Oral abstracts

01 The evolution of ASFB – reflections on 35 years of membership

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The Australian Society for Fish Biology had as its inception early meetings organised by the ichthyological staff of the Australian Museum and New South Fisheries intended as a mechanism for sharing advances in fish related science and the development of initiatives leading to the better understanding of the diversity and biology of Australia's ichthyofauna. Although the enthusiasm and casual nature of this now incorporated body has remained, the various focuses of the Society and its annual conferences have changed over the decades in line with the evolving directions of the institutions and authorities charged with addressing fish studies and management, as well as the transient influences of the many characters that have been the Society's driving force.

02 Struggling with stochasticity: metaphors, narratives and evidence

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Rather than bore you with my Greatest Decisive Datasets (I don't have any) or my Most Influential Policy Document (an oxymoron), I'm taking the opportunity to revisit the Big Idea that excited me as a PhD student in the early 1980s: stochastic, 'non-equilibrial' ecosystems. Both lotic and lentic systems seem prime examples, but have we developed appropriate ways of thinking about them – both scientifically and culturally? In reviewing our progress, I will argue that we reach for metaphors rather more than we'd like to think we do. While this can generate novelty, it can constrain the narratives we spin and the types of evidence we pursue. I will illustrate by focussing on resilience and regime shifts because they are interesting ideas and have become prominent themes in our narratives about inland waters. Gathering evidence about these can be problematic. So have the metaphors that generated these ideas in the first place have outlived their usefulness? I have no pat answers, but I hope to reinvigorate our engagement with big ideas and stochastic systems, and I hope to reinvigorate some of you too.

03 Adaptive management: good in theory, hard in practice

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Adaptive management is a systematic process for improving management by 'learning by doing'. Actions are adjusted in response to feedback on the progress towards the desired outcomes or management objectives. Adaptive management is practised by implementing and then reviewing policy, or by predicting the outcomes of management activities and then strategically monitoring the actual outcomes to gather information to improve future management. While the theory of adaptive management has become popular in natural resource management, there are scientific limitations, social issues and institutional constraints to its practical application.

The Victorian Waterway Management Program has undergone a process of reviewing and updating its state policy and is in the process of updating regional planning strategies. The new Victorian Waterway Management Strategy (2013) outlines an improved approach to the way the program undertakes adaptive management. The strength of the improved approach is the use of logic models, based on best available knowledge, to define the relationships (known or assumed) between management outputs, management outcomes and long-term resource condition outcomes. The logic models are used to target monitoring efforts and prioritise research into knowledge gaps or relationships with uncertain evidence.

Despite the improvements to the adaptive management approach, challenges remain. Monitoring costs are prohibitive and gaining landholder support for long-term monitoring of management outcomes on private land has proven to be difficult. There is little scientific knowledge on how much management activity needs to occur to generate specific environmental outcomes. Additionally, separating the influence on environmental change of extreme events (including droughts, flood and fire) from management actions is complex.

Oral abstracts

04 Seeing with sound – the behaviour and movements of fish in estuaries

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Underwater video techniques have progressed rapidly over the past ten years, and are now used in a diverse range of habitats from small creeks to the ocean depths. A limitation of underwater video cameras is they rely on high levels of water clarity and require artificial lighting if used in low light conditions. In systems such as estuaries, turbidity levels often restrict the use of conventional video. Acoustic cameras (DIDSON) overcome this problem as they rely on sound to produce near video, flowing footage. Our current research is directed in two areas which firstly include the role of light on key ecological functions such predator-prey interactions in estuaries. Artificial light was found to have a strong influence on trophic interactions around anthropogenic structure. A separate study revealed the distribution and behaviour of estuarine predators and prey were related to diel cycles. Larger fish were more active during the day with some moving into shallow habitats at night. This resulted in increased schooling behaviour of baitfish. Secondly, we are using the DIDSON to gain information on the connectivity of estuaries and the coast. Placing the DIDSON at the mouth of estuaries we have been able to enumerate the numbers of fish passing through during tidal phases. We have observed over 4000 fish passing during a single tide, highlighting the potential dynamic nature of estuarine fish populations.

05 Use of a DIDSON acoustic camera improves fishway assessment results and understanding of fish migratory behaviour

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The assessment of fishways is primarily performed to determine the effectiveness and for identifying factors that limit the passage of fish beyond man-made barriers. Traditional methodologies rely on capturing fish that successfully ascend the fishway compared with the species and size classes of those that are attempting to ascend. This approach relies on the ability to representatively sample fish and the assumption that methods such as trapping do not significantly modify their behaviours. Other methodologies utilise transponder or telemetry tagged fish that are detected within or near the fishway. The requirement to capture and tag a diversity of fish species can negatively impact on a meaningful result for movement through the fishway. Both methodologies however are often unable to resolve many aspects of fish behaviour. Dual-Frequency Identification Sonar (DIDSON) is a relatively new tool for viewing real time behaviour of fish within and around fishways and can reveal many aspects that may affect the overall success of a fishway. This study presents the findings of an assessment program using the combined approach of traditional trapping and a DIDSON acoustic camera to assess efficiency of a new fishway design. Results indicate not only the strategies utilised by fish to successfully move through a fishway but also behavioural responses to external stimuli, diel patterns of movement and use of the fishway structure as habitat. Use of this technology has the potential to optimise fishway operation and achieve more successful fishway designs by revealing fish behavioural responses that would not otherwise be obtained.

06 Using underwater video to study the breeding behaviour of Murray cod (Maccullochella peelii) in the Border Rivers region, New South Wales and Queensland

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Murray cod (Maccullochella peelii) is an icon of the Murray-Darling River System (MDRS). There was a significant decline in the abundance of Murray cod throughout the late 1800s and 1900s, and it is now listed as threatened by the Commonwealth. Whilst, Murray cod stocks have improved throughout parts the MDRS, many aspects of its biology remains poorly understood. The aim of this project is to observe and describe the breeding behaviour of Murray cod in the wild using underwater video techniques. Murray cod were monitored over two breeding seasons (2011 and 2012) in Glen Lyon Dam and the Dumaresq River in the Border Rivers region of NSW and Qld. Aggregation and site selection commenced each year in Glen Lyon Dam in mid-August, with spawning taking place in late August - early September. Nest sites and eggs were also observed in the river over this same period. Murray cod males were observed selecting nesting sites, pairing, spawning and caring for eggs and larvae. From beginning to end the process took upwards of 20+ days. Nest sites were located on hard substrate and mainly underneath rocks in the dam, whilst in the river they were on cobbles in caves along undercut riverbanks. A second round of spawning in late September – early October was observed in the dam but not in the river. Underwater video has provided a valuable insight into the breeding behaviour of Murray cod. The results have already started to feed back into the wider management of the species.

Oral abstracts

07 Conceptualizing the feeding and prey handling sequences of a muraenid

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Video imagery has facilitated detailed examination of high speed animal behaviors including prey capture and handling. We captured aquaria-based video footage of Gymnothorax polyuranodon (f. Muraenidae), a species for which feeding behavior would be difficult to obtain under field conditions. This predator exhibits multiple feeding and prey handling modes when feeding on large prey items as has been previously described in Anguilliform fishes. However, video review demonstrated that in this case feeding sequences were frequently far more complex than has been previously realized. We were able to analyse these complex sequences by breaking them down into hierarchical arrangements of simple commonly-observed behaviours, or 'motifs'. Statistical analysis of the frequency and ordering of different motif sequences allowed us to build an understanding of prey capture and handling strategy.

08 Utility of underwater video for understanding fish swimming and foraging behaviour

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Field-based observations of fish behaviour are critical for understanding how they respond to habitat variation in the wild. Our capacity to record in situ behavioural observations of fishes in marine environments has grown over the past six decades with the development of modern SCUBA equipment. Recent advances in underwater video technology and affordability is now set to provide a similar revolution, by providing a novel means for recording and analysing how fish swim and forage within their aquatic environments. We present several case studies in which we aimed to measure the utility of underwater video for recording the behavioural response of fishes to changes in their marine environment (e.g., wave energy, prey availability). Our findings reveal that video can provide unique insights into the drivers of fish behaviour, but in some cases, direct manual recordings by human observers provided an equally effective and more efficient mode of data collection. Consequently, researchers should carefully consider the pros and cons of each approach relative to their study question when deciding which form of technology to apply in an analysis of fish swimming and foraging behaviour.

09 Feeding behaviour of Murray River crayfish *(Euastacus armatus)* revealed using underwater video cameras in an upland river

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Crustaceans are regularly identified as ecosystem engineers, performing important functions in nutrient pathways and recycling. Within the Murray-Darling Basin (MDB), Murray River crayfish may have been keystone species within nutrient pathways, yet a suite of threatening processes has greatly reduced both the distribution and abundance of this species. We employed unbaited underwater video cameras within a section of the Goodradigbee River (south-eastern NSW) to explore the social and feeding behaviour of Murray River crayfish on patches of detritus in back-eddies of the main channel. Underwater video cameras provided fine-scale resolution of feeding behaviour and revealed complex social interactions among Murray River crayfish using this spatially and temporally restricted food resource. We suggest future lines of enquiry to further understand the role of Murray River crayfish in nutrient cycling in river systems.

Oral abstracts

10 Exploring the spatial structure of free-ranging fish groups using digital imaging technique: a practical example with a shoaling drift-feeding fish *(Galaxias anomalus)*

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Group-living is widespread in fish, and mono- or multi-specific assemblages can be found in a variety of environmental contexts. In streams, drift-feeding fish often form shoals. They inhabit dynamic and heterogenous three-dimensional environments, where micro-scale hydraulic features and food patchiness make spatial positioning critical for individual fitness. In this context, the spatial structure displayed by such groups is likely to have high ecological significance as it would reflect mechanisms underlying intra-specific competition and resource distribution. However, shoaling fish display complex dynamics, and the accurate description of such systems is a significant technical challenge in terms of collecting and analysing data. Here, we used a digital imaging technique (VidSync) to manually collect behavioural and spatial data from each member of the shoal, in 3-D, at a high spatio-temporal level of resolution. We developed tools to study the statistical property of space-use of each individual, enabling the quantification of key features of the spatial structure of the shoal. We studied links between individual space-use strategy, feeding and social behaviour in order to investigate how the spatial structure of the shoal could be related to its social organisation. This study was carried out on two free-ranging shoals of juvenile drift-feeding fish (Galaxias anomalus), from the same stream but inhabiting slightly different environments. Results show strong differences in the structure and organisation of the two shoals, suggesting that shoals' structures are plastic and context-dependent. Such analysis could therefore be used to provide new insights on the ecological function of group-living in fish.

11 Hydrological connectivity and the composition of aquatic and floodplain plant communities in the southern Murray-Darling Basin

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River regulation has altered hydrological connectivity characteristics throughout the Murray-Darling Basin. These alterations are likely to have affected the hydrochory (water dispersal) patterns for many plant species. It has been hypothesised that increased connectivity leads to the homogenisation of aquatic and floodplain plant assemblages by facilitating the dispersal of propagules. Equally it has also been suggested that decreased connectivity may homogenise assemblages by reducing the spatial and temporal diversity of habitats. We looked at the effects of decreased and increased connectivity on presence/absence of plant species from wetland and floodplain sites obtained from seven geographically separated locations in the southern MDB (Barmah Forest, Gunbower Forest, Hattah Lakes, Great Darling Anabranch, Lindsay-Mulcra-Wallpolla Island, Chowilla Floodplain and the Lower Lakes). We compared the composition of aquatic and floodplain plant communities both within and between locations during low connectivity (the recent drought, 2000-10) and increased connectivity (post the 2010-11 floods).
Analysis of the data indicated a high degree of uniqueness of plant species to individual sites within locations during both low and increased hydrological connectivity. Multivariate analysis demonstrated that at all locations community composition differed between periods of low and increased connectivity and that locations were distinct to each other. However, in rejection of our hypothesis, there was no consistent trend in increased or decreased homogeneity of plant assemblages with increased connectivity. Our results indicate that the observed heterogeneity of floodplain and wetland plant communities across both periods of connectivity is influenced by local factors within sites and /or dispersal limitations between sites.

12 Biodiversity benefits of erosion control plantings in the lakes Alexandrina and Albert, lower River Murray, South Australia

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Lakeshore erosion is a widespread problem in lakes Alexandrina and Albert. One control option used by land managers is to selectively plant linear stands of Schoenoplectus validus (at depths of 50–80 cm) along shorelines in order to create a "breakwater". Data from The Living Murray vegetation condition monitoring showed that at shorelines where S. validus was present (naturally occurring and planted) there was often a diverse wetland plant community compared to shorelines without S. validus, which tended to be dominated by Typha domingensis or Phragmites australis or devoid of vegetation.
The aim of this study was to compare the plant community at planted shorelines and an adjacent unplanted control shoreline to determine whether planting S. validus has benefits for the aquatic plant community. Vegetation surveys were undertaken in autumn 2013. At three out of four shorelines that were planted between 2006 and 2007 there was a higher abundance and greater species richness of wetland species compared to the control shorelines. At two of the three shorelines planted more recently (2012 and 2013) submergent species were also present but absent at the control shorelines. Results showed that planting S. validus has benefits other than erosion control. Planting S. validus can facilitate the establishment of wetland plant communities on the shorelines of lakes Alexandrina and Albert in areas that would be otherwise unfavourable. Furthermore, diverse restoration plantings are not required to establish wetland vegetation and revegetation efforts can be directed to planting a single species.

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13 The resilience of aquatic plants to wet season flood disturbance and dry season succession in the Daly River, tropical Australia

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Wet season floods in the Daly River are an annual disturbance, of varying magnitudes, when river depths can exceed 10 m and current speeds exceed 1 m/s. During the wet season, shear stress and drag forces, as well as substrate loss, remove benthic algae and macrophytes from the riverbed. The standing stock of 6 groups of aquatic plants was determined over a 3.3 km reach, comprising 2 pools and 2 runs, during the dry season in July, September and November when river flow was groundwater-fed. These groups were benthic microalgae, benthic filamentous macroalgae (notably Spirogyra), Characeae, Vallisneria nana, Schoenoplexus and phytoplankton, though the latter two groups were always a minor proportion of the total standing stock. A preliminary survey in June revealed the presence of benthic algae, while macrophytes were not observed though remnants of Vallisneria and Schoenoplexus would have been present. The total standing stock, measured as chlorophyll a, increased over the dry season, approximately doubling every 2 months. Initially, benthic microalgae and filamentous macroalgae were the dominant plant. In the mid-dry season, the dominant plant shifted to Characeae, and then to Vallisneria at the end of the 'dry'. This succession in aquatic plants and their contribution to the total standing crop is probably underpinned by the rates of algal colonisation, relative plant growth rates and carrying capacity, and the resilience of Vallisneria and Schoenoplexus to wet season flood disturbance.

14 Contrasting allelopathic effects of exotic and Australian macrophytes on cyanobacteria and green algae

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The allelopathic effects of three exotic macrophytes, Elodea canadensis, Cabomba caroliniana and Egeria densa, and three native species, Potamogeton crispus, Potamogeton ochreatus and Ceratophyllum demersum, on two species of cyanobacteria,Anabaena variabilis and Synechococcus sp. and a green algal species, Chlorella sp. were tested under laboratory conditions. Experiments were conducted using live material. Allelopathy was considered to have occurred if the growth of the cyanobacterial or algal species was significantly lower in treatments comprising live macrophyte material in comparison to controls (without live material). Both C. caroliniana and E. canadensis exerted significant negative effects on the growth of the target organisms, with the strongest effect exerted by C. caroliniana. The allelopathic effects of the invasive species were higher than those of native macrophytes (except C. demersum). These findings suggest that allelopathy may have an important role in facilitating the success of exotic macrophytes in temperate Australian wetlands.

15 Understorey vegetation: evidence that more natural hydrological history results in more resilient plant communities

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Resilience of arid floodplain ecosystems is measured by the ability of the floodplain to return to a functioning wet phase after a dry phase, and vice versa. We monitored the understorey community of an arid river-floodplain complex that was restored to an ephemeral regime in c. 2005.
Three sites were monitored annually from 2010–2013, from each of three hydrological regime categories: 1) ephemeral, 2) permanent-ephemeral (previously permanently inundated, now ephemeral), 3) permanently inundated. Surveys included wet and dry phases.
Data was analysed using functional groups to detect broad differences among hydrological regime categories and survey years. Species were allocated to functional groups reflecting water requirements, broadly: terrestrial-dry, don't require water-logged soil to germinate, don't tolerate flooding; terrestrial-damp, require water-logged soil to germinate, don't tolerate flooding; amphibious, require water-logged soil to germinate, tolerate or respond to flooding.
Functional group diversity and composition shifted significantly between survey years; terrestrial-dry plants characterised dry phases, terrestrial-damp and amphibious plants characterised the wet phase. The plant community at ephemeral sites showed the greatest response, with a larger proportion of terrestrial-damp and amphibious plants during wet years than permanent-ephemeral or permanent sites; and a larger shift in proportion of functional groups from the wet phase to the dry phase.
Our findings provide evidence that understorey plant communities of arid floodplains are more resilient under 'natural' hydrological management (i.e. ephemeral) than when artificially permanently inundated. The levels of resilience identified in the ephemeral sites may be a useful reference for measuring successful rehabilitation of the system.

Oral abstracts

16 Ecological significance of hydrological connectivity for aquatic plant communities in billabongs

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Hydrological connection can influence floodplain ecosystems by mediating flux of organisms and materials between habitats, by providing a water subsidy and by modifying hydraulic habitat; the relative influence of each of these mechanisms is likely to be modified by the physical character, notably water depth, of individual floodplain habitats. We investigate the role of hydrological connectivity as a driver of patterns in macrophyte communities in billabongs on the MacIntyre River floodplain. Surveys of macrophytes and seed bank germination experiments were carried out in billabongs across a gradient of hydrological connectivity. Results show that water depth influenced both extant and germinant plant communities. Shallow billabongs supported more abundant and diverse plant communities and greater numbers and diversity of germinable seeds in the seed bank. Germination of seeds in all sites was higher when soils were maintained in a waterlogged state than when they were maintained in a submerged state. Thus, the key mechanisms influencing plant abundance in relation to depth are inferred to be availability of waterlogged soil habitat for germination and absence of light limitation for growth. Connectivity did not influence plant or germinable seed abundance, but did influence the number and range of species present in the extant community; this effect did not extend to the germinant community. Accordingly, the study suggests that hydrological connection influences plant communities by providing a cue for germination through the delivery of a resource subsidy and by modifying hydraulic habitat, rather than by facilitating the movement of seed propagules between connected habitats.

17 How much do vegetation growth form, observer bias and data standardisation method affect repeatability of canopy cover estimates and power to detect change?

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Multiple methods exist for monitoring changes in vegetation structure, composition and condition over time with method selection representing a trade-off between precision and sampling effort. Visual estimates of canopy cover are commonly used in vegetation monitoring because they are rapid to apply in the field, but these can vary due to subjectivity (i.e. observer bias), differences in observer perspective between height strata and the precision of sampling area relocation during repeat surveys. We used vegetation survey data from shrub swamps in the Blue Mountains to evaluate the extent of variability in the data from each of these sources and the consequences for power to detect changes in cover over time. We also tested if data standardisation would reduce variability due to observer bias and consequently increase power to detect changes. Between-assessor variability was typically higher than within-assessor variability in scores. While variability in cover estimates differed according to growth form, it did not increase with growth form height as expected. Instead, variability was typically higher for growth forms with high cover and vice versa. Contrary to expectation, data standardisation often amplified the differences in scores between assessors, reducing rather than increasing the power to detect change. Small changes in transect location (i.e. 1m displacement) had little effect on cover scores for abundant growth forms but led to discrepancies in cover estimates for rare and patchily distributed growth forms, reducing the power to detect changes over time. We discuss the implications of our findings with respect to monitoring program design.

18 Restoration under Climate Change: anticipating shifting goalposts

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Climate change is transforming the landscape and with it the priorities for restoration sites and goals. Mediterranean Australia is recognised as one of the most vulnerable regions to the effects of climate change. While restoration has previously focussed on anthropogenic impacts such as eutrophication, in the now drying climate (a 15% decline in rainfall and 55% decline in runoff since 1975 in SW WA), the focus must be on which sites can retain water into the future, and issues such as connectivity become paramount. Climate change has forced us to consider restoration at the landscape scale rather than as individual sites. However, the necessity to mitigate multiple anthropogenic stressors, that reduce the resilience of wetlands to adapt to climate change, is still a major driver. A key element of restoration must now be getting the best predictions of climate change together with anthropogenic impacts, to ensure investment in restoration will provide long-term benefit. This paper outlines the use of spatial risk assessment tools to predict climate change impacts and allow rational prioritisation of restoration sites and projects to maximise biodiversity and resilience.

Oral abstracts

19 Resting metabolism and hypoxia tolerance are conserved across genetically distinct sub-populations of an iconic, tropical Australian teleost *(Lates calcarifer)*

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Extreme temperatures and altered freshwater flow regimes associated with climate change are predicted to cause large-scale fish mortalities in Northern Australia by increasing the frequency and severity of hypoxic episodes. Here, we used the iconic barramundi (Lates calcarifer) as a model species to examine resting oxygen consumption rates (ṀO2) and tolerance to acute hypoxia in five different sub-populations spanning 12° of latitude. Fish were obtained from commercial hatcheries at Gladstone, Townsville, Broome, Karumba and Darwin. Fish were maintained at two temperatures (26°C or 36°C), representing the seasonal thermal range across Australia for this species. Resting ṀO2 was lower at 26°C (mean = 1.46 ± 0.26 mg O2 kg-1 min-1) than at 36°C (mean = 3.10 ± 0.43 mg O2 kg-1 min-1). All populations exhibited a common and clear trend in response to decreasing oxygen tension, with fish maintaining a constant ṀO2 between 100% and 30% saturation, below which ṀO2 exhibited a steep decline. Mean critical oxygen tension ([O2]crit) across all populations was lower at 26°C (15.44 ± 3.20% saturation) than at 36°C (21.07 ± 3.92% saturation). Overall, we found that both hypoxia tolerance and aerobic resting metabolism are conserved across the distribution of barramundi in Australia.

20 Rethinking fisheries management as a combined response to changing climate, habitat and fishing pressure

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Colin Creighton, Chair, Climate Change Adaptation – Marine Biodiversity & Fisheries, FRDC

Under classic fisheries management theory fisheries typically move from "nascent" to "developed" and then to a "sustainably developed" phase with maximum sustainable yield as the goal of management. This classic theory looks principally at fishing pressure. A more recent trend in fisheries management is towards "economically sustainable yield" or maximum economic yield. In tracking progress towards managed sustainability the most commonly used metric is a measure of catch per unit effort [CPUE]. Fisheries managers regard stable CPUE as evidence of "sustainable" fishing. However, for many coastal / nearshore target species, and indeed about 75% of Australia's commercial catch with its estuary dependent lifecycle, fishing effort and catch may not be the major stressor. Loss of habitat, covering both physical habitat loss and declining water quality can be the major stressor on total population size. The other major influence that must be taken into account is Australia's variable and changing climate. This presentation draws heavily on the findings of multiple completed research projects undertaken as part of the FRDC – DCCEE Climate Change Adaptation Initiative and speculates on how we might need to reform our fisheries management systems. The presentation concludes with a suite of criteria for smarter fisheries management that by being centred on stock productivity can incorporate the issues of resource allocation, habitat condition and climate variability / change.

21 A semi-quantitative vulnerability assessment framework applied to northern Australian fisheries

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8. *James Cook University, Townsville, QLD*

Much of the recent efforts in understanding climate change implications in Australia have focused on identifying adaptation options to temper negative consequences. In order to do this effectively and appropriately there must first be a process to identify likely impacts and the inherent capacity for systems to adapt to changes. To achieve this objectively we used the IPCC vulnerability assessment framework for which we developed semi-quantitative criteria, and then applied this to key fisheries species in northern Australia to prioritise species for future action based on climate projections to 2030. Our approach involved several key steps: identifying key species for region-based assessment, compiling comprehensive reviews of each species, compiling relevant spatial-scale climate projections, and applying the framework using published and expert knowledge. We found that species with the highest ecological vulnerability tended to have an estuarine/nearshore habitat preference; poor mobility; reliance on habitat types predicted to be impacted by climate change; low productivity (i.e., slow growth/late maturing/low fecundity); known to be affected by environmental drivers; and were fully or overfished. Highest priority species for future action based on vulnerability and fishery importance were golden snapper, king threadfin, sandfish, black teatfish, tiger prawn, banana prawn, barramundi, white teatfish and mangrove jack. We will present an overview of the semi-quantitative aspects of the framework and focus the talk on how the framework elements inform the identification of climate change adaptation options and their feasibility, and how stakeholders play an important role in this process.

Oral abstracts

22 Snapper spawning timing, migratory dynamics and water temperature: implications of climate change to snapper spawning behavior in south-east Australia

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2. *South Australian Research and Development Institute, Adelaide*
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This presentation provides an overview of the relationships between sea surface temperature (SST), reproductive biology and seasonality of snapper, Pagrus auratus, spawning in south-eastern Australia. Based on this information and forecast modelling of future SST conditions around the south-east Australian coast, predictions of changes to spawning timing and locations are made. Along with this broad regional perspective on potential implications of SST warming to snapper spawning timing and distributions, we also discuss the local example of Port Phillip Bay, invoking data on spawning migratory dynamics from acoustic tagging, and key periods or 'temperature windows' for successful spawning based on daily ageing of 0-age juveniles.

23 Using a mechanistic approach to understand fish distributions along an altitudinal gradient: testing for thermal adaptation

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An understanding of a species' thermal niche is important for predicting how populations may respond to an altered thermal regime; whether from climate change, riparian zone alterations or thermal pollution. Unfortunately, the thermal ecology of Australian freshwater fishes is poorly understood. The objective of this PhD is to improve our understanding of this issue by researching the thermal ecology of two congeneric species; the river blackfish (Gadopsis marmoratus) and the two-spined blackfish (G. bispinosus). Anecdotal reports based on their distribution suggest that G. bispinosus may be cold-adapted while G. marmoratus may be adapted to warmer water. This PhD will attempt to provide a mechanistic explanation for blackfish distribution by determining the thermal niche of these two species.

Sampling of blackfish communities along an altitudinal gradient in two streams revealed that G. bispinosus are the only blackfish species at higher elevations, with both species coexisting in a significant zone of overlap before G. marmoratus become the dominant blackfish species at lower elevations. To test for evidence of thermal adaptation the swimming and respiratory performance of both species was determined at different temperatures using a Ucrit protocol. No significant species-temperature interactions were detected, with maximal performance of both species occurring at 22 degrees. If the two species are adapted to different temperatures, these adaptations do not appear to affect their aerobic swimming capabilities. Additional research on the effect of temperature on other aspects of fitness is needed to determine if thermal adaptation is responsible for the distribution patterns of blackfish species.

24 Fish adaptive radiation in the Australian context

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Historical transitions across the marine-freshwater interface are regarded as key triggers for adaptive radiation of many aquatic clades. Using the Australian terapontid fish family as a model system, we combine molecular genetic techniques with rapidly developing comparative phylogenetic approaches to appraise the macro-ecological evolution of the family. These combined approaches reveal several significant features of the terapontid freshwater adaptive radiation following invasion of freshwaters by marine ancestors. A range of macro-evolutionary processes such as: significantly higher rates of lineage and phenotypic evolution in freshwater clades compared to marine counterparts; significant dietary ecomorphological correlations; and convergent evolution between ecologically similar marine and freshwater species are all revealed by comparative processes. The integration of ecological data with molecular phylogenies (a field in its relative infancy in Australia) has great potential to provide similar insights into the evolutionary history of a range of additional fish families. With its unique biogeographic history, Australian freshwaters may provide a novel testing ground for many of the contemporary theories of evolutionary biology and adaptive radiation.

Oral abstracts

25 Phylogeny, biogeography and evolution of temperate perches *(Percichthyidae)*

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The family Percichthyidae is of great significance in temperate Australian freshwater environments in terms of their ecological influence and their importance to humans. The evolution of the group has resulted in massive morphological and ecological diversification from the small pygmy perches (up to ~10 cm), enigmatic blackfishes and larger perches and cods (up to ~1.8 m). On the whole, members of this family are the largest fish species historically present in most habitats and an unusual biogeographic quirk is they have the highest number of sympatric genera and species of any freshwater fish family in Australia. After a poorly understood taxonomic history, the relationships within and between other families has been clarified. Relationships to other families are not yet fully resolved, but there is a tantalising potentially monophyletic relationship with freshwater perches from North America (Centrarchidae) and Asia (Sinipercidae), along with the marine families Cirrhitidae, Cheilodactylidae, Oplegnathidae, Aplodactylidae, Chironemidae and Enoplosidae. Within the family, South American species (Percichthys, Percilia) are nested within the Australian percichthyids. One major change to the taxonomy of Percichthyidae is the placement of Bass and Estuary Perch back into the genus Percalates and their removal from the family. Percalates appears to be unrelated to any currently recognised family. In this presentation we will explore percichthyid phylogenetic relationships, provide a time scale of their evolution using a biogeographically calibrated molecular clock and provide insights into the evolution of body size and other traits within the family.

26 Insights on species distributions in Sicydiinae gobies using genetic tools

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The Sicydiinae subfamily (Teleostei: Gobioidei) is a diverse group of fish found in tropical insular river systems in the Indo-Pacific area, the Caribbean region and West Africa. They spawn in freshwater and their larvae drift downstream to the sea where they develop, before returning to rivers to grow and reproduce (amphidromous). The geographic distribution patterns of Sicydiinae species are variable and can range from endemic to widely spread across several oceans. Knowledge of how and from where species have emerged to occupy their current geographic ranges is essential for understanding evolution of the group and for developing strategies for their conservation. Phylogenetic studies show that evolutionary history has played a major role in determining species' distribution patterns, but more recent events and dispersal also appear to have shaped present distribution and connectivity patterns of Sicydiinae species in the Indo-Pacific region. We assessed past and present genetic structure of populations of two species that are widely distributed in theCentralWest Pacific and which have similar pelagic larval durations. Spatial analyses of genetic variation in Sicyopus zosterophorum demonstrated strong isolation across the Torres Strait, which was a geologically intermittent land barrier linking Australia to Papua New Guinea. However, this geographical barrier did not seem to affect Smilosicyopus fehlmanni. Historical, demographic and ecological hypotheses need to be tested to explain the different patterns of population structure and distribution between these species. Our findings suggest that strategies to conserve amphidromous fish should consider the presence of cryptic evolutionary lineages to prevent stock depletion.

27 Contrasting patterns of gene flow among aquatic insects in Australian desert waters

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In the Australian arid zone, aquatic habitats exist as isolated waterholes, connected only intermittently by occasional floods. Gene flow among populations of aquatic insects in this boom and bust environment depends, in part, on how well animals can disperse across large and often inhospitable distances. We investigated differences in genetic structuring between seven species of strong or weak-flying dispersers, and hypothesized that strong-flying aquatic insects would exhibit less genetic structuring than weak-flying taxa. We analysed up to 1000 anonymous nuclear markers per individual to identify fine-scale patterns of gene flow among spatiotemporally disconnected populations from the central Australian outback. Results from a preliminary study using single mitochondrial and nuclear DNA sequence markers indicate significant variation among populations of weakly dispersing species, while strong dispersers display minimal spatial genetic subdivision. However, the large volume of anonymous loci used in the current study will provide much more precise estimates of dispersal, gene flow and timing of these events among populations. A better understanding of the phylogeographic structuring of arid Australia's aquatic fauna is a critical step in on-going conservation and management efforts.

Oral abstracts

28 Using whole mitogenome sequencing to inform population structure: the Critically Endangered Speartooth Shark Glyphis glyphis as a case study

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In elasmobranchs, evolutionary rates of mitochondrial genes are low and variation between distinct populations can be hard to detect with the commonly used single mitochondrial gene approach. In this study, we explored the potential of whole mitogenome sequencing for phylogeographic studies in elasmobranchs by focusing on Glyphis glyphis, a rare and Critically Endangered euryhaline shark with presumably low population size and low genetic diversity.
Highly reliable mitogenomic sequences were obtained from 93 sharks sampled in three different rivers using long range PCR and amplicons sequencing with Illumina Miseq. The genetic diversity in G. glyphis was extremely low. Only 19 variable sites were found, distributed across 12 haplotypes. However, this small amount of genetic variation was enough to demonstrate the existence of barriers to gene flows between each population. We will discuss how this approach performed compared to single gene approaches, demonstrating the high potential of mitogenomics for population structure analysis in species with low genetic diversity. We will also briefly comment on the cost-efficiency of our sequencing approach and how it compares to traditional Sanger sequencing.

29 Genetic population structure of black marlin *(Istiompax indica*) within the central Indo-Pacific

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The black marlin, Istiompax indica,is a pelagic species whose distribution ranges throughout the tropical and subtropical waters of the Indo-pacific. The IUCN Red List of Threatened Species defines I. indica as 'data deficient' due to a lack of information on the population structure of this species. For the purpose of resolving the population structure of I. indica 18 polymorphic microsatellite loci were isolated and characterised from Next-Generation sequencing data. The mitochondrial control region and panel of 18 microsatellite loci were used to analyse 205 young-of-the-year black marlin samples collected by non-lethal sampling in catch and release recreational fisheries. The sampling sites comprised five indo-pacific regions (East Indian Ocean, West Pacific Ocean, North Tasman Sea, South China Sea and the Gulf of Carpentaria), which were identified as representing ocean basins or regions of inter-oceanic connectivity. Parsimony network analysis of the control region sequences suggested the presence of genetic admixture, distinguishing three distinct clades which were not concordant to geographic locality. Investigation of the microsatellite loci revealed the presence of significant structure throughout the range which conforms with the species' biogeography. The pronounced signatures in the mitochondrial clades may reflect ancient subdivision during times of sea level fluctuation, followed by periods of admixture. A comparison of the mito-nuclear markers suggests the presence of discordance.

30 Developing next generation sequencing as routine monitoring tool in aquatic environments

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Invertebrate communities are central to many environmental monitoring programs. In freshwater ecosystems, aquatic macroinvertebrates are collected, identified and then used to infer ecosystem condition. Yet the key step of species identification is often not taken, as it requires a high level of taxonomic expertise, which is lacking in most organizations, or species cannot be identified as they are morphologically cryptic or represent little known groups. Identifying species using DNA sequences can overcome many of these issues; with the power of next generation sequencing (NGS), using DNA sequences for routine monitoring becomes feasible. In this study, we test if NGS can be used to identify species from field-collected samples in an important bioindicator group, the Chironomidae. We show that Cytochrome oxidase I (COI) and Cytochrome B (CytB) sequences provide accurate DNA barcodes for chironomid species. We then develop a NGS analysis pipeline to identifying species using Megablast searches of high quality sequences generated using 454 pyrosequencing against comprehensive reference libraries of Sanger-sequenced voucher specimens. We find that 454 generated COI sequences successfully identified up to 96% of species in samples, but this increased up to 99% when combined with CytB sequences. We also found a strong quantitative relationship between the number of 454 sequences and individuals showing that it may be possible to estimate the abundance of species from 454 pyrosequencing data. The NGS approach developed here can lead to routine species-level diagnostic monitoring of aquatic ecosystems.

Oral abstracts

31 Filming and Snorkelling as Mobile Visual Techniques to Survey Tropical Rainforest Stream Fauna

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Dense tropical rainforest, waterfalls and shallow riffle-run-pool sequences pose challenges for researcher access to remote reaches of streams for aquatic fauna surveys, particularly when using capture-based collecting techniques (e.g. backpack and boat electrofishing, trapping). We compared the detection of aquatic species within pool habitats of a rainforest stream obtained by two mobile visual techniques during both the wet and dry season: active visual survey by snorkelling and baited remote underwater video stations (BRUVSs). Snorkelling detected more species than a single BRUVS at each site, both within and among seasons. Snorkelling was most effective for recording the presence and abundance (MaxN) of diurnally active small-bodied species (adult size <150 mm total length), although both techniques were comparable in detecting large-bodied taxa (turtles, fish & eels). On the current evidence, snorkelling provides the most sensitive and rapid visual technique for detecting rainforest stream fauna. However, in stream sections dangerous to human observers (e.g. inhabited by crocodiles, entanglement, extreme flows), we suggest the stratified deployment of multiple BRUVSs across a range of stream microhabitats within each site.

32 How long is enough: Comparison of baited remote underwater video (BRUV) set times to representatively sample rocky reef fish assemblages

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Baited Remote Underwater Video (BRUV) has become a popular technique to survey fish assemblages for a wide range of purposes from ecological monitoring to testing specific ecological hypotheses. BRUV methodology can, however, vary greatly due to logistical reasons to do with the habitats being sampled, the questions being addressed, the equipment being used, and due to historical reasons. In this study, we test whether there are significant differences between estimates of rocky reef fish assemblages, species diversity and relative abundance between different BRUV set times. We sampled fish assemblages on six rocky reefs (20 – 35 m) across two marine parks (Solitary Islands Marine Park: SIMP; Port Stephens Great Lakes Marine Park: PSGLMP; New South Wales). Three locations were surveyed, one in SIMP and two in PSGLMP. At each location replicate BRUVs were deployed for 30 and 60 mins in a 'no take' area and a fished area.
Multivariate analyses showed there were no differences in fish assemblages or species richness between 30 and 60 min set times. Snapper Pagrus auratus, showed a significant increase in relative abundance (Max N) between 30 and 60 mins. Piecewise regression analysis of breakpoint times for species accumulation found that there were no significant difference between locations or fished and unfished areas and that mean breakpoint, the time when species accumulation changes, occurred at 12 mins ± 1.04 S.E for all sites combined. This study quantifies either 30 or 60 minutes provides a reasonable estimate of rocky reef fish diversity and relative abundance.

33 Contrasting baited video with "traditional" survey methods for assessing freshwater fish assemblages

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Collecting accurate species occurrence datasets are fundamental to managing freshwater fishes. Traditionally, freshwater fish surveys use electrofishing and a range of net or trap techniques. However, these methods have well known biases and often result in an incomplete picture of the fishes present. For example, electrofishing is well documented to be biased toward larger bodied fishes, while bait traps capture only small bodied species. Accordingly, these techniques are often used in parallel to obtain as complete a picture as possible of the fish assemblage present. In the past decade, baited remote underwater video have gained popularity in the marine environment as an alternative to traditional fish survey methods. These baited camera methods, however, remain largely untested in freshwater systems. This presentation will contrast species assemblage and size information obtained using baited video with that of traditional survey methods in a clear-water, macrophyte dominated freshwater lake in South West Victoria.

