, they preyed mainly on small new recruits. Small new recruits were only occasionally abundant, with temporally patchy recruitment to shallow estuarine nurseries. Thus, the evidence indicates that while minor piscivores may derive little of their nutritional requirements from fish prey, they may be major sources of mortality for fish recruiting to shallow estuarine nurseries and play a significant role in structuring estuarine fish faunas.

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**Baker, Ron<sup>1,2</sup> and Marcus Sheaves<sup>1,2</sup>**

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**Against the flow: recruitment, predation and the contribution of coastal productivity to estuarine systems**

Estuaries are widely believed to contribute productivity to adjacent coastal systems. The importance of this contribution is one of the most regularly cited justifications for the protection of estuarine systems. The idea that estuaries contribute productivity to coastal waters implies that exchanges between estuaries and coastal systems result in a net movement of energy and or nutrients from the estuary to the coast. Exchanges may be passive in the form of dissolved or particulate organic matter (outwelling), or active via the movements of organisms, particularly fishes, across ecosystem boundaries. Although the quantities of nutrients transported by fishes migrating out of estuaries may be low relative to that flushed out 'passively', fishes represent high quality packages of energy and nutrients directly available to higher trophic levels in coastal waters, and thus may make disproportionate contributions to coastal trophodynamics.

My PhD research indicated that predation within tropical estuarine habitats may be far greater than previously thought, and that new recruits entering the estuary from coastal waters may experience heavy mortality. Combined with simple fish life-history models and evidence from studies of nutrient transport by migrating fishes, it is apparent that fish recruitment into estuarine nurseries may represent a significant contribution of coastal productivity into estuarine food webs. In fact, under many scenarios it is probable that the utilisation of estuarine nurseries results in a net input of nutrients and energy from coastal waters into estuarine systems, against the flow implied by the estuarine productivity paradigm.

**Ball, Eldon**

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<sup>1</sup> Centre for the Molecular Genetics of Development and Molecular Genetics and Evolution Group, Research School of Biological Sciences, Australian National University, Canberra, ACT<sup>2</sup> Comparative Genomics Centre, James Cook University, Townsville, Qld. david.miller@jcu.edu.au**Body layers, axes and overlapping developmental pathways in coral development**

The “higher Metazoa” are classically separated from the “lower Metazoa” by two characteristics: being bilaterally, rather than radially, symmetrical, and being triploblastic (having three body layers) rather than diploblastic (having two). In vertebrates, formation of the mesoderm and the dorsal/ventral axis are linked through the function of “the organizer”, a small group of cells associated with the blastopore within which a number of developmental pathways intersect.

In order to examine the validity of the diploblast/triploblast separation at the molecular level, we have characterised the expression patterns of appropriate genes, available through our EST studies, over the course of *Acropora* embryonic development. By comparing these gene expression patterns to those of their bilaterian orthologs we should also gain insight into the evolution of the organizer.

We have characterized orthologs of the *Drosophila* genes snail, orthodenticle, forkhead, decapentaplegic, brachyenteron (Brachyury), and Goosecoid. The expression pattern of greatest interest in relation to the diploblast-triploblast dichotomy is that of *Acropora* snail, which is expressed in tissue invaginating to form endoderm in a pattern suggestive of its expression in invaginating mesoderm at gastrulation in *Drosophila*. Thus, at the molecular level this dichotomy is blurred. The expression patterns of *Acropora* BMP2/4 (decapentaplegic) and goosecoid are both consistent with the hypothesis that *Acropora* is bilateral, in contrast to the usual textbook characterization. Once comparable data become available from diverse key invertebrates the evolutionary origins of the organizer may become clearer.

**Banks, Sam<sup>1</sup>, Maxine Piggott<sup>1</sup>, Jane Williamson<sup>1</sup>, Craig Johnson<sup>2</sup>, Neil Holbrook<sup>3</sup>, Ulysse Bove<sup>1</sup> and Luciano Beheregaray<sup>1</sup>**

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<sup>1</sup> Molecular Ecology Group for Marine Research (MEGMAR), Department of Biological Sciences, Macquarie University, Sydney, NSW, 2109<sup>2</sup> Tasmanian Aquaculture and Fisheries Institute, School of Zoology, University of Tasmania, Hobart, Tasmania, 7001<sup>3</sup> MEGMAR and Department of Physical Geography, Macquarie University, Sydney, NSW, 2109**Long distance dispersal and range expansion in the sea urchin *Centrostephanus rodgersii***

The sea urchin *Centrostephanus rodgersii* is the dominant benthic herbivore throughout much of its range along the south-east Australian coastline. Here we present a microsatellite DNA analysis of dispersal in *C. rodgersii* that contributes to the multi-taxa study of dispersal in the marine environment by the Molecular Ecology Group for Marine Research (MEGMAR) at Macquarie University. We sampled *C. rodgersii* from 19 localities from northern NSW to southern Tasmania, Lord Howe Island and northern New Zealand. While we found some evidence for weak but significant genetic differentiation of the NZ sample from the east Australian samples, there was no significant population subdivision among the Australian samples. Multilocus assignment tests did not reveal higher likelihoods of recruitment from geographically proximal source populations, nor did multilocus genotypic spatial autocorrelations provide evidence for local larval retention. This suggests that, in concordance with dispersal predictions based on ocean current modeling, larval dispersal occurs over such a large scale that there is no structure in the Australian *C. rodgersii* population. In recent decades *C. rodgersii* has expanded its distribution to southern Tasmania. Samples from the frontline of this range expansion showed no genetic evidence of a population bottleneck. Recruits to these populations appear to originate from more northerly mainland coastal populations. This suggests that the southward expansion of *C. rodgersii* is due to increased southward dispersal and settlement of larvae. This coincides with a recent increase in upper ocean temperatures off the Tasmanian coast. The lack of population structure detected in this species is in contrast to recent findings of stronger than expected genetic structure in species with larval dispersal stages in other coastal regions. Potential reasons for this are discussed in relation to the characteristics of ocean boundary currents.

**Bannister, Raymond<sup>1,3</sup>, Christopher Battershill<sup>2,3</sup> and Rocky de Nys<sup>1,3</sup>**

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**Environmental factors affecting the distribution and abundance of the tropical sponge *Rhopaloeides odorabile* on the Great Barrier Reef (GBR)**

*Rhopaloeides odorabile* is an abundant Dictyoceratid sponge common to the outer- and mid-shelf coral reefs of the Great Barrier Reef (Australia). However, it is rare on inshore reefs and where present has a smaller mean size. We investigated the factors driving this change in abundance and population structure focusing on the feeding biology and the impacts of sediment. One hypothesis to support the differential distribution is the increased ability to benefit from mixo-trophy in clear offshore waters. Using respirometry chambers we determined that under light conditions up to 1000  $\mu\text{mol photons m}^{-2} \text{s}^{-1}$  *Rhopaloeides odorabile* did not utilise photosynthesis as an energy source demonstrating no net energy contribution from symbionts.

An alternative explanation for the distribution of *Rhopaloeides odorabile* is the differential impact of sediment across the continental shelf. The rate of sedimentation decreases towards the continental shelf. The quality and type of sediment also varies across the shelf with inshore sediments dominated by fine (< 63  $\mu\text{m}$ ) particle sizes, which are absent offshore. The effect of these sediment fractions on feeding biology is being experimentally determined using controlled feeding studies.

While these studies contribute to an understanding of the factors influencing the distribution and abundance of *Rhopaloeides odorabile*, they are also a component of a broader program to determine optimum sites for the aquaculture of this species as a commercial bath sponge on the Great Barrier Reef.

**Barber, Marcus**

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**Points and flows: quantitative and qualitative research into an Aboriginal people's interactions with the coastal environment**

This presentation outlines the results of extensive social and environmental research amongst the Yolngu people of Blue Mud Bay, on the west coast of the Gulf of Carpentaria. The research was interdisciplinary, incorporating my training as both a marine and social scientist, and it involved both quantitative and qualitative data gathering techniques. The primary research goal was to investigate how a remote coastal Arnhem Land community relate to and use their local marine environment.

The quantitative aspect of the research was a 12 month survey of local indigenous hunting and resource use. A GPS data set drawn from this study demonstrates how different groups of people in Yolngu society use the coast in different ways, at both a group and an individual level. This data was of considerable value in the applied context of a 'sea rights' test case which is currently before the courts.

The qualitative aspect of this research produced the first comprehensive description of the way Yolngu people conceptualise coastal water cycles. They use a detailed understanding of the local flows and transformations of water (clouds, rain, river, and sea) as the basis for a complex system of coastal knowledge and ownership. The flows integrate land and sea into one coastal 'country', undermining the strong division between the two domains that has been fundamental to Western thinking for centuries. Taking this alternative viewpoint seriously would require significant revisions of the Australian legal domain, and suggests some avenues for reconceptualising coastal environmental management.

Finally, I discuss some strengths and weaknesses of the Yolngu system of coastal knowledge, how it can reveal strengths and weaknesses in Western scientific knowledge, and how it can shed light on some important non-indigenous assumptions about coastal and estuarine environments more generally.

**Barnes, Tomma Kay<sup>1</sup>, Frank Mazzotti<sup>2</sup>, and Ronnie Best<sup>3</sup>**

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<sup>1</sup> NOVA Southeastern University Oceanographic Center, 8000 North Ocean Drive, Dania Beach, FL 33004, USA.<sup>2</sup> University of Florida Ft. Lauderdale Research and Education Center, 3205 College Ave, Fort Lauderdale, FL 33314, USA. fjma@mail.ifas.ufl.edu<sup>3</sup> United States Geological Survey, 3205 College Ave, Fort Lauderdale, FL 33314, USA. Ronnie\_Best@usgs.gov**An integrated approach for evaluation and assessment of ecosystem management and restoration projects**

Ecosystem restoration and management seek to repair, improve, or maintain a suite of desired environmental conditions for a specific ecosystem. However, when working on complex estuarine ecosystems, where do you start and how can you tell when you are successful? Forecasting ecological effects of restoration scenarios provides a basis for project evaluation and selection of best restoration alternative. Ecological monitoring is also essential for evaluating ecosystem condition over time. In an integrated approach of both passive and active adaptive management a forecasting model simulates system response and is validated by monitoring programs to measure actual system response. Monitoring can then feedback as a passive adaptive management tool to modify restoration or management plans. Directed research driven by model uncertainties is an active adaptive management strategy for learning and the reduction of uncertainties in the model, and provides a basis to calibrate the models. Since all components of an ecosystem cannot be modeled or monitored effectively, scientists and managers rely heavily on ecological indicators to reveal information about ecosystem status and trends. As a result, modeling and monitoring programs focus on indicators that maximize information on ecosystem patterns and processes while minimizing cost and effort. In Southwest Florida, conceptual ecological models were constructed to support the framework of an applied science strategy by identifying estuarine indicators for ecosystem assessment and evaluation. Forecasting models were created as a set of stressor response (habitat suitability) models for individual species and incorporated into a spatially explicit decision support system to guide selection of the most beneficial restoration alternative.

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**Beaman, Robin J**

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**Surficial geology and deepwater habitats of the northern Great Barrier Reef**

The northern end of the Great Barrier Reef is both remote and relatively unexplored. The area is the focus of questions regarding the role of modern oceanographic processes on sediment transport across the northeast Australian margin, from the high-discharge Fly River to the Gulf of Papua. A research cruise to this region investigated the relationship between sediment, geomorphology and biological communities. Knowledge of the deepwater benthic habitats is essential for effective environmental management and development of regional marine plans. The results from multibeam sonar and Chirp sub-bottom profiles display an unprecedented view of the true nature of the morphology of the seafloor and the variation in sediment texture. The cruise discovered large relict reefs with karst-type erosion, deep submarine channels, and a vast inactive dune field. Large fluctuations in sea-level during the Pleistocene (last 2 Myr) have resulted in a diverse geomorphology due to both fluvial drainage of the Fly River and tidal scour during lower sea-levels. Extensive groundtruthing with grabs and underwater video established the strong relationships between surficial geology and associated biological assemblages. Diverse mixed gardens of soft corals and calcareous algae are established on the hard substrate relict reefs, with the soft unconsolidated substrate the habitat for mostly detritus- and deposit-feeding fauna. The events of the geological past have a profound influence on the present seabed, and an understanding of the long-term processes on a geological scale which have controlled the form of the seabed are very useful for interpreting benthic habitats.

**Becker, Alistair<sup>1</sup> and Laurie Laurenson<sup>1</sup>**

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<sup>1</sup> School of Life and Environmental Science, Deakin University, P.O. Box 423, Warrnambool Vic 3280**Use of flooded margins of a small intermittently open estuary by fish in south eastern Australia**

Flooded margins and main channel habitats were sampled for fish from an intermittently open estuary between July 2004 and June 2005 using mini fyke nets. Flooding of the land surrounding the Surrey Estuary was broken into two defined periods. The first being when the mouth was open, flooding occurred due to high rainfall and flow into the estuary coupled with tidal action. In this instance flooding was sporadic and extended for brief periods of time. The second defined period was due to the damming effect of the closure of the mouth, in this case resulting in the long term inundation of the floodzone. A total of 7787 fish were collected during the study representing 13 species and 11 families. *Philypnodon grandiceps* was the most abundant species and together with *Atherinosoma microstoma*, *Pseudogobius olorum* and *Galaxias maculatus*, made up 94% of the total catch. Nine species were collected from the floodzone with *A. microstoma* dominating the catch. No significant differences were observed between the assemblage sampled from the floodzone to that taken from the main channel indicating a high use of the floodzone by the estuarine ichthyofauna. There was no longitudinal variation of the fish assemblage both within the floodzone and main channel, though a shift in the assemblage on the floodzone occurred following the closure of the mouth and the permanent inundation of this habitat. The reason for fish being in the flooded margins of the estuary is likely to be varied, however feeding and predator avoidance are likely key reasons. The results lead to the conclusion that flooded margins of this intermittently open estuary provides valuable habitat for estuarine ichthyofauna and that management decisions in regard to artificially opening the mouth should take this into consideration.

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**Beckley, Lynnath E**

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**Improving spatial resolution of human usage data for better Marine Protected Area planning**

Marine Protected Area planning for the vast state of Western Australia suffers from poor spatial information about human use of marine resources. For example, although well-maintained and continuous data sets on commercial fishing catch and effort exist, they are recorded in ~12 000 km<sup>2</sup> blocks (1° x 1° grid). Creel survey data for boat-based recreational fisheries are usually collected using ~80 km<sup>2</sup> blocks (5nm x 5nm). Spatial information on non-extractive usage (e.g., SCUBA diving, snorkelling, whale watching, bird watching etc) is rarely collected. Consequently, when Marine Protected Areas are planned, although there may be locality-specific biodiversity data and habitat maps for the region, there is usually considerable uncertainty as to the fishing effort and the number of people that actually use particular areas of the marine environment. But, progress is being made, and a series of examples will be presented to illustrate how collection of spatial data on human use of marine resources can be used to better inform the marine conservation planning process, and allow some resolution of conflict amongst stakeholder groups. This presentation will make the case for *a priori* collection of high resolution spatial data on human use of marine resources in areas designated for marine biodiversity conservation, so that modern reserve planning software can be effectively used, the issue of displaced activities can be objectively assessed and more intact ecosystems can be conserved.



**Bishop, Melanie J, Brendan P Kelaher, Ralph Alquezar, Paul H York, Peter J Ralph and C Greg Skilbeck**

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**Keystone or millstone: negative impacts of a dominant consumer on a detritus-based food web**

Inputs of detritus from saltmarshes, macroalgae or microphytobenthos are generally regarded as a major structuring force of macrofaunal assemblages on intertidal mudflats. Despite several demonstrations of large negative effects of foraging gastropods on macroinvertebrates, the importance of top-down control in structuring mudflat communities is usually overlooked. A three-factor experiment manipulating the density of the highly abundant detritivore, *Pyrazus ebeninus* (Gastropoda), detritus and macrobenthic predators on a Sydney mudflat revealed large deleterious effects of the gastropod, irrespective of detrital loading or the presence of predators. Two months after experimental manipulation, the standing-stock of microphytobenthos in plots with high (44/m<sup>2</sup>) densities of *P. ebeninus* was 20 % less than in plots with low (4/m<sup>2</sup>) densities. Increasing densities of *P. ebeninus* from low to high halved the abundance of macroinvertebrates and the number of species comprising their assemblages. In contrast, the addition of detritus had differing effects on microphytobenthos (positively affected) and macroinvertebrates (negatively affected). The exclusion of predators had no effect on macrobenthic community structure but increased microphytobenthic abundance. Over the two-months of our experiment, no predatory mortality of *P. ebeninus* was observed. Consequently, in reducing the biomass of microphytobenthos and the biomass and species richness macrofauna, *P. ebeninus* detritivores may severely limit the flow of energy up the food chain to commercially important species. *P. ebeninus* appears to serve not as a keystone species that facilitates diversity and ecosystem function, but as a 'millstone' species that hinders it.

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**Booth, David and Will Figueira**

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**Damselfish settlers respond to manipulated fish assemblages on patch reefs**

Risks to newly-settling coral reef fishes are many, as evidenced by extremely high (up to 50% overnight) mortality. However, evaluating possible mechanisms for this high mortality in complex reef habitat is difficult, so most studies are conducted on small coral pieces with a limited array of fishes. Here, we conduct an experiment to assess the fate of newly-settled damselfish (*Pomacentrus moluccensis*) on small natural patch reefs (3-6 m<sup>2</sup>) in One Tree Island lagoon, southern Great Barrier Reef. First, we selected ten reefs of similar size, shape and isolation and censused the fish assemblages on these. Next, we removed fishes from the reefs and recensused, demonstrating that the removals significantly reduced densities of predatory cardinalfishes and dottybacks, as well as potential competitors such as other damselfishes. Next, we introduced a small group (n=9) of newly settled *P. moluccensis* to each reef and conducted regular censuses of them and the resident fish assemblage over the next 24 hours. Of 90 fish released on Day 1, only 11 remained late on Day 2. These fish were on average significantly larger than the average size released, suggesting size-selective predation. Complex relationships between the fish assemblage on each reef and the persistence, size and condition of *P. moluccensis* settlers existed, but it appeared that reefs with overall greater density of potential predators did not also exhibit higher predation risk to released recruits.





**Brodie Jon<sup>1</sup>, Ken Rohde<sup>2</sup>, John Faithful<sup>1</sup>, Bronwyn Masters<sup>2</sup>, Arnold Dekker<sup>3</sup>**

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## **Massive phytoplankton bloom in Great Barrier Reef lagoon follows river discharge in Mackay Whitsunday region, central Queensland**

Intense wet season rainfall in January 2005 caused rivers in the Mackay Whitsunday Region of Queensland to produce moderate discharges to the Great Barrier Reef (GBR) lagoon. Regional land use is dominated by sugarcane cultivation, beef grazing and urban uses. The high nutrient (nitrogen and phosphorus) fluxes from these land uses via river runoff produced a massive phytoplankton bloom in the GBR lagoon which after ten days had spread 150 km offshore. The plume and algal bloom surrounded inner-shelf reefs of the GBR such as Brampton Island Reef and its spread was tracked using a variety of satellite sensors over the ten day period. Samples from the plume revealed elevated concentrations of chlorophyll a (and hence phytoplankton biomass), nutrients and herbicide residues. The concentration data from the samples and estimated exposure periods from the satellite images allow some estimates of risk to marine ecosystems of the GBR to be made.

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**Brooks, Robert P<sup>1</sup>, Mark M Brinson<sup>2</sup>, Mary M Easterling<sup>1</sup>, Rick Rheinhardt<sup>2</sup>, Joseph A Bishop<sup>1</sup>, Kirk Havens<sup>3</sup>, David O'Brien<sup>3</sup>, Brian Armstrong<sup>1</sup>, Jeremy Hite<sup>1</sup>, Jennifer M Rubbo<sup>1</sup>**

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<sup>2</sup> Department of Biology, East Carolina University, Greenville, NC 27858 USA: [brinsonm@mail.ecu.edu](mailto:brinsonm@mail.ecu.edu), [rrheinhardt@earthlink.net](mailto:rrheinhardt@earthlink.net)

<sup>3</sup> Virginia Institute of Marine Science, Gloucester Point, VA 23062 USA: [kirk@sweethall.wetlan.vims.edu](mailto:kirk@sweethall.wetlan.vims.edu)

## **Stream, wetland, riparian condition index (SWRCI) for evaluating catchments contributing to estuaries along the Atlantic slope, USA**

The SWRCI, representing the extent of human disturbance to aquatic ecosystems, is based on a set of metrics and to assess the condition of freshwater catchments contributing to estuaries. The SWRCI score is based on about 20 sampling points randomly located along the stream network of 24 watersheds in the Mid-Atlantic Region, all of which eventually drain into Atlantic estuaries. We based our assessment of the degree of degradation on two levels of information; remotely-sensed data (Level 1 - Landscape) and rapidly collected field data (Level 2 - Rapid Field). The SWRCI was composed of the following metrics: vegetated buffer within 300 m corridor, tree basal area, invasive plant index, number of observed stressors, stream habitat assessment, stream incision ratio, proportional forest cover, land development index, and riparian configuration. All or a portion of these metrics can be used to construct an x-axis of a stressor-response relationship. The comparative response measure on the y-axis was derived from intensively sampled biological, chemical, or physical parameters (Level 3 - Intensive Field). For this study, we used existing Level 3 data compiled by others (e.g., benthic macroinvertebrate index, fish index, nitrate concentration). The SWRCI was effective in measuring condition along a disturbance gradient from forested, to agricultural and urban landscapes and can diagnose probable stressors. The SWRCI was most effective at assessing the condition at the site level and small contributing catchment upstream of one or more sites. Adoption of the SWRCI by resource management agencies will be discussed.

**Brunskill, Gregg J & John L Pfitzner**

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Australian Institute of Marine Science, PMB 3, Townsville MC, Qld 4810 j.pfitzner@aims.gov.au, <http://www.aims.gov.au>**Components of the annual sediment budget for the Gulf of Papua**

We provide an account of how we do the sediment budget for the Gulf of Papua. River sediment input was largely derived from surface water samples of zero salinity over 1992-2003, and the weight/vol of suspended sediment (SS) was estimated from filters or settled material in 200-1000 liter tanks. SS was multiplied by the best estimate of average annual water discharge (largely from OTML). This budget does not account for sand inputs. The contributions of river suspended sediment to the inventory of excess  $^{210}\text{Pb}$  and  $^{137}\text{Cs}$  in sediments of the inner shelf were found to be negligible. Our sediment sampling from 0-20 m water depth in the Gulf of Papua suggests that this is largely a sand transport and deposition zone, with only small pockets of mud. Cores from these small mud pockets in the 0-20 m depth zone have "J" shaped excess  $^{210}\text{Pb}$  profiles and deep distribution of  $^{137}\text{Cs}$ , suggesting deep mixing or massive deposition, frequent resuspension and transport with the tides. We consider this deposition zone to be transient on decadal time scales, and we provide an alternate metric (Transient Accumulation Rate, TMA) to allow its inclusion in the sediment budget. Mass accumulation rate estimates from the depth zone 20-100 m are easier to evaluate, and we demonstrate the consistency of radiotracer profiles at one core site that was revisited 4 times over 1996-2003. We have a few cases of extreme scavenging of oceanic excess  $^{210}\text{Pb}$  (and other metals of oceanic origin) from the base of the continental slope. Over 90% of present day sediment input to the Gulf of Papua appears to be captured in the 0-100 m depth zone of the inner shelf, with a small fraction being exported across the barren carbonate gravel of the outer shelf to the northern Coral Sea.

**Burfeind, Dana D<sup>1</sup>, Ian R Tibbetts<sup>2</sup> and James W Udy<sup>3</sup>**

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<sup>1</sup> Centre for Water Studies, University of Queensland, St. Lucia Qld 4072<sup>2</sup> Centre for Marine Studies, University of Queensland, St. Lucia Qld 4072. i.tibbetts@uq.edu.au<sup>3</sup> Centre for Water Studies, University of Queensland, St. Lucia Qld 4072. j.udy@uq.edu.au**A comparison of faunal assemblages in *Caulerpa taxifolia* and seagrass beds in Moreton Bay Queensland**

*C. taxifolia* gained widespread notoriety as an invasive alga in the Mediterranean Sea when a 1 m<sup>2</sup> patch, discovered near Monaco in 1984, rapidly expanded its range across 191 km of coastline. In 1991, *C. taxifolia* covered less than 100 ha; however, by 2000 *C. taxifolia* was estimated to cover 13100 ha. Most importantly, many of these areas were once colonized by seagrass, which was displaced by the expanding *C. taxifolia* meadows. In 2000, invasive populations of *C. taxifolia* were discovered growing in two New South Wales estuaries. Since its initial discovery in NSW, *C. taxifolia* distribution has expanded and is currently found in nine estuaries along the coast of NSW from Lake Macquarie in the north to Burrill Lake in the south, covering approximately 810 ha of benthic habitat. More recently (2002) populations of *C. taxifolia* have been found in the Port River-Barker Inlet Estuary, in South Australia. In the same time, native populations of *C. taxifolia* in Moreton Bay have increased. However unlike the Mediterranean, it is unclear whether *C. taxifolia* expansion is directly causing seagrass loss. Regardless, there is an increased distribution in *C. taxifolia* creating a new habitat type in many areas. There have been very few studies examining the impact of *C. taxifolia* on faunal communities and only one study has been conducted in Australia. We will present preliminary data for Moreton Bay from part of a larger two-year study comparing faunal assemblages in seagrass and *C. taxifolia* in Queensland, New South Wales, and South Australia.

**Burns, Kathryn A<sup>1</sup>, Diane Brinkman<sup>1</sup>, Anita Poulsen<sup>1</sup>, Peter J Hernes<sup>2</sup> and Ronald Benner<sup>2</sup>**

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<sup>1</sup> Australian Institute of Marine Science, PMB 3, Townsville, Qld. 4810.<sup>2</sup> Dept. Biological Science, U. of South Carolina, Columbia, SC. 29208. U.S.A.**Organic biomarkers to determine the dispersion and potential for long range transport of the Sepik River outflow along the Papua New Guinea coast**

The Sepik River is a major contributor of water, sediment and associated organic loads to the coastal waters of northern New Guinea and the Bismarck Sea. We compare dissolved and particulate organic carbon data from September 1997 during an extremely dry year with that from 1996, 1999 & 2000 during wet season discharges. Estimated source flux of DOC is  $3.2 \times 10^{10}$  moles  $y^{-1}$  and POC is  $1.3 \times 10^{10}$  moles  $y^{-1}$ . The estimates for nutrient loads are  $2.4 \times 10^{10}$  moles  $y^{-1}$  for nitrogen and  $3.8 \times 10^8$  moles  $y^{-1}$  for phosphorous. The Sepik DOC flux is equal to that from all four major rivers combined that enter the Gulf of Papua on the south coast of PNG. The Sepik inorganic PIC flux is low ( $0.2 \times 10^9$  moles  $y^{-1}$ ) as the river does not drain carbonate soils. With a narrow continental shelf, and strong coastal currents, much of this exported material is available for long distance transport into the coastal Bismarck Sea and beyond.

CTD instrument data showed that the river signature was visible in optical measurements of deep profiles from the Sepik Canyon. Pulses of suspended sediments are carried offshore in the water column at the interface between density layers. At depths where the transmissometer and optical backscatter sensor (OBS) showed significant deflections, discrete water samples were taken in clean Niskin bottles for organic analysis. Additional high volume samples for lipid classes were taken with Infiltrax samplers deployed on a floating mooring along with two sediment trap arrays set at 100 and 260 m depths. The Infiltrax samplers were set at 55, 180, 200 and 220 m depth in an effort to target the surface layers and those of westward flowing water in the New Guinea Coastal Undercurrent (NGUC), which tracks along the coast at a depth of ~ 200 m and at a speed of ~ 0.5 m  $sec^{-1}$  (Cresswell, 2000).

Analyses of lignin phenols, hydrocarbons, fatty acids, sterols and n-alcohols in these samples were used to estimate the dispersion of the organic input from this river system to the coastal waters and to study the possible entrainment of river derived carbon in the NGUC.

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**Approaches to the design of cost-effective seabed biodiversity surveys in Shelf and Slope depths**

Australian marine management agencies need surveys of the biodiversity of the seafloor for a range of purposes, on a range of scales. For depths beyond the reach of divers, only a very small part of Australia's marine jurisdiction has been surveyed.

Ultimately it is the biota that is of concern to agencies responsible for ecosystem-based management, but biological sampling is slow and expensive. There is a temptation to use substrate and geomorphology as surrogates but, if not to be misleading, they need to be conditioned with a variety of other variables and interpreted on a variety of spatial and temporal scales. Any "surrogate-based" mapping needs to be "ground-truthed" with direct sampling. The question is how to design the most cost-effective survey. A simple systematic, or random, design is inefficient; stratified sampling is better. But on what do we base the stratification? In CMAR we have used two broad approaches, one in continental-shelf depths (typically <100m) in the GBR and Torres Strait, and the other in outer-shelf and slope depths (typically 100 - 600m) mainly off the E, SE and S coasts.

The first approach is to develop a statistical characterisation of the seabed combining the available physical and biological data and using the (more extensive) physical surrogates but weighted for their association with biological variables. The stratified sampling design is then based on this characterisation.

The second approach is to map the target area first with multibeam sonar, and to use the bathymetry and the intensity of backscatter to identify different types of seabed terrain. Sampling with geolocated video and direct collecting devices is then stratified by these terrain types. There have been substantial recent advances in the interpretation of backscatter. Where data are available, the two techniques can be combined to maximise sampling efficiency.

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### **Estimating density of intertidal ghost shrimps using counts of burrow openings. Is the method reliable?**

This study investigated whether surface hole counts could be used as a reliable estimate of density of the ghost shrimps *Trypaea australiensis* and *Biffarius arenosus* (Decapoda, Thalassinidea) in south eastern Australia. The relationship between the number of holes and the number of ghost shrimps was explored in two ways. Resin casts were used to document any changes in the number of burrow openings per shrimp burrow over time. Manual suction pumping (bait pumping) within a given mudflat area was used to directly compare the number of holes on the sediment surface with the number of ghost shrimps occupying the corresponding volume of sediment. Resin casting showed that throughout the year, the burrows of *T. australiensis* consistently had an average of two openings whereas the burrows of *B. arenosus* showed much greater variability with two to four openings per burrow. Overall, a significant relationship between the number of holes and the number of ghost shrimps (mixed species populations) was found, with 2.1 burrow openings for each ghost shrimp. This relationship, however, showed some temporal and spatial variation so that the ratio ranged from 1.6 to 3.2 burrow openings per individual ghost shrimp. We suggest that the hole count method is reliable in estimating ghost shrimp densities within this range.

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### **Reducing land-based pollutants in three tropical Hawaiian watersheds: A collaborative multi-agency and community approach to protect coral reefs**

Land-based sources of pollutants, such as sediments and nutrients, are one of several factors threatening the quality of coral reef ecosystems globally. Recognizing this threat, the United States Coral Reef Task Force identified addressing land-based pollution as one of six priority areas for future work by U.S. federal and state agencies to protect coral reefs. In response the U.S. Environmental Protection Agency and U.S. Department of Agriculture's Natural Resources Conservation Service volunteered nationally to facilitate the development of local action strategies to address land-based pollution impacts on coral reefs.

A collaborative planning process was used to develop the overall goals and objectives of Hawaii's local action strategy, and a steering committee was formed to facilitate development and improve coordination between key federal and state agencies. A watershed-based strategy that incorporates the traditional Hawaiian land and natural resource management system, known as *ahupua'a*, was developed for three priority watersheds in the main Hawaiian Islands. The overall goal is to reduce land-based pollution to improve coastal water quality and coral ecosystem function and health.

This paper presents an overview of land-based pollution issues in Hawaii and the on-going State-wide effort to protect Hawaii's coral reef ecosystems. The collaborative planning approach used to develop the strategy and the implementation of land-based projects to reduce non-point source pollutants in three priority watersheds will be discussed. The effectiveness of these pollution reduction strategies in improving coral reef ecosystem function and condition will also be considered.

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**A novel mechanism of dispersal promotes gene flow in a rockpool alga despite habitat and reproductive isolation**

We describe the population dynamics of a rockpool alga and identify a novel mechanism that allows dispersal despite apparent habitat and reproductive isolation. *Fucus distichus* L. is a monoecious seaweed restricted to highshore rockpools. It reproduces throughout winter and spring in Maine, USA. Gamete release occurs at low, neap tides when pools can be isolated from bulk seawater for 2 to 3 days. We proposed that genetic structure among rockpools would be high, genetic diversity in pools would be low and dispersal would occur on small spatial scales. Microsatellite loci were used to characterize genetic diversity and structure among pools at Schoodic (3 sites) and Chamberlain (2 sites) in Maine. Genetic differentiation existed between Schoodic and Chamberlain ( $F_{ST} = 0.146$ ), among sites ( $F_{ST} = 0.095$ ) and among pools ( $F_{ST} = 0.237$ ). An excess of homozygotes characterized most pools indicating inbreeding or selfing. Many adults were characterised as first generation migrants, however, indicating high levels of past gene flow. Moreover, present day dispersal (recruitment) occurred among adjacent pools. Laboratory studies on zygote attachment and field data on gamete release were used to model dispersal potential. Attachment of zygotes at cold seawater temperatures (5°C) was slow enough to permit dispersal for at least 5 high tides (ca. 2.5 days) following gamete release. The unusual reproductive seasonality of *F. distichus* may be an adaptation that mitigates ecological and evolutionary bottlenecks associated with its patchy habitat.