Oral abstracts

34 Freshwater fish films and field guide for the Indian Ocean Drainage Division *(Pilbara Province)*

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The usually unheralded splendour of freshwater fish communities can be difficult to communicate to the broader community. Underwater video footage can overcome this hurdle by shining a light on what lies beneath. We have recently completed a short documentary and field guide depicting the fishes of the Indian Ocean Drainage Division (Pilbara Province). The Pilbara Province extends from the De Grey River in the north, to the Irwin River in the south, and encompasses some of Western Australia's largest rivers and spectacular gorges. The field guide and documentary depicts each of the native fishes that are found in freshwaters and includes some of the continents most threatened species, the region's diadromous species and cave fishes, as well as highlighting the encroaching threat of feral invaders from the south. The Pilbara is divided into three sub-provinces, based on their aquatic fauna, and includes the Southern Pilbara Sub-province, the North West Cape Sub-province and the Northern Pilbara Sub-province, each of which contains endemic fishes and each with its own threats. These educational materials are useful tools for the wider community, including schools, and were funded through the Rangelands Natural Resource Management Program and the Western Australian Governments State Natural Resource Program. It is the second field guide and documentary for the freshwater fishes of WA, the first being a highly successful production focussing on the south-west ichthyological province which can be viewed at www.freshwaterfishgroup.com. The south-west package has now been converted into 10 separate Teacher's Guides (years 1-10) that directly link to the National Curriculum.

35 Developing novel protocols for assessing environmental impacts using Baited Remote Underwater Video Stations (BRUVS) in marine environments in South Australia

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With the recent implementation of a new marine park network, it is an ideal time for data collection, method development, and marine research in South Australia. Many areas in South Australia currently remain under-studied, even within Gulf St Vincent, next to South Australia's most populated city, Adelaide. These areas present a chance to better understand temperate fish assemblages and the factors which may influence them. For my PhD, I am planning to assess fish assemblages using BRUVS in collaboration with the State government and private industries. I have begun an initial pilot study, which is investigating seasonal and diurnal changes in fish assemblages as well as those related to habitat and protection status. Results from a summer sampling trip have been analysed across the two locations, and we plan to repeat this sampling during winter and at night, additionally incorporating an investigation into differences between light colours. Overall, I intend to focus on how different anthropogenic impacts affect fish assemblages. Because BRUVS images are archived, there are potentially several different ways that data could be derived from them. I will discuss the novel methods we hope to use to tease apart potential cumulative impacts and assess key areas for monitoring.

36 Video assessment techniques for riparian habitat monitoring: testing the waters in the Wet Tropics

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Riparian habitat is a key component of river health monitoring and assessment. Several rapid assessment methods exist, largely based around selections of representative sites within a catchment and often stratified. The vegetation is then assessed at each site using transects or similar for a number of habitat attributes (cover, weeds, regeneration, bank structure etc). However, such approaches remain spatially limited and restricted by site inaccessibility. Furthermore, the results are difficult to extrapolate out to the broader spatial scales over which many issues of concern operate.
Video assessment techniques have been employed in community based assessment of mangroves for a number of years. MangroveWatch Shoreline Video Assessment Method is a world recognised rapid assessment method that uses volunteers and relies on assessments of shoreline habitat condition from continuous video recordings, thus covering extensive shoreline distances. The video is analysed for a number of features that relate to shoreline 'condition'. We have adapted this methodology to assess riparian condition along the Russell River and Babinda Creek in the Wet Tropics of northern Queensland with a view to developing a RiverWatch programme for community volunteers to easily collect information in a standardized format.
We assessed a number of indicators of riparian and in channel structure and health using two different platforms (boat and helicopter). This programme can be implemented cheaper and more widely than other rapid assessment methods, also providing a permanent video archive of condition across enormous river lengths and an important baseline against which future changes could be assessed.

Oral abstracts

37 Direct age determination in crustaceans is now possible: A novel technique

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The detection and measurement of annual growth bands preserved in calcified structures underlies the assessment and management of exploited fish and invertebrates populations around the world. However, the estimation of growth, mortality and other age-structured processes in crustaceans has been severely limited by the apparent absence of permanent growth structures. Here, I review the application of the novel technique for the direct age determination in crustaceans. Besides the pilot study involving northern shrimp and snow crab, the method was applied successfully on other species such as the king crab in Alaska, squat lobster and nylon shrimp in Chile, Crayfish in Louisiana. The method has proved applicable in all species that were investigated. In the method, the detection of annual growth bands in calcified regions of two body structures in crustaceans was confirmed thus providing a direct method of age determination. Comparison of growth band counts with reliable, independent measures of age indicates that the bands form annually and provide an accurate indicator of age in all of the species examined. Chemically-labeled growth bands were retained through successive molts, as was one of the two body structures containing the growth bands. Growth band formation was not associated with molting or previously-documented lamellae in the endocuticle. Sex-specific growth curves were readily developed from growth band examination in multiple species, suggesting that routine measurement of growth and mortality in decapod crustaceans should now be possible.

38 Absolute age determination methods for subtropical decapods: growth mark interpretation & validation

Jesse C. Leland[1 2], **Nicholas J. Sarapuk**[1 2], **Daniel J. Bucher**[1], **Paul A. Butcher**[3], **Renaud Joannes-Boyau**[4], **Jason Coughran**[5]

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Recent studies have reported growth marks in the gastric ossicles and eyestalks of decapod crustaceans (Leland et al., 20111; Kilada et al., 20122). The relative utility of ageing structures and validation methods (i.e. calcein staining and LA-ICPMS) for subtropical marine and freshwater species was assessed using giant mud crab (Scylla serrata) and redclaw crayfish (Cherax quadricarinatus) models. Internal and external hard parts from C. quadricarinatus contained both primary and secondary growth marks that could be used for age estimation. Scylla serrata counts were based on the primary series in zygocardiac ossicles. The maximum estimated age for S. serrata and C. quadricarinatus (4 and 3 years) are consistent with previous longevity information, but correlated weakly with size. Preliminary validation results demonstrate long-term (215 d) calcein retention through consecutive moults (for S. serrata) and the potential usefulness of temperature-sensitive elemental ratio mapping (e.g. of Boron, Barium and Magnesium) for crustacean age validation. On the weight of evidence, it appears that primary growth marks are probably deposited annually, but further research with a longer post-staining grow-out is needed to provide a definitive validation. Further assessment of alternative calcein concentrations, exposure durations and/or chemical markers could improve the existing techniques and facilitate their application to other commercially important long-lived decapods.

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2. Kilada, R., Sainte-Marie, B., Rochette, R., Davis, N., Vanier, C., Campana, S., 2012. Direct determination of age in shrimps, crabs and lobsters. Canadian Journal of Fisheries and Aquatic Science, 69: 1728–1733.

39 Defining an issue in space and time: A case study from the Northern Territory Mud Crab Fishery

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The harvest by the commercial Northern Territory (NT) Mud Crab Fishery (MCF) has shown dramatic fluctuations over the last 15 years. However, the vast majority this variation is driven by the concentrated harvest of crabs along just one third of the NT mainland coastline; i.e., within the NT component of the Gulf of Carpentaria (NT GoC).

All areas of the NT MCF experienced a poor harvest (and by inference recruitment) in 2002 and 2003. These events were preceded by two years of what is now considered exceptional recruitment and harvest. These large scale variations are indicative of a broad scale environmental driver such as rainfall.

The management response to the poor harvests post-2001 was a 10 mm increase in the commercial minimum legal size of both sexes in 2006, which applied along the entire coastline. By the time this measure was introduced, the harvest outside of the NT GoC had begun to stabilise, whereas that inside the NT GoC continued to decline.

The stability in harvest outside the NT GoC is now evident through a decadal average and standard deviation (to December 2013) in harvest of 123 t and 15 t, respectively. This contrasts markedly with the corresponding figures from inside the NT G0C; i.e., 246 t and 86 t, respectively.

This presentation will discuss possible reasons as to why these features of the harvest vary along different sections of the NT coastline and the differing impacts of the 2006 management change in these regions.

Oral abstracts

40 Trials of a light emitting BRD in the Moreton Bay prawn trawl fishery

Darcie E Hunt, **Nick Rawlinson**

The reduction of fish bycatch in prawn trawl fisheries has been a major point of interest over the last two decades with research being invested into the ways of optimising the gear. This paper presents the results of the first commercial trial in Queensland's Moreton Bay Prawn Trawl fishery of the light bycatch reduction device (BRD). This device, when attached to the headline of the prawn trawl, illuminates the area in front of the trawl. The lights were tested with paired trawling and a total of 12 tows across three nights were conducted. It was hypothesised that the increased visual warning would result in a reduction of fish species that are caught in the net with no effect on target prawn catch. These preliminary results show that there is a decrease in fish bycatch and crabs with the use of the lights. The catch rate of prawn as well as cephalopods and other crustaceans such as mantis shrimp were increased. The benefits of decreasing fish bycatch include reduced sorting time and increased survival of fish species that are subsequently discarded. Reducing the capture of crabs will also result in higher quality of catch due to less damage to the prawns.

41 From experimental trawling to MSC certification – forty years of transformation in an Australian prawn fishery

Craig Noell[1], **Simon Clark**[2], **Stephen Mayfield**[1], **Cameron Dixon**[3], **Graham Hooper**[1], **Sean Sloan** , **Annabel Jones**[4], **Brad Milic**[4]

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4. *PIRSA Fisheries and Aquaculture, Adelaide, SA*

South Australia's Spencer Gulf Prawn Fishery (SGPF) has been recognized as one of the best managed fisheries in the world, and was the first prawn fishery in the South-Pacific to be accredited by the Marine Stewardship Council. Production has been sustained throughout its history, where annual landings have generally ranged from 1,600-2,400 t, with no discernible trend. From the fishery's inception in 1968, trawling effort increased steeply to a historic peak of ~45,800 h in 1979/80, and then steadily declined by 60% to 18,000 h, where it has stabilized over the last decade. The area of Spencer Gulf trawled has also reduced, with the northern, more ecologically-sensitive areas, now largely avoided. Local, small closure areas protect key habitats and nursery areas for important commercial species. Maintaining stable annual catches with less fishing effort is the result of technological advances, an effective harvest strategy underpinned by three fishery-independent surveys each season, real-time and spatial management, a high level of resource stewardship, and co-management that reflects a strong collaboration among industry, fisheries managers, scientists and eNGOs. Faced with relatively new challenges over the past few years (e.g. high fuel prices, increasing competition from imported prawns, minimizing the impact of trawling on other species), the SGPF has adapted further by engaging in a number of research projects that collectively aim to optimize biological and economic sustainability (e.g. bio-economic model, harvest optimization model), while also being proactive in minimizing its impact on the benthic ecosystem (e.g. development of ecosystem-based fisheries management (EBFM) performance indicators).

42 The Ecological Responses to Altered Flow Regimes Cluster

Neil Sims[1]

1. *CSIRO, Clayton, VIC, Australia*

CSIRO Flagship Clusters are large scale research programs with an emphasis on people and partnerships working on a collection of strongly integrated projects relevant to a Flagship's goals. The Ecological Responses to Altered Flow Regimes Cluster was funded to address ecological knowledge gaps associated with the impacts of flow alteration due to drought and water resource development, and to help predict the responses of organisms to environmental flows. This presentation will describe the establishment of the Cluster and its objectives, which will provide a context for the remainder of the presentations in this Special Session.

Oral abstracts

43 Developing spatial predictions of hydrology and fish distributions: the good, the bad and the ugly

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Hydrology is a major driver of species distribution patterns in freshwater ecosystems, but information on hydrology is generally only available for a small fraction of sites from which biological data have been collected. To try and fill this data gap, we coupled data from hydrologic gauging sites across the Murray-Darling Basin with information on climate, physiography and water infrastructure, and used these to generate predictive models of long-term runoff variability. We then used these models to extrapolate descriptors of hydrologic variability to ungauged sites, for use in subsequent modeling of fish distribution patterns. Here we discuss the modeling results and their potential applications with reference to the good, bad and ugly sides of their use in inference and prediction. In particular we consider the problems for range-retracted and rare species, extrapolation in geographic and environmental space, and temporal dynamics.

44 Optimisation for environmental flows: river model outputs to support decision-making in wetlands

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Understanding how different ecological assets respond to flow regimes is essential to the management and delivery of environmental water. Many of our river systems have significant amounts of regulation. This places constraints on the volume of water available for the environment and its delivery. To understand how to make best use of environmental water, methods are required that allow us to: (a) better understand how different ecological assets will respond to different flow regimes and (b) plan for the delivery of water to multiple ecological assets. River system models are complex models used to assess the likely change in water availability over space and time, and support water planning processes. To determine the flow regime that will best meet the needs of single and connected ecological assets, within the delivery constraints, optimisation methods can be used to determine the delivery of environmental water over space and time. This paper details the methods used to support an optimisation tool, where a river system model has been simplified. The model is used to explore optimising flow deliveries for managing environmental water releases, considering the inundation of unregulated and regulated wetlands along the length of the Murrumbidgee River, with seasonal, peak flow and duration requirements. This simplification of the hydrology has then been used in a conservation planning framework to demonstrate how different temporal allocations of environmental water can be used to achieve an agreed set of objectives for the catchment's wetlands.

45 Optimisation models for Water Resource Planning

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Optimisation methods are routinely used in exploring decision options in conservation planning for nature reserve design, hydrology applications for storage operations, emission scenarios for climate change, and cropping decisions in agriculture. Optimisation methods are embedded in decision theory approaches to explore management alternatives for optimal solutions, which are constrained to available information. Optimisation tools differ from more scenario-based modelling methods where the focus is on predicting outcomes. Solutions seek to avoid worst-case outcomes by seeking robust alternatives that are less sensitive to uncertainties. Recent advances have been made in using optimisation methods to explore management of environmental flows in regulated river systems. In this presentation we will overview optimisation in environmental flow contexts and introduce the ecological components of the optimisation model, using the Murrumbidgee River system as a case study. Existing ecological data and response relationships were complemented with new knowledge from the CSIRO Cluster-funded project to explore scenarios of flow and optimal flow release decisions to achieve ecological objectives. A challenge in the project was in accessing ecological data at the scale and in the context for establishing objectives and in deriving response relationships. Whilst some data is available to establish overbank flow objectives, little was available for in-channel objectives. We will discuss the types of ecological data sets that are applicable to optimisation applications and the challenges of scales.

Oral abstracts

46 Identifying flow response indicators

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Two of the biggest challenges in terms of environmental-flow management are deciding what ecological characteristic to measure and then detecting whether the flow restoration had the desired impact. We used a "gradient analysis" to identify a subset of environmental indicators that respond predictably to environmental flow-disturbance gradients in the Murray-Darling Basin. Four types of potential indicators were calculated using the Sustainable Rivers Audit data and used to assess medium-term responses to managed-flow regimes: fish abundance, biomass, recruit count, and Fulton's body condition. Potential indicators were calculated for four species, including two native species and two exotic species. These potential indicators were assessed using 33 flow-disturbance metrics representing the raw, percent, and absolute change in modelled flow variability, magnitude, frequency, duration, timing, and inundation frequencies between pre- and post-development time periods. Other environmental variables such as mean annual temperature or elevation were used to account for natural variability in fish distribution, while distance-weighted land-use measures were used to account for land-use type and proximity to streams and perennial waterbodies. We were able to successfully identify and quantify a number of relationships between potential indicators and flow-disturbance gradients. We found that 1) traditional indicators of ambient condition may not be suitable as indicators of flow alteration, 2) indicators will likely be species specific and native species may be more suitable than exotic species, and 3) it may be important to use region-specific indicators if climatic conditions vary substantially or species have evolved region-specific life-history characteristics.

47 The influence of single flow pulses on river ecosystems

Ben Gawne[1], Richard Kingsford[2], Robyn Watts[3], Ross Thompson[4], Alison King[5], Skye Wassens[3], Jess Wilson[1], Amina Price[1], Leah Beesley, Mike Grace, R. Keller Kopf[3], Heather McGinness[6], Neil Sims[7], John Koehn[8]

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Environmental Flows are now a prominent restoration tool for Australian Rivers. Flow pulses represent one type of environmental flow release often used by managers as they have been affected by water resource development, are associated with environmental benefits and they are feasible, given existing constraints. Flow pulses can be characterised as an increase in flow from base flow anywhere up to bank full which can mean inundation of riparian areas and adjacent wetlands. The challenge in using flow pulses as part of a restoration program is that they are a short term and, in some cases, localised action that seeks to contribute to achievement of long-term, large scale changes in condition. This presentation will summarise what is known of the influence of single flow pulses on river-floodplain systems within the context of their longer term influences as a step in identifying their potential value as a restoration tool. Broadly, flow pulses can influence ecosystem condition in the medium to long term through their effects on habitat availability and subsequent species' survival and recruitment. Flow pulses also change patterns of connectivity either delivering subsidies that promote productivity or creating opportunities for dispersal that may influence resilience. Finally, flow pulses may influence processes such as primary production and decomposition that influence food availability. The evidence for the short-term effects of flow pulses is accumulating, however, evidence for their longer term significance is scant and this will need to be addressed if flow pluses are to contribute to restoration.

48 Scientific collaboration in freshwater science

Stuart Bunn[1]

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The Cluster demonstrates a new model for collaborative research in freshwater ecology in Australia. The Ecological Responses to Altered Flow Regimes research Cluster has brought together researchers of freshwater ecosystems from seven of Australia's leading research institutions to address a key knowledge gap in freshwater ecology: how do organisms respond to changes in the river flow regime? The many advantages of collaborative research include promoting scientific synergies and establishing the critical mass required to address large-scale issues. There are also a range of challenges, some of which are generic to large collaborative projects and others which may be specific to collaborative research in freshwater ecology in Australia. This presentation will draw on experiences from the Cluster and describe aspects of collaborative freshwater science that are successful and those where outcomes can be improved.

Oral abstracts

49 Ecological cognition in intertidal gobies

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Gobies are highly specious and found in a diversity of habitats making them ideal for comparative studies. Here we examined the brains and behaviour of common species of inter-tidal gobies found in Sydney Harbour. Initial studies focussed on the homing behaviour of rock-pool species and we found that individuals showed high site fidelity and could home when displaced by more than 30m. We then compared the spatial learning ability of rock-pool species with sand-dwelling species with the expectation that natural selection should favour strong spatial learning skills in the former but not the latter. Sand-dwelling gobies tend to move with the tides and live in a very dynamic, featureless environment. A battery of spatial learning tests supported our predictions and we found that rockpool species tended to rely strongly on landmarks to navigate whereas sand-dwelling species tended to use egocentric navigation techniques. Examination of their brains exposed a tradeoff in investment in neural tissue: Rockpool species have large telencephalons while sand-dwellers had large optic-tecta. Our results clearly show that both the brains and behaviour of intertidal fishes are shaped by the habitats they occupy.

50 Community structure in littoral, intertidal and subtidal habitats of a tropical bay

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Shallow coastal habitats are valuable for sustaining many fisheries yet are increasingly pressured by many anthropogenic impacts including fishing, coastal development and pollution. Although historical research in shallow coastal waters suggested these habitats are most important for supporting and nurturing juvenile fishes, some contemporary research has indicated that many larger and mature fish also use these habitats. Further few studies consider the contiguous nature of shallow coastal habitats and how these habitats may be preferentially used or avoided by fishes. To investigate the communities of large bodied fishes (> 200 mm) in the shallow coastal habitats of Cleveland Bay, a mosaic of littoral, intertidal and subtidal habitats were sampled across a 1 year period. Seasonal sampling with a large mesh gill net yielded 1187 individuals from 28 families and 40 species. Four families accounted for 74.6% of the total sample: namely Latidae, Polynemidae, Ariidae and Carcharhinidae. The littoral and subtidal communities were distinctly different from each other with the intertidal community sharing some characteristics with both the littoral and subtidal communities. Teleosts were the dominate group in the littoral and intertidal habitats whereas sharks dominated the subtidal habitat. Season did not influence the structure of the fish communities though some environmental factors (temperature, dissolved oxygen and salinity) did affect some species. It is clear that most species have specific habitat requirements or limits while only some are evenly distributed among the shallow coastal habitat. Why these patterns and preferences occur will be the focus of future research.

51 Choosing the right home: habitat detection and settlement decisions by a temperate reef fish on artificial reefs

Emily Fobert[1], Stephen Swearer[1]

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For marine fish species that are demersal as adults, dispersal during the larval phase sets the spatial scale of population connectivity1,2. Following this dispersal period, larvae must choose where to settle, and it has been argued this settlement decision is the most important process for benthic and demersal fish populations3,4. Using the southern hulafish Trachinops caudimaculatus as a model, this study examines what factors play a role in habitat detection and selection at settlement. This study aims to determine 1) if hulafish use habitat associated olfactory cues to detect settlement habitat; 2) if hulafish exhibit gregarious settlement in the absence of variation in habitat complexity; 3) and if distribution and abundance of hulafish at settlement is influenced by canopy cover in the absence of adult conspecifics. Response to habitat associated olfactory cues was tested using a two-chamber choice tank, in which recently settled hulafish were exposed to pair-wise combinations of four odour treatments: 1) ambient seawater, 2) reef odour, 3) conspecific odour, and 4) reef and conspecific odour. The second and third aims were addressed by monitoring settlement patterns in two in situ experiments on artificial reefs: the first in which the density of adult conspecifics was manipulated, and the second in which the percent macroalgal cover was manipulated. Preliminary results from these experiments suggest presence of adult conspecifics is the strongest indicator of quality habitat for settling hulafish, with conspecific odour eliciting a strong behavioural response, and higher numbers of hulafish settling to reefs with higher conspecific densities.

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Oral abstracts

52 Diverse habitat mosiacs underpin rocky reef fish biodiversity within a marine protected area

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Environmental surrogates (e.g., habitat type, temperature, depth/altitude) are often used in the design of spatial management plans for terrestrial and aquatic ecosystems. Critical to the success of this approach is selecting surrogates that support both biodiversity and key ecosystem functions. While habitat availability can determine patterns of distribution, abundance and recruitment potential, this can vary according to the particular habitat specialisations of each species. We aimed to assess how a mosaic of habitat types within offshore reefs of the Port Stephens-Great Lakes Marine Park supports a rocky reef fish community with a diversity of habitat preferences. Most of the species we examined (30 species from the Labridae, Pomacentridae, Serranidae & Odacidae) displayed strong preferences for either abiotic (e.g., sand, rocks) or biotic (e.g., kelp, live coral) habitat types. Consequently, the availability of preferred habitats was strongly correlated with abundance of adults and/or juvenile fishes across local (within reefs ~1-3 km long) to regional (among islands 50 km apart) spatial scales. When used in conjunction with habitat maps of similar spatial resolution, these scalable fish-habitat associations can provide an effective surrogate for developing spatial plans (e.g., identifying boundaries of Marine Protected Area zones) that protect both adult populations and juvenile nursery habitats that are critical to the sustainability of these reef fish communities.

53 The effect of an artificial reef on fish abundance, tested using regression of point detections

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2. *NSW DPI, Port Stephens, NSW, Australia*

The effect of a large artificial reef on fish abundance was tested using drop cameras. This novel method involves deploying drop cameras quickly, many times, at a range of distances from the reef, and the observed fish abundance is analysed using regression. Distance from the artificial reef was a significant predictor of fish abundance and species diversity. Fish abundance declined exponentially with distance, halving approximately every 20 m from the reef. Eight species could be tested individually; four of these associated positively with the artificial reef, two were predicted better by microhabitat, and two benthic species showed no association with the reef. Two pelagic species, kingfish and yellow-tail scad, were among the species associated with the reef, which shows that offshore artificial reefs can be successful as recreational fishing targets.
This approach to quantifying spatial relationships shows promise as a tool for aquatic environments. Drop cameras can be time-expensive and provide sparse coverage compared to traditional sonar methods, but can identify species accurately, yield detailed bottom-type information, and observe reef and benthic species (which are difficult or impossible to resolve with sonar). Using regression to examine spatially-explicit associations and distributions is a recent development in terrestrial vegetation modelling. Its use here shows it can be a powerful tool for understanding aquatic environments as well.

54 Fish assemblages of the Kimberley coast: challenges of turbid and macrotidal environments

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2. *Centre for Fish, Fisheries and Aquatic Ecosystems Research, Murdoch University, Murdoch, Western Australia, Australia*

The tropical coast of north-western Australia is an extensive yet largely understudied region that contains one of the last true wilderness areas in Australia with the Kimberley being assessed as one of the least impacted coastal areas in the world. This coast is characterized by extreme environmental conditions from regular cyclonic storms, tidal ranges that exceed 10 m, strong tidal currents, highly turbid waters and contrasting extreme wet and dry seasons. Despite these conditions the Kimberley contains a diverse fish fauna and very well developed coral reef, mangrove, seagrass and filter feeding communities. Such extreme conditions present strong selection pressures on marine species to converge in their physiology, morphology and behavior towards an optimal 'design' for living in such conditions. Many Kimberley fish species have evolved specialized physiological traits to survive in these low visibility and high-flow environments such as acoustic and bioluminescent signaling to attract mates and to maintain species fidelity in an extreme environment. The logistic challenges of sampling the ichthyofaunas in the extreme conditions of north-western Australia have resulted in a range of observation methods being employed in specialized ways in daily, lunar and seasonal cycles. From these observations we are now beginning to map the spatial and temporal diversity in this globally unique environment.

Oral abstracts

55 The oceanographic habitats of two migratory pelagic fish: dolphinfish *(mahi mahi)* and yellowtail kingfish

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The dynamics of pelagic ecosystems is becoming increasingly relevant, yet the contribution of mid-trophic level pelagic predators is typically understudied. Describing the habitat preferences of pelagic fish can improve inputs for ecosystem modelling, as well as help fisheries management strategies adapt to a dynamic and changing ocean. Using a combination of three fishery dependent and independent datasets, we examined the habitat preferences of two contrasting pelagic species, dolphinfish (Coryphaena hippurus) and yellowtail kingfish (Seriola lalandi) off the east Australian coast. The three datasets are spatially confined to the New South Wales coast and contain a total of 16,589 dolphinfish and 15,971 yellowtail kingfish presences collected between 1972 and 2012.
Binomial generalised linear models with a logit link were used for each dataset to assess the probability of fish presence. Predictor variables retained in the model include sea surface temperature, sea surface height, chlorophyll-a, eddy kinetic energy, temperature fronts, latitude, bathymetry and month. The model outputs show complex relationships between predictor variables and fish presence, depending upon the season and bathymetry. Probability distribution maps, with associated confidence intervals, reveal the seasonal habitats of dolphinfish and yellowtail kingfish as well as indicate habitat overlap between the species.
Determining the distributions for highly migratory species is complex. The use of fishery-dependent datasets with and without estimates of fishing effort will be discussed. These habitat models can be used in conjunction with forecasting products to create seasonal (9 month forecast) and long-term (2062-2073 forecast) forecasts of fish distributions.

56 Remobilizing Netukulimk: Indigenous cultural and spiritual connections with resource stewardship and fisheries management in Atlantic Canada

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2. *St. Francis Xavier University, Nova Scotia, Canada*

Recent global initiatives such as the United Nations Declaration on the Rights of Indigenous Peoples have brought the issues facing and needs of Indigenous peoples to the forefront of international attention. While underscoring respect for traditional practices, these initiatives have yet to appreciate fully the extent to which Indigenous peoples' practices engage ways of being, living and believing that encompass a holistic understanding of the relations between humans and all facets of their ecosystems. The Mi'kmaq, the Indigenous people of Atlantic Canada, capture and express their holistic understanding through the concept of Netukulimk. In this presentation we review core attributes of Netukulimk. We also review key events that have impacted onNetukulimk and resulted in marginalization of the Mi'kmaq from policy and management processes. We close the presentation with an overview and discussion of recent developments wherein the Mi'kmaq are working to revitalize the place of Netukulimkin treaty-based rights and Mi'kmaq law-ways, particularly within self-governing resource stewardship and fisheries management initiatives. The Mi'kmaq experiences provide insights regarding the challenges and requirements for achieving respect for traditional practices and point a way forward for more effective and inclusive stewardship of natural aquatic resources into the future.

57 Integrated Management of Freshwater Fisheries: cultural learnings and experience of Waikato-Tainui

Julian Williams[1]

1. *Waikato Raupatu River Trust, Hamilton, New Zealand*

Since its arrival to Aotearoa (New Zealand), Waikato-Tainui have held dominion over lands and waters in the upper section of central North Island. This area includes the Country's longest and most commercially dependent River. However, after the 'New Zealand land wars' of the 1860's, the Crown unjustly confiscated over 1.2 million acres of Waikato-Tainui lands. The lands were subsequently drained and converted for horticultural and agricultural purposes, whilst the River was dammed for energy generation, irrigation and now supplies water to many communities and two cities, including Auckland, our largest city.
In 1995, Waikato-Tainui settled an historic land settlement package with the Crown, but left the tough conversation of redress for the Waikato River for the next generation. Therefore, in 2008, Waikato-Tainui negotiated co-management arrangements through the Treaty Settlement process to restore and protect the health and well-being of the Waikato River for future generations.
Along with many other co-management agreements, the tribe has further developed integrated tools that incorporate traditional practices which provides for cultural activities in freshwater fisheries. With the assistance of respective agencies, the tribe established freshwater regulations and bylaws, in conjunction with significant research to recognise the tribes aspirations and achieve the purpose of the settlement. Julian will provide a snapshot of the health of the River in the eyes of the tribe, share the experiences of integrated management and priorities for the next generations in consideration of balancing the expectations of the community and commercial partners.

Oral abstracts

58 Trait variation: it exists and it matters (and are our fish shrinking?)

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Organisms inhabiting aquatic environments, be they bugs, fish, plants or crabs, are exposed to a range of selective pressures such as variable flow, temperature, biotic interactions and fishing that play a fundamental role in determining whether they live, die, grow, reproduce and by how much. Central to this equation is the fundamental tenet that natural selection operates on the individual, the results of which underpin population and species level demographic metrics such as mortality schedules, ages at maturity and biomass. Understanding linkages among individual-level traits, population ecology and species evolution however requires recognition that individuals and species do not exist in isolation but are part of a broader eco-evolutionary context. Natural and anthropogenic environmental gradients drive the expression of within and among species phenotypic variability in for example thermal tolerance or foraging behaviour, and these in turn alter the ecological outcomes of among-species biotic interactions such as predation and competition. Despite the strong ecological ramifications of trait variation and its obvious importance to species and environmental management and conservation, relatively few studies of Australian aquatic environments have harnessed evolutionary insight to provide context to ecological questions. Here, I will provide an overview of why we should care about understanding trait-based ecology and evolution. I will then present a short case study illustrating how trait variation can be practically used to disentangle the relative importance of oceanic warming and fishing pressure in driving long-term patterns in fish size in SE Australia.

59 Modelling the consequences of differential fishing incidental mortality on susceptible behaviour types of wandering albatross

Geoffrey N Tuck[1], **Robin B Thomson**[1], **Christophe Barbraud**[2], **Karine Delord**[2], **Maite Louzao**[2] **Henri Weimerskirch**[2], **Miguel Herrera**[3]

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3. *IOTC, Victoria, Seychelles*

Several studies have shown that animals (including birds) can exhibit different personality traits that have a strong influence on the survival of an individual and have consequent affects on population abundance. For harvested populations, given heterogeneity in behaviour within wild populations, some individuals may be more susceptible to bycatch and more likely to be removed from the populations.
Here we describe an age, sex, life-stage and spatially structured population model applied to the Crozet wandering albatross population. The model includes comprehensive data on the spatial and temporal distributions of fishing effort and foraging distributions to estimate temporal overlaps, fishery catchability and consequent bycatch. Results show that the model was not able to replicate the observed data without making broad assumptions about seabird catchability from the pelagic longline fleets and seabird behaviour. Namely, the rapid decline in breeding pairs observed between the late 1960s and the early 1970s could not be explained without assuming a heterogeneous population in which some birds were behaviourally more susceptible to fisheries bycatch than others.
This paper is the first to attempt to explain major changes in population size through differential fishing impacts on specific population phenotypes, and highlights the need for greater consideration of the ecological and management consequences of selective harvesting of susceptible behaviour types for seabirds, and other bycatch species.

60 Inter- and intra-specific variation in freshwater fish life history traits and the role of hydrology, phylogeny and spatial structuring

Mark J Kennard[1 2], **David Sternberg**[1]

1. *Australian Rivers Institute, Griffith University, Nathan, Qld, Australia*
2. *National Environmental Research Program Northern Australian Hub, Australia*

Quantifying variation in functional traits across a range of taxonomic and environmental scales can provide insight into species' niche requirements and mechanisms of community assembly, and be used to predict ecological responses to changing environmental conditions. This paper synthesises our recent work to understand the environmental, spatial and phylogenetic determinants of freshwater fish life-history traits and functional composition of Australian rivers. We also examine the phylogenetic and spatial structure of intra-specific variation in key life-history traits of the Australian smelt Retropinna semoni sampled across a gradient of hydrologic variability in 19 eastern Australian rivers. Variation in total fecundity had a stronger phylogenetic signal than variation in egg size. After accounting for the influence of phylogeny, spatial variation in both life history traits was related to gradients of hydrologic predictability and stability. Intra-specific variation in fecundity and egg size, coupled with low spatial autocorrelation at scales of population connectivity up to 100 km, and differences in life-history trait expression between geographically distinct clades observed in this study, suggest a high potential for ambiguous trait-environment relationships in studies conducted at coarse spatial grains (e.g. river basins) or higher taxonomic levels (i.e. species). Quantifying the spatial structure of intra-specific life-history trait variation, key intra-specific trait-environment relationships, and the rates at which life-history traits may respond to local conditions within a phylogenetic framework in this study has important implications for future works seeking to understand population or species responses to changing environmental conditions at local to regional scales.

Oral abstracts

61 Traits and fates: life history characteristics and the decline of native freshwater fishes

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Historical evidence suggests that many of the native freshwater fish species of the Murray-Darling Basin have suffered substantial losses of geographic range or abundance in the period since European settlement. However, other native species appear to have avoided dramatic population declines. I compared life history traits of more-impacted and less-impacted species with the aim of obtaining insights into possible reasons for differences in their fates. More-impacted species tended to mature at a significantly greater age than less-impacted species, and to spawn for shorter periods and at lower threshold temperatures. However, there was no significant overall difference between two groups in maximum body size, fecundity, egg type (adhesive/non-adhesive and buoyant/non-buoyant) or degree of parental care. Later maturation and a short spawning season at lower temperatures may render native species more vulnerable to both introduced coldwater piscivorous fishes and loss of winter-spring flooding as a result of river regulation.

62 Wet season movements of barramundi and forktail catfish: the role of fish movement as a driver of food web subsidies in a tropical lowland river

David Crook[1]**, Duncan Buckle, Michael Douglas**

1. *Charles Darwin University, Darwin, NT, Australia*

Floodplains have long been recognised as critical to the maintenance of food-web productivity in lowland rivers, but the associated mechanisms remain only partially understood. Large-bodied fish comprise a major component of the faunal biomass in healthy lowland rivers, and their movements are responsible for the transport of large amounts of assimilated energy within aquatic ecosystems and across ecotones. The movement of energy by fish often functions as a critical energetic "subsidy" that supports food webs in receiving habitats or ecosystems. For example, recent stable isotope analyses demonstrate that the productivity of fish populations in Northern Australian rivers is highly reliant on relatively short periods of floodplain inundation during the wet season that facilitate the transfer of energy from the floodplain to the main channel. To determine the role of fish movement as a driver of this energetic subsidy, we conducted a radio telemetry study of the wet season movements of 40 barramundi (Lates calcarifer) and 30 forktail catfish (Neoarius leptaspis) in the South Alligator River in Kakadu National Park. Individual fish were tracked by boat or helicopter every two weeks from October 2013 to May 2014 and their use of main channel and floodplain habitats examined throughout the wet season. The findings of the study are used to draw conclusions regarding the importance of inundated floodplains as fish habitat during the wet season and to obtain a better understanding of the nature of the energetic subsidies provided by floodplains in tropical lowland rivers.

63 The movement, fidelity and behaviour of non-recreational elasmobranchs associated with a Sydney Offshore Artificial Reef (OAR)

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2. *Resource Assessment Unit , NSW Primary Industries , Nelson Bay, NSW, Australia*

Assessing movement patterns of fish communities associated with artificial reef systems is important for examining the degree of connectivity between proximal natural reefs and the degree of site fidelity with the artificial reef system. Higher levels of fidelity with artificial reef systems suggest that artificial reefs provide suitable habitat and thus contribute to the local production of fish, whereas low site fidelity would suggest that these reefs are little more than fish attractants. The Eastern Fiddler Ray (Trygonorrhina fasciata) and the Port Jackson Shark (Heterodontus portusjacksoni) occur along the eastern coast of Australia and are common by-catch species in bottom trawl, gillnet and long-line fisheries. In this study, 9 Eastern Fiddler rays and 17 Port Jackson sharks were surgically implanted with a VEMCO acoustic tag to record the movements, activity, behaviour and residency around an Offshore Artificial Reef (OAR) located 1.5 km off South Head, Sydney Harbour. Connectivity of the OAR with surrounding natural reefs is determined by comparing the OAR data with downloads from 10-15 existing receivers within an established VR2W Positioning System (VPS) acoustic array. During the initial study period from June 2013 to February 2014, T. fasciata was most active and highly resident at the OAR during daylight hours. In contrast, H. portusjacksoni was mostly nocturnal and moved between sites, but was predominantly resident at the OAR. The preliminary results suggest that the OAR supports elasmobranch and other non-recreational species, indicating the potential for production to occur on offshore artificial reefs.

Oral abstracts

64 Mass-marking fish larvae via maternal transmission of enriched stable isotopes

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Mass-marking fish larvae can facilitate studies exploring connectivity and dispersal patterns of early life history phase fishes. Maternal injections of enriched stable isotopes can provide a means of mass-marking fish larvae during the embryonic phase, because the enriched stable isotopes become incorporated into the larval otoliths (transgenerational marking). However, this is a recent technique that has seen limited development and application. We explored the efficacy of transgenerational marking in the Purple-spotted gudgeon (Mogurnda adspersa) and Eastern rainbowfish (Melanotaenia splendida), and through a meta-analysis, evaluated the effects of this technique on larval fish morphology and growth across a range of marine and freshwater fishes. Transgenerational marking was highly effective, enabling mass-marking of larvae produced by adult females for up to 6 months post-injection. Multiple unique markers could be produced, with minimal impacts on larvae morphology, survival and growth. Our meta-analysis revealed minimal effects on marked larvae, suggesting that this technique may be applied to explore dispersal and connectivity in aquatic ecosystems[1].