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**Recovery of the seagrass *Posidonia sinuosa* following experimental shading**

Light (LS), moderate (MS) and heavy shading (HS) (12, 72 and 91% light reduction) of *Posidonia sinuosa* was carried out *in situ* at two depths (4 and 8m) in Cockburn Sound, south-western Australia, for seven months and recovery was monitored for 13 months. Shading had a significant impact on the morphology, physiology and growth of *P. sinuosa* though shoot density and biomass reductions were the most dramatic and consistent responses. Removal of the shade screens induced rapid and detectable responses in a number of physiological and growth parameters. Within just two weeks after removal of the screens, leaf growth rate at the deep site and the length/weight ratio of growth at both depths returned to control rates. Chlorophyll concentration at the deep site returned to control levels and carbohydrates (predominantly sugars) reached control concentrations after four months. Meanwhile, PAM photosynthetic characteristics demonstrated a high-light response in MS and HS at the shallow site with reduced photosynthetic efficiency ( $\alpha$ ), and increased maximum electron transport rate ( $rETR_{max}$ ) and saturating irradiance ( $E_k$ ). Light availability in the lower region of the canopy was measurably higher in the shade pre-treatments (up to 4x) resulting from reduced shoot density and self-shading probably causing the high-light photosynthetic response. Recovery of shoot density was slow, and after 13 months shoot density remained significantly lower in the MS and HS shade treatments than the control (20-60% of ambient shoot density). As recovery of shoot density relied predominantly on shoot division, where a higher number of shoots remained at the end of the shade period, a faster rate of shoot production was observed. This work has shown that *P. sinuosa* is responsive to increases in light availability following shading and that an important consideration for management authorities is the dependency of meadow recovery on the number of extant shoots.

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**Sustainable estuary management in eastern England**

The coastline of eastern England is predominantly low lying, and includes a mixture of open coast and estuaries. The estuaries are some of the richest intertidal habitats in Europe, with wide expanses of saltmarsh and mudflat that attract internationally important concentrations of wetland birds. Historically, the saltmarshes have been reclaimed for agriculture, and each estuary is now surrounded by sea walls. These sea walls are mostly maintained by the Environment Agency, which has permissive powers to do so. However, the sea walls are increasingly expensive to maintain, and the value of the agricultural land is relatively low. Government policy is to withdraw maintenance from uneconomic sea walls and hand the task back to landowners. Saltmarsh habitat, which is protected by national and international legislation, is disappearing rapidly and there is a need to create new habitat by managed realignment of the sea walls. Saltmarsh loss is caused either by ongoing loss of sediments from the system, or dropping land levels due to isostatic changes - the whole coast has been sinking ever since the glaciers retreated from Britain at the end of the ice age. Landowners are very concerned at the potential loss of land due to the economic and environmental imperatives. The whole issue is exacerbated by the need to take account of predicted increases in sea level rise over coming decades. To reconcile these conflicts and set out proposals for more sustainable estuary management over the next 100 years, the Environment Agency is producing a series of Estuary Strategies. To assist the process a Regional Habitat Creation Programme has been set up to recreate intertidal habitats through managed realignment and regulated tidal exchange, and to recreate coastal freshwater habitats such as reedbed and grazing marshes in more sustainable locations further inland. This paper sets out the key legislative and policy issues that drive estuary management in England and describes progress so far in preparing the strategies and recreating habitats.

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**Coral colour responds to changes in water quality: Validation of a bioindicator using reflectance spectrometry**

Simple and cost-effective indicators are required to examine the effects of changes in water quality on corals. The aim of this study is to combine information on physiology, population and community ecology of corals to identify indicators responsive to changes in water quality. To achieve this, we have tested the efficacy of a broad range of indicators within different regions and along gradients of water quality in the GBR. One such indicator that demonstrates potential for use in monitoring programs is the response of coral colour. Coral symbionts can photoacclimate and respond to changes in water quality and light availability by changes in symbiont density, size, and/or the amount of photosynthetic pigments. This response can be measured as a change in coral colour using a simple, but potentially subjective, coral colour chart. To address this, we used high-resolution visible reflectance spectrometry as a non-destructive, rapid and quantitative measure of coral colour. This talk will summarise results of laboratory and field experiments that have used spectral reflectance of corals to validate a coral colour chart that could be used in assessments of the health of nearshore coral reefs.

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**The characteristics, source and fate of sediment in the upper Burdekin River and Lake Dalrymple, Australia**

The Burdekin River Catchment is one of the largest catchments in Queensland, Australia. Due to its location on the north-eastern coast, highly episodic, seasonal flow events impact significantly upon the Great Barrier Reef shelf system in terms of water, sediment and nutrient exports. In 1987 the Burdekin Falls Dam was constructed to provide a storage reservoir (Lake Dalrymple) for irrigation downstream. Flows through the Burdekin River system exhibit high turbidity that persists within the reservoir throughout the year (>45NTU). Consequently, releases from the dam may potentially cause adverse affects downstream even in the dry season.

Sampling has been undertaken within the reservoir and its tributaries (the Suttor and Burdekin Rivers) during baseflow and event flow periods. Sediment mineralogy, trace elements and isotopic signatures ( $^{87}\text{Sr}/^{86}\text{Sr}$ , with  $^{144}\text{Nd}/^{143}\text{Nd}$  results pending) in benthic and suspended sediment samples have been examined to identify sediment sources. The mineralogy of suspended sediments from the two main inflowing rivers is representative of their catchment geology, while the high turbidity relates to fine clay minerals (kaolinite, smectite, illite/muscovite), generally <10 $\mu\text{m}$  in size. Integrated ICP-MS and TIMS analyses show that benthic sediments from the Suttor/Belyando catchment are characterised by lower Sr concentrations and higher  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios in contrast to the higher Sr concentrations and lower  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios of Upper Burdekin sediments. Reservoir sediments fall along a linear mixing line between the two catchment end-member compositions, from a Burdekin dominated composition towards a Suttor dominated composition near the dam wall. Geochemical data indicate that material from the Burdekin River dominates deposition within the impoundment, and may indicate that it is the Suttor/Belyando catchment clay fraction that contributes most to the turbidity associated with the dam reservoir. A combination of seismic, sediment trap and water quality data indicates that the overall sedimentation rate within the impoundment is between 1 and 6cm/year.

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**Variations in reef fish home ranges in response to body size, trophic grouping and habitat**

Individuals establish home ranges relative to body size, resource abundance and surrounding inter- and intra-specific interaction, in an effort to acquire and efficiently exploit spatially distributed resources. Studies show that a diverse array of coral reef fish species from a variety of families and trophic groupings have defined home ranges. However, many of the underlying theories upon which these studies are based, have been derived from terrestrial population based studies rather than marine based studies. This study explores the question of home range size and continues on to identify individual behaviour within an area and the way in which each individual utilises the space available to them in their chosen home range. A total of 24 species from different trophic groupings were observed on the reefs surrounding Lizard Island on the Great Barrier Reef (14°40'S 145°28'E). The results obtained from this study suggest that home range areas are dependent upon, body size, trophic organisation, depth and substrate. Results show a correlated increase in the area of a home range relative to individual body size. They also revealed differences amongst trophic groups, with coral feeding fish occupying the largest home range areas. Previous studies of butterflyfish home ranges have alluded to the idea of a "home away from home" with individuals frequenting two core areas within a larger home range, a concept that was reflected in home ranges recorded for *Chaetodon melannotus*. Whilst it was recorded that most individuals spent their time swimming and feeding within their home range, differences in behaviour relative to trophic organisation were also noted. Data collected also suggests that home range areas occupied by reef fish appear to increase and decrease respectively with depth and height above the substrate. The scope of possible interactions between habitat factors and home ranges encourages further study into the specific costs and benefits associated with both maintaining and defending home ranges.





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### **Rapid erosion of sand dunes in response to seasonal changes in hydrodynamics – A potential hazard for seagrass communities in the Torres Strait**

Submerged sand banks in the northwest of Torres Strait typically have smaller dunes superimposed upon them. Survey work undertaken as part of the Torres Strait CRC measured the rates of sand dune migration on these banks in an effort to gauge their potential impact on local seagrass communities. Marine surveys at the end of the monsoon and trade wind seasons measured very similar hydrodynamic conditions but substantially different patterns of dune migration. At the end of the monsoon season migration rates of up to 17 meters were measured over a 14 day period, at the end of the trade wind season migration rates of up to 4 meters were measured over a similar time period. Wind data acquired for the two weeks before and during the monsoon season survey indicated the onset of the trade wind season during this time. As a result, the elevated levels of dune migration observed at the end monsoon season are probably the result of wind driven-currents, changing from predominantly eastwards during the monsoon season to predominantly westwards with the onset of the trade wind season. Dunes that were influenced by wind-driven currents during the monsoon season were east facing at the start of the trade wind season but these dunes then became hydrodynamically unstable under the influence of the westward-directed wind-driven currents and experienced accelerated levels of migration to the west. By comparison, the lower rates of sand dune migration observed during the trade wind season survey are considered to be representative of dunes that are hydrodynamically stable. The main conclusions from this research are that the dunes in the study area have been observed to move rapidly in response to seasonal changes in hydrodynamics however the typical rates of dune migration suggest that only seagrass communities in close proximity to the sandbanks are likely to be threatened by dune migration.

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### **Sub-tidal habitat mapping for marine biodiversity management and monitoring in New South Wales**

Mapping of sub-tidal reef habitats has been identified around Australia as a high scientific priority for management of marine resources. The Department of Conservation and Marine Parks Authority of NSW is using an interferometric sidescan sonar system to produce high resolution images of bathymetry and backscatter on the inner continental shelf. The maps are being combined with surveys of nearshore reefs from aerial photography, singlebeam echosounder surveys and underwater towed video transects to assess the extent of habitat types.

Approximately 250 km<sup>2</sup> has been mapped in the first twelve months of operation within the newly created Port Stephens Great Lakes Marine Park and Batemans Marine, and in the Solitary Islands Marine Park Park to provide vital information for developing zoning plans. Previously unmapped reefs have been discovered with a wide range of complexity and structure. The results are beginning to show the diversity of habitat along the coast of New South Wales on a variety of spatial scales. The Batemans shelf shows the greatest extent of continuous reef with diversity of structure reflecting the complex geology of the area. In the Port Stephens area and in the Solitary Islands Marine Park, the reefs tend to be more isolated and include extensive areas of unconsolidated reef comprising coarse sediments, cobbles and boulders, each with different ecological values.

The information provided by this study will be used to further develop a hierarchical classification for marine habitats of NSW to ensure that our MPA system is comprehensive, adequate and representative. The information will also provide for improved ecosystem management. It will also provide detailed baseline information for future monitoring of marine communities. Future work will extend the coverage to beyond the boundaries of MPA's and to examine habitat condition as well as extent.

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**Copepod egg production and growth rates in the Timor Sea**

Zooplankton samples were collected in the Timor Sea in June 2005 and size-fractionated zooplankton biomass distribution was measured. In addition, incubation experiments were conducted onboard to estimate the egg production (EPR) of common copepod species, and the growth rates of the copepod community by following the development of artificial cohorts. Temperatures were very constant during the survey (from 27.7 to 28.3°C), and chlorophyll values ranged from 0.155 to 0,544 µg×L<sup>-1</sup>. The lowest zooplankton biomass was found close to the shelf break and in deep waters, whilst the highest values were found in the shelf and in shallow waters. The presence of gelatinous zooplankton may have contributed to the high biomasses found in shallower waters. *A. gracilis* had a mean EPR (22.1±10), higher than has been previously recorded for this species in other regions, whilst *P. indicus* (2±3.86) and *A. erythraea* (4.2±3.98) had lower EPR compared to previous data from the tropics. The highest and lowest growth rates were observed in two shelf break stations, and an intermediate value observed in a shallow station in the platform. The low chlorophyll concentrations may have been limiting factors for copepod production because the growth rate of similar copepods in Great Barrier Reef waters are usually higher at similar temperatures and higher chlorophyll levels. With the exception of *A. gracilis*, all copepod species registered showed low EPR. These results suggest that food may be a more important controlling factor than temperature for copepod egg production in tropical seas.

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**The sponge genome project and evolution of animal multicellularity**

In 2005, I initiated a genome project on the most ancient animal lineage - the sponges. In a very successful collaboration with the US Department of Energy Joint Genome Institute, over 1,500 Mbp of genomic sequence and 75 K developmental ESTs were procured from *Reniera* sp., a demosponge that inhabits the Great Barrier Reef. This genome is currently being assembled and annotated. Characterisation of this genome, through bioinformatic, phylogenetic and gene expression studies, are already yielding unprecedented insight into the molecular and cellular features that are fundamental to multicellular life. These processes (e.g. cell adhesion and movement; stem cell generation; body plan patterning) underlie normal and abnormal development in all metazoans, and the origin and evolution of animal biodiversity.

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## **Larval gene expression analysis reveals adaptive evolution in geographic populations of the ascidian *Herdmania momus***

The evolution of local adaptation plays a major role in generating distribution patterns of marine biodiversity. Understanding how local adaptation arises will require elucidation of the underlying genetic mechanisms. In biphasic benthic marine invertebrates, local adaptation may be especially developmentally and ecologically focussed at larval settlement and metamorphosis. It is therefore these transitional life history stages that we are targetting in our ecological genomics studies of a variety of marine invertebrates. One study currently underway involves assaying transcriptional variation in larvae from 3 populations of the ascidian *Herdmania momus*. Gene expression patterns that run counter to geographic and genetic divergence among these populations may underlie the genetic basis to adaptation to a specific local habitat. Microarray profiles revealed significant differences in expression levels of 359 clones between populations, much of which could be explained by phylogeography. However, despite geographic proximity and high gene flow between 2 eastern Australia populations, 98 genes showed significant differential gene expression, and it these that may putatively reflect candidate genes involved in local adaptation to substantially different habitats. The expression profiles of these 98 genes can be clustered into two main trends whose direction of difference between populations is correlated to their patterns of variation through larval development. Further assays, via qRT-PCR, of some these clones known to play a role in metamorphosis and postlarval development, confirmed substantial gene expression variation (-1.5 to -8-fold differences) within and between populations. Two closely related genes are being further analysed because they show (1) dramatic differences in expression levels within and between populations, and (2) spatial expression in cells that localise to the tunic-body wall interface in settled juveniles. We currently are correlating sequence variation across the entire genes with gene expression differences in individuals and populations.

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## **Daily MODIS satellite images of chlorophyll and suspended sediment of the Great Barrier Reef lagoonal waters providing massive amounts of data and information-How do we make this relevant?**

Water quality relevant satellite data at low spatial resolution (1 km pixels) but high temporal resolution (up to twice a day) has been available since 1997. However, continuous doubts were cast on the validity (e.g. is a satellite based map of chlorophyll really depicting chlorophyll- and is so, how accurate is it?) of the so-called global satellite products, especially in coastal waters.

For several years a significant line of research has been to obtain in situ samples in the GBR lagoon to validate the global satellite products. These in situ data sets, comprising of concentration and light optical properties measurements, were also designed to develop and apply regionally correct algorithms to process this satellite data into chlorophyll, total suspended matter, coloured dissolved organic matter and vertical attenuation coefficients of light in the water column.

All these procedures have now been semi-automated so we can (re)process hundreds to thousands of satellite images of the GBR lagoon. The amount of data is large (terabytes) as is the amount of information: 4 optical water quality maps per overpass of a satellite (with a typical swath of 1000 to 2200 km) as well as error maps. We will display examples of this satellite image based data set, some data-extraction applications as well as show preliminary results how this data compares with regional biogeochemical model chlorophyll and suspended matter predictions.

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**Modelling nutrient and sediment catchment exports for the Coastal Catchments Initiative**

The Coastal Catchments Initiative is a federally funded project that seeks to deliver significant reductions in the discharge of pollutants from coastal areas known as 'hotspots'. To achieve such reductions we have adopted an integrated approach that considers the interconnectedness between land based activities and receiving waters, and the interdependences among ecological, social, economic and institutional perspectives. Here we present the results of one component of our approach - catchment modelling using the distributed Annualised Agricultural Non Point Source (AnnAGNPS) pollution model. We specifically calibrated AnnAGNPS for the Myall and Wallis catchments, which were considered hotspots given the history of algal blooms in the receiving waters. Calibration necessitated event based monitoring using automatic water samplers and continuous measurements of hydrological variables such as water level and rainfall. Our initial results show the relative contributions of various soil-land use combinations to the total nutrient and sediment exports of the Myall and Wallis catchments. Through sensitivity analyses we identify the controlling variables and discuss the effectiveness of current best management practices aimed at reducing nutrient and sediment catchment exports. We demonstrate the need for alternative methods for assessing best management practices given the on-going influence of previous (and relatively long-term) unsustainable farming practices.

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whitejm@unimelb.edu.au**Sesquiterpenes from the southern Australian marine alga, *Laurencia elata***

In the continuing search for novel bioactive natural products the Marine and Terrestrial NATural Product (MATNAP) research group at RMIT University has investigated the common red alga, *Laurencia elata*. The crude extract of this specimen of *Laurencia elata* collected from Port Phillip Bay (Victoria, Australia) displayed moderate anti-viral activity. Chemical investigation resulted in the re-isolation of elatenyne which was first reported by Reiss and the synthesis by Burton has revealed that the structure originally assigned to elatenyne was incorrect.<sup>1,2</sup> In re-isolating elatenyne we were presented with the opportunity to reassign the structure of elatenyne. In addition this work has resulted in the isolation of pacifenol which was confirmed by both 1D and 2D NMR spectroscopy and single-crystal x-ray analysis along with the isolation of several analogues of elatenyne.

Isolation of these secondary metabolites was achieved primarily by reverse phase HPLC. Characterization was achieved via 1 and 2D NMR, GC-MS and ESI mass spectrometry. This presentation will outline the proposed structure of elatenyne including our attempt to determine the relative stereochemistry.

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## **Fly River discharge as an example of fluvial sediment supply to the Gulf of Papua**

A number of significant rivers discharge sediment to the Gulf of Papua, and the Fly is the largest. Recent observations provide insight to the supply of fluvial sediment from the land source to the marine sink. The Fly has two dominant tributaries: the Strickland River and the Middle Fly. The Strickland drainage basin is twice the size but has seven times the sediment discharge of the Middle Fly, due to a larger proportion of the Strickland basin in the highlands of New Guinea. During the latter Holocene, the Strickland has trapped sufficient sediment to reduce its present percentage of retention below that of the Middle Fly. Much of the retention represents sediment trapped on flood plains, but a large amount of sediment is also stored and remobilized in association with channel migration. The two tributaries join near the village of Obo, which is about six meters above mean sea level. Seasonal variability in water discharge is only about a factor of three during most years, and is suppressed by the large size of the drainage basin and the wet-tropical conditions of the basin. Decadal variations in discharge have a strong impact, as the result of El Nino periods when rainfall is reduced dramatically. Sediment discharge at Obo is estimated to be ~100 million tons/y now, and was about 20% lower before mining operations began in the highlands. The Lower Fly River (stretching ~300 km below Obo to the Fly Delta) is impacted by propagation of the tidal signal from the Gulf of Papua, which is macrotidal with a spring tidal range of ~5 m. The influence of the tidal river on sediment budgets is unknown for this region, which adds uncertainty to estimates of sediment discharge to the Gulf.

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## **The development of continental shelf valleys in the Gulf of Papua**

The R/V *Franklin* 2001/2002 cruise to the Torres Strait - Gulf of Papua region identified at least two submarine valley systems in the southern sector of the Gulf of Papua. Bathymetric maps depict them extending for more than 80 km from the eastern Torres Strait to across the northern end of the Great Barrier Reef. Some valleys, to the north of the study area, are infilled channels, which may represent paleo-river channels filled with post-glacial transgressive deposits. The valleys landward of the study area are clearly relic fluvial channels complete with cut and fill features. The valleys at the southern end of the study area, however, do not exhibit these fluvial features.

The bathymetric contours of these deep channels are closed at both ends and lie mostly in <100 m water depth. This means that during the glacial maximum when sea level was at -120 m, these valleys may have formed elevated lakes on the subaerial shelf when Torres Strait formed a land-bridge between Australia and Papua New Guinea (PNG). They may have been sinks for sediments originating in the PNG highlands during low stands. However, no lacustrine sediments have, as yet, been found in any of the cores taken from these valleys. The geomorphology suggests glacial maximum lakes with lacustrine sediments removed. There must have been a mechanism for sediment removal, or they were not lakes at all!

During eustatic sea level fluctuations, sea level has remained within a range of 40-50 m below present for much of the last 100 000 years. This means that sea level has spent a lot of the time, during the late Quaternary, at the outer shelf in this region. This may have facilitated tidal scouring of the valleys and subsequent removal of sediments from the valley floors.

**Droxler, André<sup>1</sup>, Gianni Mallarino<sup>2</sup>, Jason M Francis<sup>1</sup>, Jerry Dickens<sup>1</sup>, Bradley Opdyke<sup>3</sup>, Luc Beaufort<sup>4</sup>, James Daniell<sup>5</sup>, Samuel Bentley<sup>6</sup> & Larry Peterson<sup>7</sup>**  
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## **Early transgressive establishment of relict upper most pleistocene barrier reefs on LGM coastal siliciclastic deposits in the Gulf of Papua and Gulf of Mexico: clue to understand the mid brunhes global origin of modern barrier reefs**

Modern barrier reefs correspond to a series of stacked mid and late Brunhes thin mostly transgressive coralgal deposits separated by exposure horizons and initially established on early Brunhes lowstand siliciclastic deposits. These observations can be explained by the unique, global, and systematic flooding of late Pliocene-early/middle Pleistocene lowstand tropical paleo fluvial plains during a mid-Brunhes 140 m-amplitude sea level transgression which terminated a 2.5 My-long regression and lead to interglacial MIS 11. Results of 2004 MARGINS-PANASH and IMAGES-PECTEN 2005 cruises in the Gulf of Papua clearly illustrate that the early part of the last deglaciation was a favourable interval for the establishment and growth of coralgal edifices on top of Last Glacial Maximum (LGM) siliciclastic coastal deposits and offer, therefore, a model to understand the mid-Brunhes global origin of modern barrier reefs.

Surveys of the modern shelf edge in Ashmore Trough, uncovered a spectacular 30 to 50 m-thick ridge that parallels the shelf edge on more than 50 km with linear continuous segments exceeding 10 km in length. Analyses of a core, recovered at the basis of the ridge, demonstrate that a barrier reef established itself on top of a late LGM siliciclastic beach barrier complex and grew during Melt-Water-Pulse-1A and Younger Dryas (15,000-12,500 calendar years) keeping up with sea level rising from -110 to - 60 m to then drown during Melt-Water-Pulse-1B. On the northeast shelf edge of the Pandora Trough, a series of coralgal edifices, as thick as 80 m, were discovered and seismically imaged. A fist-sized coral colony, in living position and dated at 19,000 calendar years, was recovered at - 107 m on the flank of one edifice. These observations clearly prove that those relict reefs were established on top of a LGM shelf edge delta located at about -120 to -125 m immediately after sea level started rising.

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## **Variable mixed carbonate-siliciclastic sedimentary sinks during last sea level cycle in Ashmore, Pandora, and Moresby Troughs, and on Eastern Plateau (Gulf of Papua)**

MARGINS Source-to-Sink studies at Rice-LSU-RSMAS-ANU demonstrate that carbonate content and TOC values, inversely fluctuating relative to one another in modern highstand sediments, range from more than 80% for carbonate (a mixture of pelagic and reef-derived) and 0.18 wt. % for TOC in Ashmore Trough, to about 20% for carbonate and 1.14 wt. % for TOC in northeast Pandora Trough. In that latter area where the shelf greatly narrows, siliciclastic-rich sediments, accumulating at Pb-210 rate of 0.5 cm/y on the outer shelf, currently leak through the shelf break, accumulate on the slope at Pb-210 rate of 0.27 cm/y, and also reach, as distinct modern thin muddy turbidites, the main channel of the Moresby Trough deep sea fan at 2200 m. Shelf leakage also explains unexpectedly low carbonate values (40-55%) in modern highstand sediment accumulating in central Pandora and Eastern Plateau.

During late MIS 5-MIS 3 sea level regressions and MIS-2 lowstand, the sediments become almost exclusively siliciclastic, whereas TOC wt. % concentrations reach maximum values in the troughs and on Eastern Plateau. Numerous sandy siliciclastic turbidites accumulate in central Pandora and Moresby Troughs. The volcanic sandy turbidites in Moresby Trough appear to have their source mostly from the highlands of Southeast PNG, whereas the quartzo-feldspathic sands in Pandora Trough have their source from the Fly/Strickland drainage system. During early transgression, barrier reefs are initiated along the shelf edges on lowstand coastal siliciclastic deposits. In the troughs and plateau, the sea level transgression is marked by stepwise increases of carbonate values and the disappearance of siliciclastic sandy turbidites. A calci-turbidite observed in central Pandora Trough probably records the initial re-flooding of adjacent carbonate platform tops. On the slopes of Ashmore Trough, an early Holocene maximum flux of siliciclastics, associated with maximum TOC wt % and occurring at about 10 calendar ky, was probably triggered by a contemporaneous optimum monsoon regime.

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## **A role for Otx in the morphogenesis of the starfish body-plan**

The CNS has a high diversity of cell types and structural complexity. Uncovering the origin and mechanisms leading to pattern and cell diversity in the CNS is one of the major challenges in developmental and evolutionary biology. In the past, comparative molecular and morphological studies have investigated to expression and function of homologous genes that are involved with CNS and body plan development. The most important of these genes are the homeobox genes that encode transcription factors with temporally and spatially restricted patterns of expression. Many homeobox genes, including *Otx*, regulate gene expression during CNS development. The *Otx* family genes is implicated in forebrain and midbrain development. This study investigates *Otx* expression in echinoderm development and neurogenesis in asteroid echinoderms. The pentamerous Echinodermata have no clearly homologous head or Anterior-Posterior axis. This work investigates *Otx* expression that in sea stars may indicate potential homologies of the echinoderm body with that of other Bilaterians, and shed light on the affinities of the 'brainless' echinoderms.

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## **Linking physics and ecology in marine environments: modelling waves and benthic habitat in Western Australian coastal waters**

Habitat modelling in terrestrial systems is well advanced. However, understanding how environmental factors help determine marine community dynamics is a relatively new and challenging endeavour. One of the main benthic habitats in shallow coastal waters off southwest Western Australia are macroalgae-covered rocky reefs. There is substantial spatial variability in reef community composition which is likely to reflect ecological responses to physical factors such as substrate type, wave-induced physical disturbance and light availability rather than local adaptation or evolutionary divergence which often drives large scale variability. Due to its likely importance, the influence of hydrodynamic forces on benthic habitat has been the focus of our habitat modelling effort in the hope that the causes of the conspicuous fine scale variability can be understood. When waves enter shallow water, they induce substantial hydrodynamic forces at the seabed. The complex topography found in reef zones makes the task of characterising the hydrodynamic forces of relevance to benthic organisms challenging. We used a spectral wave model based on the shallow-water equation to estimate water velocity at the seabed and thereby to predict the forces experienced by benthic organisms in the coastal waters of WA. A highly variable wave climate off the WA coast was shown to drive large temporal and spatial variations in seabed water velocities among sampled sites throughout the coastal lagoon. Modelled annual maximum velocities and cumulative exposure calculated from timeseries of modelled extreme events correlated significantly with macroalgal diversity. Results suggest a role for disturbance in explaining patterns of species diversity because sites experiencing intermediate levels of exposure-driven disturbance had the highest diversity. This pattern has been observed in a number of biodiverse ecosystems with spatially heterogeneous disturbance regimes. We consider this and other possible ecological drivers of the patterns observed.

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## **Day-to-day variation in sea-surface temperature negatively impacts Pelagic tern foraging across the Great Barrier Reef**

An increasing number of datasets point to within-season climatic variation as a potential source of severe detrimental impacts on tropical seabird reproductive biology. Extreme sea-surface temperatures (SSTs) (1-1.5 °C above long-term averages) were observed on the southern Great Barrier Reef (GBR) during December 2005, coinciding in part with our study of Black noddy (*Anous minutus*) foraging success relative to day-to-day variation in SST. Significant negative relationships were observed between SST and daily measures of foraging success (meal size and feeding frequency) and chick growth. These findings were consistent with similar research into the relationship between Sooty tern (*Sterna fuscata*) foraging success and day-to-day variation in SST on the northern GBR where we found significant negative relationships between daily SST and both the amount of food fed to chicks and the feeding frequency during one 'regime' of each of two breeding seasons. Similar relationships have also been shown between Wedge-tailed shearwater (*Puffinus pacificus*) foraging success and chick growth and day-to-day variation in SST at the same location on the southern GBR. Combined the results imply a significant negative effect of forecasted climatic changes on multiple seabirds species breeding across the GBR.



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### **The larval biology of the chemically rich sponge *Luffariella* sp.**

A serious obstacle to the development of marine natural products (from sponges and other taxa) that are in commercial/clinical trials is supply. This is because the concentrations of many highly active compounds from marine organisms are often low. Aquaculture is often viewed as an alternative for producing compounds of interest. A key step in developing aquaculture of chemically rich species is the closure of lifecycles by settling and raising larvae, however the basic biology of most sponge species is unknown.

This study examined the larval biology and settlement preferences of *Luffariella* sp. (C: Demospongiae; O: Dictyoceratida; F: Irciinidae) as a model for the production of pharmacologically active compounds. *Luffariella* produces manoalide and analogues which are potent inhibitors of the enzyme Phospholipase A2 (PLA2).

*Luffariella* are hermaphrodites and released larvae from mid-November to late December in the Palm Islands, Queensland, Australia. Up to 800 larvae were released sporadically during the day-1 by individual sponges over at least one month.

Larvae were approximately 400µm long and had a band of cilia at one pole which appeared to maintain directional control. Settlement occurred within 30 hours and larvae demonstrated a strong negative phototaxis. Furthermore, larvae settled more rapidly under dark conditions; at higher larval densities and in the presence of settled conspecifics.

Cues often associated with invertebrate larval settlement such as crustose coralline algae had no effect on the settlement of *Luffariella*.

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### **Muddy waters: Effects of terrestrial runoff on coral reef ecosystems**

Around the world, water quality in coastal areas is changing in response to rapidly increasing land clearing and fertiliser use. Models estimate that 22% of all coral reefs are classified as at high (12%) or medium (10%) threat from land-based pollution and soil erosion. This talk provides an update and review of the present state of understanding of the effects of terrestrial runoff on corals and coral reefs. The review identifies and weighs key reef ecological responses to the four main water quality issues, namely dissolved inorganic nutrients, enrichment with particulate organic matter, light reduction from turbidity and increased sedimentation. A number of case studies are presented that represent strong new evidence that the conditions of inshore reefs on the Great Barrier Reef has been altered through present water quality conditions. For example, new research shows that hard coral species richness on Great Barrier Reef inshore reefs off the Wet Tropics, that is exposed to runoff from agriculture, is half of that expected given its latitude. While direct effects of increased sedimentation and reduced light on corals are important, it is argued that profound detrimental effects on reefs also occur through increased nutrient availability, by fostering a proliferation of macroalgae, and increasing outbreak frequencies of the coral-eating crown-of-thorns starfish *Acanthaster planci*.

## **Feary, David**

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### **Coral degradation and the structure of tropical reef fish communities**

Coral reefs can be degraded by a variety of perturbations, including bleaching and predation by crown-of-thorns starfish. The combination of these disturbances has contributed to a global decline of live coral cover on reefs. While the effects of bleaching and starfish predation on corals are relatively well known, their consequences for fish communities are less understood. We compared fish assemblages associated with two coral species, *Pocillopora damicornis* and *Seriatopora hystrix*, among three successive categories representing different stages of coral degradation following bleaching or starfish predation: (1) live, (2) degrading and (3) dead colonies with recent algal growth. Major responses in fishes with an obligate association with live coral were apparent, with additional coral-specific differences in other taxonomic and functional groups. Broad reductions in community abundance were evident on algal covered colonies of both coral species, with fishes not closely associated with live coral numerically dominating the assemblages. Reductions in fish population abundance on algal covered colonies were largely due to declines in the number of smaller size classes (new recruits and juveniles). We argue that increased algal biomass may have exerted a negative influence on settlement in a range of fish species. This study demonstrates that coral bleaching and predation by crown-of-thorns starfish can influence the abundance, diversity, size structure and functional groupings of coral-associated fish assemblages.