1. Starrs, D., Davis, J.T., Schlaefer, J., Ebner, B.C., Eggins, S.M., and C.J. Fulton (2014) Maternally transmitted isotopes and their effects on larval fish: a validation of dual isotopic marks within a meta-analysis context. Canadian Journal of Fisheries and Aquatic Sciences 71: 387-397 doi: 10.1139/cjfas-2013-0416

65 Movement pattern and habitat use of giant trevally Caranx ignobilis in offshore reef habitats

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Passive acoustic monitoring was used to track the movements of 20 Caranx ignobilis at offshore reefs in the Great Barrier Reef from 2012 to 2014. Acoustic monitoring allows long-term monitoring of the marine animal behaviour and movement via a network of moored listening stations that record the presence of tagged animals. Fifty-six listening stations were deployed on seventeen offshore reefs. Traditional spatial statistics (e.g. activity space) and network analysis (NA) determined temporal movement patterns and habitat use of this reef predator. NA is an alternative approach that treats listening stations as network nodes and analyses movement based on flows between nodes. NA provides new and useful interpretations of tracking data not provided by traditional approaches. Individual Caranx ignobilis were present in the study region between 9 and 205 days (mean = 76). Caranx ignobilis were only detected at the reef they were caught and preferred the southwest side of that reef. Preliminary results showed tide, time of day and size of fish influenced size and location of activity spaces. In addition, Caranx ignobilis individual pathways within each reef varied with time of day, height of tide and size of fish. By defining space use patterns of this important reef predator, the results of this study may improve understanding of functional connectivity within offshore reef habitats and help provide guidance for their management.

66 Connectivity, phylogeography and behaviour of a desert-dwelling fish: does habitat matter?

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While dispersal and connectivity are crucial processes for individuals and species, a range of systems remain understudied and our understanding of the behavioural underpinnings is limited. Moreover, natural habitat patches are rarely homogenous over space and time, meaning that understanding movement responses can be complex. The desert goby Chlamydogobius eremius is a remarkable fish endemic to arid South Australia, a naturally dynamic environment in which water is scarce and fragmented, and large expanses of dry land comprise the major barriers to aquatic dispersal. Additionally, habitat variation can be partitioned into two characteristic 'types': permanent, groundwater-fed springs, and highly variable, highly ephemeral rivers. Consequently, spring and river fish are likely to experience different costs and benefits of dispersal, and potentially, divergent selection regimes and opportunities for movement. We examined the effects of habitat variation on dispersal using both molecular and behavioural approaches. Using a comparison of populations from springs and rivers, I will present i) the results of a mitochondrial DNA-based phylogeography for the species, and ii) experimental data on exploratory and dispersal (emigration) propensities. While we found that some springs contained higher levels of genetic diversity, our behavioural measures detected limited evidence for adaptive shifts in dispersal and exploration. Thus, despite strong potential for divergent selective environments, it appears that dispersal behaviour in the desert goby conforms to a traditional prediction of high phenotypic plasticity, an important mechanism in potentially mediating impacts of future environmental change.

Oral abstracts

67 Diet change in Macquarie perch and rainbow trout in a newly filling reservoir

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The Enlarged Cotter Dam (ECD) poses several threats to the only viable population of endangered Macquarie perch (Macquaria australasica) in the ACT. This study is investigating changes in food resources for Macquarie perch and rainbow trout in the early and mid- filling stage of the ECD. During the early filling stage trophic upsurge is likely to occur, following flooding and the resulting breakdown of terrestrial vegetation and organic matter in top soils of the reservoirs inundation zone. This is expected to result in a change in fish food resources through an increase in the production of invertebrates, the predominant dietary items of Macquarie perch. Macquarie perch and rainbow trout diet and fish food resources were sampled in the ECD before reservoir filling and in the early and mid- stages of filling, with rainbow trout diet and food resources also collected from two other existing reservoirs in the Cotter System. Results show that during the early filling stage fish diet changed from aquatic invertebrates to terrestrial items, particularly earthworms. As the dam approaches its mid-filling stage there has been a shift back to aquatic invertebrates in fish diet. It is important to understand the impact enlargement of reservoirs has on fish diet changes and fish food resources, as changes in food availability may affect fish condition, and potentially reproductive output. Knowledge gained from this project will be used to enhance future management decisions surrounding reservoir filling and the implications for native freshwater fish species.

68 The trophic relationships of the platypus along an urban gradient

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The impacts of urbanisation on aquatic ecosystems have been well described and include; a loss of riparian vegetation, flashier hydrology, altered channel morphology, elevated concentrations of toxicants and associated poorer water quality. These impacts in turn have consequences for algal biomass and organic matter inputs. The ultimate effects on the aquatic invertebrate biota include a decrease in sensitive taxa, an increase in tolerant taxa and an overall decrease in invertebrate richness and abundance. Many of these factors have been related to platypus presence, suggesting that increasing urbanisation will affect the platypus, its diet; habitat and distribution. Trophic relationships of the platypus were investigated at three sites spanning a gradient of urbanisation in Victoria during autumn, 2013. Food webs were compared using stable isotope analysis of platypus fur, basal carbon resources and potential dietary items. The consumption of a wide range of invertebrates at all sites indicate the flexibility of the platypuses' diet and suggest that it is likely to be factors other than food supply that have resulted in local declines in the presence of platypus.

69 Using stable isotopes to identify important food sources of common fish associated with native and exotic riparian vegetation

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Riparian vegetation has been greatly modified in Australia since European settlement, including replacement with exotics and complete clearing of streamside vegetation. These modifications can alter light regimes, patterns of seasonal leaf-fall and the palatability of in-stream leaf litter material to aquatic primary consumers with potential flow-on effects on trophic pathways. We determined the C and N stable isotope signatures of biofilm, leaf packs, freshwater macrophytes and riparian vegetation as well as common native and introduced fish (brown trout Salmo trutta, common galaxias Galaxias maculatus, short-finned eel Anguilla australis and ammocoetes of the short-headed lamprey Mordacia mordax) and macroinvertebrate species from reaches of native forest, introduced willows, cleared areas and native revegetation in the Gellibrand River catchment, Otway forest Victoria. Our aims were to determine possible differences between primary producer signatures and to identify whether trophic pathways of different fish species are linked with riparian vegetation, including willows, and/or in-stream primary producers. We expected biofilm to dominate food webs in cleared areas and tested whether signatures differed between willow areas, forest and revegetated areas due to shading, leaf-fall patterns and leaf palatability. Against expectations, biofilm and macrophytes in willow and cleared areas did not have a greater influence on consumer species. Diet input of riparian vegetation and other primary producers was highly variable and calls for further study. Surprisingly, the stable isotope signatures of lamprey ammocoetes (which are considered filter feeders) were very dissimilar to all other consumers and do not reflect any of the diet sources analysed.

Oral abstracts

70 The Ecology of the Desert Goby: Community level interactions and individual level variability

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The Australian arid-zone with its dry desert climate is home to fascinating and unique aquatic ecosystems. The Stony Plains bioregion around Lake Eyre is of particular interest, as the Lake Eyre Basin and groundwater Great Artesian Basin provide a complex and interactive system of spring and river habitats. Across this region, we are investigating how the aquatic food web differs across the various habitat types and also the role that individual level variability may play in these food webs. Focusing on the Desert Goby (Chlamydogobius eremius), we have investigated individual variability in terms of their food web role (e.g. diet and stable isotope signature) and individual behaviours (e.g. boldness and exploratory behavioural traits). Isotope analysis has shown evidence of significant variability in the food-web role of gobies within and between populations. Similarly, we found evidence of significant variability within and between goby populations across various behavioural axes. This supports the idea that individual level variability plays a major role in food webs, and that behavioural differences may be an important source of that variability. Further work on these systems will focus on how habitat characteristics promote within-species variability and food-web stability, to further explore this exciting area of ecological theory.

71 Freshwater inflows to estuaries: do organic carbon subsidies support zooplankton production

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Freshwater inflows to estuaries have been greatly reduced in many regulated coastal catchments. In this talk we will outline the important role that freshwater inflows have in carbon cycling and estuarine food webs in South-East Australian catchments. The majority of organic carbon is delivered to estuaries during episodic floods and freshes. During these periods the bioavailability of dissolved organic carbon (DOC) doubles resulting in significant increases in bacterial growth and production. We carried out a mesocosm experiment on the Bega River estuary to examine whether DOC and the microbial loop could act as a link to zooplankton production. We added DOC leachate to 400 L mesocosm bags mimicking differently sized inflow events at concentrations of +1.5, +3 and +16mg C L-1 additions. DOC additions led to significant increases in bacterial production in all treatments. Between days 5-9 of the experiment calanoid copepodites of Sulcanus conflictus and Gladioferens pectinatus were significantly higher in abundance in the +16mg C treatment. Between days 9-15 adults of both species were significantly higher in both the +3 and +16mg C treatment. Stable isotope results indicate increased abundance was supported by DOC leachate. These results, in conjunction with longer term monitoring results on the estuary, provide strong evidence that inflow derived organic carbon plays an important role as a resource subsidy to estuarine zooplankton. Environmental flow rules for estuaries will therefore be important for protecting and maintaining these ecological processes.

72 Finding a balance between gear and effort based management strategies to promote stock recovery in South Australia's Garfish Fishery

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There are concerns about the status of South Australia's Southern Garfish Fishery which have been principally based on evidence that the size and age composition of the stock is severely truncated as a result of sustained levels of high exploitation. A Garfish Working Group (GWG) comprising representatives from industry, SARDI and PIRSA was established to provide recommendations to management to promote the recovery of the resource. This group developed an operational objective to develop harvest strategies that reduce the current exploitation rate of ~65% to 30% by 2020. Gear restrictions and effort reduction were considered to be important components of the rebuilding strategy, however finding a fair and equitable balance between these two strategies naturally presented a few challenges amongst the commercial fishers. Through a series of gear selectivity trials and testing various effort reduction (closures) scenarios using an extension of the GarEst fishery model, the GWG were presented with a range of management options that would achieve their short and long-term operational objectives. Although achieving the targeted exploitation rate of 30% by 2020 was the principle objective of the management strategy evaluation, the model simulation also provided biomass, egg production and economic information to assist the GWG's assessment and consideration of the management alternatives. This talk will discuss how this management strategy evaluation model was developed and used to streamline the decision making process amongst the relevant stakeholders

Oral abstracts

73 Southern garfish (Hyporhamphus melanochir) on the west coast of WA : living fast and dying young

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Southern garfish (Hyporhamphus melanochir) occurs across southern Australia including WA, SA, Victoria and Tasmania. In WA, it is a popular commercial and recreational fishery species. The main commercial fishery for this species in WA is in Cockburn Sound, a marine embayment in the Perth area. Approximately half of the recreational catch is also taken in Cockburn Sound. Catch rate trends suggest a gradual decline in the abundance of garfish in Cockburn Sound over the past 2 decades, with a pronounced decline since 2011 following a marine 'heatwave' event in the region. Recent fishery sampling indicates a truncated age structure (mostly aged <2 y) and a relatively high rate of total mortality (Z = 1.6) acting on this population, substantially higher than the previous estimate (Z = 0.98 estimated in 1998). The rate of mortality and the current age composition of this population are similar to that observed in garfish stocks in SA, which have been assessed as 'over-exploited'. Interestingly, the impact of high mortality in Cockburn Sound appears to be partly compensated for by an unusually low age-at-maturity of approximately 6 months. This is about 1 year lower than the age at which maturity is attained by this species in SA. It is unclear whether the low age-at-maturity in Cockburn Sound is fishing-induced or environmentally driven.

74 Combining indices of abundance from multiple surveys provides recruitment estimates for a widely distributed species in the NE Atlantic; Blue whiting

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The extensive distribution of blue whiting (Micromesistius poutassou) spans 35 degrees of latitude in the NE Atlantic. Strong recruitments in the early 2000s made blue whiting one of the world's largest fisheries; 2.5 million tonnes were landed in 2004. Recruitment dropped sharply in 2006, but the fishery maintained catches of 1m tonnes until 2008. Subsequent fluctuations in stock status and TAC reductions to less than 2% of the 2004 landings (40,000t in 2011) have created strong imperatives for improved assessments and management advice.

A robust index of recruitment for blue whiting does not exist. Indices previously used in assessment are problematic due to poor survey coverage and unreliable acoustic detection for small fish in the demersal zone. Whilst these indices were useful during high recruitment events, they were ineffective during periods of low recruitment (estimating zero recruitment in some years), and were subsequently excluded from the stock assessment. Current assessments are consequently over reliant on model-derived recruitment indices.

We present a robust, standardised recruitment index derived from a combination of under-utilised ground-fish surveys. Integrating over a million data-points across three decades, we apply advanced modelling techniques to estimate the recruitment of blue whiting in the Southern region of its distribution. Recruitment signals are evident in the surveyed area, and indicate less variability than suggested by the previous problematic indices. This study demonstrates the utility of examining previously neglected data sources to help resolve critical issues in fisheries resource assessment.

75 An experimental analysis of assignment problems & economic rent dissipation in quota managed fisheries

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If the spatial and temporal distribution of resources is not homogenous it creates an assignment problem. While the adoption of individual (or transferable) quota management in many commercial fisheries has resolved issues of over-appropriation, assignment problems may remain due to the spatial and temporal complexity of fisheries resources, which creates heterogeneity in the economic value of catches. This leads to competition between fishers for the most valuable portions of the stock and dissipation of economic rent. In order to solve an assignment problem, either the quota units must be fully delineated in time or space, or fishers need to coordinate their effort. When fishers' sociocultural background, wealth, business structure and/or expertise are heterogeneous, reaching an agreement on a preferred strategy for solving an assignment problem can be particularly challenging, because some may see themselves as disproportionately more affected by its adoption. To investigate whether an assignment problem could be effectively managed by two types of fishers (lease quota fishers and quota owners), a series of economic experiments were conducted. Participants were more likely to cooperate and make socially optimal decisions to prevent rent dissipation when they could communicate amongst themselves and were in an experimental group containing solely quota owners. Experimental groups containing both types of fishers were less likely to cooperate because lease quota fishers may have seen themselves as disproportionately affected by the adoption of a socially-optimal strategy for preventing rent dissipation due to: (i) inequality in wealth; (ii) insecurity of tenure; and (iii) asymmetric information exchange.

Oral abstracts

76 An Australian science communication case study based on the endangered fish red-finned blue-eye, Scaturiginichthys vermeilipinnis

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Despite the accepted need for better communication of science and research to non-scientific audiences, peer reviewed papers remain the most common – and frequently the only – method by which research results are communicated. Continuation of this practice in isolation is unlikely to present the results to a wider audience because the majority of non-scientific readers do not consult scientific journals. In this review the communication methods used to publicise a project concerning the conservation of a small endangered fish from the Australian semi-arid zone are discussed and recommendations are made regarding using such methods to promote research projects. The problem of evaluating such strategies is also discussed, as this is most-often a subjective exercise, and as such difficult to quantify using traditional measurement methods. The case study demonstrates that harnessing a range of communication media (radio, television, internet, magazines, books, public speaking and formal papers) combined with a spatial approach (local, regional, national and international) is a sensible way to garner support and encourage interest in what are often esoteric and obscure research endeavours.

77 Engaging marine communities in climate science using their own data, and the learning curve of social media tools

Dianne Bray[1] , Stewart Frusher[2] , Gary Jackson[3] , Natalie Moltschaniwskyj[4] , Melissa Nursery-Bray[5] , Gretta Pecl[2] , Keith Rowling[6] , Marcus Sheaves[7] , Jemina Stuart-Smith[2]

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Australia's coastal waters are warming faster than the global average, especially in the climate change hotspots of south-eastern and south-western Australia. Over time, these temperature increases are predicted to impact species' distributions, fisheries and conservation management. REDMAP (Range Extension Database and Mapping Project) allows the public to submit geo-referenced observational data (including photographs) on marine species occurring outside their known distribution. Species identifications are verified by a large panel of expert scientists using a semi-automated workflow which provides individual feedback to the observer. The sightings, including photographs, then appear on the website.

By logging sightings of marine species' movements, members of the community are actively and constructively contributing to this large-scale monitoring program through activities they enjoy such as fishing, diving and boating. This involvement of 'citizen scientists' is crucial to the collection of cost-effective long-term data over Australia's vast coastline. At the same time, REDMAP provides an easily-accessible and interactive source of current scientific information, thus facilitating a two-way knowledge exchange.

Within this talk, I will also discuss the steep but rewarding learning curve of social media tools for science communication. Facebook and Twitter have been the main means of communicating the comprehensive information captured within the Fishes of Australia (www.fishesofaustralia.net.au) website, a beautiful and authoritative collation of knowledge on Australia's large and diverse fish fauna. These methods not only advertise the site, but provide information on issues affecting Australian fishes and their habitats. While maintaining a presence in cyberspace is incredibly time-consuming, it's a great ride.

78 Hunting porcupines: using citizen scientists to collect data on rare stingrays to support research and conservation efforts

Andrew Chin[1]

1. *James Cook University, Douglas, QLD, Australia*

There is growing interest in engaging citizen scientists in research and conservation efforts. Citizen scientists can collect data across large spatial and temporal scales that cannot feasibly be covered through traditional research programs. The porcupine rayUrogymnus asperrimus is a rare and poorly understood species that is potentially one of the most vulnerable chondrichthyans to climate change. The 'Great Porcupine Ray Hunt' engaged the Australian recreational SCUBA diving community in collecting information on the species' occurrence, distribution, behaviour and habitat associations. 'Crowd sourcing' of recreational diver monitoring effort was achieved through social media (facebook and blogs), diving publications, the internet, email lists, and the Eye on the Reef monitoring program. Recreational divers provided 29 new valid records ranging from Western Australia to the Southern Great Barrier Reef, and even from the Louisiade Archipelago in Papua New Guinea. Submissions also included video footage of foraging and mating behaviour. While relatively few observations were received, the submitted data doubled the number of existing records on the species in Australia, confirmed the species' rarity, identified potential 'hot spots', provided a depth range for the species and extended the species' range by over 100 km. In doing so, the project demonstrated the potential for citizen scientists to contribute valuable knowledge about rare species, facilitate community education and awareness raising, and provide preliminary data to drive new research projects. Nevertheless, it is crucial to explicitly consider and plan for the potential limitations of Citizen Science before approaching the public to participate in research.

Oral abstracts

79 iSPY Fish , You SPY Fish, We all SPY Fish

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The rivers and wetlands of the Goulburn Broken Catchment provide substantial recreational fishing opportunities, and support a number of threatened fish species such as Murray Cod, Macquarie Perch, and Trout Cod. The iSPY Fish app, developed by the Goulburn Broken Catchment Management Authority and Sumo Software has been built upon the highly successful iSPY Frog Application launched in 2012. iSPY Fish is a mobile-based interactive tool presenting information on all fish species occurring in the Catchment. Primarily targeted at recreational fishers, other users include scientists, naturalists, students and natural resource managers. Colour images, physical descriptions, ecological information and conservation status are provided for 21native, and nine alien, fish species. The App allows users to upload photos and catch detail (species, weight, location, etc) to an iSpy Fish Facebook page, where data is collated to assist river and wetland management, thereby facilitating citizen science activity and community participation in aquatic resource management.

iSpy Fish is available for Apple and Android operating systems.

80 Enhancing conservation of Australian freshwater ecosystems: identification of freshwater flagship fishes and relevant target audiences

Brendan C Ebner[1]

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Flagship species, especially mammals and birds, are commonly used to increase awareness of conservation issues in marine and terrestrial ecosystems. However, comparable initiatives are scarce in the freshwater context. Furthermore , freshwaters of Australia support few aquatic mammal species. To explore the potential for freshwater species to act as flagship species in Australia, 230 fish species were assessed for their potential to appeal to a broad cross section of society. This was achieved using characteristics that have been identified as useful correlates of flagship species status in terrestrial systems; specifically relating to body size, trophic guild and threatened species status. Then, groups with an interest in Australian native fishes were identified based on expert opinion, given that engaging the public with conservation issues in freshwater systems might be more effective if the link between fish species and people were better understood.

81 Natural champions for fish habitat – building capacity in Australia's recreational fishing community through the Fish Habitat Network

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An estimated 3-5 million people in Australia fish each year. In New South Wales, one in four people identify themselves as a recreational fisher. Until recently this large stakeholder group had been largely overlooked in natural resource management activities including fisheries management. The understanding of the relationship between habitat and fisheries productivity by this large stakeholder group was also recognised as limited.

This disengagement is in stark contrast to recreational fishers in the Northern hemisphere where individual fishers, fishing clubs and organisations play a pivotal role in protecting and restoring their rivers, lakes and estuaries, and are considered as active conservationists.

In recognition of this paucity of fisher engagement, Fisheries NSW launched the Fishers for Fish Habitat Program in 2008 with funding from the NSW Recreational Fishing Trusts. The Fishers for Fish Habitat (F4FH) Program developed an evidence-based approach to communicating with the highly diverse recreational fishing community about habitat and pursued multiple strategies for improving levels of participation in habitat-related activities.

The Fish Habitat Network (FHN) is one of the Program's key communication strategies. Established in 2009 as an informal collective of like-minded people, supported by government representatives, the FHN is the first and only fish habitat focused partnership. With nearly 20 organisations and a network of everyday fishers the Network's collective vision is to improve the quality of fishing through Australia through active engagement of Australia's recreational fishing community in the protection, restoration and enhancement of fish habitat.

Oral abstracts

82 Depth and space use of coral trout *(Plectropomus leopardus)* using passive acoustic tracking

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3. *Australian Institute of Marine Science, Townsville, QLD, Australia*

Understanding the extent and frequency that fish make movements can help define the seasonal importance of different habitats and isolate spatial and temporal vulnerability to exploitation. Coral trout (Plectropomus leopardus) is one of the main targeted fisheries species in the Great Barrier Reef (GBR) and concern exists that populations may be at risk from overfishing during spawning season. The objective of this study was to determine long-term space use patterns of P. leopardus and identify any associated temporal variation that may affect vulnerability to fishing. Passive acoustic tracking was conducted at Heron Island and One Tree Island Reefs in the southern GBR, Australia. A total of 124 P. leopardus were implanted with V13P acoustic transmitters between 2010 and 2012. Forty-five VR2W receivers were deployed at both reefs to track the movements of tagged individuals. The influence of time of day, season, year, and location on several movement measures were investigated. Results showed increased horizontal movements and higher activity in deeper water during the day in the austral summer. Movement patterns, both vertically and horizontally, appeared to be influenced by either foraging or reproductive drivers. Despite increased movements during summer, individuals typically remained in a small area ~0.5 km2 throughout the year indicating that long range spawning-related movements are rare. This study is important because it provides long-term (~3 years) movement data with extensive reef coverage of an economically significant reef fish and increases knowledge of spatial and temporal space use patterns that may be driven by two key biological demands.

83 The importance of natural flow to the recruitment success of an amphidromous shrimp in tropical Northern Australia

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Tropical rivers in Northern Australian are largely pristine, however they are facing threats from developments that require water extraction or damming. It is crucial then, to understand the importance of river connectivity to productivity and biodiversity. Macrobrachium spinipes is thought to be amphidromous, plays a critical role in riverine food webs and is culturally significant to Indigenous and non-Indigenous people. There are however, considerable gaps in our knowledge of its life history. This project collected adults and larvae over two years from the Daly River, Northern Territory and conducted a series of laboratory experiments to determine patterns of reproduction, abundance and migratory behaviour. We found that reproduction occurred across a 400 km length of the river and that females were not moving downstream to the estuary to breed. Larvae were produced in high numbers throughout the river and required saltwater to develop. Larvae have only 5-7 days to reach saltwater, making flow a critical determinant in successful recruitment. This study confirms the amphidromous life history of M. spinipes and highlights the importance of natural flows for maintaining existing populations.

84 Divergent thermal performance thresholds in wild, co-habiting stingrays *(Dasyatis fluviorum and Trygonoptera testacea)*

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An organism's capacity to cope with variable temperature will depend on its ability to balance physiological constraints against a suite of dynamic biological, ecological and environmental factors. Recent meta-analyses suggest physiological adaptation to local temperatures may largely be constrained by phylogeny, yet a paucity of thermal performance data from free-ranging animals is a major hindrance to predicting the response of various taxa to future increases in temperature.

We compared thermal performance (activity) and habitat selection in two species of wild stingrays that have different biogeographies (the temperate Trygonoptera testacea and sub-tropical Dasyatis fluviorum), inhabiting the same estuary. We predicted that regional adaptation would result in similar thermal thresholds, whereas divergent thresholds would indicate phylogenetic constraint.

For the temperate T. testacea, performance increased up to 23.9°C and declined thereafter. For the tropical D. fluviorum, performance continued to increase up to the maximum temperature recorded (26.4°C). We also found evidence for thermal-habitat selection, in which T. testacea exhibit avoidance of temperatures above their thermal optimum, compared to D. fluviorum that showed no avoidance. While D. fluviorum were diurnal, T. testacea were nocturnally active, with their degree of nocturnality linking to a temperature-dependent increase, followed by a potential loss of locomotive performance beyond the thermal optimum.

These data indicate that sympatric, ecologically similar species can have divergent physiological and behavioural responses to local temperature. This pattern highlights the constraints that phylogeny can impose on thermal performance thresholds, and suggests that future increases in temperature are likely to have differential impacts within taxonomic groups.

Oral abstracts

85 A mobile predator? Variable space and depth use patterns of an exploited coral reef fish

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Movement influences the distribution and abundance of populations. Knowledge of movement patterns is particularly useful for parameterising assessments and designing management strategies for exploited fish populations. Despite importance to fisheries, limited empirical evidence have portrayed adult tropical lethrinids as sedentary with small home ranges and as mobile predators that potentially migrate long distances. To distinguish the typical movement patterns of redthroat emperor (Lethrinus miniatus), horizontal and vertical activity space use and depth utilisation were investigated. Sixty individuals were monitored for up to 12 months using an acoustic telemetry network comprising three reefs in the Great Barrier Reef, Australia. Evidence supporting a mobile lifestyle includes broad-scale movement (~160km) of one individual, periods of non-detection and potential movement away from the reef edge at night. Yet most individuals displayed high site fidelity and moderate-sized horizontal activity spaces (~4km2) over a period of up to 12 months. Individuals inhabited a variety of depths with an absence of consistent trends based on time or size of individuals. Variation in movement among adult redthroat emperor indicates that while some individuals migrate over long distances, spatial closures that cover individual reefs (>4km2) could provide protection from fishing for the more resident proportion of the population.

86 Diadromous behaviours of three species of forktail catfish in the Daly River, Northern Territory

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Diadromous species migrate between fresh and salt water on a regular, well-defined basis. These species often hold high economic and cultural value and many are at risk from flow regulation and other human activities that diminish connectivity between habitats. With the exception of barramundi (Lates calcarifer), the migratory behaviours of diadromous species in Northern Australia are poorly understood at present, partly due to the difficulties inherent in tracking the movements of fish throughout the entire life history. This study examined the movements of three species of forktail catfish; blue salmon catfish (Neoarius graeffei), shovel-nose catfish (Neoarius midgleyi) and lessor-salmon catfish (Neoarius leptaspis) in the Daly River, Northern Territory, using otolith strontium isotope ratio (87Sr/86Sr) transect-analysis.
By comparing otolith 87Sr/86Sr transects with water 87Sr/86Sr mixing models, we found that the species displayed distinct life history strategies. N. leptaspis exhibited residency in estuarine or marine water during the early life stages, with a subsequent transition into freshwater. N. midgleyi exhibited residency in freshwater only and did not migrate into estuarine or marine water at any point throughout their life history. Although N. graeffei commonly occurred in both estuarine and freshwater, they did not appear to undertake consistent, well defined migrations between fresh and saline water during their life history. The study also revealed strong variation in water and otolith 87Sr/86Sr corresponding to wet-dry seasonality in water chemistry. We conclude that analysis of otolith and water 87Sr/86Sr is an effective technique for tracing whole-of-life salinity histories of riverine fish.

87 Hydrological connectivity between wetlands and rivers and its implication for fish biota: a case study for the Flinders catchment in north Queensland

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Wetlands are important refugia for many freshwater aquatic biota. As part of the Flinders and Gilbert Agricultural Resource Assessment, hydrological connectivity of a large number of wetlands located in the Flinders floodplain and estuarine environment were investigated and fish assemblages were sampled at selected sites. These two sets of information were combined together to explore key linkages between the timing and duration of wetland connectivity and surveyed fish assemblages. The connectivity assessment was conducted using a floodplain hydrodynamic model (MIKE 21) and fish assemblages were sampled using a backpack electrofisher, combined with gill and seine beach seine nets. Model predicted flood inundation information was combined with land topography data to quantify connectivity. Results show many off-stream wetlands connected with rivers for a short period of time, while others connected only during large floods. Wetlands located in the lower floodplain produced longer duration of connection. Fish data collected here, combined with previous studies show similar trend in terms of number of fish species and total fish catches. It is interesting to note that more fish species were found in wetlands located close to estuarine environments though they had similar connectivity. This is primarily a function of connection between estuarine/marine waters and freshwater river channels. This highlights the importance of maintaining or even enhancing connectivity between floodplain wetlands and river as well as floodplain and estuarine wetlands. This study serves a blue print for future studies examining ecological health and connectivity of floodplain and coastal wetlands in developing Northern Australia.

Oral abstracts

88 Landscape-scale patterns of the diversity and distribution of Australian arid zone aquatic invertebrate communities

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Arid and semi-arid regions, where annual rainfall is less than 500mm/year and evaporation greatly exceeds precipitation, occupy approximately 47% of the global land surface and cover more than 70% of the Australian continent. Extensive river networks, most of which were established by the Palaeocene, occur in arid Australia, but none support permanently flowing water. Instead, these systems are characterised by temporary to permanent pools with highly variable hydroperiods. There are also innumerable lentic habitats, mostly also temporary other than those supported by groundwater discharging from local aquifers, or, in the case of mound springs, from the Great Artesian Basin. Past research has focused on aquatic systems within specific regions within the Australian arid zone. In this study we used existing datasets to examine continental-scale patterns of diversity and distribution of the invertebrate fauna of arid zone aquatic habitats. We found that species richness varied greatly across the arid zone and was influenced by both local and regional factors. However, the invertebrate community composition of pools within the temporary river networks displayed some similarities, despite being separated by thousands of kilometers of arid land. The greatest differences detected in community composition were between surface water and groundwater-fed habitats. Further research is now underway to better understand the connectivity between these aquatic habitats and the dispersal of invertebrate taxa between temporary and permanent waters across an environmentally harsh landscape.

89 The resilience of macroinvertebrate assemblages to multiple sediment release operations in forested, headwater streams

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Appropriate mitigation measures are required for dams impaired by excessive reservoir siltation. One common, cost-effective management technique involves flushing accumulated sediment downstream. This practice generates unnaturally high discharges and potentially catastrophic volumes of sediment likely to alter habitat conditions and disturb aquatic fauna. However, there is little scientific information on the ecological impacts of this practice and, more importantly, whether it is a sustainable, practical solution to restore dam functionality. Our study aimed to monitor multiple, simultaneous sediment releases from small flow monitoring weirs in forested headwater catchments and to assess the potential impacts on macroinvertebrate assemblages. Four weirs were desilted during the operations, which resulted in the deposition of large amounts of fine sediment in downstream reaches. Immediately after the sediment release sweep samples revealed a decrease in macroinvertebrate abundance and diversity across all impacted streams. However, based on data from macroinvertebrate colonisation of artificial substrates deployed before and after the sediment release, a generalised macroinvertebrate response to the disturbance was not evident with assemblages returning to pre-impact levels within six weeks. The apparent resilience of the fauna may be explained by the unique hydro-geomorphological conditions of these headwater streams, which already encourage the storage of large amounts of fine sediment and organic matter. Therefore, the biological community may be well adapted to this particular environment and able to withstand excessive sedimentation (i.e. resilience to burial). We contend that the ecological response to sediment release operations, and sedimentation more broadly, depends significantly on local geomorphological context.

90 The productivity of the macroinvertebrate prey of the platypus in the upper Shoalhaven River, NSW

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The platypus feeds almost exclusively on benthic macroinvertebrates, yet no attempt has been made to link its feeding and energy demands with the productivity of its benthic macroinvertebrate prey. We estimated macroinvertebrate production and recorded platypus diet in two pools of the upper Shoalhaven River, NSW. Cheek pouch samples were taken from platypuses in 2009 and benthic samples in 2009 and 2011. Specimens from both types of samples were identified to family or species and mean annual densities calculated from the benthic samples. Production was estimated using the size frequency technique. Previous estimates of field metabolic demand (FMD) of the platypus enabled calculation of the number that could be supported by a given level of production. Ephemeroptera, Trichoptera and Chironomidae were the most numerous of 6 major groups in both the cheek pouches and the benthic samples. Three other groups (Odonata, Coleoptera, Sphaeriidae) were much less abundant in the benthos, but Odonata were common in the cheek pouches. In both years the Ephemeroptera, Trichoptera and Chironomidae had levels of production that were an order of magnitude higher than those of the three other groups. Total macroinvertebrate production varied from 4 (in 2009) to 12 (in 2011) g DW m-2yr-1. Based on estimated FMD, these levels of production were sufficient to support 6 -13 platypuses in 2009 and 20-40 in 2011 along a 1.8km reach of the river. Despite catchment erosion and removal of riparian vegetation in the Shoalhaven catchment, productive foraging habitat for the platypus still remained.

Oral abstracts

91 Survival strategies of aquatic invertebrates as a response to drying in intermittent rivers

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Intermittent rivers, or rivers that periodically cease to flow, are the prevalent river type in Australia and occur across many climatic regions. It was long assumed that intermittent rivers had low biodiversity value; however intermittent rivers support a diverse range of taxa, with aquatic invertebrates pivotal in the 'boom and bust' ecology of these systems. During dry periods, aquatic invertebrates may survive in pools, become dormant or disperse as winged adults. Resilience mechanisms, or those that involve recolonisation rather than resistance in-situ, are believed to be the dominant strategy for post-drought recovery by invertebrate communities.

We know little however about the survival strategies that aquatic invertebrates use under different environmental conditions, such as different climatic regions or differing lengths of dry period. We investigated dominant physiological and behavioural strategies to survive drying, and contrasted these across different climate types or biomes. The prevalence of persistence in pools, aestivation in dry sediment and aerial dispersal as refugial strategies were quantified.

Dominant survival strategies used by invertebrate communities differed between climate types, with refugial pools supporting diverse invertebrate communities in temperate creeks, and dormancy in dry sediments dominant in the semi-arid region. Invertebrate communities exhibited taxonomic and functional redundancy in the survival mechanisms utilised. Invertebrates recolonising by aerial means were comprised of a distinct group of taxa found rarely using alternative mechanisms. These findings challenge the theory that resilience mechanisms are dominant in promoting recovery of aquatic invertebrate communities after drying.

92 Now you see them, soon you won't—freshwater mussel conservation in Australia

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Australian freshwater mussels comprise an important component of our ecosystem service economy. But, as sudden population losses can drastically reduce numbers, recruitment failure may inflate extinction debt and increase risk to some of our most ancient of Gondwanan assets. As older individuals die and are not replaced, populations disappear within very few years. This process is well-advanced in Europe and North America, where mussels are among the most imperilled fauna. Here we highlight cases to suggest Australian freshwater mussels may share similar fates.

In the Hawkesbury-Nepean River (NSW), populations of Velesunio ambiguus, Hyridella australis and H. depressa have declined sharply over a decade. Von Bertalanffy models and Leslie matrices relating age and growth demonstrate a precarious balance in the localised viability of these species and show how recruitment failure could be implicated in their decline.

In Lake Alexandrina (SA), shoals of V. ambiguus died from increased salinity and exposure to air in 2007 10. Although the lake may eventually be recolonised, elimination of such a large population is cause for alarm, particularly given projections of future climate change.

Similarly, in the lower Canning River (WA), reduced freshwater flows into the estuary and unseasonably high tides led to the upstream migration of a salt wedge which resulted in the extirpation of Westralunio carteri in 2010. Recovery may take many years and uncertainties of recruitment success will present a major conservation challenge. The story undoubtedly repeats itself around Australia, and considering similar cases, should spur action towards conservation measures.

93 Cyclones, catchments and coastal streams: disturbing changes in macroinvertebrate assemblages over seven years

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In streams draining heavily forested subtropical catchments, leaf-eating macroinvertebrates (often termed 'shredders') play a vital role in organic matter dynamics and maintaining the ecological integrity of the in-stream ecosystem. Vegetation structure of the riparian zone of many forested streams along the eastern coast of Australia has now been modified by invasive plants (e.g. camphor laurel) and human activities such as urbanization and flood mitigation. Superimposed on these disturbances are droughts and cyclones, and flows that often fluctuate widely. Our study explored associations between aquatic invertebrate assemblage composition (especially shredders) and the changes in flow regime and riparian inputs over seven years in two subtropical streams with differing riparian zone history. Despite major differences in riparian structure and composition, and the impact of cyclonic floods (e.g. Cyclone Oswald that dumped 380 mm of rainfall in 48 hours), shredder densities and aquatic community composition remained remarkably consistent over the seven years and appeared to recover rapidly from pulse disturbances such as cyclone induced spates.

Oral abstracts

94 Exploring differences in genetic diversity and population structure of two estuarine fishes from Victoria: the exotic yellowfin goby *Acanthogobius flavimanus* and the native blue spot goby*Pseudogobius sp.*

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Exotic species introductions pose a significant threat to native ecosystems, and have the potential to cause declines or even extinctions in native species. However, despite a series of favourable conditions, an introduced species may not be able to successfully establish itself if the number of individuals released into the new environment is too few. Founder effects such as genetic bottlenecks are well documented and can result in a loss of allelic richness in the population, reducing the adaptive potential of the species. In comparison, native populations that have not undergone a genetic bottleneck tend to have greater allelic richness and can therefore have a more complex genetic structure than introduced species occupying the same environment.

This work explores differences in genetic diversity and population structure between two estuarine species found in Victoria, the invasive yellowfin goby, Acanthogobius flavimanus and the native blue spot goby, Pseudogobius sp. Mitochondrial diversity in Victorian yellowfin gobies is compared to samples from several potential source populations in Japan, and assessment of a similar region in blue spot gobies gives insight into diversity and population differences between native and invasive species.

Since both species have been identified as potential bioindicator species for monitoring estuarine health, this work is important in providing an understanding of population dynamics and potential adaptability of the yellowfin goby to local conditions in Australia. Sequencing information may also be used in future studies to assist in characterising genetic differences between the eastern and western morphs of the blue-spot goby.

95 Invasion of Siamese fighting fish *(Osphronemidae)* on the Adelaide River floodplain: the Northern Territory's first serious invasive pest fish

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Siamese fighting fish Betta splendens are a well-known and popular aquarium fish kept in captivity around the world. The species is native to central Thailand being a member of a diverse species complex of labyrinth fishes occurring in south-east Asia. Labyrinth fishes typically occur in shallow well vegetated wetlands and forest swamps, tolerating a wide range of environmental conditions including anoxia through their capability to breathe air using an auxiliary sponge-like breathing chamber. Recently an invasion of Siamese fighting fish was uncovered on the Adelaide River floodplain, near Darwin in Northern Australia. This represents the first serious alien fish species incursion in the Northern Territory, with reports previously limited to livebearers (Poeciliidae) and cichlids in isolated habitats, many of which have been controlled by specific actions. This talk discusses the history of establishment and biological notes of Siamese fighting fish on the Adelaide River floodplain, where a very large and extensive population is now known to occur. It also canvasses areas for research on likely spread, possible impacts and potential control.