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### **Report of a potentially toxic algal bloom in a Western Victorian salt wedge estuary**

Several estuaries in western Victoria, including the Merri estuary, have been subject to nutrient eutrophication and algal blooms. A field based methodology was used to identify the annual hydrodynamics, nutrient status and phytoplankton communities of the Merri River estuary. The study also investigated whether algae and invertebrates that settle onto artificial substrate could be used as a measure of environmental factors such as nutrient enrichment. The hydrodynamics of the Merri River estuary were different from other estuaries in the region and it was found to have very high nutrient levels when compared with guidelines specified by ANZECC (2000). The estuary had a large diversity of phytoplankton with high algal cell densities, compared with other estuaries in the region. Kelly Swamp, a second arm of the river had a much lower number of species. This was probably because 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 closure of the water way to public access. One 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 Merri Marine Sanctuary adjacent to the estuary entrance.

**Figueira, Will** and David Booth

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**Body condition, behaviour and mortality of the damselfish *Pomocentrus moluccensis*: Mesocosm experiments with predators and competitors**

Competition and predation have been identified as two of the factors which strongly influence the ecology of coral reef fishes. Studies have clearly demonstrated the importance of predation but also that in some cases, such effects only occur when mediated through competitive behavioural responses. In this study we use controlled tank experiments to examine the effects of competitors and predators on the behaviour, body condition, and mortality of recently settled lemon damselfish (*Pomocentrus moluccensis*). Mortality rates in predator treatments were roughly twice those in controls and those in predator/competitor treatments were about eight times as high. The average post-treatment weight of the predator/competitor treatment was significantly lower than either the predator or control treatments. Behavioural observations indicated fish spent significantly more time near shelter in the predator and predator/competitor treatments but there was no overall difference in the frequency of aggressive interactions amongst them. The amount of time spent near the shelter increased slightly when the predator was added and then again when the competitor was added. Interspecific aggression on the other hand did not change much at all when the predator was added but increased by more than 50% when the competitor was added. It seems that the shelter-seeking response of newly settled *P. moluccensis* to the presence of a predator was enough to limit mortality over the time-scale of this experiment (2-4 days) to only slightly greater than the controls. The presence of competitors increased interspecific interactions which, in some way, led to much higher mortality rates. The mechanism for this likely involves a shift in time budget priorities and the reduced weight of the predator/competitor treatment fish would support the idea that they have reduced the time spent in other activities (such as feeding and vigilance) in favour of interspecific aggression. It is also possible that the initial condition (lipid stores) of these fish plays a role in determining the outcome of predator/competitor interactions and this will be explored in the future for the fish used in this experiment.

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**Vitamin C deficiency – A causative factor in spinal and opercula deformities in juvenile barramundi (*Lates calcarifer*)**

Morphological deformities are a common problem in many cultured fish species. The barramundi, *Lates calcarifer*, a cultured species in Australia and south-east Asia, suffers from abnormalities affecting the jaw, opercula and spine. This research determined the effects of dietary vitamin C, vitamin D<sub>3</sub> and the presence of ultraviolet (UV) light on the development of jaw, opercula and spinal deformities. Four diets were formulated to contain no vitamin C or vitamin D<sub>3</sub>, only vitamin D<sub>3</sub> (100,000 I.U/kg), only vitamin C (2000 mg/kg as ascorbic acid), and both vitamin C and vitamin D<sub>3</sub>. Two commercial diets were also tested. All diets were replicated in the presence and in the absence of UV light as this may effect skeletal development. *L. calcarifer* fingerlings were fed these diets for nine weeks, x-rayed for spinal deformities, and visually assessed for jaw and opercula deformities. UV light did not affect spinal or opercula deformities. Fish fed diets without vitamin C had a significantly higher frequency of spinal and opercula deformities. Spinal deformities included 'broken back' syndrome and lordosis. Diets containing vitamin C and the commercial diets significantly reduced the incidence of spinal and opercula deformities. This study quantitatively demonstrates vitamin C is essential for the prevention of spinal and opercula deformities in juvenile *Lates calcarifer*.



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**The effects of clove oil (fish anaesthetic) on coral reefs: an experimental evaluation using the coral *Pocillopora damicornis***

Clove oil is an extremely efficacious anaesthetic that is used to catch coral-reef fish for research purposes and the aquarium trade. Typically, clove oil is mixed with ethanol and sprayed onto corals using a hand-held spray bottle. Sedated fish soon emerge, after which they can be easily collected by hand.

The use of clove oil on coral reefs is increasing, both in Australia and elsewhere. However, it is not known whether clove oil is destructive to corals, the principal reef builders. The aim of this project, therefore, was to assess the effects of clove oil on a cosmopolitan reef coral, *Pocillopora damicornis*. Clove oil was applied to captive corals (n=9) in a range of concentrations (0.05, 0.5 and 5 ppt) for a range of periods (1, 10 and 60 min). The health of treated corals was then assessed for 7 days via measurement of chlorophyll fluorescence (an indicator of photosynthetic performance), tissue colour (degree of bleaching), and the extent of mortality.

Low concentrations (*i.e.* 0.05 ppt) of clove oil did not affect coral color or photosynthetic performance, irrespective of exposure time. In contrast, corals treated with high concentrations (*i.e.* 5 ppt) of clove oil died immediately, even when exposure time was short (*i.e.* 1 min). Intermediate concentrations (*i.e.* 0.5 ppt) of clove oil produced variable results: a 1 min exposure had no effect, a 10 min exposure caused bleaching and temporary inhibition of photosynthesis, and a 60 min exposure caused total mortality. Corals treated with water or ethanol alone were unaffected, suggesting these effects were directly attributable to clove oil. To validate these observations, clove oil was applied directly to wild corals using 'standard' fishing techniques. Thirty days after application, most corals were alive and healthy, although localized mortality was evident among polyps immediately adjacent to the point of clove oil application. The reduced severity of clove oil in the field was probably due to the diluting effects of water currents and turbulence. We conclude, therefore, that standard fishing techniques are unlikely to be destructive. However, our laboratory experiments indicate that nonstandard fishing techniques (*e.g.* using higher than normal concentrations of clove oil) may be destructive to coral reefs. These results will be crucial for managing and regulating the use of clove oil in the Great Barrier Reef World Heritage Area.

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<sup>3</sup> Department of Natural Resources, GPO Box 39, Sydney, NSW 2001. Rosh.Ranasinghe@dnr.nsw.gov.au**The importance of sub tidal processes on the flushing and exchange of an intermittently open shallow coastal lake**

In coastal lakes with restricted or choked inlets, the high frequency tidal motions are commonly dampened out by the inlet. The low frequency or sub tidal processes thus become important for the exchange between the lake and the ocean. The sub tidal transport processes are examined in a small, shallow coastal lake (Smiths Lake, N.S.W.) using three dimensional numerical modelling. Three different combinations of sub tidal forcing (incorporating changes in mean sea level and variations in local wind) were applied to the lake and compared against tidal forcing. The results showed that the exchange, in all four of the model runs, was dominated by a spring tidal setup process, which promoted the net advection of waters into and out of the lake on a fortnightly timescale, even when sub tidal forcing was absent. When sub tidal sea level forcing was present, the peaks and troughs varied, but the magnitude did not change. The flushing timescale of the lake was very similar under different natural forcing; however under more extreme wind forcing the flushing time was increased by approximately 10%. An examination of the localised flushing showed that the release of a tracer was predominantly restricted to the surface waters, and in the absence of any local winds there were higher concentrations of the tracer within the lake, with no preferred direction of transport. When local winds were introduced, the transport of the tracer was greater leading to lower concentrations within the lake and Coriolis effects appeared to dominate the direction of transport.

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tschlach@usc.edu.au<sup>3</sup> Centre for Aquatic Processes and Pollution, Griffith University, Gold Coast, Qld, 9726 r.connolly@griffith.edu.au**Can small estuaries supply extra carbon to marine fish and decapods?**

Estuarine plumes can act as conduits for the export of organic matter from land to the oceans. Thus, they potentially provide a trophic subsidy to consumers in the nearshore marine zone. In this study, we assessed whether marine fish and decapod species assimilate such carbon exported in a small plume (Mooloolah Estuary, SE-Queensland). The hypothesised carbon flow from the estuary to sea was traced with stable isotopes ( $\delta^{13}\text{C}$ ) in consumers collected from areas under the direct influence of plumes, contrasted with samples from offshore sites. Several species of fish and crustaceans showed some sign of uptake of estuarine carbon, but variability of such trophic links was large amongst the consumer guild. 3-spot sand crabs (*Portunus sanguinolentus*) from plume areas had significantly depleted  $\delta^{13}\text{C}$  values ( $-17.7 \pm 0.2\text{‰}$ ) compared with conspecifics caught offshore ( $-16.8 \pm 0.1\text{‰}$  and 12 mg/kg, respectively), indicating that some carbon carried by the plume is incorporated by this species. By contrast,  $\delta^{13}\text{C}$  ratios in dusky flathead (*Platycephalus fuscus*) were similar between plume- and offshore sites. A possible confounding factor in testing such trophic links with bio-chemical tracers is a significant effect of body size on ratios measured in consumers tissues: such 'size effects' were variable amongst the consumer guild. The results of this study suggest that the incorporation of organic material discharged via plumes from small estuaries is species-specific and may in several cases be influenced by the size and mobility of the consumers.

**Gehrke, Peter<sup>1</sup> and Marcus Sheaves<sup>2</sup>**<sup>1</sup> CSIRO Land and Water, 120 Meiers Road Indooroopilly, Qld 4068.

Peter.Gehrke@csiro.au

<sup>2</sup> School of Marine Biology and Aquaculture, James Cook University, Townsville, Qld 4811. marcus.sheaves@jcu.edu.au**A generalised model of biological connectivity at the marine catchment basin scale**

Historically, fisheries and aquatic sciences have tended to focus on either freshwater or marine systems, despite the continuous gradient from freshwater to marine habitats. The interfaces between systems have received less emphasis. However, with the increasing realisation that land-based processes contribute significantly to ecological processes in rivers, estuaries and coastal environments, there is an increasing need for a systems-scale approach that transcends traditional salinity-based boundaries and sub-disciplines. The marine catchment basin concept (Caddy 2000) presents a basis for integrating the different system components that link catchments, river networks, estuaries and coastal ecosystems. In this way, the marine catchment basin concept provides a template for understanding and managing physical and biological connectivity within and among habitats, as well as between adjacent catchment basins in the GBR region.

This presentation summarises prevailing conceptual models that underlie ecological production and ecosystem function in freshwater and coastal systems to develop a synthesis model that can be applied to maintain biological connectivity among habitats at a hierarchy of scales within and among catchment basins. Many existing aquatic production models rely on assumptions of physical and chemical interactions happening in predictable ways in a "reaction vat" environment. Conceptually, these approaches link easily with material budget approaches that are widely used in managing water quality in the GBR region. However, they largely ignore the role of risk-based decision making on the part of individual animals in determining their behaviour, movements and habitat use, so that simple reaction vat assumptions simply do not work at higher trophic levels. This introduces the added complexity of ecological scale to the spatial and temporal scale issues that define connectivity within aquatic ecosystems, and gives rise to a number of hypotheses regarding the role of connectivity in large-scale multidimensional systems.

## **Gershwin, Lisa-ann**

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### **Irukandji jellyfish: Myths and truths**

Irukandji jellyfishes hospitalize over a hundred people a year in Australia, and have caused deaths here and abroad. An estimated AU\$65 Million loss to tourism following two fatalities in 2002 was attributed to negative publicity about the incidents. Despite the huge public health and financial implications of Irukandjis, there is still very much an air of mystery about them in the public eye, leaving a wake of denial or fear. Erroneous assumptions about their stings and their behaviours abound, giving people a false sense of security or a disproportionate sense of concern. No, swimming like a turtle does not make them think you are a predator - No, showing no fear or exuding loving thoughts are not reasonable methods of sting prevention - No, peeing on the sting is not the best first aid. Quite simply, most people lack practical understanding on how to protect themselves, or they think it must be so random that there is no use in being safe. In fact, we know quite a bit about them, and we know how to protect from being stung while still enjoying the water in a safe and pleasurable way. I will review the most common myths about Irukandjis, and provide advice on the best ways to protect from being stung.

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### **Australia: Disneyland for taxonomists**

Some say that prostitution is the world's oldest profession; however, according to the Bible, "And out of the ground the Lord God formed every beast of the field, and every fowl of the air; and brought them unto Adam to see what he would call them: and whatsoever Adam called every living creature, that was the name thereof" (Genesis 2:19). Thus, if Adam had naming rights to all the creatures in the Garden of Eden, Australia would have certainly seemed like Disneyland, with literally many thousands of species still yet to be discovered and classified. It is commonplace to hear that Australia has high rates of endemism, or that Australia is home to more deadly creatures than any other place on the planet. But most people don't realize that this means that we only know a tiny percentage of the species in and around our own shores. For example, several thousand new species of sponges await formal classification; hundreds of species of spiders and jellyfishes, some deadly, await description; and dozens of new genera of soft corals await recognition, to name just a few. Without a thorough and accurate taxonomy, other types of research suffer: ecological comparisons within species may in reality be between species, or vice versa, and reproduction of research results may be impossible to achieve due to lack of clear delineation of species boundaries. In this presentation, I will outline the importance of taxonomy to communication and reliability of all other types of research; I will highlight some of the weird and wonderful things that await formal description; and I will highlight some of the opportunities available to students and others considering taxonomy as a field of study.

## **Glasby, Tim**

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### ***Caulerpa taxifolia*: Killer alga or just misunderstood?**

Outbreaks of a strain of *C. taxifolia* were first discovered in NSW in April 2000 and the alga is now present in 10 estuaries, growing primarily on soft sediments at depths of 0.5 - 9 metres. *C. taxifolia* is often associated with, and is thought to threaten, native seagrasses, but there is little published empirical evidence of negative impacts. Ongoing research in NSW is investigating the interactions between native seagrasses (*Zostera capricorni* and *Posidonia australis*) and *C. taxifolia*. Multiple approaches are being used, including regular mapping of the extent of infestations at the scale of estuaries, detailed surveys of the abundance of seagrass and *C. taxifolia* at scales of 1 - 50 m, and small-scale experimental transplantations of *C. taxifolia* at the scale of 1 - 10 m (done in areas where *C. taxifolia* was already abundant). No obvious effects of *C. taxifolia* on seagrass have been detected after more than 3 years of mapping and experimentation, but some complex patterns have emerged.

**Golding, Rosemary E<sup>1,2</sup>, Winston F Ponder<sup>2</sup> and Maria Byrne<sup>1</sup>**

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**Proboscis versus snout - homologies and evolution in the Caenogastropoda**

Caenogastropods are a diverse groups of molluscs which exhibit a wide variety of feeding modes and morphologies, including herbivory, predatory carnivory, filter-feeding and detritivory. Morphological structures associated with food acquisition and digestion are equally diverse and are the foundation of the current systematic scheme. A proboscis, generally associated with a predatory, carnivorous feeding mode, is found in several separate caenogastropod lineages including the diverse Neogastropoda. The homology and evolutionary origins of this structure are examined using histology and detailed examinations of the musculature. Preliminary results support the hypothesis that the proboscis has evolved several times in different caenogastropod groups.

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**Sources and fate of terrestrial and marine organic carbon in the Gulf of Papua**

Seabed sediments were collected along the particle-dispersal system associated with the Fly River-Gulf of Papua continental margin as part of the source to sink program in Papua New Guinea. Box and kasten cores were collected from the subaqueous delta located adjacent to the mouth of the Fly River as well as from the topset, foreset and bottomset regions of the active clinoform in the northern region of the Gulf of Papua. Analyses of elemental (organic carbon, nitrogen), stable isotopic (d13C and d15N), radiocarbon (14C), and biomarker (CuO oxidation products) signatures reveal significant differences in the content and composition of sedimentary organic matter (OM) along the dispersal system. The major sources of OM to the system appear to be remains of vascular plants, soil OM from the drainage basin, and materials derived from autochthonous productivity. The geographical contrasts in the concentrations and accumulation fluxes of these distinct types of allochthonous and autochthonous OM are presented in the context of patterns of sediment transport and deposition within the region. An overall OM budget for the whole dispersal system will be presented and its implication for carbon sequestration and cycling in fluvial-dominated continental margins discussed.

**Gordon, Iain and Tim Lynam**

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**The application of science in managing Great Barrier Reef catchments: Lessons learnt**

Within the GBR and associated catchments, a range of management agencies and science groups have implemented a variety of science and management interfacing arrangements that provide the experimental cases for analysing what has and has not worked in meeting the goals of the ReefPlan . These analyses are the focus of this presentation.

Drawing on the experiences of the GBRMPA and those of FNQNRM, as representatives of management agencies, as well as the scientific experiences of CSIRO and associated science partners this presentation highlights the major lessons of effective science and management engagement. The summary of lessons focuses on the different types of interface that have proved effective and those that have not across a variety of management tasks as well as across a variety of management and stakeholder engagement models. The presentation highlights both the science and the management perspectives on these important interface types and the conditions under which each would be useful.



**Gordon, Matthew**, Rhondda Jones and Jamie Seymour

School of Tropical Biology, James Cook University, Cairns Campus

## **Box jellyfish, tracking technology and tourism: Increasing safety through understanding medusae movement patterns**

Box jellyfish are common inhabitants of the tropical Australian coastline throughout the warmer months of the year. Unlike most jellyfish, they are capable of moving independently of water currents and wave action. Yet the current understanding of box jellyfish movement patterns or what drives their sporadic appearance and distribution is limited to anecdotal evidence and theories.

Research conducted in Weipa over the 2005-06 stinger season represents the first step towards resolving this situation. Small ultrasonic transmitters were fitted to the bell of medusae approximately 100mm in size, allowing their movements to be recorded for as long as a tag remained attached, up to 56 hours in one case. Not only are box jellyfish capable swimmers, they can also sustain swimming activity over extended periods. One individual covered more than 7km over a 17 hour period of constant movement. Evidence also suggests that movement patterns change once medusae find a favourable habitat whereby a more narrow range is adopted, with individuals remaining within the same 2-3km of beachfront.

It is using information such as this that a computer model predicting locations at which box jellyfish hot spots are likely to occur can be developed. Such a model would make the tropical coastline safer by reducing the risk of a stinging event occurring.

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**Grasso, Laretta**<sup>1</sup>, John Maindonald<sup>2</sup>, David Hayward<sup>1</sup>, Robert Saint<sup>1</sup>, David Miller<sup>3</sup>, Eldon Ball<sup>1</sup>

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## **Microarray analysis of development in the coral *Acropora millepora***

Development of the coral, *Acropora millepora*, encompasses a series of dramatic morphological changes, including gastrulation, settlement and metamorphosis from a motile planula larva to a sessile primary polyp, and colony formation. In order to determine the genes and gene networks that execute these changes we have used microarray to compare the gene expression profiles of four life stages; the prawn chip (pregastrula), planula larva (presettlement), postsettlement larva and adult colony. Understanding the molecular control of *A. millepora* development is important for the insight provided into the evolution of developmental mechanisms, and for the establishment of applications such as the control of settlement and zooxanthellae uptake. The microarrays contained 12,200 sequenced ESTs derived from libraries constructed from three life stages. These represent approximately 5062 unique predicted peptides of which 1170 were differentially expressed during the developmental time span investigated here. Seventeen developmentally regulated genes were shared only with Deuterostomia and appear to have been lost by other Cnidaria and Bilateria as determined by Blastx searches. In addition, 20% of developmentally regulated genes had no hits to Bilateria or other Cnidaria, indicating that some developmental genes are coral specific. Further characterisations of these genes by in situ hybridisation have been carried out and reveal spatial expression patterns consistent with the involvement of certain genes in ectoderm specification, larval settlement and calcification.

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<sup>1</sup> School of Marine Biology and Aquaculture, James Cook University, Townsville 4811**Pedicellariae of the crown-of-thorns sea star as a natural defence against fouling: At a pinch!**

Asteroid pedicellariae, which are pincer-like appendages, have repeatedly been suggested as a mechanism to prevent the settlement of fouling organisms and foreign materials. To investigate the role of asteroid pedicellariae in fouling control, the presence of macro-fouling organisms on the sea star *Acanthaster planci*, the morphology and distribution of its pedicellariae and their defensive role against fouling were examined. All specimens (n=41) were free of any macro-fouling organisms. The straight pedicellariae of *A. planci* had a mean length of  $0.7 \pm 0.03$  mm with a mean distance of  $2.6 \pm 0.1$  mm between pedicellariae. There was a weak positive correlation between the number of pedicellariae and the surface area of *A. planci*. To determine whether pedicellariae respond to settling larvae, randomly selected pedicellariae were mechanically stimulated by dropping silica beads (<106  $\mu\text{m}$ , 150-212  $\mu\text{m}$ , 212-300  $\mu\text{m}$  and 425-600  $\mu\text{m}$ , density: 2.5 g.ml<sup>-1</sup>) and zirconium/silica beads (200  $\mu\text{m}$  and 500  $\mu\text{m}$ , density: 3.7 g.ml<sup>-1</sup>) over the pedicellariae. The percentage of responding pedicellariae increased proportionally with increasing size of the silica beads. However, the percentage also increased when zirconium/silica beads of similar size but higher density were used, indicating that the weight, not size, of the beads is the driving factor. Pedicellariae were also stimulated by placing larvae of the bryozoan *Bugula neritina* of varying ages (0-2 h, 6-8 h) close to a pedicellaria and dropping fragments of the fouling alga *Chrysoecystis fragilis* of varying sizes (150-200  $\mu\text{m}$ , 550-600  $\mu\text{m}$  and 950-1,000  $\mu\text{m}$ ) over the pedicellaria. The response was consistently low, with only 15% and 11% of the pedicellariae responding to 0-2 h and 6-8 h old larvae of *B. neritina*, respectively, and none of the pedicellariae responding to the fragments of *C. fragilis*. The results suggest that asteroid pedicellariae are not as effective in fouling control as previously implied.

**Gunter, Helen<sup>1</sup>, Damian Koop<sup>2</sup> and Bernie Degnan<sup>1</sup>**

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<sup>1</sup> School of Integrative Biology, The University of Queensland, Saint Lucia 4072 bdegnan@uq.edu.au<sup>2</sup> Scripps Institute, La Jolla, San Diego. dkoop@ucsd.edu**Heat shock perturbs the molluscan organiser**

Heat shock can inhibit organiser function in the abalone *Haliotis asinina*, resulting in larvae that are morphologically similar to drug induced organiser knockouts. In spite of the similarities, there are fundamental differences in the gene expression and tissues formed in the heat shocked larvae, thus the organiser is not completely knocked out by heat shock. The molluscan organiser is specified in the period between 5<sup>th</sup> and 6<sup>th</sup> cleavage and is required for the development of mesoderm, muscles, nervous system and the general organization of all tissues. U0126, a MAPK inhibitory drug, is known to inhibit the process of D quadrant organiser specification. The resulting trochophore larvae have a 'dumbbell shape' (Martindale 1986), bearing exogastrulae, a posttrochal constriction, a posteriorly positioned stomodaeum, and radialisation of pretrochal structures. This is superficially identical to the result of applying heat shock during organiser specification. Indeed, ectodermal markers have revealed that the ventrolateral ectoderm and shell gland do not migrate to their normal positions, in both U0126 and heat shock treated larvae. However, there are fundamental differences. While many of the heat shocked larvae have a radialised pretrochal ectoderm like the drug treated larvae, a proportion of them have a normal pretrochal region, unlike the drug treated larvae. Additionally, U0126 treated larvae do not develop mesodermal bands, muscles or a full nervous system, however, heat shocked larvae do. In fact, microarray comparisons between heat shocked larvae and drug treated larvae reveal that there are very limited global expressional similarities. Our data reveal heat shock can knock down some functions of the molluscan organiser, however the resulting larvae are fundamentally different to larvae in which the organiser has been knocked out. Additionally, many tissues affected by organiser function arise independently, and their organization can be manipulated independently through heat shock.

**Gust, Nick<sup>1</sup> and Graeme Inglis<sup>2</sup>**

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**Rapid nationwide surveys for an invasive marine pest in New Zealand: delimitation methods and detection probabilities**

A surveillance program conducted in November 2005 determined the distribution and density of the non-indigenous ascidian, *Styela clava* at twenty-six high risk locations nationwide. At each survey location, we combined above-water observations, with in-water searches using SCUBA divers. *Styela clava* was detected at three of the 26 locations surveyed, and estimates of its relative abundance were made visually using a semi-quantitative log-scale. Maximum densities encountered at each infested location were in the range of 1-10 individuals per m<sup>2</sup>. These densities are up to three orders of magnitude lower than those reported for *S. clava* in Canada, where it has caused significant ecological and economic impacts.

Detection probabilities were calculated for each of the 23 locations where *S. clava* was not found, to provide an indication of the relative confidence of detection among locations, search techniques and substrata. To calculate detection probabilities, an experiment was conducted to estimate the sensitivity of the search methods. Known numbers of *S. clava* mimics were deployed at twelve sites under different conditions of water clarity. An independent team then searched the sites for the mimics using the standard survey protocols. Experimental results showed that search sensitivity for above-water searches was positively related to water clarity; however diver search sensitivity remained high irrespective of water clarity.

At the 23 locations where rapid surveillance did not detect *Styela clava*, we estimated the relative confidence that above-water surveys would have detected it if at least one individual was present. Above-water detection probabilities varied widely between locations (from 0.02 to 0.55), which often reflected the prevailing water clarity during searches, and its effect on search sensitivity. Above-water and in-water searches provided complementary approaches for rapidly determining the extent of the incursion at locations nationwide.

**Haese, Ralf R<sup>1</sup>, Emma J Murray<sup>1</sup>, Craig S Smith<sup>1</sup>, Jodie Smith<sup>1</sup>, Lesley Clementson<sup>2</sup>, David T Heggie<sup>1</sup>**

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**Diatom productivity and its control on N and P cycles in a coastal lagoon (SE Australia)**

Diatoms are important primary producers within pelagic, benthic and epiphytic communities and their siliceous frustule leads to rapid sinking to the sediment. As a consequence, diatoms play an important role in nutrient and carbon cycles in aquatic environments. In this study, benthic nutrient and gas fluxes, water column and sediment properties were studied in a coastal lagoon of south-eastern Australia (i) to identify control mechanisms coupling benthic and pelagic processes and (ii) to estimate pelagic and benthic diatom productivity. During late spring, the water column of St. Georges Basin (NSW) was oligotrophic (e.g. [Chl-a]: 1 - 2 µg/l, [PO<sub>4</sub><sup>3-</sup>] ≤ 0.04 µM) and the phytoplankton community was dominated by cyanophytes. Molar ratios of TCO<sub>2</sub> and Si benthic fluxes, however, were equal to the molar composition of diatoms suggesting that only diatoms sink to the sediment and undergo benthic degradation. The congruent release of Si and C from diatoms is intriguing and is possibly related to diatom ingestion by benthic meio- and macrofauna. Benthic diatom productivity in shallow water (< 3 meters) leads to a doubling of the carbon deposition rate as compared to sediments at greater water depth. Pelagic and benthic diatom productivity and subsequent diatom biomass degradation in sediments is an efficient pathway to reduce bioavailable N and P in the water due to coupled nitrification/denitrification and phosphorous adsorption onto ironoxyhydroxides in sediments.

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**Cryptic speciation in the Eleven-armed sea star  
*Coscinasterias muricata* (Echinodermata: Asteroidea)**

The genus *Coscinasterias* is a cosmopolitan genus of large asteroid sea stars that are common in the shallow waters of the world's continents. *Coscinasterias muricata* is the largest species found in southern Australia and tends to occur in great abundance in sheltered areas. This study aimed to discover, by comparison of specimens held at Museum Victoria the morphological differences between Waters and Roy's (2003) "northern" and "southern" clade animals and to determine whether there are two or more species of *Coscinasterias*. The findings of this study were that based on morphological and molecular evidence (provided by Roy and Waters) there are at least two species of the genus *Coscinasterias* in Australia. The morphological differences between species are relatively small and suggest that it is a form of cryptic speciation at work. *Coscinasterias muricata* possesses globose carinal spines and spatulate inferomarginal spines, with a geographical range of Victoria, Tasmania, New South Wales and New Zealand. *Coscinasterias* sp.nov. possesses conical carinal spines and digitate inferomarginal spines and a geographical range of Western Australia, South Australia, New South Wales and south west Bass Strait. Further investigation is required in order to confirm if there is a third species of *Coscinasterias* occurring in southern Australia. There are many important management implications of cryptic speciation, particularly if ecological, toxicological and biogeographical characteristics vary between the species.

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**Decision support for linking management and science: A focus on modelling and monitoring approaches for coastal systems**

Managers within organisations such as government and catchment management associations or regional bodies need to make decisions about coastal and marine environments on a daily basis, often with a lack of good scientific information. Researchers are rapidly developing techniques for answering key scientific questions but scientific descriptions of coastal systems and associated research are usually complex and often highly variable between research locations. In addition, historically there has not been a strong focus on tailoring this information to stakeholders' needs, although there is now increasing pressure on researchers to deliver targeted results. Therefore, fostering links between science and management in a consistent and clear manner is a major challenge but an important goal to ensure better decision-making and productive research.

The Coastal CRC has emphasised the need for links between science and management and many tools have been developed for specific groups of stakeholders. Coastal CRC project teams have developed innovative, tailored 'first stop shops' for those seeking to understand coastal and marine environments and scientific techniques used in these environments. The presentation will briefly describe some of the Coastal CRC's tools, such as the Remote Sensing Toolkit and conceptual diagrams of wetland processes, with a focus on the Integrated Water Assessment Decision Support System (IWADSS).

The IWADSS was developed to assist decision makers choose and review coastal assessment approaches, such as those applicable for development assessments. The system is underpinned by current expert knowledge and documented literature on monitoring, modelling, and experimentation approaches. The system helps users understand the broader application of these three areas of assessment, with particular emphasis on the highly technical field of water quality modelling. The assessment approaches covered in IWADSS include: process (biogeochemical) modelling; non-process (statistical) modelling; in-field monitoring; remote sensing; and experimentation.

These tools and projects demonstrate how scientific knowledge can be synthesised for specific audiences and incorporated into software-based decision support tools.

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**Implications of MARGINS S2S results to the environmental management of Torres Strait and the Gulf of Papua**

Conservation of marine biodiversity and implementation of adaptive management strategies to environmental threats in Torres Strait and the Gulf of Papua are priority areas for environmental managers in Australia and Papua New Guinea. New habitat maps and improved knowledge of benthic disturbance regimes generated by the MARGINS S2S program will benefit environmental managers charged with regional marine planning and the design of spatial conservation measures, such as marine protected areas. This is particularly the case in areas where biological information is scarce and physical habitat maps are used as surrogates for biodiversity. Hyperpycnal sediment flows onto the pro-delta and offshore gravity flows into relict shelf valleys are processes (disturbance regimes) that will clearly have significant ecological implications. In this context, the proposal to build a gas pipeline across the front of the Fly Delta, transverse to the direction of net sediment transport, could interrupt sediment dispersal and have unintended consequences. Undoubtedly among the most serious threats to the health of coral reefs living in proximity to the Fly River Delta, is the prospect of anthropogenic increases in river sediment loads and export to the marine environment. The better understanding of processes governing sediment export to the shelf and its subsequent dispersal provided by MARGINS S2S research will inform decisions made by government and enhance management outcomes in the years ahead.

**Heggie, D<sup>1</sup>, G Skyring<sup>2</sup>, R Haese<sup>1</sup>, C Smith<sup>1</sup>, E Murray<sup>1</sup> D Fredericks<sup>3</sup> & D Palmer<sup>4</sup>**

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<sup>1</sup> Geoscience Australia, PO Box 378 Canberra, 2601<sup>2</sup> Skyring Environment Enterprises 40 Atherton St, Downer ACT, 2602.<sup>3</sup> Sanitation & Water Consultant 4 Fox Place Lyneham, ACT.<sup>4</sup> Department of Environment, WA Water, Kimberley region, PO Box 625 Kununurra 6743.**Photosynthesis, respiration and sediment nutrient release in temperate Australian estuaries: A stoichiometric perspective**

The stoichiometric interpretations of 450 CO<sub>2</sub> and O<sub>2</sub> benthic fluxes, from chamber deployments in fifteen temperate estuaries, indicated that in paired light-dark deployments respiration dominated in 92% of sites. This indicated that most of the OM undergoing degradation in the sediments was from the overlying waters. Benthic CO<sub>2</sub> and SiO<sub>4</sub> flux ratios indicated that diatomaceous OM was predominant in the sediments: as such the OM was principally of a Redfield C:N:P [106:16:1] composition. Oxygen reduction dominated the degradation of OM, but sulphate reduction (identified from alkalinity measurements) was found to be responsible (in general) for about 30-50% of the OM degradation. A COD (chemical oxygen demand) was found in most estuaries and was a significant component of the total oxygen flux into the sediments. COD probably results from the oxidation of metallic sulphides in the sediments. A DIN flux was measured in all chambers but it was (in most instances) less than the DIN expected from OM oxidation. The 'missing N' was subsequently identified (by mass spectrometry) as N<sub>2</sub> from coupled nitrification-denitrification reactions. However, there was no universal function to describe denitrification efficiencies; some estuaries had denitrification efficiencies >70% but others were <30%, over comparable CO<sub>2</sub> flux ranges. Sulphate reduction appeared to have a negative impact on denitrification efficiencies. There was evidence for both photosynthetic and heterotrophic N-fixation in several estuaries. There was some evidence for DNRA, but in only a few instances. Most DIP released during OM degradation was not returned to the overlying waters but was trapped in surficial sediments. Biophysical processes (not diffusive) were principally responsible for the measured fluxes.