96 Vagility and vulnerability: Dispersal of adult common carp *(Cyprinus carpio, L.)* around the Murray-Darling River Basin, Australia

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Common carp (Cyprinus carpio L.), one of the world's most invasive fish species, are a major threat to wetland and waterway health throughout Australasia and North America. In a study of pest-fish vagility and vulnerability, the annual dispersal probabilities and propensity to revisit spawning or wintering areas was investigated in adult carp from 2007 to 2011. Carp were tagged and released in multiple groups and locations in the Murray and Darling rivers, Australia. Movements were monitored over four years using an array of acoustic data-logging receivers, PIT tag detecting data loggers and angler recaptures around the Murray–Darling river system (MDB). The study period included low and high-flow periods. River level and temperature were evaluated as environmental triggers for carp dispersal using general linear modelling. A significant proportion (33% ± 9.7%) of tagged adult carp dispersed into tributaries. Mean annual dispersal probabilities ranged from 0.04 to 0.51. Carp migration was partial and nomadic and few showed repeated migrations. The influence of river level and temperature on dispersal varied by release-location. Less than 4% of tagged carp were detected at any fishway along the Murray River equipped with PIT tag detectors. Migration characteristics of carp suggest low population-vulnerability to control by point-source removal, reinforcing the need for broad scale alternative biological controls that can be simultaneously deployed in multiple locations throughout the MDB.

Oral abstracts

97 The hard slog: Progress towards a National Carp Biocontrol Program

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Evaluations of Cyprinid herpesvirus-3 as a potential biological control agent for carp in Australia continue at the high level bio-secure facility located at CSIRO's Australian Animal Health Laboratory. Testing has shown that Australian carp are highly susceptible to the C07 strain of CyHV-3. CSIRO have now tested susceptibility of 13 representative native fish species, introduced rainbow trout and a mammal, bird and crustacean. Tests of reptiles and amphibians are currently being undertaken. No species has shown any evidence of infection. This concurs with international experience that CyHV-3-induced disease is entirely specific to common carp. The virus appears to be both effective and safe and represents a viable bio-control option for carp in Australia. Federal and state governments have been briefed on the Invasive Animals CRC's current carp bio-control development program in preparation for submission of formal applications under the Biological Control Act, Quarantine Act/EPBC Act and APVMA Act. These applications require detailed summaries of the pest status of carp and currently available carp control options, biological and epidemiological data, details of viral production, efficacy, safety, trade, OH&S etc., as well as proposed release and M&E strategies. NSW DPI is currently in the process of compiling these data. Other activities being undertaken to advance the program are: preparation of freeze-dried virus; sequencing the genome of the C07 strain; epidemiological modelling; compilation of international data on the effects of CyHV-3; compilation/collection of benchmark data on carp densities and their environmental impacts; and, development of costings and funding proposals for a staged national carp bio-control program.

98 Modelling recruitment dynamics of carp under different flow scenarios

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A model of carp life history has been developed to examine, in particular, the recruitment dynamics of carp under different flow regimes. The underlying construct is a 30 age class model with estimates for survival and fecundity for each age class. A number of different spawning habitat types were identified and these habitat types were specified within the model framework. Spawning, larvae and young of the year output from each habitat defined under different flow regimes provided the expected dynamics of carp recruitment. Regional differences have allowed the model to target specific wetlands/reaches in the Murray River. Given a suite of different flow regimes expected, carp dynamics are produced to provide insights to managers on how best to manage flow to minimise carp recruitment.

99 Cyclones, catchments and coastal streams: disturbing changes in macroinvertebrate assemblages over seven years

John Koehn[1], Charles Todd[1], Leigh Thwaites[2], Ivor Stuart[3], Qifeng Ye[2], Brenton Zampatti[2], Anthony Conallin[4], Lauren Dodd[1]

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Environmental water allocations are an increasingly important management option, especially in the Murray-Darling Basin with the implementation of the Basin Plan. Carp are a highly visible, widespread and abundant alien pest fish species that has invasive species attributes (e.g. high fecundities) that allow their populations to expand rapidly. Their spawning and recruitment is enhanced by flooding and hence there is concern that some environmental watering may lead to increases in their populations. To date, most management of environmental flows has ignored the issue of carp production, with most carp management (since the 1970s) focussing on population removal options. This paper illustrates the utility of a carp population model (see accompanying Todd et al. paper) to attempt to 'quantify' changes to carp populations from range of environmental watering scenarios including: differences in water allocations; habitats (especially the main channel and off stream wetlands); and sequencing of flows . Changes to carp populations are placed in the context of other events such as natural flooding and habitat changes. Risk assessments are conducted and management recommendations made to mitigate any impacts of carp. These include: that E-flow objectives for native biota must remain paramount; carp populations increase due to a range of reasons; carp must be managed in conjunction with flows and each carp 'hotspot' and each major watering site should have a carp management plan; populations need to be monitored; and use of regulating structures should be seen as major experiments relating to carp.

Oral abstracts

100 Assessment of eco-labelling schemes for Pacific tuna fisheries

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Developments in fisheries governance in recent decades—notably the 1982 United Nations Convention on the Law of the Sea and its implementing agreements—have established a framework of principles, standards, institutions and regulations that is broader and more complex than traditional fisheries management, which has generally focused on individual target species. As this framework has evolved, a number of seafood eco-labelling schemes have also developed. These schemes aim to identify well-managed fisheries and give competitive advantage to their products, thus translating the environmental awareness of consumers into direct support for sustainable fishing practices. This paper evaluates a number of these schemes in the context of international fisheries governance principles and considers the conservation benefits that may result from sustainability certification of Pacific tuna fisheries. The paper briefly summarises developments in eco-labeling of Pacific tuna fisheries in relation to the evolution of fisheries management, where focus has shifted from the maximum sustainable yield of individual tuna species to ecosystem-based approaches that directly consider the broader environmental impacts of fishing. The paper discusses two different 'Dolphin Safe' eco-labels, the third-party scheme of the Earth Island Institute and the intergovernmental scheme of the Agreement on the International Dolphin Conservation Program, and two broader eco-labels offering sustainability certification of fisheries, 'Friend of the Sea' and the 'Marine Stewardship Council'. The role played by seafood-industry associations with sustainability claims, such as the International Seafood Sustainability Foundation, is also considered.

101 Engaging with the aquaculture industry to increase support for novel biosensor technology

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Monitoring of intensively reared aquaculture animals can be difficult. Recent advancements in biosensors have enabled long-term, non-invasive monitoring of a range of physiological and physical variables that are relevant to animal health and productivity. Consequently, sentinel aquaculture animals are being linked into large scale sensor networks (e.g. sense-T network) that aggregate information from many different data sources, including biosensors. The real-time data produced have the potential to drive farm management decisions and provide insight into difficult problems such as climate change. End-user and community support is integral for uptake of novel technologies such as biosensors. Strong client relationships and can be reinforced by effectively publicising and disseminating information via traditional and new media. Maintaining a public profile benefits the science team and can additionally benefit the clients through increased media exposure. This project connects with the public, aquaculture farmers and funding bodies though both traditional (e.g. TV and print) and new media (e.g. Twitter) and community engagement. By utilising media platforms for publicity and information dissemination we aim to increase uptake of our biosensor technology leading to greater data collection and ultimately to better informed management decisions on aquaculture farms.

102 Ensuring an enduring legacy: the multiple stories of the Native Fish Strategy

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The Native Fish Strategy (NFS) is a long term approach to restoring the native fish populations of the Murray-Darling Basin. Since 2003, the NFS program has identified threats, developed and implemented effective management actions, and evaluated the response. The NFS has also embraced connecting with people and worked in partnership with a wide range of stakeholders, including and beyond the scientific community.

After a decade of NFS research, action and partnerships, the myriad forms of engagement employed throughout the program are explored, with a particular focus on those used to ensure that the legacy of the NFS is available to all; scientists, NRM practitioners, and the broader community. A range of engagement tools were used during the NFS including printed materials, online platforms, hands on activities and face to face networking. This diversity of methods recognised the wide ranging audiences that have multiple perspectives and multiple methods of accessing information across the Basin.

The NFS legacy products include traditional forms of science communication, such as a special edition of a peer reviewed journal for the scientific community, as well as emerging communication platforms for the wider community. These online products include a comprehensive website for multiple users, a set of short videos on the flagship Demonstration Reach program, an interactive Demonstration Reach Toolbox for NRM practitioners, and the Talking Fish booklets and radio programs. To understand the effectiveness of these platforms, it is essential that monitoring programs are established, guiding investment in future programs.

Oral abstracts

103 Science Communication and Knowledge Adoption: what is the difference and why should I bother?

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Within government funded research programs, research uptake is increasingly being used as a key measure of a program's success. This approach is requiring scientists to drive or participate in science communication and knowledge adoption activities, an area in which many scientists will have received no training. So what is the difference, what is involved, and what are the benefits of spending time on these activities? In this presentation, I will talk about the range of science communication and knowledge adoption activities employed by the Northern Australia Hub of the National Environmental Research Program; the different objectives of activities; and the short and long-term benefits of investing in science communication and knowledge adoption.

104 Knowledge Brokers: Unique individuals or a flawed concept?

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The CRC for Freshwater Ecology had a profound influence on the relationship between the research and water management communities in Australia. One of the initiatives spawned by the CRC FE was implementing the idea of knowledge brokers. Peter Cullen, CRC FE Foundation Chief Executive, believed that translating science into knowledge that could be applied to management and policy questions required both a significant time commitment (that would take researchers away from their core activities) and a special skill set not shared by all researchers. The passage of time has not, however, seen the concept of knowledge brokers flourish in the area of freshwater science. This raises the question of what the investment in Knowledge Broking has taught us in terms of communicating science and improving the relationship between science and management. This talk will reflect on MDFRC's experience with Knowledge Brokers and explore some of the individual and institutional characteristics that influence a Knowledge Broker's capacity to fulfil their role. The presentation will conclude with some reflections on the implications for future investments in science communication.

105 Freshwater: Gaps in the Atlas of Living Australia

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As of March 2014, the Atlas of Living Australia (ALA: http://www.ala.org.au) has nearly 45 million records of 112 thousand species, 400+ 'environmental layers', ~39 million pages of biological literature, 40 thousand species images and a host of other integrated biological data. What the Atlas lacks however is the identification of freshwater species and national spatial layers that describe their environment. The Atlas has an unknown but large number of observations of freshwater species that can currently only be related to adjacent terrestrial or marine environmental parameters. There is therefore a stark contrast between the services provided by the Atlas to the freshwater community by comparison with those working in terrestrial and marine environments.
The Australian National Aquatic Ecosystem (ANAE) Classification Framework aligns nicely with IBRA and IMCRA classifications, but seamless national geospatial layers based on the ANAE are not available. Without those layers, how can freshwater ecosystems be sustained? Successful local and regional trials have been completed and the issue has been raised in public reports but no nationally agreed practical outcomes have emerged. There is no 'champion' to maintain a list of species with at least a freshwater phase. How can we attain solutions? Who is best placed to take leadership, provide the resources and catalyse an outcome? The Atlas recognised the gap in data and services, but it does have the infrastructure to support a practical outcome when it occurs (see for example http://lists.ala.org.au and http://spatial.ala.org.au/layers).

Oral abstracts

106 Life after Kakadu: 25 years of pursuing and applying knowledge on hydro-ecological dynamics in the more complex rivers of north-eastern NSW

Keith A. Bishop[1]

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This paper provides a series of glimpses into valuable extensive data sets which uniquely display the responses of Australian freshwater fishes and their habitats to changes in river discharge. The perspective is that of an independent practitioner, unconstrained by organisational paradigms, and with a predilection for direct-observation surveying techniques.
The first glimpses of hydro-ecological dynamics arise from a decade of work on freshwater fish from the relatively hydrologically-predictable streams of Kakadu National Park in the Northern Territory. Understandings from these dynamics were, perhaps naively in some cases, then taken south to the far less predictable rivers of north-eastern NSW.
Arrival in NSW coincided with the emerging management and research interest in environmental flows and these have been the primary investigation focus over the ensuing twenty-five years. With an understanding that 'habitat volume' was a basic driver, the initial focus was hydro-habitat dynamics and glimpses are given of hydro-physical-habitat relationships based on flow manipulations across a set of rivers. Subsequently, habitat dynamics investigations included aquatic vegetation assemblages in upper estuaries. An example of these dynamics is provided for an eight-kilometre stretch of the Hastings River estuary over fifteen years. Both flood scouring and low-flow-mediated salinity impacts are dramatically demonstrated and detailed knowledge of the latter has considerable utility in refining environmental flows in the system.
An important theme in the physical-habitat investigations has been the availability of fish passage across tidal-barrier riffles in systems where significant water extraction occurs upstream. Such work can be quite challenging in lower river reaches which braid. This is the case in the Manning River where verification effort has focused on developing a better understanding of fish-migration dynamics. This work, undertaken on two spatial and temporal scales over seven years, has provided unique insights into these dynamics and demonstrated the complexity arising from the less-predictable hydrology in this system.
Understanding hydro-ecological dynamics? – long-term, landscape-scale surveying holds the key! Transferring knowledge between systems? – be cautious!

107 River recovery: How do macroinvertebrate assemblages change once antecedent flows are restored following years of heavily modified flows?

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Flow dynamics are closely linked to the life history traits of freshwater organisms. These organisms have evolved to cope with predictable flow dynamics and patterns of disturbance, such as seasonal flow variation or floods. Many rely on these predictable events and disturbances as signals for mating, hatching, emergence and migration. However, artificially altered flow regimes can interrupt or even prevent these critical life events from occurring. They also alter nutrient concentrations, flow rates and sizes, and habitat availability. Restoring natural flow regimes may improve river health, very little about the time required for rivers to return to a state of good health once human impacts cease is known. In addition, the specific effects of flow on macroinvertebrate morphology and life history traits remains poorly understood. This study aims to assess the effects of flow on macroinvertebrate life history traits and morphology, and to investigate how long a river takes to recover once returned to natural flows. Pretty Valley Creek, located in Alpine Victorian, provides a rare opportunity to study these effects as it was recently returned to antecedent flows and is pollution-free. Using an mBACI design, we investigated changes in the macroinvertebrate assemblages of the creek, both before and after natural flow restoration. Preliminary analysis indicates rapid recovery of many of the common macroinvertebrate orders following the cessation of artificial flows. This research provides important insights into the length of time required for rivers to return to pre-disturbance levels, and furthers our understanding of how flow affects macroinvertebrate assemblages.

108 Larval abundance of cod *(Maccullochella spp.)* during targeted environmental watering in the Murrumbidgee River

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Successful spawning and recruitment of native freshwater fish species is dependent upon environmental conditions that optimise larval survival and growth. These conditions seldom occur in regulated rivers where altered flows are often unsuitable for native fish spawning and or recruitment. Environmental water actions target species recovery by restoring key features of the hydrograph. We investigated larval fish abundance in a lowland section of the Murrumbidgee River during a targeted environmental watering event between September and December 2012. The event aimed to increase the inundation of spawning sites for a nesting species (e.g. Murray cod). Estimates of demographic structure indicated that cod (Maccullochella spp.) spawning occurred from mid-October through to early December, coinciding with environmental water delivery. Significant differences in cod abundance occurred among the three in-channel sampling sites. Larval cod abundance was significantly associated with abiotic variables such as electrical conductivity, water temperature, turbidity, nutrients, and river height. Importantly, microcrustacea abundance peaked during the environmental watering event, providing a food source for larvae. Collectively, these results indicate that the timing of environmental water delivery was sufficient to enable spawning, and that the associated ecosystem responses were conducive to the survival and growth of larval fish.

Oral abstracts

109 Recruitment Ecology of *Maccullochella* in the Upper Murrumbidgee 2011-2013

Alan Couch[1], **Mark Lintermans**[1], **Fiona Dyer**[1], **Pat Ross-Magee**[1], **Alica Tschierschke**[1]

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Maccullochella larval ecology in upland rivers has been little studied. This is in contrast to the situation in lowland rivers systems where the recruitment and spawning ecology of cod have been extensively investigated. Six sites spread over 40 kilometres of the Murrumbidgee River in the ACT were sampled for drifting larval fish in the spring/early summer of 2011, 2012 and 2013. *Maccullochella* larvae were the most common species captured. Spatial and temporal variation in larval drift was seen. 2012 saw low levels of larval drift compared to 2011 and 2013. But overall the high larval density observed (mean of 20 larvae per ML during peak week of drifting period) suggests this reach may play an important role for natural recruitment of cod into the Murrumbidgee River system. Size and age profile of potential recruits was examined. Relationships between observed larval cod drift, and seasonal and river conditions was considered but no significant associations were seen. The distance *Maccullochella* larvae drift from the nest before settling remains a knowledge gap and specific patterns of larval cod drift in upland river systems may have implications for management of the two sympatric *Maccullochella* species (*M. peelii* and *M. macquariensis*) in this river.

110 Functional responses to environmental flows: linking benthic metabolism and dissolved organic carbon in the Snowy River

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Controlled floods from storage reservoirs are often used in the rehabilitation and restoration of regulated rivers. These events may influence ecosystem functioning by altering basal resource availability. One such resource is dissolved organic carbon (DOC), a major energy source for the heterotrophic micro-organisms that often form the base of the riverine food web. Controlled floods in the Snowy River deliver a reduced DOC concentration pulse relative to natural high-flow events. This study examines benthic metabolic responses to the DOC signal from three experimental floods in the Snowy River below Jindabyne Dam. We expected epilithic biofilm respiration and benthic extracellular enzyme activity rates to increase concomitant with a DOC concentration pulse during each event. Tiles colonised with epilithic biofilm were exposed to real time changes in stream DOC concentration and incubated in sealed chambers to determine metabolism rates. Enzyme activity rates in benthic sediments were measured throughout each event. Preliminary results show a minor increase in DOC concentration accompanied by an approximately three-fold increase in biofilm respiration rate during two of three floods. The activity rates of some extracellular enzymes increased relative to pre-release conditions, but specific enzymes showed an inconsistent response between events. These results suggest that even a small DOC signal from controlled floods can influence benthic metabolism, and may therefore affect broader ecosystem functioning such as whole stream metabolism and carbon cycling.

111 Defining ecosystem processes for rehabilitation of Ranger uranium mine (NT)

Amy George[1], **Renee Bartolo**[1], **Andrew Harford**[1], **Chris Humphrey**[1]

1. *Dept of the Environment, Supervising Scientist Division, Darwin, NT, Australia*

The Environmental Requirements for closure of Ranger uranium mine stipulate that the minesite and associated waterbodies must be rehabilitated to a state which allows them to be incorporated into the surrounding World Heritage, and Ramsar-listed Kakadu National Park. Rehabilitation of ecosystem processes is specifically identified in these requirements. Identification of key ecological processes is an essential aspect of developing Ecological Character Descriptions (ECD) for Ramsar sites. However, the mapping of key processes to the biological and ecological measurements commonly used in monitoring programs is a step often ignored or given little attention. The current ECD for Kakadu identifies only two non-biological critical processes: fluvial hydrology and fire regimes. A number of non-critical supporting processes are further identied with ecosystem processes being listed as a supporting process. However, the ECD does not explicitly link these processes with quantifiable measurements typically applied within Ramsar wetland monitoring programs. As part of an ecological risk assessment being conducted for Ranger, ecological processes are being linked with response variables measured as part of the on-going monitoring program at Ranger. Processes have been developed for multiple spatial and temporal scales to evaluate synergies between measurement variables and ecological processes within aquatic ecosystems. The results indicate the need for processes to be considered within a seasonal context, particularly where seasonal variation is very high, as in the wet/dry tropics.

Oral abstracts

112 Riparian zones in flat sandy systems, are they up to scratch?

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The riparian zone paradigm suggests that vegetation along perennial streams on sloped sites with good soils improves water quality and aquatic biodiversity. In the Ellen Brook catchment in Western Australia, riparian vegetation is situated along coloured (high DOC) intermittent streams. While poor soils, lack of slope and surface flow limits nutrient removal capacity in these flat, sandy systems, this study has previously shown that riparian vegetation improves soil condition, nutrient uptake and storage. But what other benefits does riparian vegetation provide, particularly for intermittent streams? A survey of in-stream macroinvertebrate communities across vegetated and unvegetated stretches of intermittent and perennial streams was undertaken. Results indicated that flow regime, colour (DOC) and whether stream segments were vegetated had a comparable effect (Global R= ~0.4, P <0.001). However, pairwise comparisons showed that flow regime (R= 0.513, P <0.001) had a stronger influence then stream colour (R= 0.283, P <0.001). The presence of riparian vegetation had the largest effect in perennial streams (R= 0.537, P <0.001). In intermittent streams, flow regime was the driving factor and not riparian vegetation, possibly due to degradation of riparian vegetation at these sites. The results from this study question the fundamentals of the riparian vegetation paradigm, particularly in relation to the functionality of riparian vegetation in nutrient reduction and its contribution to stream invertebrate diversity in sandy intermittent streams.

113 Benthic algal resilience to frequent wet season disturbances by storm flows in low order streams in the Daly River, tropical Australia

Simon Townsend[1]

1. *Charles Darwin University, Darwin, NT, Australia*

Disturbance by storm flows and floods can shape lotic ecosystems. During the 3 month wet season of the Australian wet–dry tropics, storm flow disturbances are frequent. Benthic algal resistance and resilience in open canopy streams in the Daly River catchment are investigated. The following hypotheses were tested: (1) storm flow will dislodge benthic algal biomass, (2) base flow biomass will be low, (3) taxon richness will also be low, and (4) algal composition will be dominated by either resistant algae with a prostrate and/or erect growth forms, or fast growing colonizing algae. Storm flows dislodged approximately 93% of epilithic biomass, supporting the first hypothesis. Benthic biomass was typical of temperate oligotrophic streams, though maximum biomasses were more typical of mesotrophic streams. The second hypothesis is not supported unequivocally. The relatively rapid growth and high biomasses are attributed to the warm water temperatures, as well as high incident light, rapid algal nutrient uptake, and grazing pressure constrained by the loss of invertebrates caused by storm flows and physical impediments to fish access. Sample taxon richness averaged 34, higher than expected and not supporting the third hypothesis due to the occurrence of rare taxa. Nor was the fourth hypothesis supported, as epilithic algal biomass was dominated by resistant filamentous algae. Epilithic algae demonstrated a similar resistance to storm flow disturbances compared to higher latitude streams, but a greater level of resilience, and could potentially supply an autochthonous source of carbon to the Daly River.

114 Can Top-Down Consumer Effects Be 'Scaled-Up'?

Erica A Garcia[1], **Katherine S Lacksen**[1], **Damien McMaster**[1], **Michael M Douglas**[1]

1. *Charles Darwin University, Darwin, NT, Australia*

The strength of top-down (consumer) control in stream ecosystems is known to vary across temporal and spatial scales. Although little is known about whether measurements at the small scale can be 'scaled-up' to describe what is occurring at the catchment level or larger spatial scale. Here we conducted a 40 day consumer manipulation experiment (i.e. fish and shrimp removal) to test top down consumer effects and in-stream processes within three streams in the wet/dry tropics of northern Australia. Changes in benthic algal biomass as well as macroinvertebrate abundance and community were measured at the patch scale within small 1m^2 exclusion cages and at the reach scale within whole-reach exclusions (~20m). At the reach scale strong top down consumer effects were observed, with evidence of a trophic cascade. Here the removal of consumers resulted in a significant increase in macroinvertebrate abundance and a significant decrease in benthic algae biomass. However at the patch scale, there was no evidence of top-down effects, with no significant difference in macroinvertebrate abundance or benthic algae biomass between treatment groups. Our findings highlight the difficulty in 'scaling-up' top-down control results. This is particularly important for river health monitoring which is typically challenged by the need to "scale-up" from site level measurements to the whole ecosystem which is frequently the target of management actions; as many of the human induced pressures on our riverine environments occur at large scales.

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115 Multi-scale comparison of stream metabolism within the wet/dry tropics

Erica A Garcia[1], Damien McMaster[1], Katherine L Lacksen[1], Michael M Douglas[1]

1. *Charles Darwin University, Darwin, NT, Australia*

In-stream ecological processes like primary production and community respiration are known to vary across temporal and spatial scales. Addressing this variability is one of the most persistent problems in stream ecology, yet only a handful of studies have explicitly tested if ecological processes measured at the small scales can be 'scaled-up' to describe larger spatial scales. Here we conducted a 40 day consumer manipulation experiment (i.e. fish and shrimp removal) to test top down consumer effects and in-stream processes within three streams in the wet/dry tropics of northern Australia. At the conclusion of the 40 days stream metabolism measurements were taken at the patch scale using small benthic metabolism chambers (7L) and compared to single-station whole stream metabolism measurements taken at the reach (~20m) scale. Gross primary production (GPP) measurements were greater at the patch versus reach scale and no significant differences were observed between consumer exclusion control/treatment groups. In comparison, community respiration (CR) was higher (up to 25 times in some cases) at the reach scale compared to measurements at the patch scale. Mainly due to differences in community respiration, the photosynthesis to respiration (P:R) ratio was revealed to be autotrophic (>1) at the patch scale and heterotrophic (<1) at the reach scale. This research highlights the difficulty in 'scaling up' these ecological processes, particularly in the underestimation of community respiration due to excluding sub-surface respiration. Future work would benefit from a better understanding of the mechanisms behind the differences in the results across spatial scales.

116 Phosphorus limits seston and periphyton production in iron-rich dryland streams?

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Dryland streams of the Pilbara region of Western Australia have iron- and calcium-rich sediments which effectively 'lock up' the little phosphorus (P) available for production. It is hence widely assumed that productivity within these streams is strongly P limited. Yet water column measurements of bioavailable nutrients (DIN and SRP) across a range of Pilbara streams indicated that nitrogen (N) concentrations are also much depleted and potentially limiting (DIN = 0 – 36 µg l-1, SRP = 1 – 4 µg l-1, N:P ratio = 0 – 12). We measured the response of seston and periphyton to nutrient substrate addition in a series of bottle assays to determine which nutrient is most strongly limiting. Bottles were filled with either stream water (seston measurements) or stream water + periphyton inoculum (periphyton measurements). Nitrogen (NO3 + NH4) and phosphorus (PO4) substrates were added to bottles to enable 10x ambient concentrations. A full factorial design was employed with treatments of control, dark, +N, +P, and +N+P. Dissolved oxygen concentrations were measured at the start and completion of 6 hr in-stream incubations to calculate productivity and respiration. Results from bottle assays were compared to ecosystem respiration measured by the single station method for each site. This poster presents initial findings and experimental design of further investigations underway.

117 Evaluating the additive effects of large-scale native fish stocking for enhancing recreational fishing

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Fish stocking is a fisheries management tool widely used to augment fish stocks for a variety of purposes including enhancing recreational fishing. Often the measure of success for recreational fish stocking is survival, recruitment and contribution of stocked fish to the fish population or fishery, yet the potential additive effects to the wild fish population or fishery remain unknown. In Australia, fish stocking of recreationally important native freshwater species such as the Murray cod Maccullochella peelii has been occurring for over 30 years since the development of hatchery practices in the 1980s. Despite widespread stocking, the contribution and potential additive effects of stocked fish to Murray cod populations and fisheries has not been investigated. The importance of evaluating native fish stocking in Australia has recently increased due to considerable investment in large-scale fish stocking initiatives for Murray cod in south-eastern Australia (up to a million fish released per waterway). This paper presents an examination of the contribution and additive effects to fish populations (abundance) and fisheries (target preference, catch and satisfaction) from large-scale stocking of Murray cod across six major rivers, and impoundments, exposed to varying degrees of natural recruitment. Our study represents one of the largest native fish stocking evaluations to have occurred in Australia. Results will be of use to biologists, ecologists, policy makers and fisheries managers worldwide in identifying the conditions for additive effects of stocking in the wild, in order to guide the expected considerable future investment in fish stocking.

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118 Science or citizen science? Which will save the Oblong turtle?

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In the urban environment, populations of the long-lived, native, freshwater, oblong turtle Chelodina colliei may be undergoing a catastrophic decline unnoticed. The aim of this project was to determine if urban populations of C. colliei were sustainable and the factors that influenced this. Mark-recapture sampling was conducted at twelve wetlands (approx. 150 days over three trapping events). In seven of these, few turtles were captured indicating potential population decline. It also limited the capacity to credibly establish actual population size and factors that contribute to the population structure. This lack of information may prevent timely intervention to ensure species survival. In contrast, citizen science and community turtle sightings were able to provide long-term data sets (2 to 6 years) in both terrestrial and aquatic environments. By designing simple metrics (eg length of a Coke can), community members were able to contribute meaningful data e.g. whether turtles were sexually mature. Other information including location, behaviour and seasonal movements were also reported. While the ecological study was able to provide the sex ratio and distribution of age classes within specific wetlands, citizen science extended the range of information to terrestrial habitats and provided seasonal movements of specific age classes (e.g. hatchlings). Traditional ecological methods can be expensive and time-limited, while citizen science is low cost, long-term and, if well designed, can flag signs of population decline. This presentation will describe how integrating both information sources can maximise our understanding and capacity to conserve *C. colliei*.

119 DNA Barcoding and Ecological Studies: Finding Large Hidden Genetic Variation

Ros St Clair[1]

1. *EPA Victoria, Macleod, VIC, Australia*

Several people are now involved in genetically barcoding freshwater invertebrates of Australia. EPA Victoria has become involved to concentrate on the freshwater invertebrates of Victoria for biological monitoring purposes.
While this work has some way to progress for monitoring purposes, it is already producing information of wider interest. One aspect, large genetic variation within some species and genera, has big implications. Whilst for many taxonomic groups the gene sequences are confirming the morphological taxonomy, unexpected variation is occurring in others. Of the groups with larger genetic variation than expected, some are due to lack of existing morphological taxonomic research but others clearly represent variation that is not related to morphological variation. In some instances, a very large genetic distance can underlie very similar looking species, which may occur in close proximity.
Some examples of the groups with such variation are given from the Trichoptera, with barcodes for over 350 "species" now, to indicate the extent and significance of this problem. It seems that this type of variation exists particularly in taxonomic groups that are poor dispersers and have specific habitat requirements (e.g. Helicopsychidae, Antipodoeciidae) but this is not always the case (e.g. Leptoceridae: Notalina).
The implications of this variation are clearly important for ecological studies. Knowing which taxonomic groups include such large variation should be useful information to help select study species or understand population or trait variation. Taxonomic groups with such large variation within the Trichoptera will be detailed.

120 Fish spawning in the tropics - are low flows important?

Cathy Doidge[1], Alison King[1], Duncan Buckle[1]

1. *Charles Darwin University, Darwin, NT, Australia*

Rivers of northern Australia contain a high diversity of freshwater fishes, which are ecologically, socially and culturally important. Little information is currently known on their basic early life history requirements, particularly spawning times, nursery habitat and survival requirements of young. In addition, there are a variety of anthropogenic changes (e.g. water extraction, river regulation, land use change, population expansion and climate change) posing imminent threats. At this critical time, we investigated the spatial and temporal variability of freshwater fish spawning during the dry season low flow period in the Daly River, and what specific nursery habitats are being used for breeding during this period.
Sampling of fish early life stages occurred at 6 weekly intervals (May-October), in three river reaches of the Daly River. A suite of standardised methods was trialled, with Sweep Net Electrofishing and light traps being most effective, and drift and trawl nets yielding very small numbers. Spawning occurred throughout the dry season, with peak abundance occurring for some species towards the end of the dry season, leading into the resource rich wet season. A total of 14 species were collected as larvae and 24 as juveniles. Strong diel variation was also evident, with higher larval abundances at night. The majority of larval and juvenile fish were collected in littoral habitats (of varying characteristics) and not collected in the main channel.
This study forms part of a larger on-going project that will contribute towards an understanding of spawning and recruitment requirements of fishes in the Daly River.

Oral abstracts

121 Examination of sampling processing methods for macroinvertebrate community monitoring in tropical shallow billabongs

Lisa Chandler[1], Christopher Humphrey[1], Amy George[1]

1. *Supervising Scientist Division, Darwin, NT, Australia*

Aquatic macroinvertebrate communities are routinely monitored around the Ranger uranium mine in the NT to assess if any change in community structure can be linked to the effects of minesite runoff. The Supervising Scientist Division has sampled macroinvertebrate communities in shallow waterbodies (artificial or natural billabongs) intermittently, in 5 years since 1995.
In each of the thirteen waterbodies studied, samples were collected from littoral macrophyte habitats at five locations. In 1995, 1996 and 2006 all of the samples were processed using only live sorting methods, with limited follow-up laboratory sample processing conducted in 1996. Due to time constraints associated with field sample processing, the processing method was changed in 2011. The live sort was removed and replaced with field preservation of samples and subsequent laboratory subsampling and processing under stereomicroscope.
Multivariate analysis of the community structure data indicate distinct differentiation by year, with the live-sort and laboratory-processing years separated from one another in MDS ordination. Such a distinct split between the years raises the question of whether there is an actual shift in the macroinvertebrate community structure over time, or whether this simply reflects the different sample processing methods. For impact assessment studies, sample processing differences will confound particular interannual comparisons but not necessarily those whose design incorporates a reference-to-exposed waterbody type comparison. Techniques for analysis are explored to further determine the validity of comparing data across multiple years where different processing methods have been adopted.

122 Do recolonization processes in intermittent streams have sustained effects on benthic algal density and assemblage composition?

Belinda J Robson[1], Edwin T Chester[1]

1. *Murdoch University, Murdoch, WA, Australia*

Previous research shows that when intermittent streams flow, benthic algae develops from both colonizing propagules and regrowing dried biofilm, but the duration of these effects isunknown. In 2008, Robson and colleagues published a model of recolonization processes in intermittent streams. We now aimed to determine whether these colonization processes could influence algae densities and taxonomic composition beyond the period immediately following the onset of flow, and whether flow regulation would modify those processes. In a field experiment in the Victoria Range, Grampians National Park, Australia, stones were placed in two unregulated streams, and upstream and downstream of weirs in three regulated streams, after dry biofilm had been removed. Epilithic algae on treatment and control stones were collected after winter flows (12 weeks). Treatment effects were still apparent in one (unregulated) stream, but not in the other four streams. Algal assemblages and densities upstream and downstream of weirs differed, but there was no systematic pattern among streams. In these intermittent headwater streams, recolonisation processes may influence algal assemblages until spring; but in most streams, the duration of influence will be shorter, depending on assemblage composition in regrowth and refuges, which is also shaped by previous season's conditions. The effect of regulation probably depends upon how idiosyncratic flow regimes and assemblage compositions affect recolonization. Similarly, the recovery trajectories for stream communities after drought will differ among streams, depending on whether biofilm can develop during potentially short seasonal flows.

123 Torres Strait Sea Country – do we really know who makes the decisions?

Stan Lui[1]

1. *Torres Strait Regional Authority, Darnley Island, QLD, Australia*

The Torres Strait is home to Eddie Koiki Mabo who was a significant national and international figure in altering the traditional land rights landscape in Australia. The High Court delivered the decision of Mabo and others v Queensland (No.2) in 1992.
To date, 27 native title determinations have been made over the land and waters in the Torres Strait. In 2013, the Federal Court of Australia recognized non-exclusive native title rights over about 37,800sq km of sea in the Torres Strait., including the non-exclusive rights to access, remain in and to use their own marine territories to access and take resources for any purpose, including commercial use.
A complex system of State, Commonwealth and International law governs the interests of Torres Strait Islanders, the Commonwealth government, the State government, commercial industry and Treaty villages in Western Province, Papua New Guinea.
The Torres Strait fishery is managed through the Torres Strait Fisheries Act 1984. All management arrangement decision making processes are driven through the consultative framework of the Protected Zone Joint Authority (PZJA). The PZJA members are the Federal and State Fisheries Ministers and the Chairperson of the Torres Strait Regional Authority.
Currently there is no independent organisation which represents the grass-roots interests of Torres Strait Islanders within the PZJA.
This presentation will provide an account of the Torres Strait Islanders journey thus far including, important aspects of the sea claim, the challenges of independent representation, current research activities which have very little traditional owner renumerated involvement, and what we see are the future impacts for our traditional practices and cultural protocols.

Oral abstracts

124 Valuing Indigenous engagement in fisheries research

Bo Carne[1]

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Indigenous Australian's have extensive knowledge, experience and passion in managing natural resources. Their continued connection to country is being recognised by a variety of organisations, including researchers from universities, government agencies and/or non-government organisations. There is a shift towards merging both Indigenous knowledge and western knowledge to gain a better in depth understanding of our ecosystems. This shift includes localised Indigenous ranger programs, joint research initiatives at the jurisdictional level as well as a steady push at the 'sectoral' (eg north Australian) and national levels. Indigenous engagement in ecosystem research and management is an obligated activity, it is enshrined in Indigenous culture through ceremony, stories, songs, art and law (lore).
Australia needs to be proud of its Indigenous heritage and ensure it is protected, but first needs to clearly define what it is. This is best done by including Indigenous people in research and management. Benefits to engage Indigenous people in research and management initiatives are more than just about cost efficiency or social and cultural maintenance. It's about modelling holistic approaches in obtaining vital ecosystem based research that can recognise 60 000 years of research and management. This presentation will discuss the benefits of engaging Indigenous Australians in fisheries related research and management. It will provide some case studies at the local, jurisdictional, sectoral and national levels. The success of these activities has been through them being driven by a 'ground up' approach with a strong 'top down' approach used to support these initiatives.

125 Indigenous Voices in Water Rights - The NSW Experience

Phil Duncan[1]

1. *NSW Aboriginal Land Council, Parramatta, NSW, Australia*

In 2004 all Australian governments signed a world's best practice blueprint for water reform – The National Water Initiative. The NWI explicitly recognises the need to identify Aboriginal water values, their water requirements and water provision for current or future native title claims. While the NWI parties have made progress in identifying all water user requirements and values, significant opportunities remain to;

- More effectively engage and consult with Aboriginal communities to better account for their water values and requirements in water planning; and
- To encourage greater Aboriginal leadership in water planning and management issues.

This presentation provides an insight into how Indigenous people in NSW have engaged to build the necessary capacity to be proactively involved in water planning and management to the extent of being a key player in the water market trading. Cultural Flows have now been integrated into all water sharing plans across NSW.