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**Spatial and temporal variation in the structure of estuarine macroinvertebrate assemblages: Implications for monitoring estuarine health**

Estuaries are amongst the most highly modified coastal ecosystems in Australia. In part, this is because of their location at the bottom of often equally modified freshwater catchments, but also invariably due to their proximity to areas of human settlement. As human impacts in estuaries are often pervasive (estuary-wide), pre-existing or have a long-standing historical context, the identification of suitable reference points with which to assess impacts is a complex task that will inevitably require compromise. One solution is to compare potentially degraded estuaries with estuaries deemed to be within minimally impacted catchments or largely unmodified by human activities. However, there is a perception that individual estuaries are too spatially and temporally dynamic to allow valid comparisons to be made using such an approach. We tested this idea for a commonly used indicator, benthic macroinvertebrates, using a nested-hierarchical design incorporating both temporal and spatial scales between and within three adjacent meso-tidal river estuaries in northern Tasmania. Variation in macroinvertebrate assemblage structure was analysed using permutational multivariate analysis of variance (PERMANOVA). The majority of variance was found within estuaries (i.e. corresponding with change along an estuarine upstream gradient) or at the level of sites. Only 2% of variance could be attributed to seasonal differences, while no variation was attributable to differences between estuaries. Abiotic variables strongly correlated with macroinvertebrate assemblage structure ( % sediment organic C, salinity and % silt/clay) displayed a similar pattern. Although, only preliminary, this study suggests that temporal and between estuary differences are relatively insignificant when contrasted against spatial variability within estuaries for a commonly used biological indicator.

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**Towards a wetlands park at East Trinity Inlet, Cairns**

The Cairns tidal wetlands are strategically located and offer an outstanding opportunity for the development of a world-class environmental education and eco-tourism facility. The combination of the natural, degraded, remediated and rehabilitated wetlands is a positive attribute for the park concept, especially for environmental education. Proximity of the proposed Cairns Wetlands Park (CWP) to the Cairns Central Business District (CBD) is a strategically important feature, facilitating easy water access to the facility. Proximity to the Cairns CBD also has the advantage of being able to minimise the amount of investment in on-site infrastructure. For example, no overnight accommodation or road access is required. The existing tourism service businesses in the CBD will benefit from the proposal. The proposed CWP offers the opportunity for combining ecologically oriented environmental education with a new eco-tourism experience. The eco-tourism component is expected to provide the main income for the facility to ensure performance in the core business of environmental education.

By combining environmental education and eco-tourism themes with a strong commitment to world-class environmentally friendly design and operation, the proposed CWP has the potential to be a landmark feature attracting national and international interest. The proposed CWP has the potential to be a showpiece of Australia's most innovative environmental design, providing the opportunity for attracting corporate participation in the project. The proposed community-based management structure proposed for the CWP provides the benefits of being able to attract corporate and community sponsorship, a creative marketing approach and to work in partnership with a range of partners in the education, tourism and corporate sectors. The CWP would complement the rehabilitation of the already degraded wetlands, turning the rehabilitation into an educational and tourism asset. All of the lands required for establishment of the proposed CWP are in the ownership of the Queensland Government and the necessary acid sulfate remediation is well advanced. If the Cairns community and the Queensland Government fully embrace the concept of the proposed CWP, which they show every sign of doing, the project could be launched and the necessary detailed planning and fundraising commenced.

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### **Ontogenetic changes in lipid and fatty acid composition of mud crab, *Scylla serrata*, larvae**

The demand for mud crabs, *Scylla serrata*, has rapidly increased over the last decade, putting high expectations on mud crab aquaculture as a major industry in the near future. However, low and inconsistent larval survival in hatcheries is currently limiting further expansion of the industry, and poor nutrition has been identified as one of the main causes of mass mortality. Especially problematic is the unfavorable highly unsaturated fatty acid (HUFA) profile in the commonly used live feeds. This study investigates the ontogenetic changes in dry weight, ash-free dry weight, moisture content, lipid class and fatty acid composition of *S. serrata* larvae fed live rotifer and *Artemia*. Newly molted larvae were collected at each developmental stage, and the fatty acid composition of tissue lipids were determined by gas-chromatography using 14% boron trifluoride-methanol.

The results showed that dry weight and ash-free dry weight increased during larval development whereas the moisture content decrease from 91.3% for newly hatched zoea I to 78.2% for newly settled crabs. Total lipid accounted for 19.8 mg/g of the ash free dry weight (14.5% dry sample weight) in zoea I larvae, decreasing gradually to 8.87 mg/g of the ash free dry weight (12% dry sample weight) for newly settled crabs. Polar lipids (PL) was the primary lipid class throughout development, and saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) were superior to poly unsaturated fatty acids (PUFA) in the tissue at all larval stages. The fatty acid composition was relatively stable throughout larval development, with palmitic acid (16:0), stearic acid (18:0), oleic acid (18:1n-9), arachidonic acids (20:4n-6 AA), eicosapentaenoic acid (20:5n-3, EPA) and docosahexaenoic acid (22:6n-3, DHA) dominating the tissue samples. An increase level of linolenic acid (18:3n-3) was observed in the tissue as larvae grew, making this a major fatty acid for the later developmental stages. A high level of n-3 fatty acid resulted in a high n-3/n-6 ratio. The DHA/EPA ratio in larvae tissue decreased during development, indicating utilization of DHA for larval growth. These results provide an important insight into the relative significance of the different lipid classes and fatty acids in larvae tissue at the various stages of ontogenetic development. As these findings can be linked to the larvae's requirements for dietary lipids, this study is an important step towards development of nutritionally optimized *S. serrata* larvae diets.

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### **Marine education and awareness on the North Coast of NSW**

Marine education and awareness raising can take many forms but needs to be tailored to the target groups and available resources. Since May 2005 a number of initiatives have been undertaken on the North Coast of New South Wales involving Coastcare, the NSW Marine Parks Authority, the Marine Education Society of Australasia and the Northern Rivers Catchment Management Authority. These initiatives continue to involve the general public, schools, community groups, local researchers and industry, and cover a wide range of marine topics. The development, implementation and outcomes of these initiatives will be discussed with particular focus on the importance of partnerships and collaboration with local stakeholders to enable the development of high-quality educational materials and events with a relatively small amount of funding.

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**Ingleton, Tim**, Peter Davies, Alan Jordan and Tim Pritchard

NSW Department of Environment & Conservation

## **Interferometric sidescan sonar - A tool for rapid assessment of benthic habitats for NSW marine parks**

The NSW DEC recently purchased an interferometric sidescan system (125kHz) to conduct detailed surveys of targeted areas within NSW Marine Parks. As a remote sensing technique, the side scan sonar provides a rapid cost effective assessment of large areas of ocean bottom from high resolution bathymetric and backscatter data. The DEC's Geoswath is affordable compact and portable when compared to other available sidescan systems and is ideal for this type of application. An overview of the system is provided along with some data analysis in examining achievable swath widths, bottom ensonification, data population/point coverage, bathymetric and positional accuracy and motion errors.

Cleaned and processed data is projected into grids and digital elevation models for analysis within GIS. Coverages of broad substrate types are then digitized with bathymetry and backscatter used to determine texture, slope and rugosity, that along with underwater video, is then used to further subdivide substrate to habitat type. Additional sets of environmental data may be used to argue further sub-divisions. Automated classification techniques of bottom texture are also examined. Information is integrated within the ArcGIS format and used to produce a variety of hardcopy and interactive electronic end products.

Data has recently been collected within the Solitary Islands Marine Park to be used in a review of the park's Zoning Plan. A subset of data from Sidney Shoals is presented to demonstrate how the side scan information highlights the complexity of areas previously marked as homogeneous and the potential for reclassification of habitats and follow on implications for zoning.

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## **Mycobacteriosis in wild marine fishes: A synthesis of current understanding**

Mycobacteriosis is a serious, and often lethal disease of fish, affecting a wide range of species globally both in culture and wild settings. Caused by several species of the genus *Mycobacterium*, the disease has received considerable attention in recent years due to the discovery of new species in piscine hosts, epizootics in wild fisheries, and the ability of a few species to infect humans. The impact of this disease in aquaculture and the aquaria trade has been tremendous, however, the impact on wild fisheries is poorly understood and may relate strongly to species-specific interactions (host-pathogen) and possibly environmental stressors. Here we present a global view of mycobacteriosis in wild fisheries with further concentration on an epizootic in Chesapeake Bay striped bass (*Morone saxatilis*). For the past 10 years, mycobacterial infections have been persistent in this highly sought recreational and commercially important species with estimates of over 70% of the fishery infected. While much research has been focused on this issue, basic questions surrounding the etiology of disease, methods of detection, transmission to humans, role of environmental stressors, and population level impacts still remain. To address these issues and define our current state of knowledge in regards to this disease, a workshop was held in May of 2006 bringing together academic, Federal, and State scientist, fisheries managers, and stakeholders. Results of this effort and application to the investigation, understanding, and management of mycobacteriosis in marine fish will be discussed.



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**Small and large scale influences of mangroves on seagrass fish**

Mangrove forests of *Avicennia marina* and seagrass beds of *Zostera capricorni* are commonly found adjacent to one another in estuaries of temperate southeastern Australia. We conducted a survey and a manipulative experiment to test the large and small scale influences of mangroves on seagrass fish in the Brisbane Water estuary of southeastern Australia. In the large-scale survey, we sampled the small fish assemblages of 13 seagrass beds that were either close to or far from mangrove forests (distance range 1 - 1330m). The seagrass beds less than 14m from mangroves had different fish assemblages than those 100m or more from mangroves. To test which distance between 14 - 100m the fish assemblages in seagrass beds changed i.e. the small scale influences of mangroves on seagrass fish, we designed a manipulative experiment. This experiment used artificial seagrass units (ASUs) that were positioned within a continuum of small scale distances (24 - 110m) from mangroves. The ASUs that were under 70m distance from mangroves had different fish assemblages when compared to those that were over 90m from mangroves. Some of the fish that were common in mangroves were more abundant in the closer ASUs (24 - 70m) than far (over 90m). These fish included some common gobies such as *Redigobius macrostoma*, *Arenigobius frenatus* and *Afurcagobius tamarensis*. In addition, the species richness of the fish that were commonly found in the mangroves was significantly greater in the ASUs closer to mangroves than far. The influence of mangroves on fish assemblages in seagrass beds appears to diminish over a distance of 90m.

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**Johnston, Emma L<sup>1</sup>, Richard F Piola<sup>1</sup>, Katherine A Dafforn<sup>1</sup>, Tim M Glasby<sup>2</sup>, Graeme F Clark<sup>1</sup>**

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**The role of pollution in facilitating invasion**

It is unclear whether the increased occurrence of exotic species in bays and estuaries simply reflects increased rates of inoculation, or whether non-indigenous organisms are taking advantage of disturbed environments. We report a synthesis of research that includes bioassays and monitoring, as well as manipulative field studies of invasion, pollution, and restoration. Two mechanisms by which pollution may facilitate invasion are identified for marine hard-substrate assemblages. The relative importance of the two mechanisms are discussed.

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**Turbidity drives the structure of food webs in the Fitzroy River**

The Fitzroy River in central Queensland is one of the largest systems in eastern Australia, with tidal influence extending 60 kilometers inland from the mouth. Average spring tidal range is around 4.0 metres but maximum range exceeds 5.5 metres. The tidal magnitude and length of tidal incursion generates current velocities that can attain 1.5 m/sec and regularly re-suspend sediments in the lower estuary resulting in elevated turbidity levels. We used beam trawls to collect fish from four locations in the Fitzroy River, two in the upper and two in the lower reaches, and found strong upstream/downstream differences in the composition in the Fitzroy River fish assemblage. In particular, the lower Fitzroy estuary held a relatively small biomass of planktivorous fish compared to the upper estuary. In contrast, the biomass of prawn/benthos feeders was generally higher in the lower estuary. Those patterns support findings from CSIRO studies reporting substantially lower light dependent phytoplankton concentrations in the lower Fitzroy estuary than in the upper estuary. These findings point to strong differences in food web structure between upper and lower reaches of the estuary. Food webs in the lower estuary appeared to be detritus based whereas planktonic productivity was important in the upper estuary. Those upstream/downstream differences appear to be responses to the long-term turbidity regime. To utilize the upper reaches of the river most fish must pass through the less hospitable lower reaches but the extent to which this passage occurs during larval recruitment to the estuary or through post recruitment migration is unclear. If the upper estuary is populated at recruitment this implies the lower estuary is unsuitable for larval settlement. In contrast, if post settlement fish migrate to the upper estuary that provides evidence that multiple nursery habitats are used. Those may or may not include obligate settlement habitats in either the lower or upper estuary. The way fish populate the upper estuary also has implications for the transport of energy through the estuary.

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**Linking larval fish assemblages with water masses from non-depth-discriminate data in shelf waters off south-eastern Australia**

This paper discusses findings of an ongoing project to characterise water masses of south-eastern Australia using larval fish assemblages. Data comes from intensive ichthyoplankton surveys conducted in shelf waters from Hervey Bay (Qld) to Eden (southern NSW) in spring (October 2002, 2003), and from Bundaberg (Qld) to Newcastle (NSW) in winter (July 2004), encompassing ca. 850 nm of coastline. Vertical plankton samples were obtained from 256 stations to a maximum depth off 200 m. A total of 18,128 larvae were collected representing 97 identifiable families and 144 taxa. Larvae of small pelagic species (*Trachurus* spp. 30.0%, *Sardinops sagax* 18.0% and *Scomber australasicus* 4.3%) dominated the assemblages. Classification and NMDS ordination distinguished three distinct larval assemblages which appear directly associated with the water masses of the East Australian Current, Tasman Sea, and a composite mixed water mass. A new approach involving NMDS of water column temperature frequencies was used to define water masses, and to highlight linkages to larval assemblages from non-depth-discriminate data. Ordinations of stations from temperature frequencies mirrored that of the larval assemblages. Overall results emphasise the fact that current boundaries and water masses play a key role in defining the distribution of larval fishes in shelf waters off south-eastern Australia.

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## **Ratio-dependent trophic responses make it easier to predict ecological effects of nutrient enrichment in Australian estuaries**

Coastal waters around the world are experiencing increased nutrient loads because of burgeoning populations, changing land-use and urbanisation. While the negative effects of excessive nutrients are well known, it is often difficult to predict the impact of low-level enrichment. Classical resource- and the less studied ratio-dependent trophic models provide divergent predictions as to the sustained ecological effects of bottom-up forcing. We tested predictions from these alternative models in a South-Eastern Australian Estuary by comparing abundances of four trophic groups (phytoplankton, macroinvertebrates, invertebrate-feeding fishes, piscivorous fishes) in a tidal creek subject to over 10 years of nutrient enrichment to abundances in three control creeks. All four trophic levels in the enriched creek displayed increased abundances, approximately proportionate to nitrogen loading. This first evidence of ratio-dependence in an estuarine system not only demonstrates the applicability of this theory, but also has important management implications because, unlike resource-dependent relationships, the trophic consequences of ratio-dependent functional responses are independent of trophic chain length and therefore significantly easier to predict.

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**Knight, Jon M<sup>1,2,3</sup> and Pat ER Dale<sup>1,3</sup>**

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<sup>3</sup> Australian School of Environmental Studies, Griffith University, Nathan Qld Australia 4111. p.dale@griffith.edu.au

## **Patterns of tidal connection into the 12 Mile Pools, Fitzroy River, South East Queensland Australia**

The project sought to discover the pattern of tidal flooding into the 12 Mile pool complex within the south-eastern fringe of the Fitzroy River estuary in South east Queensland. The area is an expansive area of salt-marsh, salt-flat and mud-flat interfacing with a freshwater stream / pool system. The role of tidal inundation into the stream / pool system in the larger context was not well understood, for example the contribution of tidal flows to the habitats of organisms such as fish and crabs. The nature of tidal flooding pattern, such as frequency, size and duration, are key elements for habitats that require a variety of water levels, salinity regimes and isolation patterns.

The aim was to explore flooding patterns and to determine what if any high tides flooded the 12 Mile pools, what kind of water fluctuations occurred, and how these corresponded to variations in connection within the 12 Mile pool complex. Tidal observations were made at 6 locations around the 12 Mile pool complex for a period of two spring tide cycles. The tidal observations were linked back to long-term tidal observations at the nearest related official tidal station (Port Alma) as a means of gaining an understanding of tidal connectivity in the 12 Mile pool complex as it relates to the larger Fitzroy river tidal regime.

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<sup>2</sup> School of Tropical Environment Studies and Geography, James Cook University, Townsville, Qld 4811

## **Response of *Halophila spinulosa* to reduced light: an in situ light experiment on deep meadows in Moreton Bay, Australia**

*Halophila spinulosa* (R.Br.) Aschers. meadows were recently discovered growing to a depth of 15m (AHD) in North Eastern Moreton Bay. The distribution of these meadows is thought to be determined by light availability, based on seagrass distribution and light attenuation. To investigate the potential impact of declining water quality on these communities, seagrass at 10m deep (AHD) were subjected to an in situ 50% reduction in available light over a period of seven weeks. Shaded and control areas were sampled after 11, 33, and 50 days of treatment. In addition to the experimental shading, water clarity declined throughout the experimental period, with secchi depth decreasing from 7.5m to 3.5m. Seagrass demonstrated physiological and morphological responses to both ambient and experimental light reductions. The initial response detected in both the control and shaded treatments to the light reductions were a significant increase in chlorophyll *a* and *b* content, with significant declines in chlorophyll *a*: chlorophyll *b* ratios. In the control treatment this was followed by mobilisation of carbohydrate stores (total soluble carbohydrates and starch) to maintain biomass and increase potential light harvesting by significantly increasing leaf area. In contrast, the shaded seagrass appear to have been unable to access their starch reserves, probably due to rhizosphere anoxia. This inability to access their starch stores resulted in a rapid decline in both leaf area and biomass during the experiment, as photosynthetic biomass was metabolised. The severe reduction in photosynthetic biomass and the observed retention of non-photosynthetic biomass in the shaded treatment suggests that after one month of treatment, even if ambient light was restored, the meadows would have continued to experience a negative carbon balance. The responses of both shaded and control seagrass demonstrated the sensitivity of these *H. spinulosa* meadows to changes in available light. Physiological changes in the seagrass appear to be an early response to declining light availability and may prove to be a useful indicator of light stress. Our study also confirmed that *H. spinulosa* meadows in Moreton Bay are likely to be lost from habitats with less than 10% of surface light available.

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## **Grazing of mesozooplankton on phytoplankton and microzooplankton off the coast of Western Australia**

Mesozooplankton affects the community composition of prey assemblages through their grazing activities and may impact the biomass and community structure at lower trophic levels via trophic cascades. Trophic cascades may be particularly strong in oligotrophic waters (such as off the coast of Western Australia) where the dominant phytoplankton is too small to be directly grazed by mesozooplankton.

In 2003 and 2004 we conducted shipboard grazing experiments where natural assemblages of mesozooplankton were manipulated to assess their grazing impact on natural phytoplankton and heterotrophic protist assemblages. Experiments were conducted seasonally in three locations: a coastal lagoon (10 m depth), shelf (100 m depth) and offshore Leeuwin Current (1000 m depth). We hypothesized that changes in microzooplankton assemblages due to mesozooplankton grazing reduces net community grazing on phytoplankton.

Bottle incubation experiments are widely used in mesozooplankton grazing studies. However, prey suspensions contain several trophic levels, such as phyto- and microzooplankton, and experiments often yield low or negative mesozooplankton grazing estimates when the release of microzooplankton grazing pressure outweighs the copepod grazing rates on the same food items. Simultaneously conducted microzooplankton dilution experiments can be used to correct for the apparent low or negative grazing in the mesozooplankton grazing experiments (Nejstgaard *et al.*, 2001). We propose a method based on the expansion of the Frost (1972) equations to estimate the parameters for phytoplankton growth, micro and mesozooplankton grazing on the phytoplankton and mesozooplankton predation on the microzooplankton from the same experiment.

**Kroon, Frederieke<sup>1</sup> and Jim Wallace<sup>2</sup>**

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<sup>1</sup> CSIRO Sustainable Ecosystems & FNQ NRM Ltd, PO Box 780, Atherton Qld 4883<sup>2</sup> CSIRO Land and Water, Private Mail Bag, PO Aitkenvale Qld 4814. jim.wallace@csiro.au**Participatory research in the Tully floodplain**

The Cardwell Shire Floodplain Program was initiated by CSIRO, local industry groups and the Cardwell Shire Council in late 2004, to harness local community participation in achieving greater industry productivity, biodiversity and social health. With initial funding from CSIRO and the Federal Government's Coastal Catchments Initiative, the Program is taking a holistic view of managing the greater Tully-Murray catchment. The Steering Committee of local organisation representatives has formed three Action Teams to involve the community in production, biodiversity and socio-cultural projects. Current activities include improving land management practices for water quality and productivity, as well as protecting the area's unique biodiversity and lifestyle. The Program is building on activities that have already been initiated across the floodplain including the Tully/Murray Catchment Management Plan and the Sugar Industry Infrastructure Package. The Program includes CSIRO's \$1.6M Water for a Healthy Country Floodplain Renewal research program and the \$1.3M Tully Water Quality Improvement Plan, both of which started 01 July 2006. The regional natural resource management body FNQ NRM Ltd is overseeing the development of the Water Quality Improvement Plan in line with the objectives of the Wet Tropics NRM Plan and the Reef Water Quality Protection Plan. CSIRO's research program will provide the science to underpin the Water Quality Improvement Plan, as well as other objectives of the Cardwell Shire Floodplain Program. Forming a partnership between major stakeholders, the Program will aim to protect and improve the community's way of life, and to involve the whole community in natural resource management activities.

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The Coorong is a pair of interconnected shallow lagoons joining the sea at the Murray mouth. The lagoons display a temporally and spatially varying salinity ranging from fresh to hypersaline depending on position, season, riverine flows and state of opening of the Murray mouth. Historically, this region had a very high biological productivity and diversity, in particular with regard to populations of fish and migratory waterbirds. Currently, the Coorong lagoons are under stress because of the lack of river flows and resulting closure of the Murray Mouth. These two processes have led to the hypersalinisation of the lagoons, in particular the Southern one, and have resulted in dramatic population declines for key waterbirds and estuarine fish species. A change in the quantity and form of organic matter sustaining the Coorong food-web has been hypothesized to play a role in this ecosystem decline. Preliminary data from stable isotopes and <sup>13</sup>C-NMR of potential sources of organic matter from the Southern and Northern Lagoon combined with stable isotopic (C, N, S) data of primary producers and consumers are used to assess food web structures and organic matter dynamics. In this study, the differences in the sources of organic matter driving the respective food webs in each of the lagoons are investigated. We evaluate whether 1) the differences in the proportion and quality of allochthonous versus autochthonous organic matter; and 2) an enhanced degree of recycling in the Southern Lagoon relative to the Northern Lagoon, might have affected food-web dynamics in the Coorong estuary.

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**Can fish assemblages in Moreton Bay be monitored to determine environmental health?**

Estuarine systems are directly threatened by rapid urban growth. Changes in land use associated with urbanisation and industrialisation hugely impact waterways, through creating urban and catchment runoff with elevated levels of nutrients, sediments and chemical contaminants. While it is clear that effective monitoring and management is crucial to the health and productivity of estuarine systems, the impact of anthropogenic pressures on estuaries is difficult to quantify due to their already dynamic, fluctuating nature, together with the cumulative nature of impacts. The use of biological indicators such as aquatic plants, macro-invertebrates and fish, is becoming increasingly popular as a way to monitor estuarine health. Fish, due to their reliance on numerous processes at various trophic levels, have the ability to provide an integrated view of the health of the entire ecosystem. Additionally, fish are an important natural resource in both a commercial and recreational sense.

Moreton Bay has a significant history of land development and is still subject to a multitude of anthropogenic pressures that jeopardise ecosystem health and sustainability of the Bay's resources. This study assessed community attributes of ichthyofaunal assemblages in Moreton Bay to determine if fish assemblages can be used as indicators of environmental health in the Bay. Fish assemblages were sampled at five subtidal sites in western Moreton Bay that consisted of either seagrass or unvegetated sand habitat. Attributes represented community health in terms of abundance, species richness, species diversity, species abundance, trophic level, estuarine dependence and size. The environmental health of sampling areas was determined using data from the Ecological Health Monitoring Program (Healthy Waterways), which classifies sites in Moreton Bay based on environmental parameters such as water quality. Individual community attributes were compared between sites, in addition to analysis using non-parametric multi-dimensional scaling (MDS), to assess whether attributes reflected environmental health.

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The Swire Institute of Marine Science, Department of Ecology & Biodiversity, The University of Hong Kong, Hong Kong

**Impact of soldier crabs, *Mictyris longicarpus*, on the meiobenthic community of the Hong Kong shore**

Large, natural, spatial (between shores and zones) and temporal (between seasons and sample dates) variation in chlorophyll *a* concentration and total organic matter suggests that these measures are not good indicators of the impact of crab feeding. Meiofauna abundance in undisturbed sediment was, however, significantly higher than disturbed sediment in both feeding and resident zones. ANOSIM revealed significant differences in meiofauna composition at all levels (sites, seasons, zones and disturbed and undisturbed sediments); although the R values were not high to further resolve these differences. A modified Ivlev's electivity index indicated that crabs either randomly ingested or actively selected nauplius, copepods and nematodes; while cnidarians were rejected in the diet.  $\leq \pm$  In the exclusion experiment, meiofauna abundance within caged treatment was significantly higher than in control (crab access) treatments. Both experiments showed that surface and subsurface feeding activities of crabs have a noticeable impact of the meiofauna community and, given the high abundance of crabs; these suggest the crabs play an important role in structuring the benthic community on sandy shores.

## **Lemckert, Charles J**

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### **Ocean and coastal science/engineering education - An international perspective**

With the ever-growing demands and pressures being placed upon our beautiful but fragile marine zones, a need is evident to ensure our communities are well-informed and educated so existing environments can be managed appropriately. It is crucial that these communities comprise a variety of groups, including the general public; local, state and federal government authorities; and representatives from the engineering and science professions. In order to acquire some understanding of the general state of play within the (particularly tertiary) educational community, the Griffith School of Engineering (Griffith University, Gold Coast Campus, Queensland, Australia) hosted the inaugural International Conference on Ocean and Coastal Science/Engineering Education in 2005. The aim of the conference was to bring together interested individuals involved in ocean/coastal science and engineering education, with the aim of improving student learning. The Gold Coast-based conference attracted participants from around the world. Featured topics included communicating (marine) science through literature, innovations arising from modern technologies, and coastal management education at the local community level. The conference highlighted the need to develop a broad range of strategies aimed at specific communities.

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## **Lewis, Melanie, Will Figueira and David Booth**

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Department of Environmental Sciences and Institute for Water and Environmental Resource Management,  
University of Technology, Sydney nsw 2007

### **Putting Bluefish on the map: Diet and demography of *Girella cyanea* at Lord Howe Island, south-west Pacific**

Knowledge of the feeding ecology, life-history, and role in ecosystem of fishes of the family Girellidae is often based on the few studies carried out on related taxa on the other side of the world. The bluefish (*Girella cyanea* Macleay, 1881) is a conspicuous member of the fish fauna of Lord Howe Island and an important angling species for residents and visitors. As a species recently afforded protection within the waters of NSW outside of its Lord Howe distribution, it is important that we understand its population dynamics to provide for future management decisions and sustainable harvest. Current information on the ecology of *G. cyanea* is inferred from more common and widely-distributed girellids, such as the luderick (*G. tricuspidata*), or sourced from parts of studies of the herbivory and phylogeny of related groups, thus sample sizes are small. This study is the first effort to characterise the spatial variation in demographic parameters of bluefish and forms part of a broader investigation into the growth and ontogeny of feeding in the species. This presentation reports on the preliminary results and also reviews the current underwater visual census (UVC) method for collecting population data, profiling an adapted method to make UVC methods more useful for those species whose distribution and habitat associations are largely unknown or are likely to follow a patchy distribution across large areas.

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**A coral proxy record of land use in the Burdekin River catchment since the arrival of Europeans**

A massive *Porites* coral from the inner Great Barrier Reef (Magnetic Island, GBR) preserves a remarkable 175-year geochemical record of land use in the adjacent Burdekin River catchment. In the Magnetic Island coral, trace element compositions recorded in the skeletal annual growth bands can be used to trace terrestrial runoff and land practices after European settlement.

The significant rise in the coral Ba/Ca ratios suggests that there has been an increase in sediment supply to the GBR lagoon since the arrival of Europeans. It is unlikely that this extra sediment will have a direct effect on the coral reefs in the Magnetic Island region as previous studies have demonstrated that sediment from the Burdekin River is deposited in near shore environments.

Coral Mn concentrations provide a remarkable record of land use in the adjacent Burdekin River catchment. The coral Mn record fluctuates in sympathy with the fortunes of the first European sheep farmers in the region; rising dramatically with the introduction of intense sheep grazing after 1854, and collapsing in parallel with livestock numbers during harsher times, such as the 1895-1902 federation drought, before rising again during the intensification of agriculture after WWII.

Elevated Ba/Ca ratios and Mn concentrations recorded in the skeletal annual growth bands following European settlement (c. 1854) highlight the intimate connection between the terrestrial and marine environments.

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<sup>2</sup> Department of Zoology, University of Melbourne, Parkville 3010. hmpatt@unimelb.edu.au; sswearer@unimelb.edu.au

**The utility of a habitat surrogate as predictor of reef fish diversity: a case study of the Lord Howe Island Marine Park, Australia**

Marine reserves are being widely implemented as a tool for fisheries management and biodiversity conservation. Although the siting of marine reserves often includes a surrogate measure of diversity, the precision of these measures is rarely tested. To create the marine park at Lord Howe Island, Australia, the NSW Marine Parks Authority used habitat as a surrogate for community diversity. The aims of this study were to test the precision of habitat in predicting reef fish diversity, and to investigate changes in precision when varying resolutions of baseline habitat data were available. To achieve this, visual counts of reef fish species and microhabitat surveys were conducted at 31 sites around the island. Overall, the fish assemblage was closely related to habitat, with habitat explaining over 46 % of the variation in fish distributions; when spatial autocorrelation was accounted for, this increased to 63 % of the variation. This spatial autocorrelation highlights that at this scale, both habitat and assemblage data combine for greater surrogate precision than habitat alone. Higher resolution of the baseline information used to determine habitat classes improved the ability of those classes to predict reef fish diversity. Differences in diversity were found among habitat classes derived from detailed data, but not among habitat classes defined from coarse data. This study highlights the need for accurate in situ ecological information to establish precise habitat surrogates and complimenting biotic variables to more effectively site marine reserves. Otherwise, reserves may misrepresent fish diversity and be unsuccessful at long-term conservation of marine biodiversity.



**Loisier , Aude and William Gladstone**

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<sup>1</sup> School of Environmental and Life Science, University of Newcastle (Ourimbah Campus), PO Box 127, Ourimbah NSW 2258**Are rapid biodiversity assessments an efficient surrogate for the selection of intertidal protected areas?**

Detailed inventories of marine biodiversity are desirable to select protected areas but are unavailable for most planning because of patchiness in existing data, time constraints in the selection process, and taxonomic uncertainties. We tested the efficacy of a rapid biodiversity assessment (RBA) as a surrogate for detailed biodiversity surveys in selecting intertidal protected areas. The study was carried out at twenty locations from Pearl Beach to Newcastle, NSW Australia. RBAs involved a single two-hour transect at each location, assessing Molluscs occurrence. Detailed surveys of the same shores involved quadrat-based sampling that was stratified by habitat and shore height at two replicate sites within each shore. Species occurrence and density were recorded. Sampling continued in each habitat and shore height until the species accumulation curves flattened. The efficacy of RBAs was evaluated by testing for spatial congruence in species richness, assemblage dissimilarity, and the conservation value of each shore and by comparing the outcomes of a simulated protected area selection process based on the RBA and detailed survey data sets. Spatial patterns in species richness for the RBA and detailed surveys were significantly correlated. However, spatial patterns in assemblage dissimilarity were uncorrelated. Spatial patterns in conservation value of shores (quantified as summed irreplaceability value) were not correlated. The species accumulation curves depicting the incremental gains from adding shores to a simulated protected area network were significantly different, with the network of protected areas selected by the RBAs being less efficient at accumulating species. Although RBAs may be a suitable surrogate for quantifying the relative species richness of rocky shores, their use in selecting protected areas will lead to inefficiencies in species representation. Current research is testing the outcomes from including density estimates in the selection process and the potential value of physical attributes of shores as biodiversity surrogates.

**Loneragan, Neil<sup>1</sup> and Kate Wilson<sup>2</sup>**

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<sup>1</sup> Centre for Fish and Fisheries Research, Division of Science and Engineering, Murdoch University, South St. Murdoch, WA 6150<sup>2</sup> Wealth from Oceans National Research Flagship, CSIRO North Ryde, NSW 2113. kate.wilson@csiro.au**Reef use, biodiversity and socio-economics for integrated management strategy evaluation of Ningaloo**

The Ningaloo Cluster is a major research endeavour to be undertaken by a group of seven research partners as part of the CSIRO Flagships Collaboration Fund.

The Ningaloo Cluster will use multi-disciplinary approaches to provide knowledge and develop models to assess the mutual dependency between the Ningaloo Reef system, human use of the reef and adjacent areas and the influence of zoning regulations on human activities. Research in the cluster will provide high resolution spatial data on the habitats (remote sensing using hyperspectral data), biodiversity (field studies), and reef use (aerial flights, interviews and observations from shore), and information on the economics of tourism (surveys) and reasons for choice of activities in the region (random utility modelling, destination modelling). These data and the models developed will contribute directly to the models for Management Strategy Evaluation being developed in the Wealth from Oceans Flagship and will significantly enhance the information on human activities and socio-economic values in the region. This research will bring together researchers from a wide range of disciplines (e.g. remote sensing, marine ecology, sustainable tourism, socio-economic modelling and management strategy evaluation) from five universities (Murdoch, Curtin, University of Western Australia, Edith Cowan and the Australian National University), one CRC (Sustainable Tourism) and the Australian Institute of Marine Science. Combined with research on management strategy evaluation for the multiple-use of marine ecosystems in the Wealth from Oceans Flagship, it will provide the basis for much more effectively evaluating different management and development scenarios in the region e.g. the potential conflict between growth in ecotourism and the infrastructure to support this growth and the biodiversity values of the reef that are fundamental for the success of the ecotourism industry.

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## **Geochemical tracers and hydrodynamic surface water modelling reveal groundwater contaminant transport in the surface layer of a well-mixed semi-enclosed marine basin**

Maximum primary productivity in highly dynamic coastal zones often does not correspond with times of maximum nutrient load, presenting a problem for coastal managers attempting to predict and manage coastal blooms. In well-mixed oligotrophic systems, seasonal current regimes may control the availability of limiting nutrients to surface water primary producers and may be a key factor in determining surface water quality. The water column of Cockburn Sound, a semi-enclosed basin in Western Australia, is well-mixed from the strong coastal wind conditions that typify the south-west coastline. The overall flushing time of the water column is short (19-23 days) with an even shorter residence time (3-5 days) in the surface layer. Groundwater and river discharge into Cockburn Sound is maximum in late spring and early summer (September - December), however, for decades it has been noted that phytoplankton biomass and primary production peaks during mid-winter. We used a combination of geochemical tracers (radium isotopes) and a 3-dimensional hydrodynamic model (HAMSOM) to investigate the potential seasonal transport pathways of groundwater in the surface waters. Short-lived Radium isotope tracers in the Cockburn Sound surface waters indicated seasonally variable regions of groundwater influence. Hydrodynamic modelling shows that there are seasonally variable surface transport regimes. In spring, early summer and late summer shoreline groundwater discharge is rapidly exported out of the embayment (within approx. 1-3 days) with no lateral transport across the basin. In contrast, winter surface currents laterally transport water from the shoreline region throughout the embayment, and with a greater potential for nutrient recirculation within the system for longer time periods (10+ days). Using geochemical tracers in conjunction with hydrodynamic modelling has indicated that surface water flow regimes key factor in maximum primary productivity, and is an excellent method for qualifying transport pathways of contaminants between the catchment and the coasts.

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## **Molecular characteristics and heritability of growth in the tropical abalone *Haliotis asinina***

The tropical abalone *Haliotis asinina* is distributed throughout the Indo-Pacific region where it is cultured and harvested commercially in many places. The fast maturation rate and predictable, regular spawning during 6 months of the year make *H. asinina* an ideal animal for aquaculture research. As a first step in a selective breeding program, eighty-six families have been produced in a single cohort of half-sibling crosses. These abalone have been used to 1) determine heritability of growth rate and 2) identify genes associated with growth and disease using a microarray analysis and quantitative PCR. Using an animal model, heritability estimates were  $0.48 \pm 0.15$  for shell length,  $0.38 \pm 0.13$  for shell width and  $0.36 \pm 0.13$  for weight. Heritability estimates can be used to gauge the feasibility of a selective breeding program for *H. asinina*, whilst marker genes associated with high growth rates and disease may be used to identify broodstock with desired commercial traits in *H. asinina* and other more lucrative abalone species throughout the world.

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**Connectivity among populations of the olive sea snake: Assessing the differential contributions of male and female mediated gene flow at a range of spatial scales**

The genus *Aipysurus* comprises seven species, six of which are endemic to Australasian waters, thus this genus is an important component of Australia's unique tropical marine biodiversity. The olive sea snake, *Aipysurus laevis*, is the most common aipysurid and occurs on coral reefs from the southern Great Barrier Reef to Shark Bay, Western Australia. Population densities of the olive sea snake are geographically highly variable, with dense aggregations at some reef locations, and few or no snakes at other reef locales that appear to be ecologically similar. I investigated the population genetic structure of *A. laevis* at several spatial scales across its range, which extends from the southern Great Barrier Reef (GBR) to Australia's North West Shelf (NW Shelf) using the mitochondrial DNA ND4 gene and nuclear microsatellites. AMOVA analyses of the ND4 gene sequences (752bp) across 355 individuals revealed that the majority (~70%) of the genetic variation was attributable to differences between regions and 15% was accounted for by differences between aggregations (reefs) within regions. A minimum spanning tree supported this pattern, showing no sharing of haplotypes between three main geographical regions: GBR, Gulf of Carpentaria, and the NW Shelf, indicating extremely limited female mediated gene flow between regions. Within regions however, female mediated gene flow was variable. Nuclear microsatellites will be used to assess levels of male mediated gene flow and compare fine scale (within region) patterns of gene flow.

**Magnusson Marie<sup>1,2,4</sup>, Kirsten Heimann<sup>2</sup>, Andrew Negri<sup>3</sup>, Michael Ridd<sup>4</sup>**

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<sup>1</sup> AIMS@JCU, Australian Institute of Marine Science, School of Marine Biology, James Cook University, Townsville 4810<sup>2</sup> School of Tropical Biology, James Cook University, Townsville 4810 Kirsten.Heimann@jcu.edu.au<sup>3</sup> Australian Institute of Marine Science, Townsville 4810 a.negri@aims.gov.au<sup>4</sup> School of Pharmacy and Molecular Sciences, James Cook University, Townsville 4810, Michael.Ridd@jcu.edu.au**Pesticide toxicity to estuarine benthic microflora in tropical Queensland**

Estuarine sediments often contain higher concentrations of contaminants than the overlying water. The benthic micro-flora plays an important role in coastal primary productivity but has been largely overlooked in environmental studies in the Queensland region. To fill this gap, several species of estuarine benthic diatoms have been isolated from North Queensland creeks in the Townsville and Hinchinbrook Island regions in order to experimentally investigate pesticide toxicity to the local microphytobenthos. A 96-well plate assay measuring inhibition of photosynthetic yield using a maxi-imaging PAM was utilized in short term dose-response experiments. Pesticides included the herbicides diuron, atrazine, simazine and imazapic, the breakdown products 3,4-dichloroaniline (3,4-DCA) and desethyl-atrazine (DEA) and two insecticides (profenofos and imidacloprid). Initial results indicate a six minute  $IC_{50}$  of  $12 \pm 0.4$  nM ( $2.9 \pm 0.09$  µg/L) for diuron, making it 20 to 50 fold more toxic to *Navicula* sp, than the other pesticides tested ( $220 \pm 6.8$  nM ( $47 \pm 1.5$  µg/L) for atrazine and  $570 \pm 23$  nM ( $110 \pm 4.7$  µg/L) for simazine). Imazapic inhibits protein synthesis, and as expected had no effect on photosynthesis during this short exposure. The insecticides and 3,4-DCA also had no effect on photosynthesis. DEA did inhibit photosynthesis, however the maximum inhibition reached was only 50% at  $5.5$  µM ( $1.0$  mg/L). Toxicity of chemical mixtures will be investigated as a part of this study, and within and between phylum sensitivity comparisons are under way.

**Margvelashvili, Nugzar<sup>1</sup>, Mike Herzfeld<sup>1</sup>, Barbara Robson<sup>2</sup> and Ian Webster<sup>2</sup>**

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<sup>2</sup> CSIRO Land & Water, Canberra 2601barbara.robson@csiro.au

## **Modelling the transport of fine sediment in the Fitzroy Estuary and Keppel Bay**

The role of coastal areas in mediating material fluxes from catchments to the ocean is still poorly understood. The Fitzroy catchment is the largest in Queensland (144,000 km<sup>2</sup>) and delivers to the Fitzroy Estuary and Keppel Bay significant amount of sediments with high levels of nutrients. To assess sediment loads to the ocean under varying river flow regimes and sediment loads from catchments, 3-dimensional fine-resolution hydrodynamic and sediment transport models have been developed and applied to the coupled Fitzroy Estuary and Keppel Bay system. While the sediment model does not predict every individual measurement, it is capable of reproducing general trends of sediment distribution and the typical range of observed sediment concentrations. Simulation scenarios involved modelling of the sediment transport under low, moderate, and high river flow regimes with sediment loads from catchments also altered by varying land use practices. During moderate and high flow years, the model predicts that sediments accumulating in the estuary and Keppel Bay develop a sedimentary pool that is sufficient for maintaining elevated export of fine sediments to the ocean throughout the year. Increasing freshwater flows from moderate (peak discharge of 700 m<sup>3</sup>/s) to high (peak discharge of 4000 m<sup>3</sup>/s), increases fine-sediment delivery to the ocean from 163 to 1143 kT/year. Varying sediment loads from catchments during years having low or moderate flood events has a less pronounced impact on the annual loads to the ocean as the sediment loads are maintained by the background fluxes associated with past deposits. The model suggests that significant changes in sediment delivery from the Fitzroy Estuary and Keppel Bay to the ocean, due to altered land use practices, can be expected to occur during the years having high flood events, when fresh sediments from catchments dominate net annual loads to the ocean.

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**Marshall, Dustin<sup>1</sup>, Emma Johnston<sup>2</sup>, Cam Hollows<sup>2</sup>**

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## **Effect of a common pollutant on the reproductive success of a free-spawner in the field**

The reproductive success of marine broadcast spawners depends on the concentration of sperm which surrounds eggs. Because sperm quickly dilute in the ocean, spawners must be sufficiently close to one another to ensure high rates of fertilization. Thus broadcast spawners experience strong Allee effects - increasing densities can result in higher reproductive success because the benefits of high mating success outweigh the costs of increased intraspecific competition. Recently there has been a dramatic increase in the number of studies examining the effects of toxicants on fertilization success. Initial indications suggest that fertilization is a highly sensitive stage and exposure to pollutants could severely reduce reproductive success. However, we remain limited in our ability to predict the effects of toxicants under field conditions because most ecotoxicological studies utilize only a single sperm concentration and are conducted in the laboratory. We examined the effects of a common pollutant, copper, on the fertilization success of the intertidal polychaete *Galeolaria caespitosa* in the laboratory and the field. In the laboratory, we examined the effects of copper over a range of sperm concentrations and in the field, we developed a new apparatus for examining fertilization success in intertidal organisms. Our laboratory results suggest that the use of single sperm concentrations in ecotoxicological assays of fertilization is inappropriate because the magnitude of the effect of the toxicant can be estimated

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**Waves and wind: Parallel abiotic influences on autotrophs and their consumers?**

Classic abiotic factors that cause phenotypic changes to plants in terrestrial systems are nutrients and shade. These factors often alter plant chemistry and, as a result, the palatability of plants to their consumers, both invertebrate and mammalian herbivores. These patterns of change underpin the carbon-nutrient balance hypothesis and others, which attempt to explain variation in secondary compounds in plants growing in different environments. A parallel can be drawn between terrestrial plants and aquatic autotrophs, such as macroalgae, in terms of the ways in which they are affected by abiotic factors. Details may differ due to differences in pathways of supply, for nutrients for example, but the principles are the same.

One abiotic factor, likely to have large effects on autotrophs and hence their consumers, is the invisible, yet powerful energy of air or water in the form of wind or waves. Interestingly, the influence of this environmental energy is almost completely neglected in studies of “plant-herbivore” interactions, except at the grand scale of catastrophic events which wipe out biotic communities. We examine and compare the potential influence that waves and wind may have on autotrophs, at the level of structural and chemical changes to photosynthetic material (fronds, leaves). We then consider the implications of these changes in modifying interactions between individual autotrophs and their consumers, and ultimately, in shaping communities in both aquatic and terrestrial ecosystems.

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**Project BLUElink – Ocean forecasting Australia**

Australian researchers are close to completing a major study to provide ocean forecasts for coastal and marine industries, and which could generate a long-term ocean-based climate monitoring system for primary producers. Advances in technologies necessary to observe and simulate the oceans around Australia have provided scientists at CSIRO and the Bureau of Meteorology with the tools to provide near real-time information on ocean behaviour.

“At the end of the day, we want to generate ocean charts for marine users similar to weather forecast charts available to the rest of the community,” said principal investigator, Dr Andreas Schiller.

Unlike the atmosphere, the ocean changes at a much slower rate and a rule of thumb is that a day in the atmosphere is equivalent to a week in the ocean. The BLUElink initiative centres on ocean prediction and analysis, and forecasting of day-to-day variations in ocean currents, ocean eddies and temperatures.

Project BlueLink is a successful example of collaborative implementation of scientific research between the Directorate of Oceanography and Meteorology, RAN, CSIRO and Bureau of Meteorology. The project is on track for delivery of an operational ocean modelling capability by end 2006 with access to model output being available to users from 2007.

For more information visit [www.marine.csiro.au/bluelink/index.htm](http://www.marine.csiro.au/bluelink/index.htm).

**McCulloch, Malcolm T<sup>1</sup>**

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<sup>1</sup> Research School of Earth Sciences, The Australian National University, Canberra, ACT, 0200**Coral record of human impacts on land-sea interactions in the inner Great Barrier Reef**

As a direct consequence of pastoral grazing, cultivation, mining and land clearing activities that accompanied European settlement, catchments of the Great Barrier Reef (GBR) are delivering enhanced sediment and nutrient loads into the GBR. To better understand and constrain both the present-day as well as longer-term impacts of these changes on coral reef ecosystems, we describe here an approach based on geochemical tracers preserved in long-lived (300-400 year old) aragonite skeletons of *Porites* corals. This approach has the advantage of not only giving a direct quantitative measure of changes in water quality actually occurring at coral reef sites, but also providing a natural baseline against which the magnitude of anthropogenic changes can be assessed. It is shown that from the 1870's onwards, there has been a five- to tenfold increase in the sediment load delivered by the Burdekin River, the largest source of sediment to the GBR. There is a close correlation between high cattle numbers, especially during the mid-late 1970's, followed by increased sediment fluxes into the GBR. This situation is exacerbated during drought-breaking floods with the largest sediment-load being recorded in the 1981 flood following a prolonged drought. River water discharge volumes have been estimated from salinity changes at the reef, quantified using a combination of oxygen isotope and Sr/Ca tracers. It is likely that freshwater runoff into the inner GBR increased significantly following European settlement, a consequence of reduced vegetation cover, compacted soils, and hence reduced water infiltration rates. A clear link between European land use changes and greatly enhanced sediment, nutrient and freshwater inputs to the GBR is demonstrated, although the ecological impact of these changes requires ongoing study and monitoring. Nevertheless this work reinforces the need for vigilance and sustained long-term remedial actions if major deleterious consequences in the GBR are to be avoided.

**McKenzie LJ<sup>1,2</sup>, Mellors JE<sup>3</sup>, Yoshida RL<sup>1,2</sup>, Coles RG<sup>1</sup>**

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<sup>1</sup> Department of Primary Industries & Fisheries, NFC, PO 5396 Cairns Qld 4870 [hq@seagrasswatch.org](mailto:hq@seagrasswatch.org); [rob.coles@dpi.qld.gov.au](mailto:rob.coles@dpi.qld.gov.au)<sup>2</sup> CRC Reef Research Centre, PO Box 772, Townsville Qld 4810<sup>3</sup> Department of Primary Industries & Fisheries. PO Box 1085 Townsville Qld 4810. [jane.mellors@dpi.qld.gov.au](mailto:jane.mellors@dpi.qld.gov.au)**Seagrass-Watch: A non-destructive, seagrass assessment and monitoring program - 1998-2006**

Seagrass-Watch is the largest scientific, non-destructive, seagrass assessment and monitoring program in the world. Now in its eight year of operation, Seagrass-Watch provides a reliable early warning system on the condition of near-shore seagrasses throughout Queensland, Australia. Seagrass-Watch is active in 13 countries and territories throughout the Indo- and western Pacific and has evolved into an international environmental program.

Monitoring is conducted by over 500 people at approximately 165 sites throughout Queensland and the western Pacific. The Seagrass-Watch network brings together diverse groups from all sectors to work together towards a common goal of seagrass conservation. Seagrass-Watch has raised public awareness about seagrasses and their threats.

Seagrass-Watch has provided information about the health of seagrass ecosystems for local management agencies. The program has shown clear seasonal patterns in abundance across the Pacific, detected loss and subsequent recovery of seagrasses in relation to climatic events including flooding, has provided an early alert to detrimental effects from poorly managed coastal developments, and used to track the possible consequences of global climate change. The findings from the program have also contributed information for World Heritage Area listing assessments, regional and local Plans of Management, and have recently been adopted by the LMMA network and the GBRMPA as accepted protocols for monitoring seagrass and water quality condition. Through responsive management, based on adequate information, it is hoped that many anthropogenic impacts on seagrass meadows which are continuing to destroy or degrade these coastal ecosystems and decrease their yield of natural resources can be avoided.

This presentation will provide some background to the program and present examples of information collected and the management responses.

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**Is the Gulf of Papua heterotrophic?**

The metabolic balance between production and respiration in plankton communities of the Gulf of Papua was investigated in May 2004. Water samples taken at 19 stations were allocated to groups on the basis of physico-chemical characteristics. Oxygen consumption and production in flasks incubated in the dark and in the light was determined by micro-Winkler titration. Dark bottle respiration in samples influenced by the estuarine plume averaged  $3.09 \pm 1.92$  (SD)  $\text{mmol O}_2 \text{ m}^{-3} \text{ d}^{-1}$  and production within surface light bottles averaged  $7.63 \pm 3.36$  (SD)  $\text{mmol O}_2 \text{ m}^{-3} \text{ d}^{-1}$ . Corresponding values in stations more typical of the central Gulf of Papua were  $1.68 \pm 1.30$  (SD)  $\text{mmol O}_2 \text{ m}^{-3} \text{ d}^{-1}$  and  $1.08 \pm 2.25$  (SD)  $\text{mmol O}_2 \text{ m}^{-3} \text{ d}^{-1}$ . Despite a shallow (<10 m) euphotic zone within the plume stations, phytoplankton production in the surface layers was sufficiently high to subsidise total water column respiration. Integrating production and respiration over the water column resulted in a calculation of net community production (NCP) of  $626 \pm 504$  (SD)  $\text{mg C m}^{-2} \text{ d}^{-1}$ , and community respiration (CR) of  $712 \pm 492$   $\text{mg C m}^{-2} \text{ d}^{-1}$  at the plume stations, with an average P:R ratio of 1.97. In the offshore group NCP was  $157 \pm 450$  (SD)  $\text{mg C m}^{-2} \text{ d}^{-1}$  and CR was  $1620 \pm 1576$   $\text{mg C m}^{-2} \text{ d}^{-1}$ . The average P:R ratio was 1.27. Three of the 7 stations allocated to the offshore group were net heterotrophic. In contrast to earlier studies in the area, these data indicate the Gulf is in positive metabolic balance by only  $-70 \text{ mg C m}^{-2} \text{ d}^{-1}$ . I conclude that waters of the Gulf of Papua under riverine influence are net autotrophic, but that within the central Gulf there is a fine metabolic balance alternating between autotrophy and heterotrophy.

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**Tropical seacage aquaculture - Under threat from the environment?**

There are presently only two commercial seacage operations in tropical Australia, both producing barramundi. The Marine Harvest farm at Bathurst Island in the Northern Territory has been in place since 1999, but the scale of this operation has recently been greatly reduced because of the extreme environment at the Port Hurd site, where the tidal range is ~8m and currents can exceed 2.5 knots. The farm is currently applying for licences to relocate to 3 other sites, but is encountering significant community resistance. The Bluewater Barramundi farm is located in a creek off the Hinchinbrook Channel in North Queensland. This farm has been in place since the early 90's and is an anomaly within the Great Barrier Reef World Heritage Area- regulators are currently reviewing the potential environmental impact of this facility. In this presentation I will review the environmental impacts of both operations - real and perceived - and place these in context of major ecosystem processes.

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<sup>1-3</sup> Faculty of Science, Health and Education, University of the Sunshine Coast Qld 4558<sup>2</sup> tschlach@usc.edu.au, <sup>3</sup> LThomps2@usc.edu.au**Off-road vehicles reduce fauna on sandy beaches**

Sandy beaches dominate much of the Australian coastline. Sandy beaches frequently underpin many coastal economies and developments, and they are the prime sites for human recreation. In many parts of Queensland, including National Parks, such recreational activities rely on the use of off-road-vehicles (ORVs) driven on beaches. Yet, the use of ORVs is not universally embraced due to social conflicts with other beach user groups and negative environmental consequences of beach traffic.

Ecological impacts of ORVs are known for beach vertebrates (e.g. birds) and dunes, but not for endobenthic invertebrates of the intertidal zone seawards of the dunes. Thus, we quantified the degree to which assemblages of intertidal beach invertebrates are influenced by beach ORVs. The basic study design comprised a series of spatial contrasts between two reference beaches (no ORVs) and two beaches with heavy ORV traffic (up to 500 vehicles per day) located south and north of Noosa in SE-Queensland. Macrofaunal assemblages on ORV-impacted beaches have significantly fewer species at substantially reduced densities, leading to marked shifts in community composition and structure. These shifts are particularly strong on the middle- and upper shore where traffic is concentrated. Effect sizes also increase towards the summer months as a result of heavier traffic volumes. Our findings show that ORVs can have substantial effects on sandy beach invertebrates that are manifested throughout whole communities. Demonstrating such a strong ecological impact caused by a single type of human use poses a formidable challenge to management, which needs to develop multi-faceted approaches to balance environmental-, social-, cultural-, and economic arguments in the use of sandy beaches in Australia.

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**Resilience of seagrass systems to dredging: Perspectives from temperate and tropical regions**

Seagrass meadows provide valuable ecosystem services, including fisheries habitat. A raft of port expansions proposed throughout Australia to enable mineral and agricultural export pose a significant threat to seagrass ecosystems, through increased turbidity associated with dredging. This talk will discuss resilience of seagrass systems to dredging based on an on-going experiment in temperate Western Australia and from previous seagrass recovery-dynamics studies in Queensland. The West Australian project has examined the response and subsequent recovery of an *Amphibolis griffithii* seagrass community to light reduction, where the light reduction scenarios mimic what would be expected in dredging operations. Three light reduction parameters, timing, duration and intensity were investigated through a manipulative experiment in the temperate mid-west region of Western Australia. Seagrass, algal epiphytes and the flow-on effect to macroinvertebrate fauna were investigated.

Significant reductions in seagrass and algal biomass and macroinvertebrate abundance were observed following three, six and nine months of light reduction. After nine months no leaves remained, only stems were present. Recovery in the plots shaded for three months, defined as return to control conditions for seagrass biomass, occurred ten months after shading was removed. No recovery to seagrass biomass was observed in plots shaded for six and nine months, up to ten months after shading was removed. The implications of these findings on temperate, stable meadows of *Amphibolis griffithii* will be discussed and compared to tropical, dynamic seagrass meadows of *Halophila*, *Halodule* and *Zostera*. Resilience to different durations and intensities of dredging operations will be discussed.



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## **Intertidal seagrass monitoring – A component of the RWQPP monitoring programme**

A key component of the Reef Water Quality Protection Plan is the implementation of a long-term water quality and ecosystem monitoring program in the Great Barrier Reef lagoon. Intertidal Seagrass meadows are only one, of many habitats that are being monitored for the effects of changing water quality. The key aims of this project were to:

- a. Detect long-term trends in seagrass abundance, community structure, distribution, reproductive health and nutrient status from representative intertidal seagrass meadows in relation to large river inputs into the GBRWHA.
- b. Detect long-term trends in levels of ecologically significant herbicides and nutrient pollutants from representative intertidal seagrass meadows in relation to large river inputs into the GBRWHA.
- c. To work closely with and involve community partners (Seagrass-Watch) to ensure broad acceptance and ownership of the RWQPP by the Queensland and Australian community.

Eleven seagrass meadows within nine of the GBR catchments from Cooktown to Hervey Bay are currently being monitored. This presentation will discuss the preliminary findings.

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## **Coastal lakes in NSW – A sustainable future**

The ecological health of many NSW coastal lakes and waterways is at serious risk as a result of increasing pressure from human activities particularly urban development, land use intensification and changes to natural lake opening regimes. In 2002 the Healthy Rivers Commission of NSW released an Independent Public Inquiry into Coastal Lakes. The subsequent NSW Government Statement of Intent outlined Stage 1 of the *Coastal Lakes Strategy*. Stage 1 requires the preparation of sustainability assessment and management strategies for a group of priority lakes.

As part of the NSW Comprehensive Coastal Assessment, the Department of Natural Resources and the Australian National University developed Coastal Lake Assessment and Management (CLAM) decisions support tools to underpin the sustainability assessment and management strategy process.

The tool allows a range of management scenarios to be modelled and can incorporate a wide range of social, economic and environmental parameters to assist decision makers assess the impacts of various decisions. The tool has potential to be developed further and can be applied to coastal river systems and other environments.

Although the management strategies have not been completed the methodology has been favourably received and is being adopted more widely throughout NSW and will become part of the NSW Estuary Management process. This paper will discuss the methodology for carrying out sustainability assessments and developing management strategies, their broader application and current status of the project.

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## **Progress in coral genomics – Ancestral complexity and maintenance of “non-metazoan” genes**

One unexpected outcome of preliminary analyses of EST and genomic data for the cnidarians *Acropora*, *Nematostella* and *Hydra* has been the discovery that a substantial number of genes assumed to have evolved in the context of vertebrate complexity are actually much older. One corollary of this is that extensive gene loss has occurred in the model invertebrates *Drosophila* and *Caenorhabditis*, and that losses as well as gains have occurred in the vertebrate lineage. In fact, despite their morphological simplicity, corals and their relatives have surprisingly large numbers of genes relative to animals which are morphologically more complex, including most of the key families of transcription factors and cell signalling pathways, both of which appear to have been substantially elaborated prior to the divergence between the Cnidaria and Bilateria. A second surprising discovery is that a significant number of cnidarian genes have no known counterpart in other animals despite matching strongly with genes known from other kingdoms. At least some of these are likely to be ancestral, rather than having been acquired by relatively recent lateral gene transfer. The nature of these “non-metazoan” genes implies that cnidarians may use signalling pathways not previously known in metazoans, and have previously unsuspected metabolic capabilities. In addition, their presence has major applied implications - for example, coral thermal tolerances cannot be predicted based on known stress responses in “higher” animals.

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## **Good estuary, bad estuary: Determining the health of small intermittently-closed estuaries**

Information on the functioning of small intermittently-closed estuaries is scarce and the conditions that constitute a “normal, healthy” ecology remain largely unknown for these smaller estuarine systems. Small estuaries and coastal creeks have often been ignored but together represent an important habitat for many species, an important functional unit of the coastal zone, and a significant recreational resource across southern Australia. Six unique types of small estuary occur in the Otway Ranges (Mondon et al. 2003). They are subject to increasing pressures from urban and recreational development, and yet little is known about their biogeochemical cycles and their biota. Management of these estuaries and their catchments requires determination of the water body’s health status. Without knowing what conditions constitute a “healthy” status for these types of estuaries, management policies are based on guesswork. The concept of estuary health is linked to catchment condition where poor catchment condition implies poor estuary condition. The measure of “health” for estuary waters has been based largely on water quality parameters set by the ANZECC Water Quality Guidelines. However determining the health and impact on an estuary and its catchment is difficult when non-impacted catchments can exhibit characteristics typical of ‘highly impacted’ estuaries. For example several of the Otway Ranges estuaries exhibit pristine or near pristine catchments, yet their water quality can be very ‘poor’. The estuarine processes within Otway Ranges estuaries are as yet not fully understood. This presents a significant problem if the cause of apparently “poor health” characteristics cannot be determined. Are they due to anthropogenic impact or are they just the “normal, healthy” characteristics generated from natural processes?

**Morgan, Raphael<sup>1</sup> and Michel Jangoux<sup>2</sup>**

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<sup>1</sup> Marine Ecology Group, Department of Biological Sciences, Macquarie University, NSW 2109<sup>2</sup> Marine Biology Laboratory, Universite Libre de Bruxelles, Belgium 1050. mjangoux@ulb.ac.be**The terminal podia in brittle stars and their role in chemoreception**

Brittle stars possess a variety of podia either found on the oral side of the disk (i.e. buccal podia) or along the arms (i.e. paired podia, terminal podia). They are generally used by the brittle stars to capture food particles but are also considered to play a role in chemoreception. In the present study we focused on the terminal podia which are found at the tip of each arm. Using juveniles of the gregarious species *Ophiothrix fragilis*, a series of Y tube experiments were made in order to test if their aggregative behaviour was altered in any way when the terminal podia were removed. The terminal podia of various brittle stars were also observed using scanning electron microscopy and their morphology described and compared. In *O. fragilis*, juveniles were attracted to conspecifics and a true gregarious behaviour was observed. The tip of each arm, the terminal podia, seems to play a major role in distance chemoattraction with juveniles needing at least one intact to be able to initiate a response. Electron microscope observations of the terminal podia permitted us to recognize two different potential receptor structures recognised as stäbchens. The first possesses one long projecting cilia and is mostly present around the base of the terminal podia while the other has one to five short projecting cilia and is mostly found on the tip. No receptors are found on the shaft. Receptors are not associated to secretory structures.

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**The effects of nutrient additions on intertidal seagrass habitat in Western Port, Victoria**

Loss of seagrass habitat in many parts of the world has been attributed to increases in nutrient loading to nearshore areas. The role of excess epiphyte, macroalgal or phytoplankton growth in shading of seagrass leaves and negatively affecting seagrass health is generally agreed to be a prevalent mechanism in seagrass decline worldwide. In this study we have undertaken nutrient addition experiments at three sites in Western Port, Victoria. Nutrients were added to the water column using the controlled release fertiliser Osmocote™ in late summer 2005. The experiments ran for one month at two of the sites (Blind Bight and Hastings) and at the third site (Crib Point) the experiment ran for three months. Control and nutrient addition plots were monitored for concentrations of inorganic nutrients, number of seagrass leaves, seagrass, epiphyte and loose algal biomass and invertebrate faunal assemblages. Nutrient additions had increased ash free dry weight of seagrass leaves and loose algae at two of the three sites studied. There were few effects of nutrient additions on macrofaunal densities, but there were increases in isopod numbers in the nutrient addition plots relative to control plots at the Blind Bight site and increases in the numbers of amphipods in nutrient addition plots after three months at Crib Point. We consider that Western Port seagrass habitat is sensitive to increased loads of nutrients within the water column. The Blind Bight region is considered to be most at risk to increases in water column nutrient loads. It was not possible to determine realistic threshold loads from these small-scale experiments in Western Port, however it should be possible to repeat these experiments in a low flow environment and apply threshold loadings determined from these experiments to Western Port

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## **The application of science in managing Great Barrier Reef catchments**

The Great Barrier Reef (GBR) and the adjacent catchment area is a complex social and ecological system with a diverse array of interactions among social and ecological elements. Extensive understanding of the ecosystem, as well as the social systems associated with these, and cooperation between science and management is critical to managing the potential threats on these resources and the human livelihood systems linked to them. An example of a threat that crosses that catchment to reef continuum is the management of water quality in the GBR. A host of interest groups and structures vie to influence the management of this World Heritage Area; from local users and industries through to national political structures and international conservation groups. On the receiving end of these influences is the health of the ecosystems and the well being of humans living in the catchments associated with the GBR. Effective management of a highly complex system like the GBR is exceedingly difficult. It demands careful management of knowledge and establishment of appropriate knowledge management systems to ensure the best available science is brought to focus on key problems or opportunities. Single issue approaches (single factor explanations) to solving problems in complex systems has almost always failed to deliver satisfactory results.