126 Are native fish populations in the Murray River energy limited?

Nick Bond[1], Darren Baldwin[2], Gavin Butler[3], David Crook[4], David Hohnberg[5], Paul Humphries[6], Mark Kennard[1], Keller Kopf[6], John Koehn[7], Nicole McCasker[6], John Morrongiello[8], Daryl Nielsen[2], Paul Reich[7], Rick Stoffels[2], Jim Thomson[9] , Jian Yen[10]

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Native freshwater fish populations in many parts of southern and eastern Australia have undergone extensive declines since European settlement, and there is now considerable investment in trying to reverse this trend. A major focus for these efforts, both in terms of scientific research and management actions, has been directed towards addressing the impacts of habitat loss and flow alteration on opportunities for spawning, recruitment, and availability of, and access to, the necessary habitats for fishes to complete their life-cycle. Meanwhile, much less attention has been given to the impacts of altered flooding regimes on the production and carrying capacity of aquatic biota. Here we ask whether populations of high-trophic order native fish in regulated lowland rivers such as the Murray are presently limited by energy availability, either due to altered rates of production or altered energy flows, for example due to competition from introduced species. We assembled information on historical and contemporary native fish abundance and historic and present day estimates of basal energy production, and combined these data using simple food-web models. Our initial results suggest contemporary levels of riverine production are insufficient to support historical biomass estimates, and hence pose severe constraints on the outcomes that might be expected from traditional approaches to rehabilitating native fish populations. We discuss the implications of these results in terms of environmental flow management, and also discuss future research needs.

Oral abstracts

127 Knowledge of age and provenance is fundamental to understanding flow-related reproductive response, recruitment and population dynamics in freshwater fish

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Restoration of flow regimes to benefit native fish populations requires an empirical understanding of relationships between hydrology, life history and population dynamics. Golden perch is one of only a few native species in the southern Murray-Darling Basin whose reproduction and recruitment has been consistently related to flow. Consequently, golden perch spawning and recruitment constitute a common objective of environmental water allocations. Nevertheless, to measure response, and inform environmental water delivery, an explicit understanding of when and where fish originated is fundamental.

Microstructural and chemical analyses of fish otoliths provide powerful tools for determining the spatio-temporal provenance of fish. We demonstrate how these tools can be used to retrospectively elucidate the natal origin of cohorts of golden perch in the lower Murray and to determine the spawning date and origin of juvenile fish in relation to the delivery of an environmental water allocation.

Daily and annual growth increments in otolith microstructure and strontium isotope ratios indicated that golden perch larvae, young-of-year and adults in the lower River Murray were often not locally sourced, but rather, resulted from spawning that occurred over a broad period (October–January) in the Darling and potentially mid-Murray rivers. These data enable the explicit spatio-temporal association of golden perch spawning and recruitment with flow, including environmental water delivery. Ultimately, population dynamics of golden perch in the lower River Murray are driven by processes occurring at scales of 100s-1000s kilometres. To achieve positive outcomes for native fish, delivery of environmental water must consider recruitment dynamics at these scales.

128 Multi-decadal biochronologies indicate species-specific responses to environmental change/variability in the River Murray estuary

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The River Murray estuary is the largest estuarine system in Australia, supporting a diversity of fish with varying biological and ecological traits. In recent history, the estuary has undergone dramatic fluctuations in environmental conditions (e.g. the Millennium Drought). However, there is little understanding of how these environmental fluctuations have affected the fish inhabiting the system. This study assessed responses in growth to decadal environmental variation including flow in species of fish with differing ecologies: golden perch (freshwater obligate), black bream (estuarine dependent), and mulloway (estuarine opportunist). Biochronologies based on otolith growth increment widths were developed for each species using a mixed modelling approach. Biochronologies, ranging 15 to 36 years and spanning a period of severe drought, showed considerable inter-annual variation in growth. Biochronologies were then correlated to a range of local and regional hydrological and atmospheric time series data at seasonal and annual temporal scales. Among species, environmental drivers of growth variation differed. River flow at the barrages near the Murray Mouth was found to be most influential in driving golden perch growth, while the growth of mulloway and black bream responded to fluctuating temperatures and local rainfall, respectively. These results suggest that generalisations about environmental influences on ecosystem functioning mask species-specific responses, as fish respond to environmental change dependent on the constraints of their life history strategies. These findings more broadly highlight the importance of considering the diversity of ecological groups that inhabit an ecosystem when developing conservation and management strategies.

129 Investigating fish growth responses to flows in temperate floodplain rivers

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Environmental flows, which aim to reinstate or protect key aspects of a rivers natural flow regime, are now considered an essential ingredient to maintain or restore native fish populations in flow degraded rivers. Optimising the benefits of environmental water delivery for fishes is currently reliant on restoring key aspects of the natural flow regime governing population processes. Unfortunately, for many of Australia's freshwater fish species, there is still much uncertainty surrounding many of these vital links, making environmental flow recommendations and subsequent predictions of responses difficult.

Conceptually, the pathway by which flow is frequently linked to the governance of fish populations is through its influence on habitat availability, connectivity and key ecological processes affecting fish condition and growth. Fish condition and growth has been demonstrated to influence each of the key population processes governing fish populations including recruitment, survival and movement. We investigate the growth of several species of native fish under a range of flow conditions in two rivers of the southern Murray-Darling Basin. Biochronology techniques were used to reconstruct fish growth in the unregulated Ovens River and regulated Murray River over a 23 year period encompassing major drought, flood and for the Murray River, environmental water delivery. Our results are used to predict the influence of previous environmental water deliveries on fish growth and strategies to improve such deliveries to maximise any such benefits for fish.

Oral abstracts

130 Understanding fish behaviour and life history is critical to developing effective environmental flow regimes for native fish: a case study of Australian grayling

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Flows provide cues for a range of critical life history behaviours in fishes such as movement and spawning. In many rivers throughout the world, however, flow regulation has resulted in the loss or disruption of these cues. The provision of environmental flows provides an important opportunity to reinstate these cues to assist fish population recovery. A major challenge of environmental flows science and management therefore is developing understanding of critical relationships between flow regimes and fish behavioural responses. The Australian grayling is a diadromous fish species that has declined considerably since European settlement. Changes to flow regimes are a major reason for the decline. Consequently, environmental flow recommendations have been developed and implemented for the species in many regulated rivers. Although such efforts may benefit Australian grayling, gaps in knowledge of flow-ecology relationships limit the development and effectiveness of these strategies. To address this shortcoming, we investigated two critical life history behaviours of Australian grayling (movement and spawning) and relationships with flows, using larval drift sampling and acoustic telemetry. In particular, the study tested whether Australian grayling migrate to specific areas to spawn, and whether these behaviours are influenced by flow. The study found that Australian grayling migrate large distances downstream to spawn coinciding with increased river flows. The study demonstrates the need to understand fish behaviour and life history to develop appropriate flow regimes for fish in regulated rivers. Importantly, this information is now being used by river managers to refine existing environmental flow recommendations for the species.

131 Responding to McArthur River flows: How environmental flows are driving an adaptive management program for sustainability of aquatic fauna

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Publish consent withheld.

132 Seed banks on semi-arid floodplains in the northern Murray Darling Basin: Skippy is doing his bit

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Seed banks play a vital role in maintaining plant diversity, especially in highly unpredictable environments such as arid and semi-arid floodplains. In such systems floods and droughts tend to be extreme and periods between floods tend toward severe aridity. A significant ecological filter that will determine the overall vegetation structure in these hydrologically unpredictable floodplain plant communities would include the "regeneration niche" which would include the various life history strategies that plants will have to enable them to recruit periodically when conditions are favourable such as significant and persistent seed banks. In semi-arid floodplain systems these seed banks are often within the soil profile but can also be held in above-ground litter, including animal (e.g. kangaroo) scats. In order to examine the germinable seed abundance, and thus the potential seed banks across different hydrological settings we collected soil, litter and animal scat samples from 28 floodplain sites across the semi-arid northern Murray Darling Basin. Samples were subsequently re-wetand kept moist, with germination recorded. The results of the first four months of this regeneration experiment are presented and interpreted in relation to background environmental settings, including density of ground-cover and hydrological history. All three potential seed-banks supported a diverse array of plants including, grasses, sedges, forbs, herbs and woody plants, including coolibah (Eucalyptus coolabah), river cooba (Acacia stenophylla) and weeping myall (Acacia pendula). In terms of species richness, litter tended to have a higher numbers of species, followed by soil, then scats (which were predominantly grasses and forbs).

Oral abstracts

133 Soil seedbanks in a restoring floodplain wetland

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Passive restoration relies on natural regeneration, which is typically facilitated by limiting deleterious disturbance and enabling key environmental factors to return toward historical conditions. Vegetation regeneration is highly contingent on seed availability, either through dispersal from neighbouring source populations or soil seedbanks.
We examined the composition of the soil seedbank in a passively restoring wetland that is part of the Macquarie Marshes, a Ramsar-listed wetland. Portions of the area experienced 12 different land use disturbances: ringbarked 1950s, cleared 1982, cleared 1998, bulldozed 2000, bulldozed 2002 and raked 2006, bulldozed and ploughed 2003, cropped 1985-2008, cropped 1997-2008, cropped 2002&2004&2006, cropped 2003, cropped 2005-2007, cropped 2006. Levee banks reduced flooding across the study area throughout this period. After the land was purchased in 2009, levee banks were breached to facilitate natural regeneration by enabling passage of environmental and managed flows. Several years of flooding led to variable restoration success. This project examined whether restoration success was associated with seedbank composition or germination success. Within each of the 12 land use types, we sampled the soil seedbank from nine random sites, three in shallow distributary channels, three immediately adjacent to channels (riparian) and three 50-100m from channels on the floodplain (n=108). The soil samples were germinated under damp, saturated and flooded conditions in greenhouses for 12 weeks, with continual seedling identification and removal. Results suggest that both dispersal constraints (seedbank composition) and germination conditions affect the diversity, abundance and composition of vegetation germinating and reflect the varying disturbance types and flooding frequencies.

134 South lake: I know what you did last summer!

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Loss of water challenges aquatic animal survival, and although it happens annually in seasonal wetlands, its effect on faunal dynamics is poorly understood. We studied these dynamics in detail in a single wetland, South Lake. The aims of these experiments and surveys were to observe faunal occupancy over different hydroperiods and invertebrate response. Although located in suburban Perth it is relatively undisturbed, drying to a pool before completely drying out during summer. We have sampled South Lake over multiple years and hydroperiods, including the dry phase. Temperature loggers were placed in and around South Lake, logging ambient air, water and sediment temperature throughout multiple hydroperiods, showing some extreme high temperatures in summer. During spring, invertebrate diversity was very high. As the water level declined, and then dried out, diversity declined and large invertebrate predators/scavengers fed on stranded invertebrates. Before surface water completely disappeared predatory insects pupated and flew away. Other invertebrates used resting stages to survive drying, hatching once South Lake reflooded. When 'dry' South Lake retains deep crevices in the sediment that are connected to the groundwater, providing a refuge for taxa such as amphipods and isopods that do not have resting stages and cannot leave the wetland. Thus, the decline and reassembly of the invertebrate community during drying and reflooding depends on three processes: flying insects with resilience traits that leave and return; taxa requiring at least perennial dampness that make micro-scale movements into sediment crevices; and taxa with resting stages that remain in the dry sediment.

135 How efficient is wetland vegetation at trapping suspended sediment and bedload on Magela Creek in Northern Australia?

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Sediment yields have been measured for over 30 years in the Magela Creek basin in northern Australia. Sediment yields are low by global standards because of resistant bedrock, dense vegetative cover during the wet season and extremely long periods of tropical weathering. However, they are further reduced by the sediment trapping effect of flood plains, floodouts, various types of billabongs and extensive wetlands. While suspended sediment yields exceed bedload yields in this deeply weathered, tropical landscape the amount of sand transported as suspended sand and bedload greatly exceeds that for silt and clay. In the past, it has been assumed that bedload constitutes about 10 % of the suspended sediment load. In the Magela Creek catchment, the reverse is true. Nevertheless, even sand is totally stored above topographic base level or the sea. Longitudinal continuity of sediment transport is rarely maintained in this landscape. Floodplains trap about 50 % of the supplied total sediment load and floodouts store 100 % of the bedload. Backflow billabongs are efficient traps of silt and clay. As a result, suspended sediment and bedload do not move progressively from the summit to the sea along Magela Creek. We constructed a sediment budget for lower Magela Creek wetlands that demonstrate of the 48000 t/yr supplied to the wetlands from upstream and from tributaries for the period 2003/04 to 2012/13, only 4000 t/yr were exported to the East Alligator River estuary and about 90.5 % of the total sediment load input, much more than previously estimated, was trapped by the wetland. Lower Magela Creek wetland functions essentially as a terminal sediment trap.

Oral abstracts

136 The influence of urbanisation on wetland invertebrate biodiversity

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The construction of wetlands in the urban environment is primarily carried out to assist in the removal of contaminants from wastewaters, however they have the added benefit of providing habitat for wildlife. Nonetheless, stormwater can be a threat to aquatic environments as the quantity and quality of stormwater decreases as impervious area (roads, sealed areas, roofs) increases. Total imperviousness (TI) is the measure used to quantify the amount of catchment imperviousness associated with urbanisation. This study aims to establish whether the degree of urbanisation and its associated change in stormwater runoff affects macroinvertebrate species richness and abundance within constructed wetlands. Urban wetlands in Melbourne's west and south east were sampled along a gradient of urbanisation. There was a significant inverse relationship between TI and the abundance of macroinvertebrates detected. Chironomidae (non-biting midges), was the most abundant family recorded at the majority of sites. Chironomids are able to tolerate a wide array of environmental conditions, including eutrophic and anoxic conditions. As such, they are often the dominant taxa in urban wetland systems. It is likely that the overall decrease in water quality associated with increasing amounts of stormwater runoff was detrimental to the invertebrates within these wetland systems. It is important to understand the impacts of urbanisation on aquatic biota to ensure that urban wetlands can be designed and managed to continue to provide important habitat for wildlife.

137 Wetland Management in an Agricultural Landscape

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The Murray Wetland Carbon Storage project is assisting landholders to rehabilitate wetlands to increase their capacity to store carbon and improve biodiversity. To date the project has rehabilitated over 1,000 ha of wetlands in the Murray LLS (Local Land Services) region.
Landholders in an agricultural focused area were directly targeted. One of the key challenges in the target area was to increase the capacity of landholders to appreciate, understand and manage their wetlands in a landscape driven by economic priorities. To address this challenge, the project implemented a program which invested staff time to build relationships with landholders rather than management payments, used contractors to deliver on-ground works to free up landholder's time, and allowed for the development of management actions that integrated their farming activities and biodiversity and carbon storage interests. We expected to experience some hesitation towards the project from landholders due to the strong agricultural focus of the area; however, the targeted landholders had a strong desire to participate and have increased their understanding of wetland management. The project will continue to engage with these motivated landholders through the project's Wetland Champions program, which will see them promoting future project investment rounds and the values of wetlands to their networks.
The approach used to deliver this project is hoped to provide improved security of investment, reduced risk of future wetland mismanagement and increased engagement in appropriate natural resource management in the future for participants and their peers.

138 Is Salinity the Key Driver of Fish Species Assemblage in Finke River Waterholes?

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The catchment of the iconic Finke River is celebrated for its biodiversity. Situated within the endorheic Lake Eyre Basin (LEB), the area is both arid and hydrologically isolated from other major LEB rivers. In the context of the arid zone the fish assemblage of the Finke catchment is diverse (9 species, including 3 endemics), yet until recently little was known about fish species' distribution, habit preferences or the distribution of drought refuges. Monitoring for the Lake Eyre Basin Rivers Assessment (LEBRA) commenced in 2011 and is the first systematic population sampling in this catchment. LEBRA has been the catalyst for sampling at many additional sites and the collective data set provides a baseline for both future condition assessment and the necessary underlying ecological understanding. Analysis shows clear patterns in distribution and habitat preference of species, with salinity being a key driver. Differences in the salt tolerance between species not only influence distribution but also the function of particular waterholes as drought refuges. Due to complex sub-surface saline groundwater inputs, some waterholes rapidly increase in salinity after rain-fed flow events, including some of the permanent refuge pools. Some non-permanent but long-lasting pools reach very high salinities at which only the most tolerant species persist. In contrast, some waterholes persist as fresh or semi-saline habitats, even in droughts, despite evaporative concentration. Whilst salinity is an unambiguous driver in this system, other habitat parameters must also be considered to better understand population dynamics, distribution and assemblage at scales from waterhole to catchment.

Oral abstracts

139 Habitat requirements for aestivation of Galaxiella nigrostriata during the dry phase of seasonal wetlands.

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Galaxiella nigrostriata is a freshwater fish endemic to seasonal wetlands of south west Western Australia. *Galaxiella nigrostriata* are intriguing because they aestivate in the wetland sediments when the wetlands dry over summer. Nevertheless, with a drying climate forecast and increasing pressures on groundwater resources that will extend dry phases of seasonal wetlands, this unusual species faces an unknown future. This study examined the summer (dry) habitat requirements of a remnant population of *G. nigrostriata* within a complex of twelve seasonal wetlands near Bunbury. Two wetlands, that had the highest population densities the previous year, were chosen to investigate whether crayfish burrows were used to access wet sediment (wet from groundwater) when the wetlands dried over summer. Secondary aims were to investigate whether *G. nigrostriata* followed the water to the lowest point as it dried before they entered the sediments, and if the presence of vegetation affected where they aestivated. Thirty one lentocorrals, a shallow water adaptation of limnocorrals, were constructed in two dry wetlands prior to the onset of winter rains to capture *G. nigrostriata* as they emerged when the wetlands began to inundate. One wetland did not produce any *G. nigrostriata* in the lentocorrals or elsewhere within the wetland. However, the other wetland containing 15 lentocorrals produced some interesting results. *Galaxiella nigrostriata* did not necessarily require crayfish burrows to enter the sediments, they waited until the wetlands were nearly dry before entering the sediment and did so near vegetation. The implications for conservation and wetland rehabilitation will be discussed.

140 Potential impacts of water temperature on fish habitat in riverine waterholes in northern Australia

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In northern Australia in-channel waterholes in ephemeral rivers provide vital habitat for the survival of fish during the dry season. Many aspects of the water quality of these waterholes can affect habitat suitability, but water temperature is arguably the single most important parameter, since it directly affects the rates of many important physical, chemical and biological processes. In-channel waterhole temperature was monitored at a number of locations in the Flinders and Gilbert catchments as the dry season evolved in 2012/13. These data were used to derive frequency curves that show how often water temperature exceeded any given temperature threshold. To explore how often waterhole temperature may become detrimental to fish, the exceedance times for preliminary thresholds for optimum growth and lethal effects are presented. How these exceedance times increase under a future warmer climate is also illustrated using an energy balance model that can estimate water temperature from daily weather data.

141 Resistance of two fishes with contrasting lifestyles to hypoxia: Links between metabolic and behavioural traits

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The frequency and magnitude of droughts are forecast to increase throughout southern Australia, which implies our freshwater fishes will potentially face more frequent and severe episodes of hypoxia in the future. Unfortunately, however, we have a poor understanding of the resistance and resilience of our fishes to hypoxia. More generally, there appear to be few generalisations or 'laws' of fish community change in response to hypoxia; laws that ecologists and managers can utilise to forecast effects on biodiversity. Community ecologists have suggested that experimental work linking animal physiological traits to fitness along environmental gradients may yield more useful, 'functional-trait-based' laws of community change.
Here we tested the hypothesis that fish 'lifestyle' is linked to metabolic rate, which in turn drives resistance, and behavioural response, to hypoxia. Metabolic rates of a 'fast' pelagic species, unspecked hardyhead, were significantly higher than those of a 'slow' benthopelagic ambush predator, flathead gudgeon. In turn, physiological resistance to hypoxia (as indicated by critical oxygen tension) was lower in hardyhead than in flathead gudgeon. Behavioural responses to gradual hypoxia also demonstrated that the onset of avoidance to hypoxia occurred earlier in hardyhead than in flathead gudgeon. These results, combined with others, imply interesting links between fish lifestyle and resistance to hypoxia.

Oral abstracts

142 Effect of salinity on the ecosystem function, leaf decomposition: dryland salinity vs. salinity from a coal mine

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The decomposition of allochthonous organic matter (AOM) is a critical ecosystem function in streams and supplies resources to stream organisms originally produced via terrestrial photosynthesis. Stressors like salinity can impede the AOM breakdown, thus potentially impairing ecosystems services. In our study we measure the influence of salinisation caused by dryland salinity and a coalmine to leaf decomposition. The sampling sites in the field were selected to exhibit a gradient of salinity from 30 µS/cm to around 13-000 µS/cm from dryland salinity in the Murrumbidgee River Catchment and 100 µS/cm to 2-500 µS/cm from saline pollution from a coal mine in the Georges River Catchment, both in New South Wales. Dried River Red Gum (Eucalyptus camaldulensis) leaves were placed in coarse and fine bags. The leaves in the coarse bags are accessible to invertebrates and microorganisms and the leaves in the fine bags are accessible for microorganisms only. Preliminary results showed greater weight loss of the leaves at low salinity (30 µS/cm) site after just two weeks than at a site with higher salinity (1600 µS/cm). A laboratory study is in progress assessing for the effect of salinity on microbial leaf decomposition eliminating confounding environmental variables. This experiment is using salinities of 100, 1-000 and 10-000 µS/cm sodium chloride, artificial sea water and sodium bicarbonate and inoculating leafs with microbial communities from either a low (30 µS/cm) or a high (13-000 µS/cm) salinity site, in a three factor orthogonal design.

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143 Water quality fish passage barriers caused by aquatic weed infestation and black water flow events on a tropical floodplain impacted by irrigated agriculture

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The potential impacts of irrigation development on tropical Australian floodplains and fish communities is an issue of current interest considering proposals to further develop water resources in northern Australia. Studies examining risks associated with further water resource development have focused primarily on Australia's undeveloped northern river basins but could benefit from examining long established irrigation areas on seasonally dry tropical floodplains in north Queensland. The lower Burdekin river floodplain is intensively developed to irrigated agriculture producing about a quarter of Australia's sugar cane crop. It has a high level of hydrological modification including the use of historically seasonal floodplain distributary channels as conduits for the supply or irrigation water and shallow aquifer recharge operations. The loss of hydrological seasonality and other catchment and basin scale impacts has led to extensive submerged macrophyte and aquatic weed infestation and associated water quality decline. Conditions become most chronic during wet season flow events preventing recruitment of catadromous fish species from estuarine to floodplain habitats. In this presentation we examine the integrated causes of water quality fish passage barriers, broader ecosystem risks associated with high BOD in floodplain distributary wet season flows and potential adaptive management options.

144 Burnett River riparian stabilisation – practical examples of reducing sediment loads to the Great Barrier Reef

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The Burnett River experienced severe flooding in early 2011 and 2013, with the latter flood breaking historical records. Bank erosion from these floods caused considerable damage to ecological assets, infrastructure and the loss of agricultural land. The Burnett Mary Regional Group (BMRG) commissioned Cardno ENTRIX to determining cost-effective flood recovery strategies to protect riparian assets and assess the relative contributions of bank sediment, particularly fine-grained material, to overall sediment loads in the Burnett River catchment and implications for sediment export to the Great Barrier Reef.
Empirical and modelling analysis revealed that a total of about 27.8 million m3 (47.3 Mt) eroded from the banks of the lower 300 km of the Burnett River main channel between 2009 and 2013. Assuming 100 years of simulation, a conservative value for the average, annual rate of bank erosion is 2.0 Mt/y, and this does not include tributary contributions.
This paper outlines BMRG's adoption of cost effective measures to stabilise riparian areas. The design and implementation of works involved the use of stream geomorphic processes, bank stability and soil measurements, river flow dynamics and modelling tools to determine effective revegetation, engineering and land management solutions. Community partnerships, especially the involvement of landholders, asset management authorities (mainly State Government) and community groups, were essential for the implementation of stabilisation works, improved riparian management, and hopefully to reduce future effects of flood erosion.

Oral abstracts

145 Channel bank stability (or lack of), the implications and rehabilitation options for the Mid Brisbane River

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Channel bank erosion is the dominant source of sediment in southeast Queensland waterways, and can increase with increased hydraulic force or when bank resistance (stability) decreases. Increased sediment loads can have detrimental effects on the downstream environment, and quality and quantity of potable water. Significant erosion of the Mid Brisbane River was observed during the 2011 and 2013 flood events, and became an issue for landholders, Seqwater and other Mid Brisbane stakeholders. This study aimed to identify and quantify the main types of erosion present, the erosion processes and rehabilitation options for the Mid Brisbane River following the flood events. Using on-ground rapid visual assessments and repeat LiDAR analyses, the main types of erosion were identified as a large number (168) of wet flow failures and a small number of large fluvial scour failures, which accounted for 237,000 m3 and 350,000 m3 of sediment volume change, respectively. Historical evidence shows the main catchment disturbances in the Mid Brisbane since European arrival are riparian vegetation clearing, alteration of flow regime and gravel extraction. Modelling indicates that the probability of fluvial erosion and wet-flow failures occurring could have been decreased through vegetation to stabilise the bank toe and increase the cohesive strength of the soil, respectively. Our study shows that for the Mid Brisbane River, more than 90% does not require major engineering works to stabilise the channel banks and re-establishing dense riparian vegetation would decrease the probability of channel bank erosion and therefore, reducing sediment loads and improving water quality.

146 A Case Study for Measuring Outcomes from Large Management Interventions on Fishes: The Murray River Resnagging Experiment

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In the field of restoration ecology, understanding, and indeed measuring, links between management interventions and target environmental outcomes is much debated. For aquatic systems, fish are often used to justify investment in restoration, such as environmental watering, invasive species control, or habitat rehabilitation. However measuring the drivers of change in inherently complex systems, following management interventions, at population scale, is problematic. Here we provide an example of a well-designed, long term experiment, measuring population scale response of fish to a large intervention.
Between 2005 and 2008, 4500 pieces of structural woody habitat (SWH) were restored in a reach of the Murray River, and a 7 year monitoring program implemented. We hypothesised that the size of the fish population in this study reach would increase in comparison to reference reaches, through increases in immigration and survival, and decreases in emigration. In particular, while previous programs have shown that native fish use re-introduced SWH, there have been few studies undertaken which show this use is directly related to an increase in population size, rather than a redistribution of fish already present (ie a 'honeypot' effect). Our presentation will discuss final results of this seven year experiment, and show a significant increase in population size for Murray cod following the intervention. We present a multiple lines of evidence approach to define fish population change in response to the management intervention. The monitoring approach used here can be applied to monitor outcomes of many management interventions, including provision of environmental water or fish stocking.

147 Strengthening science to policy outcomes for waterways protection at a local level in the Kimberley, WA

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The "science to policy" pathway has received increasing attention in recent years, however there are still gaps in ensuring the process results in land use management outcomes on the ground. The two stages in the pathway (science then policy incorporation) are of equal importance and one is meaningless without the other.
This case study focuses on the Ord river system, a modified, Ramsar listed wetland that provides a significant water supply for irrigated agriculture in the East Kimberley, WA. The limited science available for assessing environmental impacts of foreshore developments meant Natural Resource Managers were often providing generic setback advice which was not being well received by decision makers, developers and stakeholders. A foreshore Biophysical Criteria Assessment was completed to provide site specific scientific information. A cross agency collaborative process was then undertaken to ensure that science was imbedded well in the regulatory process overseeing local land use decisions within the foreshore area.
Each stage of the pathway required a very different set of skills, strategies and approaches. Recognition of these differences is critical for facilitating the effective uptake of science into policy. Here we have demonstrated that with effective cross agency collaboration, science can be implemented well in the decision making process at a level that will result in on ground outcomes for the protection of a significant waterway.

Oral abstracts

148 Monitoring and evaluating the outcomes of Commonwealth environmental water

Ben Gawne[1]

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Monitoring and evaluation are best practice in Commonwealth environmental water management as they underpin effective program management and reporting, and are fundamental to adaptive management. There has been gradual improvement in our capacity to monitor the effectiveness of river and wetland restoration as strategies have been developed to deal with spatial and temporal variability and the effects of multiple interacting stressors. However, our capacity to evaluate has not kept pace, yet evaluation is as important to adaptive management as monitoring. The Commonwealth Environmental Water Office (CEWO) has established a five year program to monitor the outcomes of their management of Commonwealth environmental water and evaluate its contribution to Basin Plan environmental objectives. This presentation will describe some of the challenges associated with this task and the proposed strategies for overcoming them. Some of the major challenges include: 1) Scale - the Basin Plan environmental objectives are set at a Basin scale over a ten year time-frame, while environmental watering occur in river reaches or individual wetlands over periods of weeks to months; and 2) Ability to quantify the contribution of Commonwealth environmental water - although the CEWO has a large volume of environmental water to utilise, within the context of climate variability and the influence of other stressors, at a Basin scale the signal to noise ratio may be quite small. While these challenges are significant, the CEWO's Long-Term Intervention Monitoring Project represents a significant opportunity to develop and implement effective evaluation, thereby contributing to the effectiveness of adaptive management.

149 Research into the efficacy of fish screens in the Murrumbidgee to Googong water transfer scheme

Rhian Clear[1], Ben Broadhurst[1], Mark Lintermans[1]

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The Murrumbidgee to Googong water transfer pipeline had the potential to transfer larval fish and eggs from the Murrumbidgee River into Burra Creek and then ultimately Googong Reservoir. It also had the potential to locally impact larval fish (primarily cod species) in the Murrumbidgee River, through impingement of fish and eggs on exclusion screens placed around each pump intake. The aim of this project was to determine the efficacy of fish screens to exclude fish and eggs from being transferred between catchments, and to determine the incidence of fish impingement on exclusion screens. Larval drift nets were set three sampling sites (Murrumbidgee River upstream of transfer intake; screen flushing outlet and Burra Creek pipeline outlet) in early December 2013. Larval fish were detected at the screen flushing outlet, indicating that fish had been impinged. No fish were detected at the Burra Creek pipeline outlet, indicating that the screens were effective at preventing cross-catchment transfer at the level of pumping assessed.

150 Vulnerability of Western Australian fishes to changing flow

Stephen Beatty[1], David Morgan[1], Mark Allen[1], James Keleher[1], Jeff Whitty[1], Alan Lymbery[1]

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Western Australia contains three ichthyological provinces, each with relatively high proportions of endemic fishes and widely different climatics. We discuss long-term studies that examine the life-cycles of fishes, their habitat use and environmental variables to determine how they could be impacted by ongoing flow and/or groundwater declines. South-western Australia is an unfortunate global 'pinup' of rainfall and flow reductions due to climate change; dramatic reductions in river flow has occurred since the 1970's; with universal agreement that this drying trend will continue. The south of the State is seeing considerable range reductions and localised population declines of fishes. Hydrological change is likely to continue to both directly and indirectly impact freshwater fishes of the region; many of which are threatened. We demonstrate that the strength of spawning migrations of potamodromous fishes will decline with ongoing flow reductions. Variation in the wet season in the Kimberley region has considerable implications for fishes. A prime example relates to the level of recruitment of a threatened catadromous elasmobranch, with pressures to extract water from the region's large rivers potentially exacerbating a reduction in recruitment. The thirst for water resources is expanding in the Pilbara; an area where surface water is scarce and where groundwater is a potential resource of potable and industrial water. Implications of groundwater extraction for the desert fishes which rely on it for survival are highlighted. The hydro-ecological relationships we discuss illustrate the vulnerability of freshwater fishes throughout Western Australia to altered flow regimes which are crucial to consider in water resource development.

Oral abstracts

151 Shock, stress or signal? Implications of freshwater flows for a top-level estuarine predator

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Physicochemical variability in estuarine systems plays an important role in estuarine processes and in the life-cycles on estuarine organisms. In particular, seasonality of freshwater inflow to estuaries may be important in various aspects of fish lifecycles. This study aimed to further understand these relationships by studying the movements of a top-level estuarine predator in response to physicochemical variability in a large, temperate south-east Australian estuary. Mulloway (Argyrosomus japonicus, 47 – 89 cm total length) were surgically implanted with acoustic transmitters, and their movements and migrations monitored over two years via fixed-position VR2W acoustic receivers configured in a linear array along the length of the estuary. The study period included a high degree of abiotic variability, with multiple pulses in fresh water to the estuary, as well as broader seasonal variation in flow, temperature and conductivity. The relative deviation of fish from their modal location in the estuary was affected primarily by changes in conductivity, and smaller fish tended to deviate much further downstream from their modal position in the estuary than larger fish. High-flow events which coincided with warmer temperatures tended to drive mature fish down the estuary and potentially provided a spawning signal to stimulate aggregation of adults near the estuary mouth; however, this relationship requires further investigation. These findings indicate that pulse and press effects of freshwater inflow and associated physicochemical variability play a role in the movements of mulloway, and that seasonality of large freshwater flows may be important in spawning.

152 Understanding the influence of flow on spawning and recruitment in freshwater fishes: importance of life history, antecedent conditions and long-term data sets

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Flow plays a dominant role in influencing patterns and processes in riverine ecosystems. For example, spawning and recruitment of freshwater fish has often been linked to flow. Since the mid 1990's, many Australian studies have examined the importance of flow for initiating spawning, and enhancing the survival of young, and hence improving recruitment. An important outcome of this research has been an increasing number of environmental watering objectives that are targeted at enhancing native fish spawning and recruitment. Despite this, there has been little improvement in our knowledge base of relationships between aspects of flow and key life history events, or of environmental flow management. We contend that the current trend of short-term funding and event-based monitoring is perpetuating this problem, and what is needed is longer-term research, perhaps at a few 'sentinel' sites. This will enable scientists and managers to determine: (a) the importance of flow relative to other factors; (b) which flow components (e.g. timing, duration, magnitude etc.) are critical in driving responses; (c) life history variation among co-existing fishes; and, (d) the importance of antecedent conditions on spawning and recruitment outcomes. We will present examples from long-term Australian studies on spawning and recruitment, and describe how they have been used to explore these issues. We will also propose novel design and analytical approaches that could be used in future research to better understand the flow requirements of fish and manage environmental water allocations.

153 Working together for ecosystem health in Darwin harbour

Robyn Henderson[1], Anna Belford[2], Aleana Talbot[2], Jade Murphy[2], Carol Palmer[2], Simon Townsend[1]

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2. *Larrakia Nation Aboriginal Corporation, Darwin, NT*

The Darwin Harbour Indigenous Marine Ranger program is an innovative monitoring and research collaboration between the Northern Territory's Department of Land Resource Management (DLRM) and Larrakia Nation Aboriginal Corporation (LNAC), with additional support from the North Australian Marine Research Alliance (NAMRA). The program aims to train Indigenous rangers in technical skills, whilst increasing the level of Harbour environmental research and monitoring. The program was initiated to meet the requirements of the Environment Protection and Biodiversity Conservation (EPBC) Act, as an offset for the Darwin Harbour East Arm Wharf expansion; however, it is expected to achieve broader social and environmental benefits through enhancing Indigenous capacity at individual and organisational levels. Whilst most of Darwin Harbour is in near-natural condition, there are small but significant developed areas and Darwin is an expanding population centre, sea transport and industry hub. The monitoring and research program is an important element in the adaptive management of Darwin Harbour's environment.

The Larrakia, salt water people, are the traditional owners of the greater Darwin region and LNAC provides an Indigenous cultural foundation to the program. The program supports the established LNAC Ranger Group by funding four additional marine rangers, who receive training from the DLRM and NAMRA partners. The program provides opportunity for the rangers to work on sea country and coastal areas of Larrakia traditional land, participating in the research and monitoring programs for migratory shorebirds, water quality, dolphin, dugong, fish, seagrass and sediment. Rangers will also engage in community education, providing positive role modelling to other young Indigenous people.

Oral abstracts

154 Collaborative research partnerships inform monitoring and management of freshwater habitats by traditional custodians

Christy Davies, Yoshi Akune[1] , Ninjana Walsham[1], Rebecca Dobbs[2], Douglas Ward[3], Neil Pettit[2], Brad Pusey[2]

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2. *CENRM, University of Western Australia, Kununurra, WA, Australia*
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Freshwater springs and billabongs are central to the life of Nyul Nyul people of the Dampier Peninsula in north Western Australia. . For countless generations they have been an important source of food, clean drinking water and served as a place to cool off; and many are also places of deep cultural significance. Since the arrival of Europeans, new threats to the health of freshwater habitats have emerged including inappropriate fire regimes, grazing by feral donkeys, and introduced fish species. A collaborative research approach has brought together Indigenous Rangers, Traditional Owners and researchers to utilise local traditional knowledge and scientific techniques to gain a richer understanding of culturally and ecologically important freshwater habitats on the Dampier Peninsular. Core components of the project include onground sampling to gather vital baseline scientific data including fish species distribution and riparian condition. This data, combined with the analysis of remote sensing imagery on Nyul Nyul freshwater habitats, have been used as the basis for discussions and integration of local and traditional knowledge about these areas. The information gathered through these various means will identify practical monitoring techniques and allow for the development of culturally appropriate data collection tools, for the ongoing monitoring and protection of both the cultural and ecological values of Nyul Nyul freshwater habitats. This novel approach represents a best practice model for supporting Indigenous land and sea managers like the Nyul Nyul Rangers, who are the key to managing biodiversity across Australia's vast and sparsely populated north.

155 Competing narratives? Contestation in managing floodplain country

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Coastal freshwater floodplains are highly vulnerable to the impacts of climate change. As a socio-ecological system, this has ramifications for people utilising floodplain resources. Determining acceptable management strategies can be contentious. In considering adaptive management strategies to cope with future environmental change (e.g. salt water intrusion from sea level rise), examining responses to environmental change from the past and present can shed light on how stakeholders perceive environmental change, as well as their capacity to respond. The East Alligator River floodplains in the Northern Territory, provide a case study to examine this. Aboriginal land owners across this floodplain region retain a strong connection to floodplain country and the freshwater resources it provides. This research employed semi-directed interviews, on-country visits and biographic mapping of customary resource use activities to consider Indigenous responses to past and contemporary environmental changes, including invasive weeds, feral animals and to fire regimes. This research outlines the contemporary alternative narratives of 'acceptable' uses of floodplain country. These are managing floodplain country for customary resource use, for livelihoods derived from the cattle industry, for conservation and for tourism. The degrees to which these narratives compete or converge are discussed as are the effects of their respective management strategies on customary harvesting. This research presents a framework for understanding the influences on people's perceptions of environmental change, and the drivers influencing their capacity to respond. This is the first step in considering future adaptive strategies, both in the floodplain country of the Northern Territory and in any vulnerable freshwater socio-ecological system.

156 Participation of Aboriginal communities in wetland management in the Natural Resources SA Murray-Darling Basin region

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Engagement of local Aboriginal communities in wetland management and conservation is a key objective of the Natural Resources SA Murray-Darling Basin (NR SAMDB) wetland and floodplain program. The program actively engages a number of Ngarrindjeri Communities within the SA MDB region, Aboriginal Learning on Country (ALOC) Teams and Organisations (e.g. Ngarrindjeri Regional Authority), through the NR SAMDB Community Partnerships program, in a range of wetland and floodplain management, monitoring and on-ground activities.