In this presentation we start by describing a simple conceptual framework to guide our discussion of key elements of the interface between science and management in complex social and ecological systems such as the GBR. We then go on to highlight the specific difficulties, challenges and opportunities that management of such social and ecological complexity across multiple scales presents.

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## **Australia's input into the international Ocean Biogeographic Information System (OBIS)**

Australia has been formally involved in the international Ocean Biogeographic Information System or OBIS for the past 12 months. Australia participates in this network through the combined effort of the Department of the Environment and Heritage - National Oceans Office and CSIRO Marine and Atmospheric Research. The aim of OBIS is to make data about marine species available on the internet to any interested parties. The Australian Node of OBIS was formally launched in December 2005 in Hobart. Since its launch, OBIS Australia has increased the amount of marine spatial data that is available to the OBIS network. Access to marine spatial information, particularly marine species data, is often very difficult to find, especially if you are new to the domain area for research. It is difficult for government to know who has what kind of information, and about what particular species. OBIS provides a mechanism for anyone to be able to find data about marine species, and get access to this information. This paper aims to provide you with an update on the achievements of OBIS Australia, invite you to participate in the OBIS network, and demonstrate to you the value of accessing and using this information.



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### **Increasing equitable access and benefits from natural resources for communities in Uganda**

Securing equitable access to, and gaining benefits from, natural resources is essential for poverty reduction and in turn leads to sustainable use of resources. Within fisheries whilst access must be controlled for sustainable management, systems can also support poverty reduction and gender equity objectives in order to sustain the increasing populations. On lake George Integrated Lake Management [ILM] supported the development and implementation of a new decentralized and participatory approach to issuing fishing boat licenses thus increasing access to poor and women. This paper will first discuss the Integrated Lake Management [ILM], the approach which brings together government and communities to plan and manage lake resources through an integrated and Co-management approach. ILM worked with local and national governments and fishing communities on two lakes in Uganda; Lake George [260km Sq] in the southwest and Lake Kyoga [2,800km Sq] in the centre of the country. ILM also provided support to the five fishing communities on Lake Edward as this lake is connected to Lake George by the Kazinga channel though is shared between Uganda and Democratic Republic of Cong. The paper puts much focus involving the poor and women in the management of natural resources and eradication of poverty through secure access to natural resources. Legal rights of access to natural resources are essential to the poor for improving livelihoods and increasing livelihood security. Within fisheries, access rights can be established through licensing systems, issuing fishing boat licenses is a source of revenue for local governments, and when the number of licenses is limited, licensing system provides a management tool for controlling the level of fishing efforts. There four key points, namely;

- Securing access to natural resources for natural resource management and poverty reduction.
- Decentralized, participatory licensing increase, transparency and accountability.
- Allocation of boats licenses for marginalized groups.
- Access agreements for other natural resources management

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### **From conversion to conservation: Fifteen years of managing wetlands and the environment in tropics of Uganda**

From 8<sup>th</sup>-15<sup>th</sup> November 2005, Uganda hosted the 9<sup>th</sup> Conference of Contracting Parties (COP9) to Ramsar Convention on Wetlands, in Kampala the capital city. This is considered a rare opportunity since Uganda happens to be the first among the developing Countries and on the African continent to host this conference. The selection for Uganda to host COP9 Ramsar conference was dependant on among others the tremendous and visible achievements Uganda has registered in a period of fifteen years since it ratified the Ramsar Convention in 1988, building on its commitment to the outcomes of the Stockholm Conference in 1972.

13% of Uganda's 241,000km<sup>2</sup> total surface area is covered by wetlands, which are widespread and complex. In the south and west, they form an extensive low gradient drainage system in steep V-shaped valley bottoms with a permanent wetland core and relatively narrow seasonal wetland edges. In the north, they mainly consist of broad floodplains. In the east they exist as a network of small, vegetated valley bottoms in a slightly undulating landscape.

In the 1980s, pressure on wetlands mounted in both rural and urban areas. In urban areas particularly Kampala the capital city, wetlands were the last free or cheap areas for infrastructure development. Many wetlands were converted to industrial or agricultural uses and others gradually taken over by semi-slum residential housing and associated uses such as cultivation, waste disposal and informal commerce.

In 1986, the establishment of Uganda's Ministry of Environment Protection, proposed a ban on wetlands drainage and conversion, based on several reports of UNEP and IUCN about the decline in wetlands and their functions. The Government followed the ministry's advice until a policy on sustainable use of wetlands could be developed.

In 1988, the Government of Uganda ratified the convention on wetlands (Ramsar) as commitment to promote sustainable management of wetlands. A year later, with technical assistance from IUCN, the first phase of the National Wetlands Programme started purposely to develop a national wetlands policy to guide the wise use of wetlands resources in the country. In subsequent years, it became clear that a much wider, multiprolonged approach was required to achieve the goal of sustaining Uganda's Wetland resources. This paper will show that, even though wetlands still remain threatened, much progress has been made in Uganda towards sustainable / wise use of wetlands. The paper will also reveal the advances of the National Wetlands Programme over the past fifteen years, when subsequently describe and examine in detail the development of the knowledge base, the formulation and implementation of policy and development of institutions, community-based / involvement approaches to wetlands management and some of the operational aspects needed to make all this happen.

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## **Differing key nutrient processes of estuaries in south-western Australia**

In March this year, Geoscience Australia measured the benthic flux and porewater concentrations of key parameters (DO, CO<sub>2</sub>, NH<sub>4</sub>, NO<sub>x</sub>, N<sub>2</sub>, PO<sub>4</sub>, SiO<sub>4</sub>) in order to identify the major processes influencing water quality in three estuaries (Wellstead Estuary, Gordon Inlet, and Beaufort Inlet), located between Albany and Esperance, south-western Australia. Results revealed that major influencing processes differed between different estuarine habitats as well as surprisingly, between each estuary, despite their similar geomorphology (all are ICOLLs<sup>1</sup>, and classified as *wave-dominated* by the NLWRA<sup>2</sup>) and catchment characteristics. The three estuaries all have a broad shallow basin (1-2m deep) fed by an incised, narrow channel (up to 10m deep). Generally, processes differed between channel and basin environments, for example, higher NH<sub>4</sub> release from basin sediments, compared to channel sediments in Beaufort Inlet, and high rates of N fixation in basin sediments, compared to channel sediments in Wellstead Estuary. However, these same environments differed for different estuaries. For example, we measured large PO<sub>4</sub> release from sediments in Beaufort Inlet, whereas Gordon Inlet sediments appear to trap PO<sub>4</sub>. In fact, N:P ratios differed markedly between all three estuaries with N:P ranging from high to low in Wellstead, Gordon, and Beaufort respectively. Therefore, although these estuaries appear similar, they differ significantly in their nutrient dynamics and thus would require different water quality management strategies.

<sup>1</sup> ICOLL: intermittently closed/open lake/lagoon. These estuaries have a sand bar on their seaward side which is intermittently breached after heavy rain forming a connection with the ocean. For much of the time, wave-action maintains the sand bar, stopping tidal exchange with the ocean.

<sup>2</sup> National Land and Water Resources Audit (NLWRA) geomorphic estuary classification. <http://www.nlwra.gov.au>

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**The classification of New South Wales estuaries for water planning**

The New South Wales government is in the final stages of implementing its water reform process. The reforms require plans to be written that provide a means of sharing water between the environment and water users. Extraction of freshwater from rivers and tidal pools for domestic, agricultural and industrial uses reduces fluvial inputs into estuaries. Altering estuarine hydrodynamics may result in changes to physical, chemical and biological processes, reducing ecosystem health.

Estuaries were classified using a range of physical, environmental and economic parameters to assist with the establishment of water rules that balance environmental and social needs. For each estuary in New South Wales, four factors were considered: the hydrologic stress of the catchment; the sensitivity of the estuary to change when freshwater inflows are reduced; intrinsic instream value, including ecological, non-extractive and place values; and the economic dependence of communities living in the catchment on water extraction. This was a broad-scale approach that provided a relative assessment of where water rules should provide environmental protection, equity between water-users or a balance between the environment and extraction.

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**Impacts of spearfishing on the marine environment**

On the basis of anecdotal information (as little other information is available) I argue that recreational diving (in particular spearfishing) has had devastating effects on the fish and crayfish (southern rock lobster) populations of accessible shallow reef environments along much of the Australian coastline. The paper reviews the global scientific literature on the subject, providing a backdrop against which local anecdotal information may be judged. Overfishing of shallow reefs appears to have taken place where reefs are within ready access (by car or boat) from population centres of all sizes. Damage to shallow reef environments along Australia's sparsely populated coastline seems likely to be concentrated at the more accessible or attractive sites. These impacts are significant in a national context, yet appear to have been ignored or under-estimated by both spearfishers and the government agencies charged with conserving and regulating marine environments. This relaxed managerial approach runs counter to the voluntary *FAO Code of Conduct for Responsible Fisheries*, which Australian governments claim to support. Current government management of the sport of spearfishing fails internationally accepted precautionary benchmarks in all Australian States. Further controls over spearfishing by State Governments are recommended, covering nine specific issues.

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### **Strengths and weaknesses of the european community's policies for the protection of marine biodiversity**

Broadly speaking, European marine environments, like the oceans of the world, face five major threats:

- overfishing with attendant bycatch problems, from commercial fishing, recreational fishing, and from illegal, unregulated and unreported fishing (IUU);
- habitat damage caused by fishing gear, especially bottom trawling, and by the destruction of estuaries, coral reef communities, and coastal wetlands such as mangroves;
- global changes brought about by increasing levels of atmospheric and oceanic carbon dioxide;
- pollution, particularly from human activities in coastal areas; and
- the effects of alien organisms, especially those transported by ballast water and hull fouling.

Programs to protect marine biodiversity must address these threats.

Recent policy initiatives are examined and discussed, set against background provided by a brief history of EU marine policy development. An examination of EU policies and programs relating to the protection of marine biodiversity reveals that all of the major threats to marine biodiversity are addressed, at least on paper. Unfortunately however, the EU has been slow to implement the rhetoric of conservation, and most policy instruments are confined to high levels of generality. The result has been that many operational programs appear to be inadequately funded, or strangled by bureaucratic inertia or political wrangling. Actual activity to protect marine biodiversity by the Community and its Member States, to date, has been too little too late

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## **Newton, Gina M**

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### **Climate Change and Australia's Coast**

Scientific evidence is now overwhelming that anthropogenic climate change is occurring. This is likely to result in changes to climate drivers such as increases in sea surface temperature, changes in rainfall patterns and an increased frequency or intensity of extreme events such as storm surges and cyclones. It has also recently been found that sea level rise around Australia is accelerating compared to earlier estimates. Increased acidification of ocean waters is another impact of increased atmospheric greenhouse gases that is only beginning to be understood. Australia's coastal environs are particularly vulnerable to the combined likely impacts of climate change - which may affect ecological systems and natural resources, in addition to socio-economic aspects such as infrastructure, fisheries and tourism. The Australian Greenhouse Office, as part of its National Climate Change Adaptation programme, is leading a collaborative national approach to assessing Australia's coastal vulnerability to climate change. Technical and methodological components of this work will be discussed. Further information on climate change is available at [www.greenhouse.gov.au](http://www.greenhouse.gov.au).

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## Modern sediment accumulation in the Gulf of Papua

The northern Gulf of Papua receives sediment from a number of rivers, which form a line source to the continental shelf. The largest is the Fly River, which enters in the southwest and whose sediment discharge is generally transported northeastward. The combined fluvial discharges (>300 million tons/y) coalesce to cause the highest accumulation rates in the central Gulf, and to bury shelf irregularities - including numerous shelf valleys left from the last low-stand of sea level. Similar valleys are still exposed southwest of the Fly River delta, and provide insight to fluvial processes in the past. Filling of the valleys occurs first as gravity flows that spread along the floor, and subsequently as foreset beds of prograding clinoform deposits. These deposits occur throughout the inner shelf of the Gulf of Papua, and reflect the great sediment supply to the Gulf. The mechanism for clinoform progradation is likely associated with tidal currents and seasonal variability in wave resuspension. When these two occur energetically (e.g., spring tides, periods of strong SE trade winds), sediment is resuspended in concentrations (>10 g/l) sufficient for gravity flows to move it from topset to foreset regions of the clinoform. This transfer process leads to non-steady-state sediment accumulation on the foreset, which can be documented in Pb-210 profiles. On decadal time scales, impacts of El Nino events can be recognized as periods of minimal sediment supply. Modern sedimentation in the Gulf is neither steady nor uniform.

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## Enriched carbon isotope labelling to trace the contribution of benthic microalgae to the nutrition of consumers in mangrove forests

Benthic microalgae (microphytobenthos (MPB)) is abundant in mangrove forests. Despite high biomass, few studies support major contribution of mangroves to consumer nutrition. Carbon stable isotope analysis suggests that MPB may be the main source. Natural abundance stable isotope studies have been unable to resolve this issue because MPB and mangrove carbon isotope signatures ( $\delta^{13}\text{C}$ ) are too similar. To circumvent this, we labelled MPB in a mangrove forest with  $^{13}\text{C}$  and monitored  $^{13}\text{C}$  uptake by consumers (crabs (*Parasesarma erythroactyla* and *Australoplax tridentata*) and foraminifera (*Ammonia beccarii* and *Trochammina inflata*)) over 35 days. Crab muscle, gill and hepatopancreas tissues were analysed separately. Treatment (spiked with  $^{13}\text{C}$ -enriched bicarbonate at days 0, 7, and 14), procedural control (non-enriched bicarbonate) and control plots were destructively sampled every 7 days. All crab tissues and both foraminifera were measurably enriched within 7 days. Maximum enrichment was at 28 days. For crabs, enrichment was generally greatest in the hepatopancreas, then gills, then muscle. All tissues of *A. tridentata* were more enriched (e.g. 521‰ for hepatopancreas at day 28) than those of *P. erythroactyla* (92‰). *Ammonia beccarii* (245‰) was more enriched than *T. inflata* (12‰). Compartment modelling indicated that 99% of the nutrition of *A. tridentata* was derived from MPB, compared to 35% for *P. erythroactyla*. MPB also provided more nutrition to *A. beccarii* (34%) than to *T. inflata* (<1%). Application of compartment modelling to trophic ecology is relatively new and in this study confirms that MPB is an important source of primary nutrition to consumers in mangrove forests.

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## **Sediment-transport processes operating on the variable morphology in the Gulf of Papua, Papua New Guinea**

An actively forming clinoform was studied in the Gulf of Papua, Papua New Guinea to evaluate the processes involved in formation and evolution of this feature. Modern processes generally move sediment discharged from the Fly and other nearby rivers in a clockwise gyre creating a clinoform with a great lateral extent. But spatial variation in processes causes alongshelf heterogeneity in the mechanisms of formation and seabed character for the modern clinoform.

Density-driven processes (due to suspended-sediment loading) are prevalent in two regions but due to different mechanisms. Near the mouth of the Fly River, density flows associated with estuarine processes and focusing of tidal currents appear to be maintained in shelf valleys. Farther away from the river mouth, density flows were also identified and these were related to temporary storage of sediment in broad, shallow regions and horizontal convergence of flow. Between these two regions, there is an expanse on the topset and foreset environments where resuspension and advection of sediment do not involve density flows, but asymmetry in tidal fluxes plays a role in maintaining the temporary storage of sediment on the inner topset of the clinoform. The influence of tidal currents and waves in the broad, shallow nearshore region plays a dominant role in distributing sediment from the Fly River alongshore, and the irregular morphology creates zones where conditions are prime for density-driven flows. The processes combine to result in a clinoform building across shelf with spatial heterogeneity not only between the topset, foreset and bottomset regions, but also along the foreset of the feature.

## **Olley, June**

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## **Seafood technology for a rapidly changing world environment: A sixty year personal tour through the challenges**

The background to this talk is 60 years involvement with fish technology and the marine environment. Twenty years were spent at the Department of Scientific and Industrial Research (DSIR) Torry Research Station, Aberdeen; twenty as Leader of the CSIRO Tasmanian Food Research Unit and 17 years in an honorary position at the School of Agricultural Science, University of Tasmania.

The DSIR encouraged its scientists to divide their time equally between basic and industrial research. My work was on fish lipids and industrial by-products with strong emphasis on standardisation of analytical methods. Marine lipids have sprung to prominence because of their Omega-3 essential fatty acids, but 50 years earlier they were hydrogenated for margarine.

If fish are to be used as by-products, for example, fishmeal, processing must be available at nearby ports. No satisfactory, cheap preservatives have emerged for storing fish for fishmeal production. Preservation of the raw material with preservative mixtures containing sodium nitrite caused unexpected production of a carcinogen to which mink were particularly susceptible. The subsequent lawsuits clearly showed the need for training more lawyers with a scientific background.

In a global economy, the key to the financial viability of transporting fish products is the cost of transporting water - approximately 80% of fresh fish, 10% of fishmeal. Luxury water (lobsters to Paris for Christmas) does not assuage world hunger, while factory ships at sea could quickly deplete the oceans irrevocably. The quandary of expanding aquaculture (feeding fish with fish) is not discussed.

The apparently disparate themes presented as examples in this abstract will be drawn together in the video presentation to provide a personal and holistic evaluation of the current state of seafood technology. The author will advance the hypothesis that disciplines as diverse as biology, philosophy and law, and economics need to interact productively to advance the seafood industry sustainably, ethically and profitably.



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**Seaweed - herbivore interactions at small scales: a direct test of feeding deterrence by filamentous algae**

High growth rates and temporal or spatial opportunism are considered central to the success of filamentous algae, in particular for escaping or minimising herbivory. However, the role of chemical defences in filamentous algae has received far less attention. We investigated possible chemical feeding deterrence by filamentous red algae that have conspicuous cellular inclusions (*Asparagopsis armata*, *Anotrichium tenue* and *Balliella amphiglanda*) and two others without inclusions (*Callithamnion korfense* and *Enteromorpha* sp.). The three algae with cellular inclusions were consumed at lower rates by a generalist amphipod than the two algae lacking such structures. To determine the role of chemical defences for *A. armata*, we conducted tests against herbivores using algae in which halogenated metabolite production was manipulated. This manipulation had no effect on carbon and nitrogen values, and allowed us to directly test the role of algal secondary metabolites in defence against herbivores without using artificial diets. Individuals with halogenated metabolites deterred grazing by two mesograzers (the amphipod and juvenile abalone) more than metabolite-free algae. Interestingly, larger abalone were not deterred from feeding on bromide (+) algae, indicating a size-specific shift in response to algal secondary metabolites. The sea hare *Aplysia parvula* was also undeterred by the chemical defences. In field assays, artificial diets containing crude extract of *A. armata* were active against consumers. Although functional form models typically predict that tolerance - not resistance - should be the key defensive strategy for marine algae with simple architecture, this study demonstrates that resistance traits may also be important and more broadly utilised in filamentous species.

**Paxinos, Rosemary<sup>1</sup>, Trevor Ward<sup>2</sup> and Jon Emmett<sup>1</sup>**

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**Marine planning framework for South Australia: Performance assessment system**

A Framework has been developed for South Australian waters to manage development and use in an ecologically sustainable way. The *Marine Planning Framework for South Australia* will consist of six regional marine plans, developed under the principles of ecosystem based management, ecologically sustainable development and adaptive management. The Performance Assessment System (PAS) was developed for the Framework to evaluate the success of the Marine Plans by assessing and reporting on the maintenance of ecosystem conditions. In particular, the PAS will review the effectiveness of the Marine Plans in providing guidance for the regulatory functions of management agencies in accordance with marine planning goals and objectives. The PAS incorporates criteria from the ANZECC (1997) Best Practice Model. Marine Plans consist of four ecologically rated (ER) zones that conserve and protect marine, coastal and estuarine habitats and related biota whilst allowing for a full range of activities to occur. The PAS operationalises the objectives underpinning marine planning ER zones by first prescribing performance indicators and benchmarks for guiding agency decision making in conservation, development and use of the marine environment, and second by establishing an assessment system that reports on the effectiveness of a Marine Plan.

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**Age and growth of four Pristid species common to the Queensland Gulf of Carpentaria, Australia**

The growth of *Pristis microdon*, *P. zijsron*, *P. clavata* and *Anoxypristis cuspidata* in the Queensland Gulf of Carpentaria were investigated by the examination and determination of age from vertebrae "growth" rings. Verification for age and growth estimates was obtained from tetracycline injected specimens, tag-recapture data, limited laser ablation studies, and the growth of animals in captivity. In this study all four species exhibited a rapid growth rate in the first twelve months, with *P. microdon* reaching 56cm total length, *P. clavata* 35cm, in *P. zijsron* 52cm and *A. cuspidata* 42cm. In the last ten year of their lifespan the combined growth is only 14cm in *P. microdon*, 7cm in *P. clavata*, 19cm in *P. zijsron* and 9cm in *A. cuspidata*. Sawfish longevity based on 99% of their  $L_{\infty}$  ranged from 51 years (*P. microdon*), 48 years (*P. clavata*), 41 years (*A. cuspidata*), to at least 36 years (*P. zijsron*). From age length data of combined sexes, the von Bertalanffy growth parameters for *P. microdon* are  $L_{\infty} = 632\text{cm}$ ,  $T_L$ ,  $K = 0.08$ ,  $t_0 = -1.72$ ; in *P. clavata*,  $L_{\infty} = 484.9\text{cm}$ ,  $T_L$ ,  $K = 0.09$ ,  $t_0 = -1.83$ ; in *P. zijsron*,  $L_{\infty} = 535.1\text{cm}$ ,  $T_L$ ,  $K = 0.12$ ,  $t_0 = -1.25$ ; and in *A. cuspidata*,  $L_{\infty} = 470\text{cm}$ ,  $T_L$ ,  $K = 0.11$ ,  $t_0 = -1.28$ . The age at maturity of combined sexes for *P. microdon*, *P. clavata* and *P. zijsron* was 8 -10 years and in *A. cuspidata* 4 years for males and 5 years for females. These life history characteristics suggest that *A. cuspidata* is likely to be the most resilient of the four pristid species to the fishing pressure in the GoC.

**Piggott, Maxine<sup>1</sup>, Sam Banks<sup>1</sup>, Neil Holbrook<sup>2</sup>, Peter Tung<sup>1</sup> and Luciano Beheregaray<sup>1</sup>**

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<sup>1</sup> Molecular Ecology Group for Marine Research (MEGMAR), Department of Biological Sciences, Macquarie University, Sydney, NSW 2109<sup>2</sup> MEGMAR and Department of Physical Geography, Macquarie University, Sydney, NSW 2109**Genetic evidence of long distance dispersal and local larval retention in the abalone, *Haliotis coccoradiata***

We are investigating population structure and dispersal in a range of marine invertebrates with differing larval stages along the east coast of Australia. This is part of a larger research program currently being undertaken by the Molecular Ecology Group for Marine Research (MEGMAR) at Macquarie University. One of the invertebrate species we are studying is the abalone, *Haliotis coccoradiata* which has a limited distribution along the Australian east coast. Samples were collected from more than 200 individuals from 12 locations along the New South Wales coast. All *H. coccoradiata* samples collected were genotyped using five microsatellite loci. Preliminary analyses indicate significant yet minor population subdivision and no evidence of isolation by distance. The low genetic differentiation and lack of a significant isolation by distance relationship suggest the existence of long distance dispersal in this species. Dispersal predictions from ocean current modeling support the potential for long distance dispersal. It appears that dispersal up to 500km could occur via the East Australian current even with the relatively short larval stage of 6-7 days for *Haliotis*. However, we found evidence for local larval retention from spatial analyses of multilocus genotypic arrays. Significant positive spatial autocorrelation of multilocus genotypes was detected among individuals separated by less than 50km, indicating that a certain proportion of dispersal events is restricted to this local scale. These results and further analyses will be discussed in relation to larval dispersal and the East Australian current to provide an overall picture of dispersal and population structure in this species. Comparisons of dispersal patterns between *H. coccoradiata* and other invertebrate species targeted by our MEGMAR program will also be discussed.

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## **Fresh-water influences on the hydrology and seagrasses of intermittently-open estuaries**

Intermittently-open estuaries have been increasingly studied over the last ten years. Much of this effort has been focused on larger, often lagoonal systems (aka ICOLLs), with relatively less attention paid to the smaller, but numerous, 'coastal creek' systems (<-5 km long).

Compared to larger estuaries, these smaller systems have proportionally more variable freshwater flow volumes, more confined channels and often an increased separation from the sea caused by closure of sand bars. Such features result in very dynamic systems over inter-annual time scales. In two Victorian estuaries, periods of salinity stratification and de-stratification, hypersalinity and fresh-water flushing were all observed over a three year period. Depending on the state of the sand bar and the amount of tidal influence, there was also considerable variation in the extent of estuarine habitat that was intertidal [CAN'T BE BOTH!] or permanently submerged (e.g. 80% reduction in sub-tidal area).

The responses of two types of seagrass, the Zosteraceae and *Ruppia*, to the hydrologic regimes of the estuaries were examined over time-scales ranging from seasons to 16 years. In the long term, there was an inverse relationship between rainfall and seagrass cover. Within this pattern, seasonal fluctuations in seagrass distribution were modified in association with a combination of unpredictable hydrologic processes.

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**Prior, Sheryn<sup>1</sup>**, and Lynnath Beckley

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<sup>2</sup> School of Environmental Science, Murdoch University, South St, Murdoch WA 6150 l.beckley@murdoch.edu.au

## **Recreational boating and fishing in the Blackwood Estuary, a proposed conservation area in south-western Australia**

The Blackwood Estuary in south-western Australia is a popular holiday destination designated to be included in the proposed 'Capes' Marine Park. During 2005, four seasonal sampling trips were undertaken to determine the spatial and temporal distribution of recreational boating and fishing in the estuary. In addition, recreational anglers were interviewed to ascertain their catches, demographics, socio-economics, frequency and locations of fishing and attitudes to conservation and fisheries management. There was marked seasonality in recreational use of the estuary, with high numbers of boats encountered over summer and autumn. Boats with anglers actively engaged in fishing constituted 30% of the 958 vessels recorded and some spatial patterns related to boat launching sites were apparent. Most anglers were visiting tourists from towns in south-western Australia and, although half of the angling parties were family groups, most respondents were 31-45 year-old males with relaxation their primary motive for fishing. Tradepersons, professionals and retired farmers were common occupations amongst interviewed anglers. Cumulative expenditure on bait, tackle and capital equipment was considerable. Local residents and extended-stay caravanners who reside in Augusta over the summer months fished more frequently than short-stay visitors. Catches were dominated by yellow-finned whiting, *Sillago schomburgkii*, and Australian herring, *Arripis georgiana*. Support for biodiversity conservation measures and fisheries management regulations was high, but non-compliance with size limits was common, apparently due to species misidentification of juvenile fish by visiting anglers.





**Radke, Lynda<sup>1</sup>, Phillip Ford<sup>2</sup>, Ian Webster<sup>2</sup>, Grant Douglas<sup>3</sup>, Jodie Smith<sup>1</sup>, Barbara Robson<sup>2</sup> and Ian Atkinson<sup>1</sup>**

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## **Transformations and fate of nutrients transported from the Fitzroy Catchment to Keppel Bay, tropical northern Queensland**

The Fitzroy catchment is the second largest terrestrial source of nutrients and sediment to the Great Barrier Reef (GBR) lagoon. Nutrients (dissolved and particulate) are discharged from the Fitzroy River into Keppel Bay (KB), via the Fitzroy River. Two estimates of long-term average nutrients loads are 1.1 and 3.2 kt year<sup>-1</sup> for P and 5.1 and 8.9 kt year<sup>-1</sup> for N. Catchment soils are the major source of particulate nutrients, and it is estimated that ~70% of these nutrients are liberated from the soils prior to their deposition in KB. A change from terrestrial to marine organic matter properties ( $\delta^{13}\text{C}$  signatures and TOC:TN ratios) also occurs. An efficient decomposition system, characterised by alternating oxic and sub-oxic processes, ensures that sediment organic matter (and sediment-bound nutrients) is maintained at near-refractory concentrations in KB. There is evidence that iron oxy-hydroxide reduction of organic matter might be particularly important in the degradation of organic matter. Nutrient burial rates based on the sediment nutrient concentrations and measured sedimentation rates are estimated at 1.7 to 3.3 kt year<sup>-1</sup> respectively for P and N. Based on simple mass balance calculations (input minus burial) and depending on which estimate is used for average input load, P is either exported to- or imported from GBR waters, in annual amounts of 1.5 or 0.6 kt respectively, while 1.8 or 5.6 kt y<sup>-1</sup> of N is exported from the system. However, the mass balance calculation for N does not account for N that is contributed to KB by N-fixation. We estimate that N-fixation rates in KB are considerable, at 3.2 kt year, based on a calibration between the rate of N<sub>2</sub>-N uptake by sediment (in core incubation experiments) and the ferric iron concentrations of the same sediments. That N-fixation is really occurring at this high rate needs to be confirmed.

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**Rasheed, Michael<sup>1,2</sup>, Helen Taylor<sup>1,2</sup> and Rob Coles<sup>1,2</sup>**

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## **Long-term monitoring of seagrasses at risk in north Queensland**

Seagrass habitats often occur in sheltered coastal sites associated with ports, harbours and urban centres. As such they are potentially at risk from activities associated with these activities such as dredging, oil and fuel spills and new facility development. Long-term seagrass monitoring programs have been established in several areas at risk from development in tropical north Queensland over the last 10 years. Programs have been developed as a partnership between industries that may potentially affect seagrasses and the Queensland Department of Primary Industries and Fisheries. These monitoring programs have the dual aims of collecting long-term condition and trend data for the state's seagrass communities and of facilitating effective planning for coastal development and infrastructure maintenance operations with minimal impacts on marine habitats.

The program has revealed substantial changes to seagrass meadows with significant declines and recovery in biomass and area occurring at all of the monitoring locations. Changes to seagrass meadows were often consistent between geographic locations with strong evidence to suggest that regional climate rather than local anthropogenic influences were the driving force behind seagrass change. By providing information on how these systems vary naturally we are in a better position to assess the impacts from port and urban activity as well as the health of coastal environments in north Queensland.

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Peter.Ridd@jcu.edu.au: Thomas.Stieglitz@jcu.edu.au**Sediment export from the Markham River, Papua New Guinea**

The Markham River, with an estimated annual sediment load of  $\sim 4\text{Mtyr}^{-1}$ , discharges directly into a submarine canyon which follows a steep path down the submarine delta front. The evidence of high rates of sediment delivery to high relief shelf slopes is analogous to rivers discharging into margins during low stands of sea level. Salinity, temperature and turbidity profiles were taken at various locations in the Markham River estuary during a field deployment between January and February 2006. A combination of Optical Backscatter Sensors (OBS) and current meters were deployed at selected locations near-shore around along coastline. River level, tidal and wind data were also collected.

Salinity and suspended sediment distribution profiles along and across the axis of the river mouth indicate that the estuary is highly stratified. Sediment is dispersed via a plume with both a surface and subsurface component during flooding. Suspended sediment concentrations (SSC) ranged from  $1500 - 2500\text{mg l}^{-1}$  at the river mouth to about  $100\text{mg l}^{-1}$  and less 2km away with a plume thickness of 1 - 2m. Subsurface plumes flowed at isopycnal surfaces at various depths (20 - 80m) with SSCs nearly equal to the surface SSCs when closer ( $<500\text{m}$ ) to the river mouth. No distinctive subsurface plumes were observed during low river flow periods. The SSCs were lower ( $<300\text{mg/l}$ ) as the plumes flowed seaward within the canyon channel. Estimates of the surface flux across sections of the estuary show that between 30 - 40% of the sediment discharged into the estuary is lost from the surface plume within the first square kilometer of the outflow. The resulting settling velocities range between  $0.04 - 0.14\text{cms}^{-1}$ .

**Reyes-Bermude, Alejandro z<sup>1</sup>, Laretta C Grasso<sup>2</sup>, David C Hayward<sup>2</sup>, Eldon E Ball<sup>2</sup> and David J Miller<sup>1</sup>**

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eldon.ball@anu.edu.au**Cellular mechanisms of coral calcification**

Scleractinian corals bring about much of the deposition of calcium carbonate occurring on coral reefs. In these cnidarians, cells of the calciblastic ectoderm secrete and mature an organic matrix in which calcium ions are concentrated and nucleation of  $\text{CaCO}_3$  crystals occurs. However, many aspects of calcification are unclear, largely due to the technical challenges associated with access to the site at which the process occurs.

We are characterising genes in the model scleractinian, *Acropora millepora* that are candidates for roles in calcification, and are applying expression and microarray analysis in an effort to understand the early stages of coral calcification. A number of calcium sensors have been identified and their expression patterns characterised during metamorphosis and the initiation of calcification. We have identified two *Acropora* genes whose products are clearly related to the major matrix protein from *Galaxea sp* (galaxin); these are likely to play key roles in architecture of the coral organic matrix. Consistent with their proposed roles, the galaxin genes have temporally distinct (but overlapping) expression patterns in the aboral ectoderm of pre- and post-settlement larvae through to adults, implying a succession of organic matrix components during coral development. Preliminary microarray experiments, combined with in situ hybridisation and microscopy data, suggest the involvement of lipid metabolism and novel genes in calcification in corals.

## Ribbe, Joachim

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### Modelling ventilation time scales for Hervey Bay, Australia

A three-dimensional coastal ocean model was implemented to investigate the circulation and spatial distribution of ventilation pathways within Hervey Bay, a large coastal embayment off the central Queensland coast. Ventilation time scales are often utilised to characterise the water renewal process of coastal embayments, estuaries and large ocean basins. The impact upon the coastal ocean due to population growth, tourism, fishing, aquaculture, coastal industries and other constructions is immense and knowledge of these time scales assists in assessing the water quality of the marine environment. Ventilation time scales computed for Hervey Bay varied between 50 and 180 days and depended strongly on bathymetry, model forcing, and horizontal mixing parameterisation. Ventilation time scales exhibited strong spatial variability. About 90 % of the Bay was ventilated after about 50-80 days. The concept of one 'typical' distinct ventilation timescale characterising this particular coastal embayment is oversimplified and consideration of spatial variability is clearly important.

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## Richards, Zoe<sup>1,3</sup>, Madeleine van Oppen<sup>2</sup>, Carden Wallace<sup>3</sup> and David Miller<sup>1</sup>

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### Molecular phylogenetics of geographically restricted *Acropora* species: Implications for conservation genetics

Over one third of known *Acropora* species have geographically restricted distributions (have ranges <20% of that of the most widespread species) and have not previously been included in molecular phylogenetic analyses due to difficulties collecting and identifying samples. Species that have restricted distributions are assumed either to be remnants of "old" species that are undergoing range contraction (and are perhaps on the way to extinction) or "young" species that have evolved recently and may be expanding their ranges. Distinguishing between these two possibilities is of particular significance for conservation purposes. We are studying a total of sixteen *Acropora* species that have geographically restricted distributions in the Indo-Pacific. Molecular sequence data for single copy nuclear and mitochondrial loci have been obtained for these sixteen species and are being analysed in conjunction with existing datasets for more widely distributed *Acropora* species. Whilst the study is still in progress, analyses conducted to date imply that some of the species are likely to have evolved only recently, whereas others appear to be much older and are therefore potentially of higher significance in terms of conservation genetics.

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**Are we currently able to assess scleractinian coral connectivity?**

Coral reefs are in serious decline, and research in support of reef management objectives is urgently needed. Despite the number of new molecular genetic tools and the wealth of information that is now available for population-level processes in many marine disciplines, scleractinian coral population genetic information remains surprisingly limited. The technical difficulties and possible reasons for this delay have recently been reviewed and it was suggested that microsatellites and introns hold the best hope for coral population genetics. Whilst microsatellites were originally considered to be rare in corals, recent population genetic assessments of *Acropora palmata* and *Pocillopora meandrina* provide strong support for microsatellites. However, microsatellite markers, besides being expensive to develop, appear to be extremely taxonomically specific in corals, often not transferable outside of the species boundary. Introns, due to their high polymorphicity and ease of primer design in flanking coding sequences, do provide another testable alternative to microsatellites, and recent large scale sequencing projects do provide new sequence information for the first time. Current work using three newly isolated intron regions show them to be applicable at revealing population genetic structuring in *Acropora millepora* on the Great Barrier Reef (GBR). This talk presents the current state of scleractinian coral population genetic data, by combining published microsatellite studies with preliminary analyses of introns from *Acropora millepora* from the GBR, and *Pocillopora verrucosa* from East Africa. In summary, as with all studies, the ultimate challenge seems to be to find the appropriate method that reliably reveals adequate genetic variation with the minimum amount of effort and expense. Most importantly, it seems that connectivity assessments based on scleractinian coral data may finally be becoming a reality.

**Riginos, Cynthia<sup>1</sup>**

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<sup>1</sup> School of Integrative Biology, University of Queensland, Brisbane 4072**Moving beyond  $F_{ST}$  – What can coalescent and non-equilibrium population genetics tell us about genetic connectivity?**

Genetic markers are often used to infer either dispersal patterns of planktonic larvae or historical events (such as divergence times between populations and changes in population size). Analyses of such genetic data frequently employ F-statistics, which are transformed into estimators of gene flow, divergence time, or historical population size. These  $F_{ST}$ -based estimators, however, make implicit assumptions that are unrealistic for most marine animals. In the case of estimating gene flow, it is assumed that populations have reached an equilibrium between migration and genetic drift. Given inherently large population sizes combined with Pleistocene oscillations in temperature and sea levels, it is unlikely that most populations of marine animals have attained a migration-drift equilibrium. On the other hand,  $F_{ST}$ -based estimates of historical events assume that no recent gene exchange has occurred among populations, and this is also an unreasonable assumption for most animals with planktonic larvae. Coalescent population genetics (and other non-equilibrium models) allow greater flexibility regarding underlying assumptions and can simultaneously take into account both contemporary (gene flow) and historical processes and, thus, may be especially useful for understanding genetic connectivity in the sea. This point will be illustrated by considering regional patterns of contemporary gene flow and historical divisions in reef fishes and corals.

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## **Predicting responses to catchment changes in Fitzroy Estuary and Keppel Bay, tropical northern Queensland**

The Fitzroy Estuary and Keppel Bay lie between the tropical catchment of the Fitzroy River and the Great Barrier Reef Lagoon. There has been considerable emphasis on quantifying and characterising catchment loads, but the downstream effects of changes in land-use depend on how sediments and nutrients are transported and transformed in the coastal zone. A hydrodynamic, sediment transport and biogeochemical model of Fitzroy Estuary and Keppel Bay was used to predict how nitrogen and sediment dynamics might change in response to the changes in catchment loads predicted to occur if catchment vegetation cover is changed from approximately 55% to either 30% or 70%. For each scenario, high-flow, low-flow and median-flow year simulations were run. The simulations suggest that the predicted changes in sediment and nutrient loads could have a substantial impact on water quality in the Fitzroy Estuary, the Coastal Creeks and in Keppel Bay near the mouth of the estuary. For median and high-flow years, changes in sediment and nutrient loads can be expected to affect conditions in Keppel Bay not only during the flood events of the wet season, but throughout the year. Higher loads increase the amount of fresh sediment material in the bed, providing a larger pool susceptible to resuspension and decomposition. The model suggests that either increases or reductions in sediment and nutrient loads could result in lower pelagic primary production in some years. Reducing the particulate nitrogen load to Fitzroy Estuary by one third reduced the simulated amount exported to the Great Barrier Reef Lagoon by almost 50% in a high flow year, while doubling the nitrogen and sediment load approximately doubled the amount exported. For median- and low-flow year scenarios, the simulated amount of material exported to the Great Barrier Reef Lagoon was less sensitive to changes in catchment land use.

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## **Determinants of the patchy distribution of South Australia's endemic sea star *Parvulastra parvivipara* (Asteroidea: Asterinidae)**

Understanding ecological determinants of the distribution and abundance of marine organisms is a fundamental requirement for their management and conservation. *Parvulastra parvivipara* is Australia's smallest sea star and is found in tide pools on remote granite platforms on the west coast of the Eyre Peninsula, South Australia. It is one of only six sea stars known to exhibit intra-gonadal development of offspring and give birth to non-dispersive fully formed juveniles. Their distribution is extremely patchy; specimens occupy few of many ostensibly suitable tide pools. The distribution and abundance of *P. parvivipara* at all known population locations was examined in relation to twelve ecological variables. *Parvulastra parvivipara* was found at seven locations and their total population was estimated to be approximately 48,500 individuals. Within tide pools that contained *P. parvivipara*, multiple linear regression analysis showed that abundance was negatively related to wave energy but positively related to tide pool complexity. Although many tide pools at each location provide seemingly suitable habitat for *P. parvivipara*, only 29 % of pools contained specimens. Laboratory experiments showed that differences in the biofilms on rocks were not a determinant of their distribution. Similarly, sea stars tolerated a range of salinities, and did not determine their distribution. It is proposed that their patchy distribution represents a dynamic mosaic of ephemerally and perennially suitable tide pools, in which the presence of *P. parvivipara* is largely related to the stochastic influence of transport around granite platforms by wave action. Due to the low relief of the granite platforms they inhabit, and the restricted number of these platforms on the Eyre Peninsula, global sea level rise is likely to pose a significant risk to their survival.

**Romanescu, Gheorghe<sup>1</sup>**

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<sup>1</sup> Faculty of Geography and Geology; University "Alexandru Ioan Cuza" Iași, 700505, Romania,**Genesis and morphology of the Razim-Sinoie barrier spit (Romania)**

The Razim-Sinoie lagoon complex is the largest lake complex in Romania (96.950 hectares). The barrier spit separating it from the sea is sandy, of variable thickness: tens of meters in the sector of Leahova lakes, 5 km next to the Chituc levee. It originates from the sediments transported by the northern drift. Its formation started when the Sulina delta was decapitated. The beach sector is poorly developed; as on most of the spit abrasion is predominant and only on a small area (30-40%) progradation is dominant. In the Portita Lighthouse area the width of the barrier spit has reduced with 75m in 20 years. Erosion occurred, resulting in the diminution of the sedimentary storage. In the Chituc sector the most important accumulation rate is noticed, with a sedimentary storage of around 25m<sup>3</sup>/m. On the littoral alignment linear avant dunes are developing; continuous and covered with psamophyle vegetation. The inlets are reduced, and are human controlled: Gura Portitei was closed in 1960 and Gura Periboina is controlled by a canal lock. The beach of the barrier spit is long, continuous and straight. The beach profile is continuously changing, as it has to adjust itself to the hydrodynamic conditions. The mineral / organic material ratio next to the spit has the value of 50/50. This ratio is of 90/10 on the Sulina-Sahalin sector, 60/40 in Sahalin-Zatoane, 80/20 in Perisor. The sectors characterised by the existence of a relative equilibrium have one or two berms, while those characterised by abrasion do not have such forms. In the sectors of relative equilibrium, the avant dunes are at distances of 12-15m from the shore, while the avant dunes in the abrasive sectors are situated at distances of 8-10m. The lakes behind the barrier spit have a higher level than that of the sea.

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**Bycatch in the Torres Strait prawn trawl fishery**

The impact of prawn trawling on bycatch in a tropical environment has been examined in the Torres Straits. Annual research trawl surveys for status of prawn stocks provided an opportunity to compare the bycatch community structure and composition between areas exposed to trawling within the fishery and adjacent prawn nursery areas protected from fishing. During both February 2004/05 sixteen sites were trawled for one nautical mile using the Department of Primary Industries and Fisheries research trawler.

Across both years and all sites 302 bycatch species were collected. Most species occur rarely with just 10% of the species accounting for >1% of the total bycatch weight. Fish dominated the bycatch at 78% of the weight which is identical to other bycatch work conducted in the Torres Straits two decades ago and also in 1997. Similarly, of the top 10 dominant fish families collected, six of these were also dominant two decades ago. This indicates that the dominant fish bycatch in the trawl grounds of the Torres Strait have changed little since the mid 1980's.

A comparison of trawled with non-trawled areas shows no significant difference in numbers of bycatch species or numbers of individuals. Preliminary analysis also indicates no major differences in the bycatch community composition between these two areas. Samples from the same sixteen sites were also collected in 2006 and are currently being processed. The analyses to date indicate that the Torres Strait prawn trawl fishery is sustainable with regard to the dominant species of bycatch.

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**Saltmarsh as habitat for Gastropod assemblages**

Saltmarshes are spatially heterogeneous habitats with a variety of vegetation including *Sarcocornia quinqueflora*, *Sporobolus virginicus*, *Juncus kraussii*, *Casuarina glauca* and bare unvegetated areas. Although saltmarshes are listed as an endangered ecological community, we have little understanding of their ecology and whether the spatial patterns of the vegetation influence the macrofaunal assemblages living within them. The aim of this study was to describe the gastropod assemblages living within saltmarshes as part of a longer-term study to determine the ecological role of these organisms in maintaining saltmarsh vegetation. The locations selected for this study were four saltmarshes in the upper reaches of Port Stephens, New South Wales (NSW), Australia. Five habitats within each saltmarsh were sampled. Sampling was done by removing the vegetation and/or the top layer of the sediment in 3 replicate quadrats in 3 transects at each saltmarsh location. Generally, there were significantly more taxa and individuals in the vegetated than in the non-vegetated areas, with the diversity of gastropod species being similar in the vegetated habitats. The mean number of individuals was, however, similar in the vegetated habitats of *S. quinqueflora*, *S. virginicus* and *J. kraussii*. In addition, the majority of gastropod assemblages were associated with the shoots of *S. virginicus* and *J. kraussii* and strong correlations were found between the densities of gastropods and biomass of vegetation. Until we have better base line data on the spatial and temporal patterns of macrofauna in saltmarshes, it will be very difficult to determine how anthropogenic impacts influence these organisms and what role these organisms have in maintaining the saltmarsh vegetation.

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**The Wealth from Oceans Flagship**

The CSIRO Wealth from Oceans National Research Flagship has been established to provide Australia with a key capacity to discover and realise the economic and environmental benefits of our oceans' territory.

The goal of the Flagship is to position Australia by 2020 as an international benchmark in the delivery of economic, social and environmental wealth based on leadership in understanding ocean systems and processes. Its charter is to realise, responsibly, the potential of our oceans, through the application of breakthrough sciences in partnership with industry and the community.

The Wealth from Oceans Flagship provides a new model in strategic research collaborative development, integrating across the breadth of CSIRO and in conjunction with industry and research partners. The Flagship is combining the scientific expertise and resources from across Australia's entire research community, not just CSIRO, providing research capabilities previously not accessible to industry. The Flagship's research efforts are focused on four major areas: the fundamentals of ocean processes, how the oceans affect our climate, the development of new ocean-based industry opportunities and sustainable management of our coastal ecosystems.

A key principle of the Flagship program is the Collaboration Fund. Of the A\$305 million provided by the Government to the Flagship initiative over seven years, A\$97 million has been allocated to enhance and reinforce the development of collaborative partnerships with other research providers which reflect the National Research Priorities.

The Flagships offer many opportunities for collaborative work or study. The Flagship Collaboration Fund includes a contestable collaborative research program, which offers funding for Flagship clusters and projects, visiting fellowships and postgraduate scholarships.

For more information visit [www.csiro.au/wealthfromoceans](http://www.csiro.au/wealthfromoceans)

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## **Modeling the development of high turbidity in Torres Strait marine ecosystem**

A model of ocean circulation and sediment movement has been developed for the Torres Strait region, with a view to better understand the significant dieback of sea-grasses in the northern parts. The most recent atmospheric and oceanographic reanalysis products have been used to force the hydrodynamics, which provide a transport framework for an embedded model dealing with fine sediment movements. This model has been calibrated against available data, including temperature and salinity profiles, tidal predictions, long term tide gauge records, and suspended sediment concentrations.

The resulting 5-year simulation provides time series for investigating the seasonal variability of the circulation. Results reveal that seasonal currents driven by winds are typically around 10% of the tidal current magnitude. Trade winds drive a westward flow through strait for more than nine months of the year, resulting in an annual net inflow into the Gulf of Carpentaria. Fine sediments tend to accumulate to the west of Torres Strait during the trades, but then are resuspended during the monsoon and transported back into the strait where they settle. This mechanism is responsible for observed cycle in the strait of increasing turbidity during the monsoon decreasing turbidity during the trades.

Future work will focus on estimating the bottom light reduction due to the presence of suspended sediment in northern Torres Strait, so as to assess the potential impact on seagrass health.

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## **Training and experience in community-based monitoring: Value-adding for MPA management**

Community-based monitoring (CBM) is a participatory environmental management tool with numerous potential aims and outcomes. Predominantly applied to community education and developing stewardship, CBM has also been advocated for its ability to extend or complement ecological data sets collected by professional scientists and management authorities. Ideally, CBM programs integrate the collection of good quality data with providing a rewarding and worthwhile experience for volunteers. This project investigated the effect of training and field experience on the data quality, knowledge, and attitudes of participants of Sea Search, a new CBM initiative in Victorian Marine National Parks and Marine Sanctuaries. Sea Search volunteers at three sites attended four intertidal monitoring sessions together with marine biologists between November 2005 and February 2006. Half of the volunteers received ongoing training before each session, whereas other participants received only introductory training. All participants completed a questionnaire and species identification exercise before and after the monitoring period. Ongoing training significantly improved the data quality of volunteers, however volunteer data was consistently different to that recorded by marine biologists. A trend in trained volunteer data over time tentatively suggests that participants required between 8-12 combined training and monitoring sessions to be equivalent to marine biologists when assessing species richness. Participants were primarily motivated by the desire to contribute to marine conservation and to learn new skills, and over 90% agreed that CBM made an important contribution to conservation and environmental education. Although all volunteers significantly improved in identifying intertidal organisms, untrained participants expressed frustration and dissatisfaction at their lack of knowledge, and believed that the lack of training limited their ability to learn. Volunteers stressed the importance of sharing information with fellow participants in terms of community learning and their enjoyment of intertidal monitoring.





**Seneca, Francois<sup>1</sup>, Madeleine van Oppen<sup>2</sup> and David Miller<sup>1</sup>**

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<sup>1</sup> Comparative Genomics Centre, James Cook University, Townsville 4810. david.miller@jcu.edu.au<sup>2</sup> Australian Institute of Marine Science, Townsville 4810. m.vanoppen@aims.gov.au**Microarray analysis of gene expression in *Acropora millepora* during a natural bleaching event**

Over the last two decades, coral bleaching episodes have increased in both frequency and severity, leading to major loss of coral reefs on a global scale. The initial stage of bleaching involves loss of algal symbionts and is reversible, but may lead to the death of the coral host if it is not re-colonized by symbionts within a short period of time. The mechanism of algal expulsion is unknown, as are the molecular bases of coral stress responses. We are using microarray approaches to analyze the response of *Acropora millepora* through a natural bleaching episode. In the pilot experiment, we have compared the expression levels of three thousand genes at corresponding times between bleaching and non-bleaching years for individual *Acropora* colonies. Approximately 200 genes were significantly up- or down-regulated in the bleaching year, and a subset of these has been validated using RT-PCR. These differentially expressed genes include candidates for roles in coral stress responses and in the expulsion of algae. The possible significance of these candidate genes, and experiments in progress with larger *Acropora* microarrays, will be described.

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**Biological connectivity: The devil is in the detail**

There is increasing awareness of the importance of connectivity between coastal ecosystems and offshore systems such as coral reefs. This is often seen as a simply physical flow of materials, pollutants and nutrients, but also involves biological connectivity. Biological connectivity encompasses many important functions including migrations to utilise nursery grounds, spawning sites or feeding opportunities, and the biologically mediate transport of nutrients that supports offshore fisheries production and ecosystems. While these functions are understood in a general way there is little awareness or understanding of many of the ecological processes that support these functions. In fact, catchment-to-reef biological connectivity is supported by a hierarchy or mosaic of smaller scale connectivities, each influenced by a range of supporting and controlling ecological processes. The importance of smaller scale connectivities is exemplified by the presence of ecological bottlenecks with the potential to control the success of juvenile fish (and other animals) recruiting to estuarine, wetland and freshwater nurseries.

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**Predation as a structuring force in estuarine nurserygrounds**

Biological connectivity is central to the ecological functioning of estuaries at many different scales. Among its most obvious manifestations are the life-history migrations of fish and mobile invertebrates to utilise nursery grounds. These migrations often coincide with the transition from larval to juvenile stages, a period when mortality rates for most species are high. In carrying out these migrations recruiting juveniles must pass through a series of physical bottlenecks (the ocean-estuary interface, the estuary-wetland interface, the estuary-freshwater interface etc.). Each of these provides a focus for predator-induced mortality with the ability to profoundly influence the structure and function of nursery ground assemblages. At smaller scales the need to migrate between intertidal feeding habitats and low tide refuges provides another bottleneck where predation can concentrate. In each case, the imperatives of biological connectivity provide a focus for both the regulation of nursery ground value and support for predators, which in many case are themselves predators.

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### **Environmental flow needs of SE Australian estuaries**

While the environmental flow needs of the freshwater reachers of rivers have received considerable attention the same cannot be said for their estuaries. Pierson et al. (2002) have reviewed the available research into establishment of environmental flows for Australian estuaries. They point out that studies of estuarine environmental flows are “relatively scarce” and identified only two substantial studies into Australian estuaries - for the Derwent (Tasmania) and Richmond Rivers (NSW). In Victoria environmental flows have recently been recommended for the Barwon, Barham, Werribee and Gellibrand estuaries. This paper will report on the approaches used to determine two key characteristics of the hydrodynamic cycle of western Victorian estuaries that are particularly dependent on river flow:

- a. Winter flows sufficient to flush “aged” salt water from an estuary
- b. Adequate summer/autumn flows to maintain estuarine circulation.

Not all of the sixteen major flow - related ecological processes listed by Pierson et al. (2002) are of equal importance in any particular estuary and some of the more significant ones for western Victoria are identified.

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### **Linking science to environmental protection policy and decision making**

Environmental protection policy frameworks which are underpinned by sound science are key ingredients for consistent and defensible decision-making and environmental management of new development proposals. A ‘resources boom’ is occurring in Western Australia and this ‘boom’ is driving demand for new port and coastal developments and for the expansion of existing developments around WA. Collectively, these developments are increasing anthropogenic pressure and cumulative environmental impacts on WA’s marine environment. In WA, the Environmental Protection Authority (EPA) is responsible for the formulation of environmental protection policy and making recommendations to the WA Government on the environmental acceptability and management of significant new development proposals. The EPA relies on scientifically robust information to perform these functions. While a large volume of very good scientific work has been done in WA, it has often been the case that the utility of this science for policy formulation and decision-making is limited. In recent years the WA State Government has implemented collaborative marine research initiatives which have as a primary objective the delivery of strategic research outcomes to improve the State’s capacity to protect, conserve and manage its marine environment. In addition, the Department of Environment has supported tactical research to address specific questions of interest that arise from marine development activities. Examples of science and scientific challenges which are being, and need to be, addressed to inform environmental protection policy formulation and decision-making will be described.

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**Satellite ocean colour remote sensing algorithm development to assess Great Barrier Reef lagoon and coastal water quality**

Field measurements have been made throughout the GBR Lagoon and coastal regions over 3 years to understand the optical properties of different marine and terrigenous water constituents and their net effect on the ocean colour as measured by polar orbiting satellite. Based on a sufficiently large database of field information covering a wide range of optical conditions, inversion algorithms may be created to use satellite ocean colour measurements to quantify broad water quality parameters such as Chlorophyll-a, Total Suspended Solids and Dissolved Organic Carbon concentrations in GBR waters. A number of algorithms are proposed and their performance is evaluated with the intention of applying the best algorithms to the data from the SeaWiFS and MODIS-aqua satellite sensors, which are currently archived at the Australian Institute of Marine Science. The end result will be the provision of an ongoing time series of water quality image products for the region starting from late 1997.

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**Demand-supply cycles:Where integrated research and management interface**

Integrated research, like adaptive management, relies on the development of close and functional links between science and management in order to respond more effectively to changes in social-ecological systems. This paper discusses how both sides interface in relation to the life cycles of policies and their instruments on the one hand (from setting and prioritising goals to the implementation and evaluation of instruments) and research on the other hand (from proposal development and funding to final results analysis, interpretation and communication). Based on the authors' experiences with several research projects designed to address elements of the Reef Water Quality Protection Plan (RWQPP) this paper highlights problems in shaping and maintaining the interface with decision makers, and provides recommendations to improve the interactions between management and integrated science.

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### Consequences of food-limitation and intraspecific variation in maternal investment on the growth and development of larvae of a marine polychaete

Variation in the availability of planktonic food influences the growth, development and timing of metamorphosis in marine invertebrate larvae. Similarly, variation in maternal investment in lecithotrophic offspring can influence offspring growth and fitness. The consequences of food-limitation and variation in maternal investment on the growth and development were investigated for a common marine polychaete with planktotrophic larvae, *Galeolaria caespitosa*. Laboratory experiments using cultured micro-algae showed that food-limitation reduced larval growth rates. More importantly, larvae provided with limited food reached developmental stages that immediately precede settlement at a smaller size than larvae provided with more food. Similar experiments using natural planktonic food provided evidence for food-limitation in the waters of South Australia. Larvae fed a concentrated diet of natural plankton grew faster than larvae fed ambient concentrations of plankton and reached development stages that precede settlement at a smaller size. Maternal investment in offspring (i.e. egg size) was higher for larger females than for smaller females, and differences in maternal investment between geographic locations were apparent when the effects of female size were controlled for. Larvae developing from larger eggs were larger than larvae developing from smaller eggs at development stages immediately preceding settlement. Therefore, despite having the capacity to feed, differences in the level of maternal investment in offspring of *Galeolaria caespitosa* affected the size of its larvae immediately prior to settlement.

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### Stoichiometric evidence for nitrogen fixation in temperate Australian estuaries

Nitrogen fixation, the process by which certain type of bacteria convert atmospheric nitrogen gas into ammonia, is a poorly studied process in temperate Australian estuaries. Over the past 12 years Geoscience Australia has conducted almost 500 benthic chamber experiments in selected sites within 20 temperate Australian estuaries. Data obtained from these studies has been examined stoichiometrically to identify if nitrogen fixation plays an important role in the nitrogen cycle. Some sites within 10 of the 20 estuaries studied were found to have negative N<sub>2</sub> fluxes, indicating nitrogen fixation dominated denitrification in these environments (ie net nitrogen fixing). Of the approximately 300 benthic chamber experiments that were thought to be dominated by a 'Redfield' source of organic matter, 73 experiments from 13 estuaries were 'missing' nitrogen when examined stoichiometrically. Nitrogen fixation may be a possible source of this 'missing' nitrogen. Therefore, more than half of the temperate estuaries studied have either direct or indirect stoichiometric evidence of nitrogen fixation occurring, and the importance of this process within the different estuaries is discussed.

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## **Nekton edge effects in patchy seagrass landscapes**

Seagrass beds form naturally patchy habitats with large areas of seagrass-sand interface, or edges, but our understanding of how nekton assemblages change across seagrass edges is poor. Nekton were sampled using small (0.5 m<sup>2</sup>) push nets in seven microhabitats associated with seagrass; the seaward unvegetated sand, seaward sand edge, seaward seagrass edge, seagrass middle, shoreward seagrass edge, shoreward sand edge and shoreward unvegetated sand at three sites; Blairgowrie, Grassy Point and Indented Head within Port Phillip Bay, Victoria. Samples were taken during the day and night, and seagrass variables collected to describe structural complexity. Regardless of site, overall fish density was greater at the seaward seagrass edge than the seagrass middle, but there was no difference in density between the seagrass middle and the shoreward seagrass edge. At Blairgowrie more fish were sampled during the night than the day, but there was no difference in fish sampled during the night and day at Grassy Point and Indented Head. Two species of pipefish, *Stigmatopora argus* and *S. nigra*, were sampled in similar numbers during the day and night and showed strong preference for the seaward seagrass edge at all sites. Conversely, *Nesogobius sp.*, a goby species was sampled in greater numbers during the night and showed a preference for the shoreward seagrass edge over the seagrass middle habitat at all sites, while weedfish, *Heteroclinus adalidae* was sampled more often at night but showed no preference for seagrass edges at any site. We suggest that within patchy seagrass habitats, patterns of nekton abundance change across the seagrass edge, although this pattern varies with site, time of day and species.

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## **Land-ocean interaction in the tropics: Submarine groundwater discharge along the central Great Barrier Reef coastline**

In the Great Barrier Reef (GBR) region, a World Heritage Area, to date little is known about incidence and magnitude of submarine groundwater discharge (SGD) from coastal aquifers into the near-shore ocean. In this talk, an overview of recent SGD studies in the central GBR region is presented.

Ongoing work provides evidence for SGD to occur in a variety of geological settings, originating from both unconfined and confined coastal aquifer system. Hydrogeological settings of SGD in the region include (1) recirculation of seawater through animal burrows in mangrove forests, (2) fresh SGD from unconfined aquifers as a narrow coastal fringe of freshwater along Wet Tropics beaches, (3) SGD from confined aquifers in large coastal dune systems and (4) offshore SGD from confined submarine aquifer systems comprised of riverine paleochannels incised into the shelf.

**Summers, Robert<sup>1</sup>, David Weaver<sup>2</sup> and Simon Neville<sup>3</sup>**

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<sup>1</sup> Department of Agriculture and Food, Western Australia, 120 SW Highway Waroona, WA 6215<sup>2</sup> Department of Agriculture and Food, Western Australia, 444 Albany Hwy, Albany, WA 6330. dweaver@agric.wa.gov.au<sup>3</sup> Ecotones and Associates, RMB 1050, South Coast Highway Denmark WA 6333 silou@denmarkwa.net.au**Nutrient pollution in the Peel-Harvey Western Australia**

The algal blooms experienced in the estuaries in the south of Western Australia are the result of excessive nutrient application to a poorly buffered landscape and insufficient management of nutrients once applied. To date, much of the management focus has been directed towards symptomatic treatment. To guide the effective treatment of nutrient pollution causes, the efficacy of a number of management practices and their costs must be assessed to influence adoption. A model was developed in the Peel-Harvey catchment (70 km south of Perth) to assess water quality and economic futures due to the adoption of Best Management Practices (BMPs). The current BMP effort was assessed and compared with scenarios including the maximum achievable nutrient reduction and the most cost effective approach to BMP implementation. These scenarios were assessed using a risk based model that considered factors such as farm-gate nutrient surpluses, soil risk factors such as nutrient retention capacity, slope and inundation, proximity to watercourses and other influences on transport and in-stream assimilation. These combined risk factors allowed an estimate of nutrient export to be derived and the influence of BMPs and costs to be assessed. The current BMP effort is estimated to provide <5% water quality improvement but still costs \$4M, the cost effective scenario reduced nutrient movement by 43% (close to target) costing \$25M and the high reduction scenario reduced nutrient movement by 68% and cost \$53M. Due to the nature of the BMPs applied, these capital costs were offset by productivity gains and all but the current BMP effort showed positive economic outcomes. A significant outcome was the recognition of the importance of "nutrient balance" at farm and catchment scale, and its influence in the choice of management actions. Also economic barriers to the adoption of these BMPs appear limited and bring the current low adoption levels into question.

**Szymczak, R, J Twining, S Hollins, C Hughes, D Mazumder and N Creighton**

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**A kinetic approach for determination of coastal ecosystem contaminant and energy fluxes underpinned by nuclear and isotopic techniques**

The historical operation of manufacturing, chemical and other industries in the Sydney Harbour catchment over many decades has left a legacy of high chemical contamination in the surrounding catchment, such that a recent report describes Port Jackson as one of the most contaminated harbours in the world. The legacy in Homebush Bay is amongst the worst in the harbour and presents a considerable management problem. Elucidation of environmental processes is the key to effective ecosystem management, however few tools are available to determine their inter-relationships, rates and directions.

This study has four components: (1) determination of linkages between high trophic order species and different habitats resources using stable isotopic analyses of carbon and nitrogen. These studies identify trophic cascades forming the basis for selection of biota for contaminant transfer experiments; (2) short-term (weeks - months) chronology and geochemistry of sediment cores and traps in Homebush Bay to determine rates of sedimentation and resuspension (using environmental/cosmogenic <sup>7</sup>Be). Models derived from these studies provide the contaminants levels against which risk is assessed; (3) biokinetic studies using proxy radiotracer isotopes (eg. <sup>75</sup>Se & <sup>109</sup>Cd for analogous stable metals) of the uptake and trophic transfer of contaminants by specific estuarine biota. Here we identify the rates and extent to which contaminants accumulated and transferred to predators/seafoods; and (4) application of a probabilistic ecological risk assessment model (AQUARISK) set to criteria determined by stakeholder consensus.

In this study we analysed the distribution of natural isotopes and redistribution of artificial isotopes injected into ecological compartments to determine the key trophic linkages, contaminant pathways and their rates in temperate NSW estuarine systems (Sydney Harbour & Botany Bay) and contribute to improving the accuracy and specificity of a probabilistic ecological risk assessment strategy.