In the last two years, particular progress has been made in regard to the development of wetland management plans, that incorporate both sound technical and scientific advice regarding the hydrological management of a particular wetland, while also incorporating the knowledge of Elders, language and spiritual ties (e.g. Dreamtime) into a management document. In the last 12 months, several ALOC Teams, and the Mannum Aboriginal Community Incorporated Association have been actively involved in, monitoring and on-ground works. The teams have become proficient in standard monitoring techniques for example the use of 'The Living Murray' tree health assessment method, and have undertaken a number of on-ground works projects including improving habitat through reed and willow control, training in pig control, mapping of pest plant and animals, fencing of River Red Gum saplings and set-up of a trial watering system.

Oral abstracts

157 Extinct habitat, extant species: lessons learned from conservation recovery actions for the Pedder galaxias *(Galaxias pedderensis)* in south-west Tasmania, Australia

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5. *Wayne Fulton Consulting, Alexandra, Victoria, Australia*
6. *Upper Canada College , Toronto, Ontario, Canada*
7. *Department of Primary Industry, Albury, New South Wales, Australia*

The Pedder galaxias (Galaxias pedderensis) from Lake Pedder, Tasmania, Australia, is one of the world's most threatened freshwater fish. The flooding of Lake Pedder in 1972 for hydroelectric power generation caused a major change to the ecosystem that initiated an irreversible decline in the Pedder galaxias within its natural range. The flooding inundated another headwater catchment and native and introduced fish from this catchment colonised the impoundment.
Numbers of the Pedder galaxias declined markedly as the impoundment matured and as colonising fish proliferated. Surveys in the 1980s confirmed the parlous state of the population, highlighting the need for conservation intervention.
Several urgent conservation actions were undertaken to save the species from extinction. Translocation was considered the most important recovery action, given the critically low numbers in the wild. The species is now extinct from its natural range and is known from only two translocated populations. The conservation program, and specifically the translocation recovery action, saved the Pedder galaxias from extinction. The conservation management was extremely challenging since rapidly declining fish numbers needed timely and critical decisions to underpin the future of the fish.
Recommendations are provided arising from this case study to guide conservation of freshwater fish in similar circumstances.

158 Twenty years of conservation management of threatened upland galaxiids *(Galaxiidae)*: blood, sweat, tears… and a little joy

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Conserving threatened species is challenging and often involves undertaking complex management actions with few resources in the face of competing social or environmental values or needs. The south-east of mainland Australia harbours a high diversity of non-migratory native galaxiids. Of 18 species, 78% have only recently been discovered. Fifteen species are found in upland areas, many in alpine environments, and 11 are considered critically endangered. The current global distribution of each of these consists of a short and narrow headwater reach of a single stream, usually upstream of a natural waterfall. Populations of each are considered to have declined dramatically, due primarily to predation from alien Brown and Rainbow Trout, and are now at greater risk of extinction from further predation and from stochastic events such as drought (loss of surface water), fire, and large-scale instream sedimentation from high rainfall events following fire. These taxa share relatively similar biology and are subject to similar threatening process, hence allowing broad application of conservation measures across taxa, albeit with subtle differences. We have undertaken successful conservation management of one species for twenty years to prevent extinction, and have recently applied the methods developed and lessons learnt to the management of additional species to achieve similar outcomes. Following a mix of largely successful conservation actions (e.g. predator control, ex-situ captive management, artificial breeding, translocation), a key outcome was the demonstration of the utility of fairly simple management actions, though improved by adaptive refinement, and complimented by novel methods.

159 Predation rates of two threatened species by trout

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Trout predation is listed as a threat to two-spined blackfish Gadopsis bispinosus and Macquarie perch Macquaria australasica. Dietary analysis of 757 rainbow trout Oncorhnychus mykiss and 40 brown trout Salmo trutta for the presence of two threatened fish species was conducted in a tributary & reservoir of the upper Murrumbidgee River catchment, Australian Capital Territory. In general piscivory by trout was low, though increased with size. Predation rate of two-spined blackfish was extraordinarily low, with only five confirmed individuals found. The incidence of predation of two-spined blackfish is surprising given anecdotal evidence that predation was more common. There was no evidence of trout predation upon Macquarie perch. Morphometric analysis of Macquarie perch and goldfish Carassius auratus revealed no significant difference, even though the latter was consumed. The lack of predation on Macquarie perch is most likely attributed to habitat partitioning and behavioural differences between predator and prey. Expansion of a reservoir in the catchment is likely to lead to an increase in the size and abundance of trout as well as an increase in the abundance of Macquarie perch, which may alter the current predator prey relationship between these species.

Oral abstracts

160 The low down on threatened paragalaxiids: interactions between fish ecology, habitats and hydrology are critical to population viability

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Reproduction of littoral-spawning lacustrine fishes can be constrained by unfavourable water levels conditions in impoundments during breeding seasons. This is especially the case when spawning sites are restricted to certain types of substrata in systems with dynamic hydrological regimes and heterogeneous habitats. Arthurs Lake and Great Lake, central Tasmania, Australia are integral resources within the Tasmanian hydro-electric power scheme. Collectively, endemic and threatened Paragalaxias dissimilis, P. eleotroides and P. mesotes occur in these lakes and water level fluctuations have the potential to impact their populations. Interactions between: (1) the reproductive strategies of these fishes, (2) lake habitats, and (3) water level regimes were examined over a 5-year period encompassing variable hydrological conditions.
Paragalaxias species in Arthurs Lake and Great Lake have strong habitat-specific requirements for spawning, with discrete egg clusters being adhered to the undersides of boulders at a median depth of 0.68 m (0.1 and 0.9 quantiles of 0.38 and 1.18 m, respectively) during spring-summer. Habitat mapping found limited areas of substrata in these lakes that could be suitable for spawning, and relationships between water levels and inundated spawning substrata were non-linear, with critical thresholds evident at relatively low water levels. In addition, biological traits such as low fecundity (<400 eggs per fish) and short longevity (predominance of fish <3 years of age) may limit the resilience and resistance of these fishes to water level-induced recruitment failures. To sustainably manage water levels in systems containing paragalaxiids, prescriptions that protect paragalaxiid breeding should be included in operational regimes.

161 Macro-ecological patterns and processes in the distribution and conservation status of Australian freshwater fishes

Matthew C Le Feuvre[1], Stephen Swearer[1], Tim Dempster[1]

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There is strong evidence for a positive relationship between geographic range size, body size and relative abundance in terrestrial systems, so much so it is considered an ecological "norm." However, in marine fishes the evidence for this relationship is weak and in freshwater fish it is equivocal. If such patterns exist, they can be used to identify species at risk of extinction. Using existing information from databases and the literature, and accounting for phylogenetic signatures, we analysed the relationship between range-size, body-size and abundance in 263 species of Australian freshwater fish. We tested if these three factors relate to diadromy, latitude, longitude, endemism at the regional and national level and conservation status. Range size and body size were strongly positively correlated. Species listed as threatened under the Federal Government's EPBC Act had a range size an order of magnitude smaller than unlisted species for a given body size. Relationships with abundance were weakly negative, with no effect of conservation listing. Thus, geographic range size may be a good indicator of potential extinction risk, whereas abundance is less reliable. This study suggests that many species may be at risk of extinction and require conservation listing. Further, the macro-ecology of Australian freshwater fish is distinct from freshwater fishes in North America and Europe, likely due to the relatively stable nature of the Australian environment and the absence of large-scale glaciations.

162 Fish and pools: Sampling 101 for ecologists

Wayne Robinson[1], Paul Brown[2]

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2. *The Murray-Darling Freshwater Research Centre and, La Trobe University, Mildura, VIC, Australia*

We discuss the common mistake of pooling of field ecological data by field ecologists and managers, particularly in the grey literature where peer review is often limited, or when using data collected for a different purpose. The most common misuse is to pool data from organisms collected across a number of sampling sites, effectively treating the organisms as independent replicates rather than the sampling sites, which are the true replicate, or primary sampling unit. Amongst other common errors is to weight sites in the selection process, such as by using strata to allocate sampling effort, but then combining data collected in sites across different strata. Examples and guidelines for pooling data are demonstrated using species accumulation curves and fish biomass data from Koondrook forest where 99.6 of the pooled wetland fish biomass in 2013 was from common carp. Yet the true interpretation of native fish biomass for the wetlands in Koondrook forest in 2013 was only 85% alien fish biomass. The principles also apply to temporal sampling, and we demonstrate this with fish data collected from fishways on the Hawkesbury-Nepean River system where the primary sampling unit is each trap rather than each fish inside the trap. Ideally this talk will start a discussion among the audience members that will lead to more consideration of sampling designs before starting sampling in future projects.

Oral abstracts

163 Benthic diatoms as indicators of herbicide toxicity in rivers

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Benthic diatoms are common phototrophic organisms of lotic and lentic environments and have the potential to be used as in-situ indicator communities of herbicide pollution. Since many herbicides mode of action is light dependent, such as the photosystem II inhibitors (PSII), light conditions during exposure may alter which species are most at risk of herbicide toxicity in the field. There have been no studies investigating light effects on the relative herbicide sensitivity of freshwater benthic diatoms. Additionally the potential for herbicides of differing modes of action to alter the relative sensitivity of benthic diatoms within a natural benthic community is not well understood. The results of two experiments are presented and discussed, the first investigates whether relative sensitivity is altered by herbicide mode of action, and the second compares the relative sensitivities of multiple benthic diatom taxa under different light exposure scenarios exposed to either Atrazine or Glyphosate. Natural benthic diatom communities were collected in-situ and then exposed to herbicides in rapid toxicity tests. There were significant interactions between light level and herbicide concentration response in 4 out of 31 taxa; Ulnaria sp., Gomphonema cf. olivaceum, Eunotia sp., and Navicula cf. veneta. However, in no cases did sensitive species appear to be tolerant, or vice versa, under altered light conditions. The relative herbicide sensitivity of benthic diatoms was independent of herbicide mode of action. This indicates freshwater benthic diatoms may be a suitable indicator for detecting toxicity of multiple herbicides, including those with differing modes of action.

164 Biomonitoring in Victorian estuaries using the Eastern blue spot goby, *Pseudogobius sp*

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The Eastern blue spot goby, Pseudogobius sp. is a small benthic species native to south-eastern Australia. It is abundant and widely distributed throughout Victorian estuaries and as such may be a valuable indicator species for determining differences in environmental 'health' among estuaries. Here we describe differences in size and condition of gobies collected from a range of Victorian estuaries that differ in their levels of anthropogenic impact and surrounding land use. Collection sites ranged from pristine conditions to ones impacted by waste water discharge or influenced by urban or agricultural development. Based on gonad histopathology we observed differences in reproductive stage, degenerative changes in the gonads as well as the first observation of intersex in this species. This work demonstrates the merits of using blue spot gobies as a model species for biomonitoring and ecological research in the context of estuarine environmental assessment.

165 Factors affecting egg-laying responses of the freshwater snail, *Amerianna cumingi*, deployed in wet season toxicity monitoring of water quality

Chris Humphrey[1], Mark Ellis

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One of the methods used to assess the effects of runoff water from the Ranger uranium minesite (NT) on the adjacent receiving-waters uses a form of 'early warning', biological monitoring – so-termed 'toxicity monitoring' – where reproductive output (egg production) of the freshwater snail, Amerianna cumingi, is measured. This snail species demonstrates relatively high toxicological sensitivity to the main mine wastewater contaminants (Mg and U). Refinements to the monitoring technique have been made periodically since 1991 when the method was first introduced. A BACIP design is employed in which paired (P) control (upstream, C) – impact (downstream, I) response 'differences' are compared before (B) and after (A) potential mine-related disturbances.
Statistical tests for impact detection have invariably resulted in 'no change' in responses between the several tests conducted in the wet season just completed (A period) and all previous wet seasons (B). However, after the 2009–10 wet season and relative to previous years, significantly greater egg production was observed downstream of Ranger compared with upstream. As a consequence of this finding, recent efforts have been directed at better understanding the environmental conditions (viz water quality, hydrology, snail husbandry) affecting the production of snail eggs. This work helps distinguish mine-induced from natural effects on snail egg numbers for impact assessment purposes. Factors found to affect egg production include flow rates of creek waters through test containers, culturing method of snails, and the water quality variables, water temperature and electrical conductivity (EC) where a significant interacting effect has been observed.

Oral abstracts

166 Identifying the primary factors influencing aquatic ecosystem health in the Maribyrnong River

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Aquatic ecosystems in urban areas are often ecologically impaired but causative factors are rarely identified, thus proving a challenge for environmental management agencies to improve ecosystem health. Causal effects may emerge by considering multiple lines of evidence at different levels of biological organisation to investigate impairment. This study was undertaken in the Maribyrnong River in the north-west of Melbourne, Victoria. Numerous pollution sources enter the catchment including runoff from residential properties, industrial estates and wet weather sewage discharges. The aims of this study were to identify the primary factors causing biological impact in the Maribyrnong River and to determine if biota are showing signs of exposure to sewage–related contaminants. To elucidate biological impairment we conducted chemical (pesticides, metals, nutrients, hydrocarbons) and faunal and flora assessments, including caging studies of mudsnails (Potamopyrgus antipodarum) and amphipods (Austrochiltonia subtenuis), oxidative stress biomarkers in shrimp (Parataya australiensis) and flatheaded gudgeon (Philypnodon grandiceps), endocrine disruption-related endpoints in fish (P. grandiceps; Gambusia holbrooki) and toxicological studies with algae (Scenedesmus sp), chironomids (Chironomus tepperi) and amphipods. Numerous metals, hydrocarbons and pesticides, including zinc, nickel, copper, lead, organochlorine and synthetic pyrethroid pesticides, were detected throughout the catchment at levels exceeding the ANZECC guidelines. These contaminants were determined to be originating from two main sources. Pollution is likely to be affecting aquatic fauna, with P. antipodarum, A. subtenuis and C. tepperi populations ecologically impaired. The usefulness of considering multiple lines of evidence approach for aquatic biomonitoring and integration into management practices to achieve successful remediation will be discussed.

167 Climate change impacts on changes in flow regime & hydrological connectivity of floodplain wetlands

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Global climate change has been identified as one of the major factors that could potentially alter the duration and timing of floodplain inundation and the hydrological connectivity between floodplain waterbodies. This study simulated potential changes in flow regimes and hydrological connectivity under the historical climate and projected future climates in the Fitzroy catchment (WA), a high conservation value aquatic ecosystem in northern Australia. The study was conducted using hydrodynamic modelling in conjunction with remote sensing and GIS. Simulated inundation information was combined with land topography data to quantify connectivity between wetlands and the Fitzroy River. Given the very large number of wetlands on the Fitzroy floodplain, 30 off-stream wetlands were investigated for connectivity based on their importance to fish biota. Connectivities were quantified for three different floods, ranging from a mean annual flood to a 20-year return period flood under present climate and predicted future climate for 2050. Hydrology, topographic relief and river bank elevation were found to be key factors controlling the level of connectivity. Under a wetter future climate the length of time wetlands were connected to the main river channel increased up to 16% and under a drier climate the wetland connectivity was simulated to decrease by 27%. The projected level of connection of individual wetlands under the historical climate and project future climate provides useful information to future studies on the movement and recruitment patterns of aquatic biota, wetland habitat characteristics and water quality, and biodiversity of individual wetlands.

168 Soil and water impacts following wildfire: current and past biogeomorphology of Dunphy Lake in the Warrumbungle National Park, NSW

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Publish consent withheld.

Oral abstracts

169 Effects of hypoxic blackwater events on microinvertebrate and aquatic plant communities emerging from wetland sediments

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The increased prevalence of hypoxic blackwater events as a consequence of river regulation and other river management practices poses a threat to the management of many river-floodplain systems. However, we still know little of the effects of hypoxic blackwater events on the aquatic biota. We investigated the impact of hypoxic blackwater events on river-floodplain microinvertebrate and amphibious plant communities by examining the effects of varying carbon (dissolved organic carbon - DOC) and dissolved oxygen (DO) concentrations on microinvertebrates and amphibious plants emerging from the sediments of two floodplain wetlands in the southern Murray-Darling Basin (MDB). Hypoxic conditions significantly reduced the taxon richness and abundance of microinvertebrates emerging from the sediments of each wetland, whereas carbon (i.e. DOC concentration) alone had little influence. The effects of hypoxia on microinvertebrates were partially reversed when oxygen concentration were returned to normal values within three weeks. The results for the plant communities were less clear because the plants did not grow to an identifiable size during the experiment. Nevertheless, the limited data indicated that hypoxia had no adverse effect on seedling density, and instead, seedling density was significantly higher in the hypoxic treatments for both wetlands. These results suggest that hypoxic blackwater events can severely reduce microinvertebrate abundance in river-floodplain systems, although microinvertebrate abundance may be restored reasonably quickly if oxygen returns within a short time (three weeks). In comparison, the seedling emergence of some amphibious plant taxa may actually be promoted after being exposed to the hypoxic conditions associated with such events.

170 The eradication and management of European carp from two large freshwater lakes in Tasmania

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European carp (Cyprinus carpio) were first discovered in Lakes Crescent and Sorell in January 1995, where they had previously been deemed absent from Tasmania. As a result, the Carp Management Program was established to contain, control, and ultimately eradicate carp from the lakes. Through the development of various techniques over 12 years (1995-2007), a complete eradication of carp from Lake Crescent was achieved using an integrated approach. By using these strategies in Lake Sorell, the carp population was estimated to have been reduced to less than 50 fish by 2009. However, a spawning event which occurred in spring that year resulted in the introduction of approximately 50 000 carp. The techniques used to target these fish varied with life stage. Juvenile carp were initially targeted using rotenone poison, as they were concentrated in marsh environments. As they developed further, intensive netting, electro-fishing, barriers, and traps were used to target these fish as they became more mobile. Biotelemetry techniques were also used to gather knowledge of seasonable habitat preference. In early 2012, a mark/recapture population estimate was initiated using both the Peterson and Schnabel methods of calculation. The most current population estimate calculated in May 2014 suggested that there are now less than 10 000 fish remaining, with 82% of the original population removed. There will be increased emphasis on targeting the remaining carp this coming spring/summer, to take advantage of a strong sex bias towards maturing males. The prevention of spawning will also be a high priority.

171 How do widespread generalist fish species persist in the extreme arid environment of the Lake Eyre Basin, central Australia

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The Lake Eyre Basin in the central Australian arid zone is one of the harshest environments freshwater fishes inhabit. Waterholes are often the only available habitat for riverine species, but this habitat becomes greatly limited during drought periods, and within some river basins almost all waterholes have dried at least once in the past 200 years. Fish species in the Basin range from specialised endemics, to widespread generalists found across Australia. Generalists are expected to utilise a resilience strategy to persist, where they are able to rapidly disperse and recolonise habitat when conditions improve, while specialists are able to withstand extreme conditions – a resistance strategy. This study uses genetic techniques to investigate the population ecology of three generalist fish species (bony bream Nematalosa erebi, barred grunter Amniataba percoides, and spangled perch Leiopotherapon unicolor), sampled across the Basin's river systems. Preliminary results, based on mitochondrial sequence data, show little genetic diversity within river systems, but significant variability among them. This suggests that populations in different drainages are functionally isolated and subject to genetic bottlenecking and drift, counter to expectations that these taxa would show significant gene flow due to high mobility. Further analyses of additional mitochondrial and nuclear sequence data, and comparisons with two resistant taxa (desert goby Chlamydogobius eremius, and Lake Eyre hardyhead Craterocephalus eyresii), will also be presented.

Oral abstracts

172 Increasing the science capability of Indigenous Marine Rangers

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The Indigenous Community Marine Ranger Program is funded by the NT Government and provides valuable surveillance and research information back to the NT Fisheries Division. Current funding is allocated to eight ranger groups with some 70+ rangers have been trained in a Certificate II Fisheries Compliance course. The success of this program has led to the development of a Measurement and Analysis Certificate II course that will provide rangers with skills in collecting and recording scientific data in both the field and laboratory and a background into natural resource management. Initially 12 students will trained from communities across northern Australia and if successful the course will become available to other marine rangers. This training course will provide benefits to indigenous communities by increasing the marine ranger groups skill set, provide avenues to future employment for students and support their interest in being involved in co-management of their marine resources. These students will also provide a valuable asset in remote areas of northern Australia enabling the collection of a range of scientific information at a much lower cost than if a research team had to travel and conduct the sampling themselves.
This project is funded by the Northern Territory Government, FRDC, WA Fisheries and Queensland Department of Agriculture, Fisheries and Forestry.

173 Aboriginal cultural fishing in coastal far northern NSW

Stephan Schnierer[1], H Egan[1]

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Indigenous cultural fisheries are now acknowledged as one of three fishing sectors in Australia along with the commercial and recreational sectors but little is known about them. This presentation is based on a study of Aboriginal cultural fishing in NSW funded by FRDC. The study focussed on the Tweed region of far north NSW and was done in partnership with traditional Aboriginal owners. A specially designed questionnaire and cultural fishing logbook were used to obtain quantitative and qualitative catch data. Fifty-six Aboriginal participants completed the questionnaire and 20 kept logbooks. This study found that cultural fishing still occurs on a regular basis, is predominantly shore-based around estuaries and adjacent coastal waters. The main gear types used were rods and handlines and to a lesser extent nets, traps and spears. The cultural catch was made up of a range of finfish and invertebrate species. The finfish component was dominated by estuarine and near-shore species such as tailor, (Pomatomus saltatrix) sand whiting, (Sillago ciliata), mullet, (Mugil cephalus), swallowtail dart (Trachinotus coppingeri), bream (Acanthopagrus australis) and dusky flathead, (Platycephalus fuscus). A few Indigenous fishers fish offshore in deeper waters and their catch tends to be dominated by snapper (Pagrus auratus). A variety of invertebrates are also caught with the dominant species being pipis, (Plebidonax deltoides), oysters, (Saccostrea glomerata), beach worms, (F. Onuphidae), bait yabbies (Callianassa australiensis), mud crabs, (Scylla serrata), and prawns. The cultural catch is consumed by the fishers, their families, extended families and other community members. To a lesser extent some of the catch is bartered or traded for other goods and services within the community.

174 Coastal aquaculture in British Columbia: Perspectives from three indigenous communities

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Most aquaculture tenures in British Columbia (BC), Canada, are located in coastal First Nation traditional territories, making the aquaculture industry very important and relevant to First Nation communities. First Nations, however, are severely underrepresented in decision-making and management of the industry. Key informant interviews were conducted in three indigenous communities in BC's central and north coast to achieve a greater understanding of perspectives towards finfish, shellfish, seaweed, and Integrated Multi-Trophic Aquaculture (IMTA). This research illuminates major issues, concerns, and the need for greater transparency in Canada's aquaculture sector, as well as areas that are in-line with First Nation values. From drawing on the results of this study it is evident the majority of issues are rooted in finfish aquaculture and that including indigenous knowledge and participation in decision-making will make for a less contentious industry.

Oral abstracts

175 Victorian Traditional Owner involvement in waterway management

Amber Clarke[1]

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The new Victorian Waterway Management Strategy provides the policy framework for managing Victoria's waterways for eight years. The 2002 Victorian River Health Strategy had limited consideration of Traditional Owner rights and interests in waterway management. The policy development process for the new strategy incorporated a comprehensive stakeholder engagement program. Involving Traditional Owners in the development of state policy was challenging, since Traditional Owner groups generally only speak for their Country. Knowing the right representatives to speak for Country continues to be difficult for policy makers. Specific policies and actions were developed for the new strategy to ensure the involvement of Victoria's Traditional Owners in waterway management. Cultural values of waterways were separated from social values to demonstrate the importance of Aboriginal values in their own right. Traditional Owners will be involved in the development of regional Waterway Strategies and a state guidance note was developed to support this process, in consultation with relevant representatives. Formal evaluation of the regional engagement processes will be undertaken to enable continuous improvement in this area. The regional Waterway Strategies must identify Aboriginal values associated with waterways in their region and incorporate traditional knowledge where culturally appropriate and desired by Traditional Owner groups. A research project is commencing to investigate methods for identifying Aboriginal values associated with waterways and how they can be better incorporated into regional planning processes. Opportunities for education, training and capacity building are provided through scholarships to university graduate programs in waterway management and natural and cultural resource management.

176 Capacity building and science mentorship for Indigenous communities

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NT Fisheries Research and the Indigenous Development Unit are currently working on a project that aims to collect biological data and harvest viability information of under-utilised fish and invertebrate species that are abundant in coastal waters near remote NT communities. This project involves the active collaboration of fisheries staff, Indigenous rangers and remote communities. Researchers will use a holistic approach to bring together technical, scientific and local knowledge of fish, invertebrates and marine habitats to identify new opportunities for small-scale enterprises whilst increasing Indigenous participation in the seafood industry.

The development and sustainability of these enterprises will be underpinned with ongoing capacity building, science mentorship and monitoring. Therefore the ability to correctly identify, measure, weigh and sample marine resources is crucial for the success of any future management and monitoring programs of marine resources.

Most remote communities and outstations do not have reliable access to markets, resources or infrastructure and thus the ability to diversify the range of species caught and gear used is important for maintaining a fresh and consistent supply of product within and outside of the community. We are incorporating traditional techniques such as spearing and fish traps with modern methods and gear such as line and nets in order to minimise the learning curve and effort required to fish. Trials have successfully investigated the biology and harvest viability of species such as whiting and mullet. In addition to providing valuable skills that are transferable across a wide range of industries we anticipate this project will provide the dual benefit of improved nutrition and sustainable self-management and monitoring of on-country marine resources.

177 The Kimberley Ark: assessing and conserving freshwater fish biodiversity in Australia's last pristine river systems

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3. *Natural Sciences, Museum & Art Gallery of the Northern Territory, Darwin, NT, Australia*

Freshwater ecosystems worldwide are experiencing a period of unprecedented biodiversity loss. Effective biodiversity conservation requires accurate estimates of biodiversity and knowledge of species' threat of extinction. The Kimberley region in remote northwest Australia, which now faces imminent expansion of mining and agricultural operations, is both a biodiversity hotspot and a black hole in scientific knowledge. At least 18 (~40%) of the region's diverse freshwater fish species are found nowhere else and many of these endemics are extremely range-restricted. However, a dearth of surveys, and ecological and genetic studies means that current biodiversity estimates are not robust and the risk of extinction these species face is unknown.

This project will help to establish the true biodiversity of the Kimberley freshwater fishes and assess their extinction risk using a combination of molecular techniques and ecological analyses. Hypotheses on the causes of diversity in fish communities will be tested by constructing phylogenies for two of the regions major families (Terapontidae and Melanotaeniidae). Furthermore, microsatellite data will be used to assess gene flow, population connectivity, and population genetic structure within species to evaluate their extinction risk in the face of future impacts. Finally, reproductive and early life-history ecology will be investigated to assess their contribution to the range-restriction and evolution of the Kimberley's endemic species. I will present my project ideas and design and the results of my phylogenetic analysis, which provides evidence for a sweet of undescribed freshwater fish species.

Oral abstracts

178 Conservation of an endangered fish species Murray hardyhead (Craterocephalus fluviatilis) in the upper South Australian Murray-Darling Basin region

Lara Suitor[1]

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The Murray hardyhead Craterocephalus fluviatilis, a native fish species endemic to the Murray Darling Basin, is listed as 'endangered' under the Commonwealth EPBC Act. Its current distribution is thought to be limited to seven remaining populations within the Murray Darling Basin. Due to prolonged drought in the South Australian Riverland region, followed by high flows and flooding in 2010 - 2012, the status of Murray hardyhead in the region was unclear. High levels of connectivity and subsequent potential for movement of fish, together with increased difficulty in sampling fish during flood conditions, resulted in the capture of low abundances or even absence of the species from most sites where it was once abundant. However, recent flooding also resulted in the inundation and alteration of salinity regimes of habitats that were previously unfavourable for the species. Post flood management actions through collaborative projects are likely to have assisted the recovery of the species within the region owing to improvements in habitat conditions. Sampling results at sites between 2012 and 2014 have demonstrated successful recruitment and increased abundance within individual Murray hardyhead populations. This is an encouraging result in regards to the status of this species in the region, however should be viewed with caution due to the Basin wide vulnerability of the species.

179 Spawning dates of the endangered Macquarie perch in the regulated upper Murrumbidgee River

Mark Lintermans[1]

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Macquarie perch Macquaria australasica is listed as endangered under national and state legislation. The species is now confined to a handful of self-sustaining populations across its range, several of which are in rivers with regulated flows. One of these rivers is the Upper Murrumbidgee River, with a large regulating storage (Tantangara Dam, storage capacity 252 GL, altitude 1256 m) at its head. Tantangara is part of the Snowy Scheme and diverts approximately 99% of inflows across the range into the coastal Lake Eucumbene. Releases from Tantangara are managed by Snowy Hydro, with environmental releases made since 2005 and since 2010-11 a major objective of annual flow releases has been to enhance spawning of Macquarie perch. Flows for this purpose have been released from 2010/11 onwards, with 2011/2012 being the largest volume of water ever released (or likely to be released) from Tantangara. A small sample of otoliths from Young-of-Year (YOY) Macquarie perch collected at Kissops Flat (18 km upstream of Cooma) in mid-2011, early-2012, and early-2013 were daily aged, and spawning dates estimated by back-calculation. In 2012 spawning occurred from late October-mid December and in 2012 in November. Calculated spawning dates from 2010 are problematic and will be discussed. Correlation of spawning with water temperature is unclear, possibly as a result of the highly regulated flows in the river and cyclic releases from Tantangara. Spawning dates and cues in the upper Murrumbidgee are compared with lower altitude populations of this species.

180 Understanding natural spawning behaviors to enhance captive breeding success of endangered Macquarie perch *(Macquaria australasica)*

Prudence McGuffie[1]

1. *Institute of Applied Ecology, Canberra University, Canberra, ACT, Australia*

Populations of Macquarie perch have declined severely since the nineteenth century and only a small number of isolated remnant populations remain. Current captive breeding – reintroduction programs to aid in the recovery of the species in both Victoria and New South Wales have had limited success for a variety of reasons. Attempts at artificial propagation of the species in Victoria (due to its popularity as a sporting and table fish) have been under examination for nearly a century, but only wild-caught spawning run broodfish could be successfully propagated. The utility of this method for conservation breeding was limited and this hurdle has now been overcome. Conservation breeding programs are no longer reliant on collecting spawning run broodfish, however mediocre fertilisation success still limits hatchery production. It is likely that key aspects of pre-conditioning and the timing of hormone induction in captivity play a role. Understanding these processes in the few wild populations that remain may provide clues which will lead to enhanced captive husbandry and breeding strategies. This study used acoustic telemetry paired with back calculation of spawning dates from young of year fish to identify environmental triggers of spawning migrations and timing of successful spawning events of wild Macquarie perch. Initial analysis suggests that spawning migrations occur within the receding tail of flow pulses and are associated with a subsequent increase in water temperature.

Oral abstracts

181 The ecology of juvenile Largetooth Sawfish Pristis pristis in the Adelaide River, Northern Territory: movement patterns and habitat use

Kate Buckley[1], Peter Kyne[1], David Crook[1], Richard Pillans[2]

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2. *CSIRO, Brisbane*

The sawfishes (family Pristidae) are considered one of the most threatened groups of aquatic species, with all species assessed as Critically Endangered or Endangered on the IUCN Red List. The Largetooth Sawfish Pristis pristis was once globally widespread across the tropics but now northern Australia represents one of the species' last remaining viable stocks (1). Nevertheless, this subpopulation has still undergone considerable declines in abundance and extent of its distribution. In northern Australia, many anthropogenic activities are considered threats to Largetooth Sawfish populations, including fishing and habitat modification (2). Effective management of the species is hampered by a lack of knowledge of the distribution, movement patterns, habitat use and requirements, life history and threats facings their populations. This information is required to provide a scientific basis for protection of critical habitats, mitigation of impacts, and regulation of harvest regimes (3). We aim to support the management of Largetooth Sawfish by providing an improved ecological understanding of juvenile Largetooth Sawfish. Acoustic tracking of juvenile Largetooth Sawfish in the Adelaide River of the Northern Territory is being undertaken using both active tracking and a passive receiver array. Preliminary results for the movement patterns and habitat use of Largetooth Sawfish are presented. Clearly identified and consistent movement patterns have been detected on larger spatial and temporal scales. On smaller spatial and temporal scales movement patterns are more variable.

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182 A 100-year assessment of biological change in SE Australian waters: novel insight using fish otoliths AWARD TALK

John Morrongiello[1]

1. *Wealth from Oceans Flagship, CSIRO, Hobart, Tasmania, Australia*

Understanding and predicting the impacts of environmental change on biological systems are key tasks facing researchers today. This requires good data. Unfortunately long-term biological data-sets are uncommon for aquatic systems and animals such as large-bodied fishes are unsuitable for experimentation. Aquatic biochronologies, generated from time-dependent information recorded in fish otoliths that are archived in their millions worldwide, can provide valuable long-term data-sets that facilitate the development of ecological and evolutionary insights into marine and freshwater environments.

South east Australian waters support both unique biodiversity and major commercial fisheries, but the region and its natural resources are increasingly being exposed to rapid oceanic warming. Here I present the results of a large-scale project investigating the environmental drivers of fish growth and recruitment variation using a data-set of unprecedented spatial, temporal and biological coverage. Over 30 otolith and catch-based growth and recruitment time series, up to 100 years in length, from across nearly 3000km of ocean have been analysed. Long-term growth and recruitment patterns for many species display temporal synchrony, pointing to universal ecosystem drivers. Directional trends are indicative of warming (via direct and indirect pathways) either promoting or inhibiting growth, whilst quasi decadal oscillations re-emphasise the importance of zonal westerly winds in driving recruitment and system productivity variation. Within species, significant growth plasticity exists that may confer some resilience on species faced with climatic change. Together, these results highlight the valuable information stored within otoliths and their potential to provide unprecedented levels of spatial and temporal detail in aquatic environments.

183 Fishing for revenue: how leasing quota can be hazardous to your health (AWARD TALK)

Timothy J Emery[1], Klaas Hartmann[1], Bridget Green[1], Caleb Gardner[1], John G Tisdell[2]

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2. *Tasmanian School of Business and Economics, University of Tasmania, Hobart, TAS, Australia*

Fisheries management decisions have the potential to influence the safety of fishers by affecting how and when they fish. This implies a responsibility of government agencies to consider how fishers may behave under different policies and regulations in order to reduce the incidence of undesirable operational health and safety outcomes. In the Tasmanian southern rock lobster fishery, Australia, the expansion of the quota lease market under individual transferable quota (ITQ) management coincided with a rise in the number of commercial fishing fatalities, with five between 2008 and 2012. A discrete choice model of daily participation was fitted to compare whether physical risk tolerance varied between fishers who owned the majority of their quota units (quota owners) and those who mainly leased (lease quota fishers). In general, fishers were averse to physical risk (wave height), however this was offset by increases in expected revenue. Lease quota fishers were more responsive to changes in expected revenue than quota owners, which contributed to risk tolerance levels that were significantly higher than quota owners in some areas. This pattern in behaviour appeared to be related to the cost of leasing quota. Although ITQs have often been considered to reduce the incentive for fishers to operate in hazardous weather conditions, this assumes fishing by quota owners. This analysis indicated that this doesn't hold true for lease quota fishers in an ITQ system, where in some instances there remains an economic incentive to fish in conditions with high levels of physical risk.

Oral abstracts

184 The Lake Condah restoration: combining traditional knowledge and science to reactivate Australia's oldest and largest traditional aquaculture system

Denis Rose[1], Danny Lovett[1]

1. *Gunditj Mirring Traditional Owners Aboriginal Corporation, Melbourne, VIC*

Lake Condah in south-western Victoria is at the heart of Gunditjmara country and the Budj Bim lava flow and is a place where Gunditjmara people developed Australia's oldest and largest aquaculture system for the farming of eels.

A drain through Lake Condah was continually excavated from 1904 until 1954 to allow farmers increased access to land for agricultural purposes. It has always been an aspiration for Gunditjmara people to restore water to the Lake and enable us to continue our traditional practices. A small diversionary weir was constructed in the drain during the mid-1980s in an attempt to restore water to the lake, but it proved unsuccessful.

In 2004, the Lake Condah Water Restoration Business Plan outlined a renewed strategy for one of the most significant wetland and archaeological restoration projects ever undertaken in Australia. Planning for the construction of a weir and fishway to restore permanent water in the wetlands included extensive community engagement and detailed scientific research. An important aspect of the project was an assessment of biodiversity and fish movement that provided baseline data relating to eels and other aquatic species prior to the works. This study was a collaborative effort between Traditional Owners and the Arthur Rylah Institute of Environmental Research, and utilised a blend of Aboriginal traditional knowledge and scientific approaches.

In 2010, the new weir in Lake Condah was constructed and has reactivated the ancient eel fishery network and restored the lake's ecology. Large numbers of fish and acoustically tagged eels moved into the lake soon after it was flooded and have continued to live there. Gunditjmara people can now enjoy access the Lake more often throughout the year and we continue to make traditional grass eel baskets for the harvest of eels.

185 Talking together, working together, walking together

Michael Douglas[1], Mona Liddy[2]

1. *NERP Northern Australia Hub, Charles Darwin University, Darwin, NT*
2. *Wagiman Traditional Owner, Palmerston, NT*

Environmental scientists and indigenous people are increasingly becoming involved in collaborative research projects. For the past decade we have been involved in a collaborative study of fish and environmental flows in the Daly River as part of a bigger team of researchers and Traditional Owners. In this talk we look back on what we have learnt from this project and where we need to go in the future. We started out by discussing what we all wanted to get out what was originally a 3 year project. From talking together we moved on to working together to do the research and on other activities like communicating the research findings. Opportunities and support to continue the partnership has meant that what began as a short term project now has a longer term vision and after 10 years we can see a wide range of outcomes from working together. This includes new scientific knowledge, greater recognition of Indigenous knowledge, capacity building and community development and the influence of the project extends beyond just the researchers and Wagiman people directly involved. In fact, even though it began as just a scientific research project the broader contribution to the social and emotional well being of the community has been a key to the continued interest in the ongoing partnership. It hasn't always been easy and although overcoming challenges has been difficult at time, its helped the partnership grow stronger. We believe that its now much more than just a professional relationship and that we are now walking together on a journey to achieve bigger benefits for the river and for the people who rely on it. But this raises interesting questions about the nature of these collaborations, the different perspectives and expectations of the partners and the roles and commitment required to meet these expectations.

186 Connecting land and water: understanding vertebrate fauna diversity in river floodplains and riparian zones

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River floodplains and riparian zones are disproportionately important habitats for vertebrate fauna worldwide, and are prominent in fragmented landscapes. Landscape-scale changes in both hydrology and vegetation in these systems have implications for habitat condition and organism movements, and consequently for biodiversity persistence. However, water resources and the terrestrial landscape are usually managed separately, often by different management bodies. Consequently, river floodplains and riparian zones are rarely incorporated into landscape-scale conservation in a truly integrated way. Yet the dual mediums of water and vegetation interact to create complexities and interdependencies that are unique to these systems, especially over time. Improving understanding of the relative influence of hydrological and vegetative connectivity on semi-aquatic and terrestrial fauna species could reveal better ways to combine water and land management and implement more integrated landscape-scale conservation approaches. Here we present a series of conceptual models developed to synthesise current understanding of how key processes influence the persistence of terrestrial and semi-aquatic vertebrates in river floodplains and riparian zones. We define three major functional groups of species based on their relative dependence on water and associated vegetation for habitat or movement, and describe conceptual models for each functional group built from the ground up, synthesising models for multiple Australian species in each group. We translate these models into spatially and temporally explicit management goals to explore useful synergies and generalisations across functional groups, and ways in which landscape management can integrate spatial and temporal variability in vegetation and water to support a full suite of species.

Oral abstracts

187 Groundwater as a key driver of freshwater water ecosystem responses to drought

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Groundwater is important for wetland, stream and floodplain habitats throughout the world. In times of drought groundwater could be particularly important in freshwater habitats by decoupling them from declines in precipitation and stream flow, but this has rarely been investigated. Additionally, there may be threshold relationships between groundwater and ecological responses that could indicate when certain ecological communities may become more at risk from drought. We tested the importance of groundwater when assessing drought responses in both macroinvertebrates and floodplain forests in catchments of the southern Murray-Darling basin (MDB) and also examined whether there was a threshold response of tree condition along groundwater depth gradients in the Condamine catchment (northern MDB). In the Campaspe catchment, forest condition (EVI) over drought periods declined more in areas of high salinity groundwater (µS/cm>2500) relative to areas of low groundwater salinity. In the Condamine catchment, where groundwater salinity is low, groundwater depth was an important determinant of tree condition, with tree condition declining sharply at depths of 12-20m. Groundwater was also important for macroinvertebrates, with communities in areas of 'high groundwater influence' (based on hydrogeological proxies) undergoing less change in periods of low flow compared to sites of 'low groundwater influence'. The studies highlight the importance of groundwater for both in-stream and terrestrial floodplain ecosystems and indicate that changes in groundwater depth and / or quality may have important implications for understanding ecological responses to drought, as well as for the maintenance of drought refuge.

188 Darwin River Reservoir and Manton River Reservoir, Northern Territory; the role of hydrodynamic transport processes in risk assessment for the Darwin water supply

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Data on the hydrodynamics of inflows into Darwin River Reservoir (DRR) and Manton River Reservoir (MRR) are described in respect of seasonal changes in entrained inflows. Both reservoirs are located near Darwin in the wet-dry tropics. During the transition period leading to the onset of the monsoon season (the 'build-up') and the monsoonal period proper, entrained inflows are clearly evident in both reservoirs but show high variation in their position in the water column. This position is largely determined by the density of inflow combined with the strength of stratification and the location of the thermocline in each reservoir's water column. These factors play a core role in the neutral density intrusion point of inflows in the reservoirs. Seasonally variable inflow density and the large variations in the strength of stratification and its persistence at this time year have a significant influence on the transport time of potential pathogens to each reservoir's offtake and thence to the Darwin and regional water supply. Detailed hydrodynamic modelling will be required to accurately describe these processes and provide accurate information to water supply managers.

189 Long-term trends in condition of flow-dependent ecosystems of the Murray-Darling Basin

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Short-term data on ecological condition have been used to underpin the case for restoring the balance of water between production and environment in the Murray–Darling Basin, Australia, even though trends of ecological time series provide a more informative picture. We assessed trends of 128 data series (mean 22 years, spanning 1919-2012) on floodplain vegetation, aquatic macroinvertebrates, reptiles and amphibians, fishes and waterbirds. Of 114 series (excluding invasive species and initial-final studies), 55 (48%) showed monotonic (n = 49) or step-change (n = 6) declines, but 59 (52%) were stable (n = 52) or showed a monotonic increase (n = 7). There was no significant relationship between type of trend and ecological component, response variable, duration, number of data-points or years of drought. Declines pre-dated the Millennium Drought (1997-2010) and increased irrigation diversions from the 1950s (though only 15 series commenced pre-1950) and are likely due to differential effects of multiple long-term stressors. Improvements in response of 22/40 series after the Millennium Drought support our finding that the most common pattern is of stability with fluctuations between wet and dry conditions, indicating that resilience of flow-dependent ecosystems of the Basin may be higher than has been anticipated.

Oral abstracts

190 Utility of Unmanned Aerial Systems for environmental monitoring of wetlands

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Wetland environments in Australia are often remote and inaccessible. They are also spatially heterogeneous and have high habitat complexity. In northern Australia, the inaccessibility is compounded by strong seasonality with widespread flooding during the wet season. The use of optical satellite imagery for monitoring tropical wetlands is limited due to the highly seasonal environment characterised by a wet season dominated by ubiquitous cloud cover and a dry season dominated by atmospheric smoke resultant from wildfires. Unmanned Aerial Systems (UAS), commonly known as 'drones', enable very high resolution imagery of wetlands to be captured which are not restricted by the same limitations as those of satellite imagery. There is unprecedented flexibility and cost effectiveness in obtaining high resolution imagery through the use of a UAS as they can be readily deployed when conditions are optimal.
This paper presents the results of a test flight over part of the Magela Creek floodplain, located in Kakadu National Park, and Buffalo Billabong (located downstream of the Ranger Uranium Mine). Both standard red, green, blue, and near infrared imagery were captured in October 2013 at a spatial resolution of .The results indicate that the data can be used for many applications including detailed vegetation community mapping, weed identification, animal usage of habitat (through detection of tracks) and population surveys (e.g. waterbirds). The imagery may also be used to survey creeks and riparian zones in a way not previously available.

191 Dams in Northern Australia – An Example of the Limnology of the Burdekin Falls Dam and its Effect on Downstream Environments

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The Burdekin River, on Queensland's tropical east coast, has variable water clarity, running turbid during elevated wet season flows and relatively clear the remainder of the year. A 1.8 million ML dam was constructed on the river at the Burdekin Falls in 1987. Despite the environmental assessment predicting it would be clear, the dam has remained persistently turbid ever since. The persistent turbidity has been found to be due to limited settling of the suspended colloidal sediment trapped in the reservoir during the wet season, which would otherwise pass through the system within days. Management options such as reducing catchment erosion may reduce turbidity to some extent, but in the main, the turbidity of the dam results from its size, trapping a large amount of turbid water, and the highly seasonal flow regime whose post-wet season flows are unable to dilute the stored turbid water.
The turbid dam water is distributed downstream through 159km of river and across the irrigated floodplain through numerous previously clear streams and wetlands, greatly altering ecosystem processes in the downstream environments. However, due to surrounding intensive agricultural land uses, the remaining clearwater wetlands have significant eutrophication issues and associated fish kills, whereas wetlands affected by persistent turbidity have a more favourable oxygen status for aquatic biota - the turbidity providing some benefit.
Impoundment limnology is a key driver of downstream effects in water resource developments, though rarely considered in impact assessments. Further large dam developments currently proposed for tropical catchments may have similar impacts

192 Ecological responses to changes in environmental flow release strategies for a temperate river system in NSW

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Publish consent withheld.

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193 Opening the flood gates: the compromises necessary to achieve environmental flow releases

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Most ideal environmental flow regimes are designed by hydrologists or ecologists to meet a set objective(s), such as improving the ecological condition of a particular ecosystem. This involves determining a volume likely to achieve the objective, designing a release hydrograph and developing a monitoring program to assess the impact of the flows relative to the objective.
Moving from such an idealised design to opening the flood gates to deliver an actual environmental flow event is constrained by a large number of factors other than how best to meet environmental objectives. Policy and political constraints can have a large impact on the amount of water that may be available and the manner in which water is shared among a wide range of users, including across political boundaries. Socioeconomic constraints can also be relevant: for example, the timing of irrigation flows can influence when channel capacity is available. Finally, water-delivery constraints such as channel capacities can all influence how an environmental flow event may be possible.
We compare the impact of such constraints on the objectives and flow delivery profile of the first environmental flows in the Colorado River, USA/Mexico with the planning process associated with such flows in the Murray-Darling Basin, Australia. Differences between the case studies in the existing flow regimes, allocation of water rights, competing interest of multiple states and countries and in the maturity of the science regarding potential ecological impacts of flows result in very different planning processes and potentially very different environmental and other outcomes.

194 The effects of altered flow and bed sediment on benthic macroinvertebrates in stream mesocosms

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In regulated rivers, environmental flows (the provision of water to maintain ecosystems) are the main management technique used to ameliorate the ecological effects of flow alteration. In addition to altered flow regimes, increased bed sedimentation is also frequently associated with lower flows in regulated rivers. We tested the separate and combined effects of altered flow and river bed sediments (colmation) on benthic invertebrates in twelve flume mesocosms at the Freshwater Biological Association's River Laboratory in Dorset, UK. Each mesocosm contained two bed sediment types; clean sediment in the upstream section and experimentally colmated (EC) sediment (10% by weight of fines) in the downstream section. Two flow rates were initially established equally amongst the twelve mesocosms, a higher flow rate to create turbulent flow and the lower flow rate to create a transitional flow between turbulent and laminar flows. After 30 days invertebrates were sampled and the flow in six of twelve mesocosms was reversed. The experiment was finalised after sampling invertebrates at day 70. We demonstrated that the addition of fines to stream sediment and the alteration of flow affected benthic macroinvertebrate composition. However, higher flows did not ameliorate the effects of added fines. It is possible that the differences between the turbulent and transitional flow regimes (and their alteration) in the mesocosms was not great enough to create enough shear stress or power to remove fines or alter sediment dynamics.

195 Benthic algal biomass and assemblage changes following environmental flow releases and unregulated tributary flows downstream of a major storage

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The Severn River, Australia, is regulated by a large dam which reduces the magnitude of high flow events. Environmental flows (EFs) have been allocated to increase the magnitude of flows to improve ecological outcomes such as reducing filamentous algal biomass and re-setting succession to early stage communities. Benthic algal biomass and assemblage structure were examined at two cobble dominated riffle sites downstream of the dam before and after two EFs. Both EFs had discharges of ~11.6 m3s-1 (near bed flow velocity of ~0.9 m s-1). Neither EF reduced benthic algal biomass (as chlorophyll a) but sometimes led to increases with some filamentous algae (Stigeoclonium and Leptolyngbya) increasing in density. An unregulated flow event from a tributary between the two sites increased discharge to 25.2 m3s-1 (flow velocity of ~1.2 m s-1) which decreased biomass and filamentous algal density. The similarity in flow velocities between scouring and non-scouring events suggests that thresholds may exist and/or suspended sediments carried from unregulated tributary flows may contribute to reduce filamentous algal biomass. As EFs are becoming more widespread, target velocities to reduce filamentous algae biomass are useful. EFs with flow velocities ~1.2 m s-1 may achieve this in river cobble dominated riffle sections dominated by filamentous algae. Lower flow velocities <0.9 m s-1 may result in no change or an increase in filamentous algae.

Oral abstracts

196 The impact of feral camels on remote waterholes in the Katiti Petermann Aboriginal Land Trust

Glenis McBurnie[1], Jayne Brim Box[1]

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The Katiti Petermann Aboriginal Land Trust in central Australia contains significant biological and cultural assets including the World Heritage-listed Uluru and Kata Tjuta National parks. Until relatively recently waterbodies in this remote region were not well studied, even though most have deep cultural significance to local Aboriginal people. The region also contains some of the highest densities of feral camels in the nation, and was a focus area for the recently completed Australian Feral Camel Management Project. Within the project, the specific impacts of feral camels on waterholes were assessed throughout the Petermann ALT. We found the aquatic invertebrate biodiversity was significantly lower at camel-accessible sites, and fewer aquatic species considered "sensitive" to habitat degradation were found at sites when or after camels were present. In addition, the water quality at camel-accessible sites was significantly poorer (e.g., more turbid, more DO supersaturation, etc.) than at sites that camels could not access. The results of a multi-year camera trap study at the same waterholes suggest that camels can trigger a "competitive cascade" whereby native species are displaced by apex predators that have been displaced by camels. These results, in combination with emerging research and anecdotal evidence, suggest that large feral herbivores, such as camels and horses, are the main immediate threat to many waterbodies in central Australia. Management of large feral herbivores will be a key component in efforts to maintain and improve the health of waterbodies in central Australia, especially those not afforded protection within the national park system.

197 Gold mining contamination 150 years on: Using spatial analysis to identify 'hotspots' for a bioaccumulation study

David Mossop[1], Fatima Basic[1], Chris Garland[1]

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Gold mining in Victoria began during the 1850s gold rush and continues to this day. Alluvial gold was initially found using basic panning techniques, however techniques quickly progressed to mining buried gold deposits, motivating the need for new extraction methods. As a result, two environmental pollutants emerged: mercury and arsenic.
EPA Victoria is leading a project to identify 'hotspots' of freshwater stream contamination occurring on multiple scales as a result of Victoria's past gold mining activities. Our adopted approach has been to spatially analyse gold mining data in conjunction with data on stream health, soil types, geology and hydrology to determine areas of concern. In addition to spatial analysis, intelligence from Catchment Management Authorities has influenced the identification of 'hotspots'. Our analysis shows some of the worst affected areas fall within the tribal boundaries of the Djadja wurrung and Wada wurrung in the west of the state, and those of the Daung wurrung and Waveroo in the east. This information will be used in catchment management and potential remediation works.
Our 'hotspot' analysis has now guided the selection of a series of field sampling sites for mercury and arsenic. Environmental samples (water, sediment, soil) from control and impact sites around former gold mine locations provide a current context for conditions. Bioaccumulation is also examined through the analysis of tissue from the common yabby Cherax destructor. Characteristics of this species make it a suitable bioindicator and additionally it provides information for health authorities, given C. destructor is commonly consumed by recreational fishers.

198 On the development of a new weighted average biotic index of water quality for Singapore's freshwater reservoirs

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In Southeast Asia, there is a growing concern for monitoring water quality not just from the standpoint of municipal water management but also from an ecological health perspective. Historically, the biggest challenge in developing biotic indices for tropical systems has been the dearth of information on taxonomic composition and faunal sensitivities to local stressors. This led to the inception of a long term biomonitoring project in Singapore, geared towards collecting comprehensive biological and physico-chemical data from all 17 freshwater reservoirs. A previously developed benthic quality index was recently modified based on the addition of newly acquired benthic invertebrate and water quality data collected from 13 reservoirs in 2011-2013. In total, 68 taxonomic groups were sampled represented by over 243,000 specimens. We employed non-linear generalized additive models to evaluate response curves of each taxonomic group against organic enrichment parameters. This was followed by a weighted average approach to calculate tolerance weights for each taxonomic group resulting in a single index score. A range of indices were derived representing various combinations of organic enrichment parameters, including chlorophyll a, turbidity, dissolved oxygen, phosphorus and nitrogen. Each index was evaluated against the respective environmental driver(s) using a combination of multivariate techniques. Further steps in the analysis will explore relationships between each index and a composite stressor to determine the suitability of the index in reflecting a gradient of organic pollution.

Oral abstracts

199 How do we assess the health of rivers when they are dry? – Solutions using a novel approach

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Rivers and streams that dry up are found on every continent, and can form a large proportion of river networks. When they are dry, traditional indicators of river health, such as aquatic macroinvertebrates, fish or water quality, cannot be sampled. Dry river beds can be the 'typical' state of many temporary rivers; however, the ecological health of these habitats is rarely, if at all, assessed in monitoring programs. Aquatic indicators can and have been used to assess wetted habitats, but currently no known terrestrial indicators have been developed or are in use to assess dry river health. A novel solution to assessing rivers when they are dry could be to use terrestrial biota as indicators.

We trialled the use of terrestrial invertebrates as indicators of dry river health in the Cooper Creek catchment – a large, dryland river system in Central Australia – and found that terrestrial invertebrate communities responded to a gradient of disturbance, based on land cover. Our aim for this study was to apply the findings of the Cooper Creek trial to the assessment of the Queensland portion of the Murray-Darling Basin. Our results were confirmed and the assessments were successful in identifying impacted sites.

We conclude that terrestrial invertebrates are appropriate indicators of dry river health, in the same way that indicators such as aquatic macroinvertebrates are traditionally used to assess river health. These indicators of dry and wet habitats could be combined to provide a holistic assessment of the condition of temporary river ecosystems.

200 Quantifying changes in tropical wetland vegetation using time series high resolution satellite imagery

Tim Whiteside, Renee Bartolo

The Magela Creek floodplain within Kakadu National Park in northern Australia and its biodiversity are recognised through listing by the Ramsar Convention on Wetlands. The wetlands have been identified as being at risk from a number of sources, chiefly the landscape-scale risks of weeds, feral animals, fire and climate change. In addition, the Magela Creek floodplain is a downstream receiving environment for the Ranger uranium mine. Off-site monitoring of this area will become increasingly important in the years following mine closure and rehabilitation. Vegetation within the wetland is spatially and temporally variable and, therefore, mapping and monitoring wetland vegetation is required at scales that can detect this variability. The vegetation communities within the floodplain were mapped using multispectral WorldView-2 satellite data acquired for the early dry seasons for four consecutive years 2010-2013. The four final maps each consisted of 11 vegetation community classes. Change analysis indicated that for much of the floodplain community change was minimal; however some areas change in community composition each year. Most of the change was attributable to the varying depths and extent of water associated with seasonality and inter-annual rainfall variability, while some change may be attributed to the spread of weeds and to fire disturbance. Mapping the vegetation's spatial and temporal variation is now an integral to the establishment of an ongoing off-site landscape scale remote sensing monitoring program for the mine.

201 Victorian Fishways- past, present, future

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A recent review of fishways in Victoria found that a significant number fishways are not operating efficiently due largely to there being no standard fishway design criteria or requirements for performance review. The recently released Victorian Waterway Management Strategy provides the framework for government, in partnership with the community, to maintain or improve the condition of rivers, estuaries and wetlands so that they can continue to provide environmental, social, cultural and economic values for all Victorians and includes actions specifically aimed at fishway management in Victoria. This presentation discusses the history and future of fishway management in the context of the policy and actions outlined in the Strategy. Actions and approaches to achieve these outcomes include guidelines outlining performance, operational and maintenance requirements and a workshop aimed at sharing experiences around fishways in Victoria and exploring ways to deliver better fishways.

Oral abstracts

202 A multi-antennae passive integrated transponder (PIT) tag array improves fishway passage assessments in a vertical slot fishway

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A passive integrated transponder (PIT) antenna array was used to assess fish passage through the Bromelton Weir vertical slot fishway, located on the Logan River, south east Queensland. The fishway constructed in 1996 is 72m long, has a 3.2m elevation, a maximum slot velocity of 1.4m/second and has a 180° turn 1/3 along its length. The PIT array installed in 2011 (Karltek Model KLK5000) comprises three antennas, located in the 3rd, 19th and 32nd cells of the fishway. Fish >100mm were tagged at various locations along the Logan River system with 23mm, 9mm and 8mm PIT tags. Fish movement was highly seasonal with 82% of fish detections being recorded in summer, 12% in spring, 5% in autumn and only 0.5% in winter. Six of the eight tagged species successfully ascended the fishway and overall passage success was high (range 60% - 100%). Average passage duration was variable between species, the slowest being eel-tail catfish (9.2 hr) the fastest, sea mullet (0.35 hr). Total passage times also varied between all species for example, freshwater mullet ranging between 0.05 hr and 1.45 hrs; long finned eel between 0.16 hr and 9.13 hrs. The use of three antennas provides information about ascent characteristics, unsuccessful attempts and other behavioral information that trapping alone, or fewer antennae could provide. Despite some individual fish having slow ascent times, overall this study confirms the vertical slot fishway design at Bromelton Weir is effective for the majority of larger bodied fish species in the Logan River.

203 Defining downstream fish passage guidelines for the protection of fish in the Murray-Darling Basin

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Within the Murray-Darling Basin (MDB) many species undertake extensive downstream migrations as eggs, larvae, juveniles or adults and passage through river infrastructure has been shown to impact on their survival. The relative contribution that different stresses (such as rapid decompression and fluid shear) make to overall injury and mortality remains poorly understood, and this in turn makes it difficult to assess the risk associated with infrastructure projects or to develop engineering and operation guidelines to manage the downstream fish passage risks.

This presentation details laboratory experiments that were used to determine the tolerance of various species and life stages of fish from the MDB to rapid decompression (in hypo/hyperbaric chambers) and elevated fluid shear (in a shear flume). Fish were exposed over a wide range of conditions so that the probability of injury and/or mortality could be modeled. In doing this, the ultimate goal was to determine critical thresholds for injury and mortality and develop criteria that if applied would protect downstream migrating fish at river infrastructure. We present criteria in an attempt to better inform policy relating to the development and management of mini-hydropower and irrigation infrastructure for the protection of downstream migrating fish.

204 Mulloway movement within the Glenelg River Estuary within Southwest Victoria

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There is little knowledge of movement patterns of Mulloway (Argyrosomus japonicas) within, entering or exiting estuaries. Understanding the movements of fish in relation to changes in the environment is a critical first step in managing estuarine ecosystems to support fish and ultimately forms the basis for future research programs on biodiversity-habitat linkages such as spawning and recruitment. Twenty-eight Mulloway were acoustically tagged within the Glenelg River estuary in South-west Victoria and were tracked via twenty receivers placed throughout the estuary. Estuarine attributes such as salinity, freshwater flows and mouth condition (open or closed) were also measured so that fish movements could be examined with respect to these parameters. Twenty-two of the tagged fish provided movement data. Increased flow discharge triggered exiting the system or movements towards the river mouth. The period from November to January was a "hot" period for Mulloway exiting the estuary, with exiting also correlated with days when flow was higher. Both season and flow conditions were more variable when Mulloway re-entered the system with no specific driver evident. Four Mulloway exited the Glenelg estuary and moved to the Murray Mouth (approx. 400 kilometres away), with two of these subsequently returning to the Glenelg estuary. The extreme angling pressure on Mulloway within the Glenelg estuary is also highlighted. Fifteen of the 22 (68%) tagged Mulloway were captured by recreational anglers, with only one of these fish being released. This data contrasts with the previously documented higher release rates of Mulloway within the Glenelg estuary.

Oral abstracts

205 Revitalising Australia's Estuaries

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Colin Creighton, Fisheries Research and Development Corporation
In the late 1990's scientists across Australia undertook an Australia-wide assessment of ~1,000 estuaries and embayments. This was part of the National Land and Water Resources Audit. Generally, the bigger the catchment and floodplain, the more degraded was the estuary and the more altered were the processes, flows and fluxes that characterise estuarine ecology. Urban, industrial and most importantly, agricultural development have been the fundamental causes of degradation of Australia's estuaries and embayments. This degradation has had major impacts on biodiversity, commercial and recreational fishing and indeed the Australian lifestyle. Revitalising Australia's Estuaries is a business case that builds on expertise and knowledge across Australia and provides an inventory of opportunities for repair, estimates the cost of repair and then through case studies demonstrates that an Australia wide investment of $350 million into estuarine rehabilitation will be returned in less than 5 years. This represents an outstanding return on investment, possibly far greater than most of Australia's previous environmental repair initiatives and with clear outcomes across the Australian food, lifestyle and services economies. Following a summary of Revitalising Australia's Estuaries this presentation will speculate on next steps and the necessary paradigm shifts in our thinking as scientists and managers if we are to once again have productive, healthy estuaries and embayments.

206 Shellfish – more than just an entrée: history and potential for restoration of the lost shellfish beds of Port Phillip Bay

Paul Hamer[1]

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Recognition of the ecological role of shellfish reefs and the major declines and ongoing threats to these habitats worldwide has stimulated major community/government/industry based partnership programs aimed at their protection, enhancement and restoration, most notably along the U.S. east coast. Shellfish reefs are defined as essential fish habitats in the U.S. In Australia there is also a history of decline, loss and degradation of wild shellfish habitats, although there has been limited investigation of the value of these habitats to fish or for provision of other ecosystem services, or efforts to restore wild shellfish populations in Australia.
Native flat oyster (Ostrea angasi) and blue mussel (Mytilus edulis) beds were once ecologically important features of Port Phillip Bay, recognised as important fish habitat by commercial and recreational fishers. While these two shellfish species are still common in Port Phillip Bay, they no longer occur on sediment areas in the densities or areal coverage that could be considered as 'functional habitats' or 'ecosystem engineers'.
This presentation discusses some history of loss and the current opportunity and prospects for re-establishing lost shellfish beds in Port Phillip Bay, with benefits to fish and fisheries.

207 Threats to the Great Barrier Reef World Heritage Area concomitant with an expanding coastal urban and industrial seascape

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Conservation and resilience of the Great Barrier Reef World Heritage Area has recently come into media focus following correspondence from UNESCO calling government agencies in Australian to prepare a strategic plan addressing exactly how anticipated urban development expansions could continue while still satisfying conservation and protection obligations under the world heritage agreement. To examine the scale of coastal development in the world heritage estate, we used a mapping tool and found that approximately 10% of the coastline has been urbanised. While most (60%) development occurs along the coastline or within the first few kilometres upstream along estuaries the result is a mosaic of natural and urban fish habitat. In several estuaries, the entire linear length has been completely modified, replaced with rock breakwalls, marinas, boat ramps, port developments or pontoons/jetties. We argue the need for explicit data on the utility of the new seascape in achieving long term fisheries production and resilience. At the least, practicable ecological engineering designs are necessary to achieve dual benefits of habitat complexity and human gain. By incorporating seascape considerations in assessment of new developments, managers may have better success in preserving biodiversity and maintaining healthy, functioning ecosystems, a necessity for this world heritage estate.

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208 The effects of drought and anthropogenic activities on ecosystem state cycling and the fish fauna of Africa's largest estuarine lake

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Lake St Lucia, on the East Coast of southern Africa, is a major nursery area for juvenile marine fish and prawns. It comprises 80% of the estuarine area of the Province of KwaZulu-Natal and more than 50% of that of South Africa.
In June 2002 drought resulted in mouth closure and hypersaline conditions followed reaching the highest on record (>200‰) while the lake level dropped to <10% of the system's 325km2.
Anthropogenic activities relating to the separation of the Mfolozi River from St Lucia over 50 years ago appear to be the root cause of the extremes reached. With the drought over and the mouth still closed 14 years later a semi-permanent connection between the two was established in July 2012. This resulted in a significant volume of freshwater entering St Lucia causing the lower part of the system to become fresh. It also caused a reverse salinity gradient to establish which ranged from 1 at the mouth to 15‰ in the northern part of the lake. A switch in ecosystem functioning, from the hypersaline state that typically ranges between 65 and 120‰ (and higher during the most recent event) to a freshwater state with salinities ranging from 0 to 12‰, was also initiated.
This paper reviews ecosystem state cycling in St Lucia and the changes that have occurred over the past 14 years as well as the impacts that the hypersaline period has had on the fish fauna.

209 Fifty shades of flow: catadromous fish migration in a regulated river

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4. *Marine and Atmospheric Research, CSIRO, Brisbane, Queensland, Australia*

Management of water resources in regulated rivers is a balancing act between environmental requirements and anthropogenic uses. Understanding the environmental flow requirements for fish spawning migrations and upstream dispersal is essential for the effective management of dam releases and fishway operations. Here we used a combination of underwater passive acoustic telemetry and flow records to reveal the minimum natural flows required to stimulate migratory movements in three catadromous fish species: Macquaria novemaculeata, Mugil cephalus and Trachystoma petardi. Over a 12-month period the movements of 190 fish were tracked throughout an array of 46 acoustic receivers. The acoustic array was installed throughout the Logan River basin in south east Queensland, from the river mouth to approximately 140 km upstream. M. novemaculeata moved downstream on relatively small flow events in June and July, travelling up to 110 km from the release location to the lower estuary where presumed spawning grounds are located. Not all M. novemaculeata moved to the estuary on one flow, some moved part way and continued to the estuary on the second flow event. Only one M. novemaculeata was observed moving past the tidal limit during the upstream dispersal in spring. Some M. cephalus tagged in November migrated downstream on low flows commencing in February. T. petardi have generally moved upstream, however no clear migration patterns have yet emerged. Over the next two years experimental flow releases which simulate natural migratory triggers will be used to test hypotheses. The outcomes will inform water resource planning in south east Queensland.

210 Coastal floodplains, wetlands and weeds: a bigger problem than commonly envisaged

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It is often assumed that the physico-chemical environment of coastal wetlands is so severe that they are relatively immune to invasion by troublesome exotic plant species. This assumption is implicit in almost all recent published reviews of threats facing mangroves, coastal saltmarshes and other types of brackish-water coastal wetland, where a limited range of vascular plant plant taxa, often focussing on Spartina, are invoked as the major species of concern. Even though the weed flora of southern Australia is derived largely from agriculture and horticulture, neither of which includes many species tolerant of variably saline environments, a detailed State-wide assessment of threats to Victorian coastal wetlands indicated that weeds were the third most pervasive threat, after land reclamation and grazing by domestic animals. Taxa of most concern were Lophopyrum ponticum, Parapholis incurva, Hordeum marinum, and Juncus acutus. Of these, Tall Wheat Grass, L. ponticum, until recently widely promoted by government agencies as a salt-tolerant pasture grass, is the most serious invader of upper saltmarsh in Victoria because of its very broad ecological amplitude and robust life form. We assessed the effectiveness of various control measures, including slashing and various herbicides, in controlling L. ponticum infestations and their side-effects on adjacent wetland communities. A nominally grass-specific herbicide widely used for Spartina control, Fusilade®, was ineffective in controlling L. ponticum. The broad-spectrum herbicide glyphosate was more effective in controlling L. ponticum, but had severe effects on some native plant species. It seems that controlling weeds in coastal wetlands remains difficult and problematic.

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211 Environmental Outcomes – Can We Substitute Infrastructure For Environmental Water?

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In 2002, a landmark decision was made to invest $700 million (AUD) to recover 500 gigalitres of water to restore the iconic River Murray south-eastern Australia. A cornerstone of this initiative was the construction of pumps, regulators and levees to deliver water onto the floodplain.
We are now embarking on a more ambitious $12+ billion restoration program to recover an additional 2750GL. Building on the success of the River Murray initiative and recognising the potentially significant impacts to rural communities, it has been agreed that the target can be reduced by up to 650GL where equivalent environmental outcomes can be achieved through the use of works.
Can this be done? The political stakes are high – livelihoods can be dramatically affected and lots of cash is on the table. The scientific challenge is immense – the method to assess the 'equivalence' must be defensible and yet there is limited experience in the use of large scale works to base it on. This paper explores the lessons learnt thus far and the technical and political challenges we face as we embark on the largest river restoration project in Australian history.

212 An Introduction to the Murray-Darling Basin Environmental Water Knowledge and Research Project

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The Environmental Water Knowledge and Research Project (EWKR) project has been established by the Australian Government to provide information to support implementation of the Basin Plan. The purpose of EWKR is to improve identification and reporting on the outcomes of environmental flows including the way that these outcomes may be influenced by other threats and stressors. The project will achieve this through generation of new knowledge, development of decision support tools and communication to support achievement of Basin Plan objectives. The Murray-Darling Freshwater Research Centre (MDFRC) has been appointed as the lead organisation that will work in collaboration with other researchers. The project will comprise two phases; the first phase is a planning phase that will identify the key questions and approach. The second phase will undertake research and management tool development. It is anticipated that the project will be undertaken at four sites (including a Queensland floodplain vegetation research site) that will be selected during the first year of the project on the basis of critical research questions. This presentation will describe; 1) key relationships between the MDB EWKR project and other environmental flow and research activities 2) the role of MDB EWKR in the adaptive management of environmental water and 3) Phase 1 of the MDB EWKR project and opportunities for researchers to become involved.

213 Regulated recruitment: native and alien fish responses to widespread floodplain inundation in the Macquarie Marshes, arid-Australia.urban and industrial seascape

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Rivers and wetland ecosystems are degraded by diversions of water upstream. In response, governments have reallocated water to flood wetlands, mimicking natural inundation of habitats known to drive booms in native freshwater fish production. Individual flow events allow the influences of various factors on the ecological outcomes of restoration efforts to be evaluated, in order to improve ongoing adaptive management. This study investigated the population size and recruitment responses of seven native and three alien fish species to widespread floodplain inundation at 15 sites across the Macquarie Marshes, a regulated wetland in Australia's Murray-Darling Basin. Flooding during late-winter, when water temperatures were 4 to 12.6 degrees C below the spawning threshold for native fish species present in the system, promoted reproduction and recruitment by alien species, which were significantly more abundant than native species after flooding. Fish assemblage structure also differed significantly between main-channel and floodplain habitats, with macrophytes, pH, emergent vegetation, flow velocity and small wood debris accounting for 59% of spatio-temporal variation in fish assemblage structure. Strong correlations were identified between the length of spawning window and post-flood abundance of young-of-year and recruit size classes in the most abundant alien and native fish species. Future environmental flows, particularly those that inundate floodplain habitats, need to be delivered in light of the confounding effects of flow-temperature coupling and the lower spawning temperature thresholds of alien species.

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214 Spatio-temporal variability of native flow-cued spawning fish larvae in association to environmental water in the lower River Murray

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Water has become a precious resource in many parts of the world and its informed management is essential to a successful balance between human and environmental needs. As part of achieving this balance environmental flows have received much attention, but little rigorous biological evaluation. However reliably investigating biological responses to find causal links to E-flows has proven to be a challenge. The monitoring of larval fish abundance over eight years in the lower River Murray under a broad range of flow scenarios, including the Millennium drought, natural flood and within channel flows with delivery of E-flows, provides reliable information that associate E-flows to the presence of larvae of flow-cued spawning native fish. Our results show that the delivery of a flow pulse of appropriate magnitude and timing can prolong the period of time over which larvae of flow-cued spawning species are found in the lower River Murray. The temporal extension of early life history stages in the water column increases total abundance of larvae and potentially recruitment success. The results also highlight greater abundances of larvae in the gorge than floodplain geomorphic region of the lower River Murray, indicating the need for large spatial scales in the monitoring of E-flows. Identifying causal links of the observed patterns and relating them to ecological processes and function is essential for E-flow management in the lower River Murray and merits future research.

215 Testing/evaluating the use of fish habitat availability for monitoring the anthropogenic impact on dry season flows in the Katherine River, tropical Australia

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We developed Habitat Suitability Curves (HSC) for 26 fish species that occur in the Katherine River in the top end of the Northern Territory. These models, based on depth and velocity, were then used to investigate relationships between optimal habitat availability and dry-season environmental flows. As expected, the HSC performed best with species that showed strong fidelity to particular depths and velocities (e.g., species found in shallow, swift habitats). For a sub-set of species we used a two-dimensional depth averaged finite element hydrodynamics model, developed for a 9-km reach of the Katherine River, to examine changes in optimal habitat availability over 16 modeled discharge scenarios. Not surprisingly, the total optimal habitat available varied greatly between species and discharge scenarios. We then tested the relationship between habitat availability and species abundance for an eight-year period to gain insight into the strength of habitat availability as a driver of end-of-dry season species abundance. Implications for monitoring the anthropogenic impact on dry-season flows are discussed.

216 Environmental flows for Australian lungfish: From push-net to release valve

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Finding the balance between species water requirements and maintaining water security is challenging for water managers. We provide a case study about the science that has led to improved water resource management and targeted environmental flow strategies for Australian lungfish. This threatened and iconic species was prioritised for assessment based on previous studies suggesting a critical link between spawning and riverine flows/aquatic macrophytes. A 6-year monitoring and research project was undertaken in the Burnett River, Queensland, which focused on hydraulic habitat requirements for the species and impacts of water impoundments. Firstly, the study investigated the role of stream flow in riverine and impounded habitats, and its effects on lungfish spawning (where eggs were collected using push nets). Lungfish spawning was found to be a seasonal strategy, reliant on variable low-flow and dense macrophyte, within shallow riverine habitat1. Having established these requirements, the second part of the study investigated spawning habitat availability in riverine and impounded reaches subject to current water management. Impoundment operation was found to substantially decrease the availability of spawning habitat for lungfish as water level fluctuations led to inundation/desiccation of aquatic macrophytes. However, irrigation releases from dams were found to be of a suitable magnitude to cue spawning. Finally, the study assessed the effectiveness of current water resource management and proposed alternative strategies for ecologically sustainable development. Redirecting the focus of management from storage operations, to providing releases for the downstream environment was a key recommendation which culminated in legislated revised environmental flow strategies.

1. Espinoza, T., Marshall, S. & McDougall, A. (2012). Spawning of the endangered Australian lungfish (Neoceratodus forsteri) in a heavily regulated river: a pulse for life. River Research and Applications 29: 1215-1225 DOI: 10.1002/rra.2607

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217 A social license to care: the challenges of involving recreational fishers in fish habitat rehabilitation

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This paper explores the challenges associated with engaging Australian recreational fishers in the environmental issues that directly affect the viability of their sport but which are divisive and contentious within the fishing community.
The impact on fisheries productivity of habitat loss and degradation is increasingly well documented. What to do about it and who needs to be involved is more contested. Fishers participate in a sport that is dependent on healthy aquatic environments and they could play a significant stewardship role. In other parts of the world, they are a driving force for environmental conservation and rehabilitation.
Fishers fall into two quite distinct motivational profiles, reflecting the fact that identification as 'a recreational fisher' is as much about the enjoyment and anticipation of going fishing as it is about catching a fish. However, the natural environment is notable by its absence in the mainstream recreational fishing media, especially as it relates to its importance for fish, and in some of the public dialogue about linkages with 'green' groups. The task with which we are engaged is to effect a cultural change and to communicate the stories from fishers who are actively engaged in habitat rehabilitation in ways that supports this.
Reflection on our practice leads us back to basics: to communicate effectively with fishers about the environmental issues affecting the sustainability of their sport we need to work from underlying values, have a credible voice that is 'of the community' and facilitate the voice of change from within the community.

1. NSW DPI. (2010) More Habitat More Fish: A Strategy for Educating Recreational Fishers about Habitat. Available at: http://www.fishhabitatnetwork.com.au/pdfs/educating%20Recreational%20Fishers%20Strategy_final.pdf. 2. Miles, M., Baker, E. and Copeland, C. (in prep) Educating recreational fishers about habitat issues: input from the recreational fishing media.

218 A coordinated national data collection for recreational fishing in Australia: what's changed since the last national survey?