**Tanner, Jason**

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**Effects of habitat fragmentation in seagrasses on mobile epifauna**

The influence of seagrass habitat fragmentation on small mobile epifauna was studied by fragmenting patches of artificial seagrass. One square meter plots of artificial seagrass were allowed to recruit a range of epifauna, and then divided into four. Each quadrant was separated from the others in a patch by distances ranging between 0 m and 2 m. After 3-4 weeks, 1 quadrant from each unit was collected in a mesh bag, and the mobile epifauna retained for identification and enumeration. Plots with a spacing of 0, 0.25 and 0.5 m had similar assemblages, while those with a spacing of 1 m were substantially different. In a second experiment, plots were established in a similar pattern, but were fragmented at the time of deployment. In this experiment, there were no differences in assemblages between plots with different spacings. Recruitment into artificial seagrass units at different distances from the edge of larger natural patches was also studied. ASUs within 2 m of natural seagrass recruited a similar faunal assemblage, while those at 5 m distance attracted a different assemblage. These findings suggest that small mobile epifauna treat patches separated by small distances (1-2m) as a single habitat patch, while greater separation results in a patchy habitat.

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**Temmerman, Stijn<sup>1</sup>, Tjeerd J Bouma<sup>2</sup>, Johan Van de Koppel<sup>2</sup>, Mindert B De Vries<sup>3</sup>, and Peter MJ Herman<sup>2</sup>**<sup>1</sup> University of Antwerpen, Department of Biology, Antwerpen, Belgium.

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<sup>2</sup> Netherlands Institute of Ecology (NIOO-KNAW), Centre for Estuarine and Marine Ecology, Yerseke, The Netherlands.<sup>3</sup> WL | Delft Hydraulics, Delft, The Netherlands.**Interactions between plants, flow and geomorphology determine the spatial self-organisation of tidal wetland landscapes**

In many wetlands, such as tidal marshes, mangroves, river floodplains, etc., bio-physical feedbacks occur between vegetation, water flow and geomorphology. We studied to what extent these interactions lead to the spatial self-organisation of both vegetation patterns and geomorphic patterns that are typically observed in a tidal wetland. This was done using a spatial simulation model, incorporating dynamic feedbacks between plant growth, hydrodynamics and sediment transport. The model showed that two different, scale-dependent feedbacks occur. Within vegetation zones, flow velocities are reduced and sedimentation takes place, leading to a higher bottom elevation and thus less tidal inundation stress for plant growth. In contrast, in between vegetation zones, the flow is concentrated and the initial erosion of a channel takes place, leading to a lower bottom elevation and thus more tidal inundation stress for plant growth. The model shows that these scale-dependent feedbacks lead to the self-organized pattern of tidal marshes, typically consisting of a network of unvegetated, deeply-incised channels and of vegetated, elevated platforms with a levee-basin topography in between these channels. The model simulations are in good agreement with aerial photos documenting the development of vegetation and channels in tidal landscapes. In contrast to earlier studies on terrestrial landscapes, our simulations suggest that channel drainage density increases with the density of the vegetation cover. Implications of our findings for other vegetated wetland systems, such as river floodplains, are discussed.

**Teruaki Yoshida<sup>1</sup>, Tatsuki Toda<sup>2</sup> and Othman Bin Haji Ross<sup>1</sup>**

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<sup>2</sup> Department of Environmental Engineering for Symbiosis, Faculty of Engineering, Soka University, Tangi-cho, Hachioji, 192-8577, Japan. toda@t.soka.ac.jp**Size structure and biomass of seasonal zooplankton succession in tropical coastal waters of the Straits of Malacca: The importance of smaller size fractions**

Zooplankton abundance, biomass (organic carbon and nitrogen) and taxonomic composition were studied within an annual cycle (Jul 2004 - August 2005) in the tropical coastal waters of the Straits of Malacca, Malaysia. Biweekly plankton sampling included vertical tows made with a 140 µm plankton net, and Niskin water bottle samples from 5 discrete depths representative of the entire water column, to adequately collect macro-, meso- and microzooplankton. Total zooplankton abundance and biomass showed high variability but were generally higher during the SW monsoon season. This seasonality is brought about by the microzooplankton which dominated on average 93.3 and 89.1 % of total zooplankton abundance and biomass, respectively throughout the study period. Carbon-nitrogen ratio values indicated alternating differences in nutritional quality between larger and smaller zooplankton fractions relative to the monsoon seasons. Species composition within the zooplankton community displayed a distinct succession throughout the year. In general, copepod nauplii were dominant during the SW monsoon and tintinnids during the NE monsoon in the microzooplankton. The mesozooplankton showed a more diversified community with cyclopoid copepods (*Oithona* spp.), calanoid copepods (*Paracalanus* spp.), harpacticoid copepods (*Euterpina acutifrons*) and poecilostomatoid copepods (*Oncaea* spp.) predominant. Except for the occasional population bloom such as those by ostracods and siphonophores, mesozooplankton abundance and biomass values showed a general increase during the SW monsoon and were often an order smaller than the microzooplankton. These results suggest the need for accurate samplings of entire zooplankton assemblage and consideration of inherent seasonality such as monsoons when characterizing the structure and dynamics of zooplankton communities in tropical coastal waters.



## Simon Townsend

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### Anthropogenic loads to Darwin Harbour, northern Australia, and their impact on mangrove sediment metal concentrations

The catchment of Darwin Harbour comprises the cities of Darwin and Palmerston, a rural residential hinterland, agricultural land and a large portion ( $\approx 80\%$ ) of native vegetation. Over the last two decades, there has been at least a doubling in the area of intensive land-use. This increase is expected to continue with projections for Darwin's population to grow by approximately 50% over the next 15 years. The impact of land-use on the loadings of nutrients, sediment and metals to the harbour has been assessed. Urban land-use increases nitrogen and phosphorus loads on a per unit area basis, respectively, by factors of 4 and 20 relative reference catchments. Urban land-use increases sediment loads by a factor 7, whilst metals loads are increased by between 3 and 30 times. Although only 3% of the catchment, urban areas make a large contribution to sediment, nutrient and metal loads entering Darwin Harbour, increasing catchment load to Darwin Harbour by factors of 0.1 to 3.8. Rural land-uses, however, have not made detectable increases in nutrient, sediment and metal loads. The impact of elevated metals loads from an urban catchment on mangrove sediments has been assessed. Metal concentrations were low in both the urban and undisturbed catchments, though concentrations of Cu, Pb and Zn were significantly higher in the sediments of the urban catchment. These low concentrations would not be expected to have a significant impact on mangrove infauna. However, whether metals will accumulate in mangrove sediments over time is unclear, owing to a lack of knowledge about the movement of the sediments in the harbour.

## Underwood, Jim<sup>1</sup>, Luke Smith<sup>2</sup>, and Madeleine van Oppen<sup>3</sup>

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### Larval dispersal and disturbance in two coral species in northern Western Australia

For marine organisms whose life histories include a pelagic larval phase, our understanding of the spatial scale and pattern of demographic connections among populations is particularly deficient. However, because this "population connectivity" has profound ramifications for the survival and regeneration of populations following disturbance, development of realistic and spatially explicit models of connectivity is crucial for the effective conservation of threatened marine species. Here, we utilise variation of microsatellite markers to quantify the genetic structure and infer patterns of larval dispersal in two species of coral in northern West Australia. Specifically, we explore the extent to which recent recruits at Scott Reef, an isolated group of coral reefs that are recovering from a severe coral bleaching event, originated from few survivors on their natal reef or from other reefs within this system. Our results indicate that populations of the brooding coral *Seriatopora hystrix* are highly subdivided, with the majority of larvae recruiting to within 100 m of their natal colony. However, this localised recruitment has been recently supplemented by less frequent broader dispersal over scales of tens of kilometres, and it appears that these between reef dispersal events reflect recruitment into severely damaged areas from sites with the highest cover of *S. hystrix* following the bleaching. We conclude that the genetic structure of this brooding coral reflects a highly opportunistic life history strategy, in which prolific, local recruitment is occasionally supplemented by larvae produced on other reefs under suitable conditions. In contrast, preliminary results from the broadcast spawning coral, *Acropora tenuis*, indicate substantially less localised structure and a greater degree of connectivity among reefs within the Scott system. Currently, we are analysing samples from a neighbouring reef system that is 400 kilometres to the south of Scott Reef, and these results and the management implications for these corals will be discussed.

**Underwood, Avril H & Jamie E Seymour**

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**The relationship of venom ontogeny, diet and morphology in *Carukia barnesi*, a species of Australian box jellyfish**

Venom profiles of two age groups of the medically important Australian box jellyfish, *Carukia barnesi* (Southcott, 1967) were compared. Sodium dodecyl sulfate-polyacrylamide gel electrophoresis revealed differences in protein banding between tentacular venom from immature and mature animals. These changes in venom components correspond to a switch from invertebrate prey in immature *C.barnesi* medusae to vertebrate prey in mature medusae indicating that venoms may be specific to the prey groups favoured at different stages of the animal's development. Ontogenetic venom changes observed in *C.barnesi* may be a factor of prey capture capabilities of immature and mature medusae.

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**Uthicke, S, K Nobes and K Fabricius**

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Australian Institute of Marine Science, CRC Reef Research Centre, and 'Catchment-to-Reef' CRC.

**Are benthic Foraminifera indicators for water quality of the Great Barrier Reef (GBR)?**

Benthic foraminifera are established indicators for water quality (WQ) conditions in Florida and the Caribbean. The 'FORAM-index' is simply based on relative abundances of 1) large symbiont bearing, 2) opportunistic and 3) small non-symbiotic taxa. Here, we investigate the use of foraminifera as indicators to assess status and trends of WQ on inshore GBR reefs subjected to increased nutrient and sediment loads. We quantified the distribution and community composition of benthic foraminifera along a nutrient and turbidity gradient at the Whitsunday Islands. Foraminifera showed a distinct shift in species dominance towards larger symbiont-bearing species from turbid inner shelf towards clearer outer shelf reefs. Several large foraminifera with diatom or dinoflagellate symbionts were identified as indicators for offshore, clear water conditions. In contrast, heterotrophic rotaliids and a species retaining plastids (*Elphidium sp.*) were highly characteristic for low light, higher nutrient conditions. Application of the FORAM index to GBR community data showed a significant increase of this index with increased light and decreased nutrient availability. However, several individual species with symbionts did not follow light and nutrient gradients as predicted by the assumptions of the FORAM Index. Aquaria experiments with some of these species showed that they exhibit positive growth even in very low light conditions. PAM-fluorometry measurements of the photosynthetic efficiency and Rapid Light Curves indicated that diatom symbionts in these species rapidly adapt to low light levels by increasing the efficiency of light usage. We conclude that it will be possible to apply the FORAM index to GBR reefs, but some adaptations based on a better understanding of their physiology and ecology will distinctly improve the index' specificity to certain environmental factors. Together with improved understanding of indicator species ecology, a GBR FORAM index will provide a valuable tool for assessment of reef health.

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**Vaïtilingon, Devarajen<sup>1</sup>, Philippe Grosjean<sup>2</sup> and Michel Jangoux<sup>2,3</sup>**

<sup>1</sup> Marine Ecology Group, Department of Biological Sciences, Macquarie University, NSW 2019

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<sup>3</sup> Marine Biology Laboratory, Université Libre de Bruxelles, 1050-Bruxelles, Belgium. mjangoux@ulb.ac.be

**Population structure, growth and mortality of the echinoid *Tripneustes gratilla* (Echinodermata) on the barrier reef off Toliara (Madagascar)**

The population dynamics of *Tripneustes gratilla* inhabiting the outer reef flat of the barrier reef off Toliara (Madagascar) was investigated during three consecutive years. Parameters such as recruitment frequency and rate, growth rate and lifespan were estimated from size-frequency data. Results indicated annual recruitment pulses with rates ranging from 20% to 37% of the population from one year to another. Timing of recruitment was suggested to be correlated with the reproductive cycle of the species, temperature and food availability. New recruits played a considerable role in shaping the population structure since population size was observed to track recruitment levels. Cohort separation method, applied to size-frequency data, was used to estimate growth rate. Growth was described using Richard's function fitted to mean size of new recruit cohorts. Population of *T. gratilla* showed rapid growth rate where the asymptotic size was reached 10 months after settlement. Growth profiles were also assessed from laboratory reared individuals either separately or grouped. Similar growth patterns to that observed from population in the field were found. Survivorship was estimated from size-frequency data for populations resulting from two consecutive annual recruitment events. Observed annual mortality rates ranged from 56 % to 59 % inferring that individuals of the outer reef flat's population have a short life-history strategy. The observed rapid growth rate and density-independent mortality confirmed such strategy. A short-term comparison was done with another population living in more sheltered habitat and its population structure revealed secondary life-history strategies tending to longer lifespan. The life-history strategy developed by this species on the outer reef slope was therefore suggested to be due to the high water movement characteristic of the outer reef slope.

**Verrier, Frances<sup>1</sup>, Deb Bass<sup>2</sup>, David Haynes<sup>1</sup>, Carol Honchin<sup>1</sup>, Jacqui Goonrey<sup>3</sup>, Hugh Yorkston<sup>1</sup>**

<sup>1</sup> Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, 4810

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<sup>3</sup> Department of Environment and Heritage, GPO Box 787, Canberra 2601

**Implementing the reef water quality protection plan: An end-of-catchment perspective**

In December 2003, the Australian and Queensland governments launched the Reef Water Quality Protection Plan (the Reef Plan), which aims to "halt and reverse the decline in water quality entering the Reef within 10 years". The Reef Plan identifies 9 main strategies and 65 actions to address declining water quality from diffuse sources of pollution, mainly runoff from agricultural lands. The Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for implementing a long-term water quality and ecosystem-health monitoring programme to track the effectiveness of the Reef Plan. This monitoring programme monitors the concentrations of nutrients, sediments and pesticides at priority river mouths along the Great Barrier coast. The programme also assesses intertidal seagrass and inshore coral reef ecosystems within the Great Barrier Reef Marine Park (Marine Park), and mud crabs (*Scylla serrata*) for pesticide residues. Information gathered from this monitoring programme, together with previous research is informing the development of ecosystem health guidelines for the protection of the Marine Park. These guidelines will determine acceptable water quality and ecosystem status. They will be made available to regional natural resource managers, local government and the community through regional Water Quality Improvement Plans, which are funded under the Federal Government's Coastal Catchment Initiative.

## **von Baumgarten, Patricia**

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### **The Amazing Adventures of Gavin, a Leafy Seadragon: An animated film for marine education**

This paper discusses an alternative tool for marine education: animated short film. It describes the reasons and experience of establishing such an approach in South Australia.

The *Amazing Adventures of Gavin, a Leafy Seadragon* is a 16 minutes animated short film that has been recently launched by the South Australian Minister for Environment and Conservation. The film is a Coast Protection Board initiative that had the support of the Department for Environment and Heritage, South Australian Film Corporation, Marine Discovery Centre and Waterline Productions. The partners came together more than two years ago to promote South Australian marine species and habitats. The film was made for 8-12 years old children. However, it can be used as a tool to educate and inform the general public. The film is a product of the hard work of many artists, scientists and educators, and a good example of government and non-government partnership for educational purposes, and will be distributed free of charge for education and information purposes.

The leafy seadragon is South Australia's marine emblem and, together with other species of the Syngnathidae family, a protected species under the *Fisheries Act 1982*. The film showcases the different types of habitats found in South Australia's marine bioregions, as Gavin finds his way home after being lost during a storm. On his way to Rapid Bay jetty, Gavin meets other South Australian marine bio-icons such as the cuttlefish, Goolwa cockles, Southern Right Whales and Australian Sealion. The film also introduces the less known invertebrates. As Gavin meanders through mangroves and kelp forests, he matures and becomes an adult ready to breed. The film is also about a journey of self discovery.

The Department for Environment and Heritage is now working in partnership with the Marine Discovery Centre to produce educational material that will provide more detailed information about the scientific aspects of the film to be used together with the film by educators.

The presentation of the paper includes the screening of the film.

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## **Wachenfeld, David**

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### **Science to support natural resource management in the Great Barrier Reef**

The Great Barrier Reef Marine Park is one of the world's largest marine protected areas and one of the most diverse and healthy tropical marine ecosystems. It provides the ecological goods and services that underpin a \$5.1b regional tourism industry, a \$610m recreational sector and a \$150m fishing industry. It is under pressure from a wide variety of sources, including fishing, land use practices, climate change, tourism, and shipping. This combination of size, diversity, value and pressure creates challenges for management and science in the Marine Park. The Great Barrier Reef Marine Park Authority bases its management decisions on the best available information. This means that it has a heavy reliance on information derived from science, however, the Authority is not a research agency so the delivery of its research needs comes through partnerships. Active partnerships between scientists and managers through planning, implementation, analysis, reporting and adaptation of science is the most productive way to deliver on the ground management outcomes informed by top quality science. Especially given the changing nature of the social and ecological world of the Great Barrier Reef under climate change, targeted, management driven research is critical to provide information for ongoing management. Specifically, this paper will focus on the science/ management interface during the development and implementation of the Great Barrier Reef Marine Park Zoning Plan. This will be used as a case study to examine successful strategies for how science and management can work together.



**Wasno, Bob M<sup>1</sup>, Stephen A Bortone<sup>2</sup> and Tomma Kay Barnes<sup>3</sup>**

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<sup>3</sup> NOVA Southeastern University Oceanographic Center, 8000 North Ocean Drive, Dania Beach, FL 33004, USA. tomma@nova.edu

**Development of an optimum release strategy for Red Drum, *Sciaenops ocellatus*, in a southwest Florida estuary**

In a cooperative effort between local volunteers, the Sanibel-Captiva Conservation Foundation's Marine Laboratory and the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute, an optimum release strategy has been determined for red drum (fish species *Sciaenops ocellatus*, family Sciaenidae) in the Charlotte Harbor (southwest Florida, USA) estuarine ecosystem. REDstart is a marine aquaculture program, organized by Florida Sea Grant College and operated by a network of volunteers, that receives economically important fish as post larvae (20-25 mm TL) and raises them to a size that will have a high survival rate when stocked in the wild (i.e., 150 - 250 mm TL). Scientists from the Sanibel-Captiva Conservation Foundation Marine Laboratory have begun evaluating the use of these hatchery-reared fish to determine their optimum or preferred habitat. With the identification of specific habitat requirements, then management and restoration activities will have a higher probability of success when attempting to maintain or increase this preferred recreational fish species. To date, over 300 sites have been sampled for red drum and specific habitat measures have been recorded to help determine specific habitat requirements for the species. In addition, over 3000 juvenile red drum have been tagged and released at sites deemed optimal habitat as based on field sampling data.

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**Waycott, Michelle<sup>1</sup>, Kathryn McMahon<sup>1,2</sup> and Ainsley Calladine<sup>1</sup>**

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**Lineage hybridisation in the seagrass *Halophila ovalis*: speciation or biogeography**

The seagrass *Halophila ovalis*, has a very broad distribution, across the Indo-West Pacific in both tropical and temperate waters. This species is taxonomically problematic due to significant phenotypic plasticity observed, typically across different locations, but sometimes within locations. In addition, this species tolerates a wide range of habitats from deepwater > 20 m, to intertidal and even estuarine conditions. *Halophila ovalis* also is one of the preferred grazing species of dugong and is known to have a rapid recovery following intense grazing events in Moreton Bay, Qld. We have investigated the genetic diversity of *Halophila ovalis* and suggest that phenotypic plasticity may be associated with isolation and reconnection of *Halophila* evolutionary lineages during periods of habitat restriction over geological times scales. Evidence of these processes is based upon the genetic structure of *Halophila ovalis* populations where two of the major clades evident within the species co-occur, such as in Moreton Bay. Nuclear DNA diversity of the internal transcribed spacers of rDNA support the hybridization of the different clades and even provide evidence of extant hybrids. We use this data to develop a workable species concept for this taxonomic entity and infer the recent evolutionary history on the east coast of Australia for this seagrass species.



## **Waycott , Michelle<sup>1</sup>**

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### **Future trends for seagrasses globally**

Seagrasses, marine flowering plants, are an old evolutionary lineage which are today under stress from with rapid environmental changes as a result of coastal human population pressures. Seagrasses provide key ecological services, including organic carbon production and export, nutrient cycling and sediment stabilization, and trophic transfers to adjacent habitats in both tropical and temperate regions. Seagrasses respond quickly to anthropogenic influences in coastal ecosystems, with large scale losses, and a few gains, reported worldwide. Multiple stressors, including sediment and nutrient runoff, physical disturbance, invasive species, disease, commercial fishing practices, aquaculture, overgrazing and algal blooms, cause seagrass declines at scales of m<sup>2</sup> to 100s of km<sup>2</sup>. Reported seagrass losses have led to increased awareness of the need for seagrass habitats to be maintained. However, the rapid increase in seagrass science, has not translated into public awareness of seagrasses and their status, which has significantly lagged behind the attention paid to other coastal ecosystems such as salt marshes, mangroves and corals. To preserve seagrasses and their ecological services, there is a critical need for a targeted global conservation effort that includes a reduction of watershed nutrient and sediment inputs to these habitats. This review is based on a National Center for Ecological Analysis and Synthesis (USA) Working Group on Global seagrass trajectories lead by R. J. Orth and W. C. Dennison.

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## **Webster, Ian<sup>1</sup>, Helen Bostock<sup>2</sup>, Lynda Radke<sup>2</sup>, and Barbara Robson<sup>1</sup>**

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### **Material fluxes and storage in the Fitzroy Estuary and Keppel Bay – a highly episodic system in dry, tropical Australia**

The Fitzroy River delivers large loads of sediments and nutrients to the lagoon of the Great Barrier Reef (GBR). A major aim of our project on the hydrodynamics, fine-sediment dynamics, and biogeochemistry of the Fitzroy Estuary and adjacent Keppel Bay was to assess how these water bodies mediate the delivery of riverine material to the lagoon. Seasonal and inter-annual variability in discharge poses significant challenges for studies of dynamics and material budgets. I will present an overview of variability in the Fitzroy system ranging from tidal to inter-annual timescales particularly as it impacts transport and storage of dissolved and particulate nutrients, organic matter and fine sediments. Material is delivered during relatively short-lived flows in summer. Due to the high inter-annual variability in run-off, the delivery of material to the estuary varies by a factor of more than 100. Redistribution occurs during the rest of the year mainly by tidal currents, but virtually all the dispersal of fine sediments occurs during spring tides only. A combined measurement and modelling approach was chosen to address this issue and to estimate the role that the estuary and Keppel Bay play in mediating the delivery of nutrients and sediments to the GBR Lagoon. Here, we compare estimates of nutrient and sediment delivery derived using measurements of sedimentation with those determined using a dynamical modelling approach. The direct measurement and modelling approaches are consistent in that both suggest a large proportion (~1/3) of nutrients and sediments delivered by the Fitzroy River to be stored within the estuary-bay system when considered over the long term. However, the modelling demonstrates that the proportion of riverine material delivered to the lagoon to be highly variable with dry years predicted to show a net input of nutrients from further offshore.

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**Abrolhos Islands Research Institute: A major new marine research facility in Western Australia**

Located at Latitude 28-29°S off the central west coast of Western Australia, the Houtman Abrolhos Islands are one of the most fascinating marine areas of the State. The marine system is the highest latitude coral reef in the Indian Ocean, where tropical corals intermingle with a diverse mixture of temperate algae and Western Australian endemic species. The high latitude coral system is made possible by the warm waters of the south flowing Leeuwin Current which is strongest in winter. The Abrolhos is the centre of the fishery for the western rock lobster, the most valuable single species fishery in Australia and the largest rock lobster fishery in the world. There are also important scallop and scalefish fisheries and developing aquaculture and tourism industries. The Abrolhos was the first, and is still the largest, Fish Habitat Protection Area in Western Australia.

The Western Australian Department of Fisheries has recently developed the Abrolhos Islands Research Institute to conduct a wide range of marine and terrestrial research in the islands. Core fisheries research will be enhanced with environmental studies to understand the systems which support these valuable fisheries. AIRI has two primary facilities: the Saville Kent laboratory at Rat Island which sleeps up to 20 researchers, and has a new kitchen, dining area, laboratories, jetty and access to boats, and a modern new laboratory at Separation Point, Geraldton, which has 10 work stations. Separation Point offers opportunities to study the inshore, cooler water environments and compare the inshore system with the Abrolhos.

Fisheries welcomes interest from interstate and overseas scientists who wish to use the AIRI facilities.

**Whalan, S<sup>1,2</sup>, D Jerry<sup>1,2</sup>, C Battershill<sup>2,3</sup> and R de Nys<sup>1,2</sup>**

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<sup>1</sup> School of Marine Biology & Aquaculture, James Cook University, Townsville, QLD, Australia<sup>2</sup> AIMS @JCU Tropical Aquaculture, James Cook University, Townsville, QLD, Australia<sup>3</sup> Australian Institute of Marine Science, Townsville, QLD, Australia.**Larval dispersal behaviours and population genetic structure of *Rhopaloeides odorabile***

Elucidating patterns of larval dispersal and recruitment of marine organisms is fundamental in guiding our understanding of adult distributions. This is particularly relevant for sponges that exhibit a mobile larval phase followed by a sedentary adult life. Indirect estimates of larval dispersal using molecular markers have not routinely been applied to sponges, but for those few species where such data exists larval dispersal has been inferred to be restricted and to contribute to population subdivision for these taxa. There is a conspicuous absence of data, however, that links quantitative assessments of larval behaviours to their corresponding population genetic structures. This study collected data on the larval dispersal behaviours and population genetic structure for the sponge *Rhopaloeides odorabile*.

Larval dispersal behaviours were assessed by experiments on swimming speeds, larval longevity, and vertical orientation within the water column over time. Settlement preferences were also determined. Population genetic structure was elucidated using mtDNA markers on samples collected to assess genetic structure at spatial scales ranging from metres to hundreds of kilometres.

*Rhopaloeides odorabile* broods larvae, which have the ability to control their vertical position within the water column and prefer to occupy surface waters before returning to the benthos approximately 24 hours post-release. Low levels of genetic differentiation amongst samples indicate that minimal population subdivision exists and suggests sufficient genetic exchange is occurring to prevent genetic divergence. The ability of larvae to utilise wind driven surface currents for approximately 24 hours contributes to their ability to disperse over sufficient distances to promote genetic connectivity among reefs separated by tens of kilometres. This is the first study on sponges, within the Great Barrier Reef, that clearly demonstrates the influence of larval behaviours on population genetic structure.

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**Uncovering the molecular basis of variation in settlement/metamorphosis in the abalone *Haliotis asinina***

In marine invertebrates, pelagic larvae must successfully settle on the benthos and metamorphose in response to an inductive cue if they are to be recruited into the adult population. Interestingly, selection on this stage appears to favour the maintenance of variability, as evidenced by observations of variation in larval settlement specificity and timing in a wide variety of benthic marine invertebrates. Larvae of the tropical abalone *Haliotis asinina* show species-specific responses to induction by coralline algae, while at the same time demonstrating intrapopulation variations in settlement response that almost certainly reflect an underlying molecular basis. By using microarray experiments to analyse global gene expression in *H. asinina* larvae and postlarvae sampled from 66 to 146 hours after fertilization (haf), we have identified candidate genes potentially involved in competency, settlement and metamorphosis. Our results reveal that there are dramatic changes in global gene expression associated both with attaining the state of competency and responding to an inductive cue. Genes that are effected can be clustered in (1) genes up/down-regulated through development, (2) genes sharply up/down-regulated between 90haf and 109haf, suggesting an involvement in competence, and (3) genes up/down-regulated after induction, potentially relating to the events of metamorphosis. To investigate the generation and maintenance of variability in settlement and metamorphosis in *H. asinina*, we will utilize the genes identified in this study in comparisons of induction response across families and populations of larval *H. asinina*.

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<sup>1</sup> ARC Centre of Excellence for Autonomous Systems, University of Sydney, Sydney, NSW 2006<sup>2</sup> Australian Institute for Marine Sciences, Fremantle, WA 6160 m.rees@aims.gov.au**Autonomous underwater vehicle surveying on the north west continental shelf of Australia**

This paper will describe our current work in the deployment of an Autonomous Underwater Vehicle used for surveying marine habitats. Data collected using this vehicle is being used to develop algorithms and methods capable of modelling natural marine environments. The long term goals of this work are to provide a set of tools to support research into the ecologically sustainable use and protection of our marine resources. The University of Sydney's Australian Centre for Field Robotics (ACFR), part of the ARC Centre of Excellence for Autonomous Systems, has a research class Autonomous Underwater Vehicle (AUV) capable of undertaking high resolution survey work (see **Error! Reference source not found.**). This experimental platform is a modified version of a mid-size robotic vehicle called Seabed built at the Woods Hole Oceanographic Institution. The submersible is equipped with a mechanically scanned low frequency terrain-aiding sonar, a depth sensor, Doppler Velocity Log (DVL) including a compass with integrated roll and pitch sensors, Ultra Short Baseline Acoustic Positioning System (USBL), forward looking obstacle avoidance sonar, a conductivity/temperature sensor and a high resolution stereo camera pair and strobes. This vehicle has recently returned from deployment on board the AIMS Research Vessel Cape Ferguson. A series of trials were undertaken to assess benthic habitats off the Ningaloo Reef, WA. This paper will describe the results of these trials including a comparison of the data collected with the AUV and that collected with towed video surveys in the same region.

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<sup>1</sup> Marine Ecology Group, School of Biological Sciences, Macquarie University, Sydney 2109<sup>2</sup> School of Life and Environmental Science, Deakin University, Warrnambool 3280 craig.styan@deakin.edu.au<sup>3</sup> Dept. of Marine Ecology, Göteborg University, Tjärnö Marine Biological Laboratory, Strömstad 45296, Sweden jon.havenhand@tmbl.gu.se**Fertilising eggs is easier than we thought: We've just been measuring the wrong thing**

It's widely recognised that many marine invertebrates release gametes freely into the water column, where fertilisation takes place. For the last 20 years, research in this field has alternately suggested that sperm are rapidly diluted in natural spawning events so that only very low percentages of eggs are ever likely to be fertilised, and (more recently) that sperm-limitation is in fact rare and that too many sperm may be a frequent problem in free-spawners. These observations led to a proliferation of papers on sperm-limitation, spawning behaviours, polyspermy, and adaptations of eggs to maximise (or mediate) fertilisation success.

Studies that measure fertilisation success typically do so by estimating the proportions of eggs/embryos that are dividing within the first minutes or hours after mixing gametes. This practice is commonplace, even though it is well-established that polyspermic eggs will complete the first few cell cycles before development is arrested. Thus, initiation of cell division is not a reliable indicator of successful mono-spermic fertilisation. Here we summarise the results of a comprehensive series of fertilisation kinetics experiments that compared fertilisation success in two species of sea urchins in a series of sperm concentrations. We measured fertilisation success as the number of developing embryos during the first hours post-fertilisation and as the number of actively swimming larvae 24h later. Sperm concentrations that yielded the maximum number of larvae were approximately an order of magnitude lower than those that yielded the maximum number of developing early embryos. If this phenomenon is widespread, the many reports of sperm-limited fertilisation success in marine invertebrates may be in error. The reasons for, and implications of, our findings will be discussed.

**York, Paul<sup>1A</sup>, Brendan Kelaher<sup>1B</sup> and David Booth<sup>1C</sup>**

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<sup>1</sup> Department of Environmental Sciences, University of Technology, Sydney, PO Box 123 Broadway 2007 NSW<sup>B</sup> Brendan.Kelaher@uts.edu.au, C David.Booth@uts.edu.au**Trophic responses to sustained nutrient increases in seagrass beds: Do ecological models accurately predict food chain dynamics?**

Seagrass beds are ecologically and economically important habitats that are in decline the world over. Many major estuaries in NSW have lost as much as 50% of their seagrass beds in the last 60 years. Increased nutrient loads have been highlighted as a major cause of seagrass decline, as they can significantly increase the biomass of epiphytic algae which in turn reduces light available for seagrass photosynthesis. Nevertheless, these epiphytic algal assemblages also play an important role in seagrass ecosystems because they sustain a complex food web. An important link in this web is a four-level food chain consisting of epiphytic algae, grazing invertebrates, juvenile fishes and larger piscivorous fishes. We are currently determining the relationship between nutrients and this trophic chain by comparing biomasses of epiphytes, grazing invertebrates and fish in nutrient enriched versus more natural seagrass meadows in Broken Bay and Brisbane Waters. Specifically we are testing hypotheses derived from resource-consumer models with either (i) ratio-dependent or (ii) resource-dependent functional responses. Each of these models makes different predictions about the trophic response at each level when a system is exposed to sustained increases of bottom up forcing such as nutrients. This seminar will discuss some of our preliminary results as well as some of the possible implications of these outcomes for effective estuarine management.