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2. *ABARES, Canberra*
3. *IMAS, Hobart*

A national project funded by the Commonwealth Government's Recreational Fishing Industry Development Strategy (RFIDS) was undertaken to provide an update on the national picture of recreational fishing in Australia since the last national survey in 2000/01. The project was able to provide an improved understanding of the available datasets, and data deficiencies, relating to recreational fishing in Australia through the successful collaboration of researchers and fishery managers from state, territory and Commonwealth fisheries agencies and recreational fishing groups. The project identified and prioritized recreationally-important species at the national level. A quantitative assessment using statistical modeling demonstrated the available datasets are too fragmentary in space and time to produce reliable national estimates, indicating that a dedicated national survey or better coordination of jurisdictional surveys is required. Revised jurisdictional estimates of the participation, total catch and effort, and catch of key recreationally-important species provided an up-to-date picture of recreational fisheries nationally, indicating that participation and catch of key species had generally decreased since 2001. A framework and web-based prototype of a national recreational fishing data portal was completed to improve access of updated information for recreational fisheries stakeholders, which may be used in management of specific fish stocks, marine bioregional planning, resource allocation for shared stocks, identification of regionally important areas and economies, and business and infrastructure planning through identification of growth trends.

219 Assessing the effectiveness of harvest tags in managing the recreational catch of snapper in Shark Bay, Western Australia

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Harvest tags are commonly used to regulate hunting however their application in recreational fisheries is rare. Stocks of snapper in the inner gulfs of Shark Bay, Western Australia, support an important recreational boat-based fishery. Following research that showed all three stocks were depleted, stricter management was progressively introduced between 1998 and 2002. In 2003, a Total Allowable Catch (TAC) was set for each stock for the first time and different combinations of measures implemented to manage catches to the respective TACs. These included a novel harvest tag system in the Freycinet Estuary, where a limited number of tags were made available each year via a lottery based system, to limit the recreational catch within a TAC of 5 tonnes. The effectiveness of the harvest tags was evaluated, based on a series of phone interviews conducted with all tag recipients in each year over three consecutive years (2011-2013), in terms of capacity to limit the recreational catch, levels of compliance, and acceptance by recreational fishers. These surveys indicated that 76% of tag recipients fished for snapper in Freycinet Estuary, more than 50% thought that illegal fishing activity was not significant and importantly, more than 80% of those interviewed considered harvest tags to be an effective measure for managing the recreational snapper catch. This study provides important information for recreational fisheries managers elsewhere where harvest tags may have potential application with similar recreational fisheries that are based on highly vulnerable fish stocks.

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220 Meeting the requirement of recreational fisheries data for Integrated Fisheries Management

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Catch allocation among fishing sectors requires credible data for decision-making, allocation and management. In 2004, Integrated Fisheries Management (IFM) policy was adopted in Western Australia. Three multi-sector species have been allocated: Western Rock Lobster (WRL) (Panulirus cygnus) with allocations of 95% commercial, 5% recreational and 1t customary; Roe's abalone (Haliotis roei) with allocations of 36t commercial, 40t recreational and 500kg customary; and West Coast Demersal Scalefish (WCDSF) with allocations of 64% commercial and 36% recreational. While total commercial catch are obtained from statutory return obligations, recreational catch estimates depend upon the nature of the fishery and spatial and temporal scales of the resource. The WRL recreational fishery has a specific fishing licence (~40,000 annually), and covers large spatial and temporal scales. Mail surveys supplemented with occasional phone surveys have provided a cost effective method of monitoring this fishery over 27 years. The Roe's abalone recreational fishery has a specific fishing licence (~15,000 annually) and operates over a limited temporal scale allowing data collection from onsite surveys. The WCDSF had no specific licence until the Recreational Fishing from Boat Licence was introduced in 2010 (~125,000 annually). A phone-diary survey provides harvest estimates with high precision for key species. In 2014, the lower West Coast Blue Swimmer Crab (Portunus armatus) fishery was identified for IFM with allocations and ongoing monitoring yet to be formalised. Monitoring and managing allocations are an ongoing process, with routine surveys of recreational catches required to provide estimates with a known confidence that are comparable with other sectors.

221 Sand flathead in Port Phillip Bay – story of a recreational fishery in decline

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Sand flathead (Platycephalus bassensis) was once both a significant commercial fishery and the largest recreational fishery in Port Phillip Bay. Between 2000 and 2010 sand flathead stocks declined by 87% in Port Phillip Bay. The cause/s of this decline are unknown; and attempts to rebuild stocks are unlikely to be successful without identifying and addressing the cause/s as part of any management response. This project drew on a range of data sources to summarize what is known about the current status of the fishery in Port Phillip Bay, the probable causes of the decline, and the prospects for recovery. There was little evidence that fishing pressure contributed to the decline of sand flathead stocks, or that the population was overfished during this period. Fisheries exploitation rates remained relatively stable between 2000/01 and 2006/07, despite a significant decline in the overall stock biomass due to a three-fold reduction in the total catch over this period. By comparison, there is substantial evidence that the decline was linked to environmental changes. Environmental impacts were investigated by examining changes in sand flathead recruitment and the environmental drivers of recruitment, growth and diet. Sand flathead recruitment in Port Phillip Bay was characterised by very high recruitment pulses in the late 1980s/early 1990s, but little recruitment from 1997 onwards coinciding with a period of prolonged drought in southern Australia from 1997–2009. The prospects for recovery in the short-to-medium term for this fishery appear positive, but less optimistic over the longer-term due to expected climatic changes.

222 The Changing Character of Recreational Fishing

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1. *ABARES, Canberra, ACT, Australia*
2. *IMAS, UTAS, Hobart, TAS, Australia*

The nature and landscape of recreational angling is changing in Australia. Using social media, anglers are developing a more coordinated and influential voice on fisheries management issues. This has included a more collaborative relationship with conservation groups on emerging common interests, much as has happened in the US and Canada. As a result, the recreational sector is having increasing influence on key fisheries policy and management decisions.
A measure of this influence is the Federal election commitment to conduct regular national surveys of recreational fishing. Recreational sector calls for such surveys have increasingly been associated with calls for more secure resource sharing arrangements between the commercial and recreational sectors. The sector is also expecting increased social licence for commercial activities which they perceive to affect fisheries, and want more of a say in how angling licence revenues are spent. Some species and areas have already been set aside only for recreational anglers, and resource-sharing is an important issue for stocks such as southern bluefin tuna. This talk will look at recent examples of some of these important changes; how recreational survey approaches have evolved; how recreational participation and key fishing areas and stocks can be measured; how social and economic importance can most effectively be evaluated; and how recreational anglers can best contribute to a better understanding of their sector.

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223 Making sense of all the monitoring. Why the synthesis of monitoring information is a key step in adaptive management and how it is being done for The Living Murray initiative

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The adaptive management of rivers occurs over a variety of scales from the management of individual wetlands, through large icon sites to the river as a whole. As a consequence, management or a river system can require gathering large amounts of information over time on discrete variables. These can be collected at a variety of scales in an effort to both identify progress toward objectives and prioritise future restoration actions. While specific questions about cause and effect on one variable of interest may be answered, translating the information into a form that can be used in the adaptive management processes to optimise future actions has historically presented a challenge.

Monitoring programs that assess a number of different variables over a range of temporal and spatial scales, face a particular challenge in integrating the full suite of monitoring information into a clear story about what the management actions have achieved. An example of this is the monitoring program for The Living Murray Initiative. Monitoring in The Living Murray has a focus on monitoring fish, waterbirds and vegetation. The Living Murray Monitoring Program has recognised the challenges of synthesising the full range of data from multiple variables and temporal and spatial scales and has worked toward addressing them.

This talk will discuss these challenges and how The Living Murray has begun addressing them. In particular, how it developed an annual synthesis report that makes sense of the full range of monitoring information along with hydrological data and broader climate information.

224 Setting and evaluating ecologically relevant water quality targets for the Great Barrier Reef – progress in the Burnett-Mary region

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1. *Burnett Mary Regional Group, Bundaberg, QLD, Australia*
2. *Natural Decisions, Bendigo*
3. *TropWater, Townsville*

Understanding water quality impacts on natural resources, identifying pollutant sources, determining ecologically relevant targets to protect significant environmental assets is a complex and challenging endeavour. Furthermore, assessing the socio-economic and political feasibility of relevant actions to meet those targets, including a realistic assessment of costs has rarely been tackled with success in Australia and overseas (Roberts et al, 2012). Nowhere is this more starkly evident than for the Great Barrier Reef (Brodie et al, 2009). Water Quality Improvement Plans (WQIPs) are being developed for river basins on the Great Barrier Reef (GBR) catchment. An acknowledged weakness of previous plans has been a lack of integrated bioeconomic assessment of the benefits and costs of achieving pollutant reduction targets.

BMRG collaborated with Natural Decisions and TropWater to utilise robust, transparent evidence-based processes to develop a region wide WQIP. The development of the Burnett-Mary WQIP has focused on the development of ecologically relevant targets, which were evaluated through the application of a purpose-built bioeconomic model, based on detailed biophysical information available from both Paddock to Reef paddock-scale and catchment scale modelling.

This information was used as an input to an integrated benefit: cost assessment using INFFER (Investment Framework for Environmental Resources). INFFER (Pannell et al, 2011) uses the principles of benefit: cost analysis to undertake integrated assessments of projects that aim to achieve environmental outcomes. Bioeconomic modelling analysis can inform the cost component of INFFER, particularly the costs associated with management practice changes on private land to achieve environmental targets.

1. Pannell, DJ, Roberts, AM, Park, G, Alexander, J, Curatolo, A & Marsh, S 2011, Integrated assessment of public investment in land-use change to protect environmental assets in Australia, Land Use Policy, vol. 29, pp. 377–387. 2. Roberts, AM, Pannell, DJ, Doole, G & Vigiak, O 2012, Agricultural land management strategies to reduce phosphorus loads in the Gippsland Lakes, Australia, Agricultural Systems, vol. 106, pp. 11–22. 3. Brodie, J, Lewis, S, Bainbridge, Z, Mitchell, A,J. Waterhouse, J, & Kroon, F 2009 Target setting for pollutant discharge management of rivers in the Great Barrier Reef catchment area, Marine and Freshwater Research, 2009, 60, 1141–1149.

225 The global need to recognise and manage intermittently flowing rivers and streams

Jonathan Marshall[1]

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Temporary waterways are dominant in dryland river networks, and occur throughout the world. There is a growing scientific recognition of their importance. They support high biodiversity and provide ecosystem goods and services. They are important conduits for exchanges of water, energy, material and biota, even when water is absent.

Despite these values, temporary streams are being degraded in many places, in part because their legal status is at best uncertain in many countries, meaning many are not considered in regulation, policy and management. In the US and in the EU their status is determined on a case by case basis. Australia is more inclusive and our approaches can guide other regions. To align policy with scientific thinking, temporary waterways should be recognised as part of the river network if they flow and connect to the network, and if they are habitat for obligate aquatic biota or terrestrial biota unique to dry river beds.

To better implement water policy in temporary waterways, there needs to be i) better mapping of temporary waterways - they can be recognised by the presence of defined channel banks and fluvially sorted sediments; ii) better methods to measure and predict flow intermittency; iii) better biological indicators to monitor and assess their ecological condition. Costs to recognise and manage intermittent systems have been estimated to be minimal and offset by resulting economic benefits, especially where people critically depend upon them. This paper is based on Acuña et al., 2014, Science 343:1080-1081, with full acknowledgement of all co-authors.

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226 Managing Inland NSW Aquatic Habitats – past, present and future planning tools

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Inland New South Wales Rivers are facing a gamut of issues with regards aquatic habitat management. Most of the inland rivers in New South Wales are already in a poor state of ecosystem health as reported in the Sustainable Rivers Audit. Land management issues have a crucial role in influencing the health of aquatic ecosystems and the region is currently under pressure from resource development for coal seam gas, coal and other extractive resources.

This presentation aims to review initiatives that the New South Wales Department of Primary Industries have been involved in within the planning process to maintain and or improve the management of aquatic habitats within New South Wales inland waterways. The suite of tools available include involvement on a local government level to map Key Fish Habitats for inclusion within councils' statutory planning document, the Local Environmental Plan (LEP) and inclusion of provisions within the LEP which specifically relate to development within or adjacent to Key Fish Habitats. Recently at a more regional strategic level, the synthesis and analysis of over 20 years of data from the Freshwater Fish Research Database has been the basis of developing aquatic biodiversity value maps to assist with the identification of high conservation value aquatic habitats when developing Regional Growth Plans and Strategic Regional Land Use Plans (SRLUPs). These plans are designed to support sustainable growth and provide some certainty for resource development within inland New South Wales whilst recognising and protecting high value environmental assets.

227 Prioritizing management of dynamic threats in protected areas: a decision support tool for Kakadu National Park

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2. *Australian Rivers Institute, Griffith University, Nathan, QLD, Australia*
3. *CSIRO Ecosystem Sciences, Winnellie, NT*

Protected areas are a cornerstone in global conservation strategies. Constrained budgets for protected area management make it essential that protected area management plans take into account the heterogeneity of values, such as biodiversity and cultural sites, as well as dynamic threats. Furthermore, there is a growing interest in joint management arrangements of protected areas to better integrate conservation on Indigenous lands and allow for traditional resource uses. Therefore, better methods of accounting for complex objectives associated with these different types of management arrangements are needed. We use Kakadu National Park, a world heritage site, as a case study and present a decision support tool designed specifically for the park which integrates dynamic aquatic weed and management models and mapped environmental and cultural values to evaluate the performance of different management strategies in a dynamic and uncertain future. We present three invasive weed management scenarios for Kakadu's floodplains designed in collaboration with park staff and traditional owners which reflect different stakeholder values and priorities as well as real world constraints such as budgets. For each scenario we evaluate the total costs of weed management and the benefits of management as the percentage lost or recovered of a range of biological and cultural assets. We discuss the feasibility of each scenario and contrasting benefits and efficiencies that they present.

228 Fish parasites: just another tool for water planners working on a shoestring budget

Susie Williams[1], Rob Cossart[1]

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There has been a proliferation of research into water planning in response to water reform in the past 5 years. Research has focused on reviewing water planning case studies, applying theoretical models and developing tools for planners.

Much of this research has not adequately described the real-world complexity of water planning. Planning theory often describes a linear process with minimal recognition of externalities. We have learnt that the only way to effectively engage in planning is by seeking opportunities to build on existing initiatives and responsing to local concerns.

As part of a regional water planning process we visited a remote indigenous community at the edge of Lake Gregory in the Kimberley,WA. We visited the community to discuss water planning. We came away with a collaborative research program to study fish parasites infesting local fish.

This is an atypical response to a typical problem in water planning. The greatest water issue for people at Lake Gregory was 'worms in their fish'. In addition, the community was embarking on Indigenous Protected Areas (IPA) planning which was their current focus of cultural and environmental planning; there was not much room for other planning.

In this case we integrated water planning with IPA planning, addressed local issues through collaborative research and built capacity through tailored waterways education. These strategies were required to ensure that scarce regional capacity was strengthened and that our work respected existing planning effort and didn't divert energy and focus. Above all, it was a necessary approach to engage community in water planning.

Oral abstracts

229 Murray-Darling Basin Plan – My Involvement and Experiences

Barry Hart[123]

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It is interesting to look back over one's professional career and reflect on the twists and turns that lead to where one ended up. In this Lungfish Chapter lecture, I will spend some time in such a reflection of my career, and will seek to bring out some of the experiences that underpinned my appointment (as a scientist) in 2009 to the Board of the new Murray Darling Basin Authority. I will discuss the importance of keeping flexible your horizons, making the most of opportunities that will arise from time to time, recognising that there will be (difficult) career choices presented along the way (forks), and that fate will also be in the mix. Additionally, I will use my experience in the development of the Murray-Darling Basin Plan to discuss the role of science (particularly ecology and limnology) in the decision-making process involved in this major policy reform.
Finally, I will make some personal reflection on key aspects of the four-year journey to develop the Basin Plan, and seek to draw out a number of key lessons.

230 Modelling population growth of river red gum and black box communities in relation to water availability

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Understanding and meeting environmental objectives requires knowledge of the amount of water needed to sustain water-dependent ecological communities. To enhance understanding how changes in water availability can affect floodplain vegetation communities, it is necessary to understand the effects of varying water availability on the different life stages. We used a 'stock-and-flow' system dynamics tool to develop population models for river red gum (Eucalyptus camaldulensis) and black box (Eucalyptus largiflorens) communities in the Murray Darling basin, outputting systems response models for normal, and extreme wet and dry conditions. We interviewed experts to gain knowledge of survival and death rates at the different life stages and used these to populate our models. While mature trees were able to withstand extreme conditions for longer periods, saplings and poles were mostly affected by infrequent flooding or limited duration. Densities of the plants were also a factor in the earlier life stages. Overall the population of river red gum increased more than the black box with the variability in the interflood interval and flood duration affecting survival across the stages. These models help bridge the current knowledge gap on population dynamics of riparian vegetation by offering two population models for estimating water availability requirements across life stages for healthy floodplain vegetation communities.

231 Lakes sensitivity to climate change and nutrients availability: a coupled hydrodynamic ecological modelling study

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2. *University of Western Australia, Crawley, SA*

Changes in temperature and nutrients are considered the most important factors controlling phytoplankton composition and cyanobacterial abundance in freshwater lakes, although their relative importance and their interaction are still unclear. In this study we applied a recently developed open source 1D model GLM-FABM to two lakes (Mt Bold reservoir, AU; Lake Tarawera, NZ) with different trophic state. After calibration and validation a matrix of 25 scenarios, combining temperature and nutrient changes during a period of two years was simulated. It was analysed how changes in physical and chemical variables affected phytoplankton abundance and composition. Additionally relative importance of temperature and nutrient and their interaction was evaluated. Modelling experiments showed that seasonal variability and trophic states affect the relative importance of these two factors. Moreover, the competition between algal groups (e.g. Chlorophytes and Cyanobacteria) was identified as a significant factor controlling the development of the phytoplankton community and its response to the external drivers

Oral abstracts

232 At The Coalface: Developing A Decision Support Tool To Assess Hydro-Ecological Risks To Lake Eyre Basin Rivers

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A decision to develop mineral resources within unregulated, ephemeral surface water catchments of the Lake Eyre Basin requires a proper assessment of social, economic and environmental risks within the socio-political context of the day. But, how do decision-making authorities properly assess and make an informed decision on a mining proposal without a way to incorporate ecological complexity into their risk assessments? This presentation outlines data gathering, analyses and modelling currently being trialled to aid future decision-makers in exploring hydro-ecological risks that alternate decision and management scenarios present for aquatic ecosystem 'agents' (represented by four native fish species) and 'domains' (represented by defined aquatic ecosystem function zones) in the Arckaringa Basin in Northern South Australia. Our experience shows that developing a useful decision support model (DSM) requires a consultative process to understand the context of regulatory needs and uncertainty. We discuss options for DSMs that allow managers and decision-making authorities to openly explore priorities and risk criteria setting for highly valued but lesser known aquatic ecosystems of Lake Eyre Basin Rivers.

233 A mark-recapture method using tissue genotyping for estimating the number of narrow-barred Spanish mackerel *(Scomberomorus commerson)*

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Fine spatial scale capture rates of narrow-barred Spanish mackerel (Scomberomorus commerson) from the commercial fishery adjacent to Darwin (Northern Territory) were estimated in a mark-recapture framework by genotyping tissue sampled non-invasively with a specially designed hook. Once struck, the hook tip contained a small sample of tissue that was genotyped and compared to genotypes of landed fish caught during the same fishing trip. This simultaneous mark-recapture design was used to estimate the average number of actively feeding fish encountered per fishing day. The mean was 281 fish, with a 95% confidence interval ranging from 187 to 312 fish. The 95% confidence interval for the percentage of actively feeding fish caught ranged from 11% to 19%, with a mean of 17%. We propose that genetic sampling combined with random sampling of fishing transects may be useful in monitoring changes to abundance over time.

234 A novel field method to reliably distinguish between the cryptic carcharhinid sharks, *Carcharhinus tilstoni* and *C. limbatus*

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There hs been a proliferation of research into water planning in response to water reform in the past 5 years. Research has The Common Blacktip Shark, Carcharhinus limbatus, and the Australian Blacktip Shark, C. tilstoni are the primary chondrichthyans targeted by the Northern Territory Offshore Net and Line Fishery (ONLF). These sharks are similar in appearance and until recently could only be distinguished through slow and/or destructive means. Despite their similar appearance, these sharks have very different life histories. The Australian endemic, C. tilstoni breeds annually, matures faster and at a smaller size, than C. limbatus, which breeds biennially and is found in tropical and warm coastal waters world-wide. Our aim was to develop a method that would enable accurate field identification of these two species.
Ninety seven morphological measurements were collected from 112 sharks (95 C. tilstoni, 17 C. limbatus) identified by precaudal vertebrae counts and genetic analyses. Multivariate and machine learning techniques were used to identify six key measurements (fork length, caudal-fin peduncle height, interdorsal space, second dorsal-fin height, pelvic-fin length and pelvic-fin midpoint first dorsal fin insertion) that can be used to distinguish between the two species. There were also significant differences in pelvic fin markings between species: C. limbatus had a distinct black mark greater than 3% of the total pelvic fin area, while C. tilstoni had either smaller markings, markings with diffuse edges, or no markings at all.
The morphological differences identified here will become an important part of a multi-faceted approach to C. tilstoni/C. limbatus identification in the ONLF and will inform the management and conservation of these commercially important sharks.

Oral abstracts

235 Standards for the effective management of fisheries bycatch

David S Kirby[1], **Peter Ward**[2]

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2. *ABARES, DAFF, Canberra, ACT, Australia*

Mitigating the environmental impact of commercial fishing, by avoiding, minimizing and compensating for adverse effects, is core business for fisheries management authorities. The complex interplay of ecological, economic, and social considerations has often resulted in bycatch management being reactive, confrontational and costly. In many cases it is difficult to demonstrate success and to establish whether management has been efficient or effective. This paper proposes standards for bycatch management following reviews of literature, international agreements and management policies, and consideration by technical experts and stakeholder representatives. The standards were developed for Australian Commonwealth fisheries – and from the international fisheries agreements to which Australia is party – but are applicable to other domestic and regional/international governance systems. The proposed standards involve quantifying fisheries bycatch, agreeing on operational objectives, assessing the effects of fishing on bycatch populations, establishing the cost-effectiveness of mitigation measures, and evaluating performance. The standards encourage domestic management measures that are consistent with international agreements. The importance of engaging stakeholders is recognised. The standards provide a framework for measuring performance and a checklist of management actions. They have the potential to lead to more strategic and effective approaches to bycatch management, with defined goals, monitoring systems, and adaptive decision-making. This review of past bycatch management, including retrospective application of the standards to mitigation of shark bycatch in an Australian longline fishery, demonstrates that the standards are operationally feasible but that they have not always been applied. Specifically, monitoring the performance of bycatch management measures has not always followed implementation.

236 Fine scale distribution of two lowland rainbowfish species in north-eastern Queensland

Keith Martin[1]

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North-eastern Queensland, including the Wet Tropics and southern Cape York Peninsula is a biodiversity hotspot for Australian freshwater fishes. In particular, there are seven currently recognised rainbowfish taxa, and a likelihood of additional undescribed species. All but one of the rainbowfish taxa are either endemic to the region, or reach their southerly distribution limits in the region. Although there are large tracts of protected areas in north-eastern Queensland, coastal lowland freshwater habitats are poorly represented and potentially vulnerable to disturbance. Analysis of habitat and distribution of rainbowfishes in the region based on historical records can be misleading due to past misidentifications, translocations and possibly localised extinctions. Further, some lowland rainbowfish species have specialised habitat requirements and highly fragmented distribution patterns.
This study examines the historic and current distribution of two coastal lowland rainbowfish species (Melanotaenia trifasciata and Cairnsichthys rhombosomoides) in the Wet Tropics and adjacent regions. The current fine scale distribution of these species was determined through field surveys and included documentation of sites and habitats, local extent of populations and the discovery of some new populations. The continued viability of some populations is of concern due to their small size and restricted habitat.

237 Biodiversity discovery expedition to the Hindenburg Wall region, Papua New Guinea: Fishes, Frogs and Odonates

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1. *Museum & Art Gallery of the Northern Territory, Darwin, NT, Australia*
2. *South Australian Museum, Adelaide, SA*

The heady days of early exploration saw adventures to remote parts of the world, leading to the first European observations of spectacular and sometimes bizarre animals. Surprisingly, there are still many regions of Australasia which are yet to be fully explored, and much remains to be discovered. In February 2013 scientists from MAGNT joined a Wildlife Conservation Society expedition to the Hindenburg Wall region of Papua New Guinea where around 80 news species of plants and animals were discovered! The presentation features some interesting, spectacular and unusual aquatic animals (including language names for fish), but more broadly shows what it is like to spend a month in remote tropical jungle working closely with local communities as part of a team contributing to biodiversity conservation.

Poster abstracts

300 Ecological impacts of extraction during summer low flows on pool refuges in South Coast NSW

Robyn Bevitt[1]

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Whilst the ecological impacts of dams are well known, such as changes to thermal regimes and reduced diversity of macroinvertebrate assemblages, there have been fewer studies of the ecological impact of water extraction on rivers where flows have not been modified by dams. Irrigation extraction during low flows in summer is likely to have similar ecological impacts to drought including reduced habitat and increased water temperature causing changes to macroinvertebrate assemblages. Several studies have examined the potential for pools in inland and intermittent river systems to provide refuge during drought and low flow conditions, but few studies have examined pools in coastal rivers. This study investigates the impact of extraction during summer low flows on water temperature and macroinvertebrate assemblages in two rivers on the far south coast of NSW that have high water demand and high in-stream conservation value. Macroinvertebrates will be sampled quantitatively in 6 refuge pools and upstream riffles in test and control sites. Sampling will be bi-monthly for a 12 month period to determine the ecological impact of pool draw-down from water extraction, whether pools serve as refuges for rheophilic invertebrates, and determine potential recovery rates. Water temperature, dissolved oxygen and pool size will be measured continuously to investigate the relationship between these variables and macroinvertebrate assemblages during pool draw-down. The results of this study will be used to inform Water Sharing Plans which set rules for water use during very low flows.

301 Connecting science with management in a multi-tenure, cross-border landscape - Strategic Adaptive Management in the Lake Eyre Basin

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The rivers of the Lake Eyre Basin are unique on a world scale. River flows are highly variable and unpredictable, creating a distinctive 'boom and bust' environment. These rivers are relatively pristine and unregulated but face challenges from climate change, introduced species, agriculture, tourism and mining activities. A strategic adaptive management framework is being used to determine if the condition of the Lake Eyre Basin is shifting beyond a natural condition and to develop management responses to address these changes. The first step in this process was to clearly express a widely shared vision for the Lake Eyre Basin: Lake Eyre Basin – Australia's unique, natural, desert river system: healthy environments, sustainable industries, vibrant communities, adaptive cultures.
This vision has been developed over the past three years through consultation among Lake Eyre Basin stakeholders including the Community Advisory Committee and Scientific Advisory Panel. Members of these committees include representatives from, industry, science, community and indigenous and cultural values.
The ongoing challenge is for science, community, industry and management stakeholders to work together to understand thresholds of change for Lake Eyre Basin environmental assets. By understanding these thresholds it will assist stakeholders to respond to environmental threats before these thresholds have been reached or passed. The management approach being used is the thresholds of potential concern method.
This poster will be of interest to people working on arid zone rivers, indigenous engagement and methods to set environmental thresholds.

302 Performance of Small Mesh Drift nets in Rivers

Alan Couch[1], **Fiona Dyer**[1], **Mark Lintermans**[1], **Pat Ross-Magee**[1]

1. *Institute for Applied Ecology, University Of Canberra, ACT, Australia*

Deploying small-mesh drift nets in rivers is a well-established method for sampling drifting fish larvae and eggs. Quantitative comparisons are sometimes made on the basis of numbers of larvae captured per unit volume or time. In this study a GoPro ™ camera was mounted inside the drift net to record the change in flow over time (1 to 5 minute intervals for 3 hours). Although a small number of net nights (7 nights at 3 locations) were sampled, variance in the change in flow within and between sites was observed – even during soak times as little as 2 hours. In one case there was almost no change in flow over 180 minutes but at the most extreme, the flow dropped from 4.6 m3/min to 0.8 m3/min in just 130 minutes. Variance is probably due to the level of suspended particulates at different sites or times. If volumetric or temporal estimates are made on the basis of total flow only they could in some cases be misleading and at worst make comparisons almost meaningless. While there are dedicated data logging flow meters available they are prohibitively expensive for routine sampling. Researchers could consider the method used in this study to cost effectively assess the decay in net performance during sampling.

Poster abstracts

303 Environmental drivers of depth use by an exploited reef fish

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Redthroat emperor (Lethrinus miniatus) is an important species to fisheries of Australia, Japan, New Caledonia and Tonga, yet little is known about its movement patterns. Recent research has revealed variability in movement patterns among individuals, with no consistent patterns observed in presence or depth use related to individual size or time of day. Knowledge of how environmental conditions influence movement patterns of redthroat emperor is vital to better understanding response of this species to changes in climate. Utilising an acoustic telemetry network at three reefs combined with in-situ real-time monitoring of environmental conditions, this research investigates the vertical space use of redthroat emperor in relation to water temperature, tides, rainfall, air pressure and wind speed. Sixty adult individuals were fitted with Vemco V13P transmitters over three deployments, and monitored within a network of passive acoustic receivers in the southern Great Barrier Reef, Australia (April 2011-September 2013). Models compared environmental data with weekly and monthly vertical activity spaces and identified the environmental parameters that drive patterns in depth use. This study offers new insights into the ecology of this important species, and will allow managers to better predict the effect of environmental conditions on the movement patterns of this species.

304 Persistent Waterholes in an Arid-zone River – Surprising Diversity and Abundance on the mid-Finke

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Rivers in arid Australia only flow intermittently so long-lasting waterholes are critical locations for aquatic life. Knowledge of the location and basic character of waterholes should underpin catchment scale condition assessment and associated ecological understanding. Across the Lake Eyre Basin, waterhole monitoring is conducted to assess river health, however, in the Finke River poor mapping was a barrier to interpreting monitoring data. Work to address this knowledge gap in the mid-section of the Finke combined consultation with pastoralists and traditional owners, inspection of satellite imagery, aerial survey and ground survey. Only 20 waterholes were previously mapped; all of undocumented character. Information from landholders convinced us that 3 waterholes are permanent, but that relatively few others lasted more than a year without flow. Aerial survey 15 months after a flow event identified 274 distinct pools. Ground survey indicates most were shallow (< 1m) but with depths ranging up to 9 m deep. Water levels in many pools were surprisingly close to cease-to-flow level, and the majority of pools were saline, consistent with a significant groundwater influence. All 9 Finke fish species were present. The mid-Finke is now considered to be as important as the rocky headwaters in sustaining the fish fauna, with many pools that only dry out in major droughts (e.g. >2 years without flow). The abundance and diversity of long-lasting waterholes both help explain why the Finke has a higher diversity of fish than other isolated arid zone rivers. The results also demonstrate the importance of adequate wetland inventory.

305 What's the angle? Could trout angling benefit threatened native fish species in the ACT?

Lisa Evans[1], Travis Howson[1], Mark Jekabsons[1], Matthew Beitzel[1]

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Native fish in the Cotter River are exposed to a number of potential threats including river regulation and interactions with introduced species, particularly from trout. Recreational angling also occurs along part of the Cotter River with self-sustaining populations of trout in close proximity to the city of Canberra. Regular fish monitoring has been conducted along the Cotter River since 2001 and provides information on the distribution of several threatened native fish, as well as Brown and Rainbow Trout. Fish monitoring results suggest that there may be a pattern of low trout and high Two-spined Blackfish (Gadopsis bispinosus) numbers, particularly at sites that are more accessible by anglers. It is hypothesised that take from recreational angling for trout may benefit threatened Two-spined Blackfish by reducing trout abundance. A project is proposed that will investigate interactions between anglers, trout and Two-spined Blackfish in the Cotter River. A number of different options are being considered to investigate this interaction, including re-analysis of existing data and a survey of anglers.

Poster abstracts

306 Investigating trophic role of roving apex predators in tropical estuaries across space and time of northern Australia: a case study with euryhaline elasmobranchs

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4. *CSIRO, Hobart, Tas, Australia*

Determining the spatial and trophic niche of tropical euryhaline elasmobranchs is critical to understanding their functional role as apex predators within riverine and estuarine ecosystems. Euryhaline elasmobranchs of the South Alligator River, in the World Heritage National Park, Kakadu, Northern Territory, Australia, include Glyphis garricki, Glyphis glyphis and Carcharhinus leucas. The Glyphis species are rare and have been listed as threatened species. This combined with the fact that their taxonomy was only recently resolved has resulted in a paucity of data in their ecology that encompasses dietary preference, spatial and seasonal axes of variation. Using a novel combination of techniques, we will establish both the trophic (stable isotopes and fatty acid analysis) and spatial (acoustic tagging) niches. It is anticipated that these preliminary data will indicate the niche occupied by these species to reveal links between these predators and their prey across wet and dry seasons along a series of key habitats throughout the length of the South Alligator River.

307 When common species become rare: freshwater mussels in the Hawkesbury-Nepean River

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Unlike their US and European counterparts, conservation of freshwater mussels in Australia is frequently met with disinterest or disregard. Despite their importance as ecosystem engineers, their applications as bioremediators for river systems, and the food source they provide for our aquatic mammals, little consideration has been given to managing rivers to ensure the ongoing health of mussel populations. To address concerns for their survivorship we collated data from a number of research projects across Australia.
Starting with data collected from the Hawkesbury-Nepean River in NSW in 2004/5 we used the von Bertalanffy growth equation to estimate site specific population structures for three species of mussels (Velesunio ambiguus, Hyridella australis and H. depressa). We used Leslie Matrices to model population projections for selected populations of these species over 10 years. Modelled scenarios included ongoing recruitment, reduced recruitment, and no recruitment - a situation indicated by some of the initial survey data. Much of the data required for accurately predicting population trajectories is simply not available for these species so we extrapolated data for similar species in the Avon River in Western Australia.
We resurveyed selected sites in the Hawkesbury-Nepean after about a decade, and found greatly reduced recruitment evidenced by changes in the population structures for species, or no recruitment at all. As well, there was considerable reduction in population densities for each species assessed. We believe this gives clear evidence of the decline in freshwater mussels, and that this is happening throughout our river systems across Australia.

308 Long term water quality monitoring in the Intersecting Streams

Tracy Fulford[1], Monika Muschal[1]

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The Intersecting Streams located in north-western NSW forms part of the Darling River drainage system that crosses the New South Wales-Queensland Border. The rivers drain a remote low relief landscape and are largely ephemeral in nature. They provide for irrigation, stock, domestic, mining, town water and recreation. Annual rainfall averages less than 500mm with the western areas being classed as semi-arid.
Water quality monitoring began in the early 1990's to better understand the base-line characteristics of these remote semi-arid systems. We have collected over 20 years of data from six rivers spanning multiple wetting and drying periods, enabling a unique long-term understanding of the water quality characteristics of these ephemeral rivers during different climatic conditions.
Electrical conductivity of the Warrego and Paroo Rivers are notably lower than the other Intersecting Streams, with medians of 89ms/cm and 133ms/cm respectively. Turbidity levels are highly variable throughout and have the potential to be very turbid, with most sites giving median turbidity levels over 300NTU and the Paroo and Warrego Rivers having medians over 600NTU. The Paroo River has extremely fine sediments that remain in suspension indefinitely regardless of environmental conditions, with the lowest Total Suspended Solids result being 64mg/L.
The Paroo and Warrego were the only rivers in the Murray-Darling Basin Sustainable Rivers Audit (2012) to be given scores that suggests their overall condition is close to natural. Examination of this water quality record will provide valuable information about these unique semi-arid river systems for future water management within the Murray-Darling Basin and across Australia.

Poster abstracts

309 Nutrient release from inundated terrestrial vegetation in the Enlarged Cotter Reservoir

Sally Hatton[1] , Fiona Dyer[1], Mark Lintermans[1]

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Worldwide, dams will continue to be built and enlarged to supply water for the growing human population. The inundation of large areas of land and vegetation in the process of filling new reservoirs provides a large input of nutrients into the aquatic system, resulting in trophic upsurge. A trophic upsurge is likely to result in a change of fish food resources and cause other water quality changes, such as a decrease in dissolved oxygen. While many reservoirs designed for domestic water supply purposes limit the influx of nutrients through the removal of vegetation and topsoil prior to filling, the vegetation and topsoil in the inundation zone of the Enlarged Cotter Dam (ECD) has not been removed. Cubic metre samples of topsoil and dominant vegetation types in the inundation zone of the ECD were collected, including blackberry, eucalypt, pine and silver wattle. The samples were submerged in 1m3 Intermediate Bulk Containers with 1m3 water extracted from Cotter River. Water samples were analysed for TN/TP, dissolved oxygen, temperature, turbidity, electrical conductivity and pH on day 1, 2, 3, 4, 6, 8, 10, 14, 17, 21, 25, 29, 37, 44, 53, 65, 74, 84, 106. Results indicate that inundation negatively impacted on water quality across all vegetation types. DO fell below 1mgL-1 after 10-20 days in the eucalypt, pine and wattle containers. By the conclusion of the experiment DO fell to such severe levels that there would have been extreme stress and mortality of aquatic biota under all sampled conditions.

310 Translocation of Murray hardyhead *(Craterocephalus fluviatilis)* from captive bred populations to aid in species recovery

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1. *Murry Darling Freshwater Research Centre, Mildura, VIC, Australia*

Murray hardyhead are a threatened small-bodied native fish species currently limited to three known isolated populations in Victoria and perhaps five in South Australia. Since 2004 management of Murray hardyhead has been problematic due to prolonged drought (the "Millennium Drought"), with captive maintenance and translocation programs established to prevent a state-wide extinction. At least four Victorian populations became extinct during the drought, and the persistence of remaining populations remains tenuous. Lake Koorlong was the first wetland site in Victoria actively managed for the translocation of Murray hardyhead. This poster outlines the details and success of the release of captive bred Murray hardyhead through examination of its population structure and recruitment. We also highlight lessons learnt in regards to the conservation of threatened small-bodied fish species.

311 Parenting behaviour in threatened paragalaxiids of the Tasmanian central plateau

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2. *School of Biological Sciences, University of Tasmania, Hobart, Tasmania, Australia*

Knowledge of reproductive strategies of threatened fishes is critical to the management of their populations, especially attributes that can enhance breeding success. Approximately 20% of teleosts exhibit 'parental care', a behaviour that enhances the survival and development of offspring; however, this strategy has not been documented in galaxiids, which are dominant in temperate inland waters of several land masses in the Southern Hemisphere.
Arthurs Lake, Great Lake and Lake Augusta are home to all four species of Paragalaxias, which is an endemic genera to central Tasmania, Australia.
During a five-year study, snorkel-based observations and in situ underwater camera equipment were used to examine spawning sites and parental behaviour of all four Paragalaxias species (Paragalaxias dissimilis, P. eleotroides, P. julianus and P. mesotes). These fishes deposit discrete broods of eggs (<400 eggs) on the undersides of cobbles and boulders in shallow lake margins (mean depth ~0.6 m). Interestingly, all four species appear to exhibit a form of parental care, with egg defence, egg care (fanning and cleaning of broods) and possibly filial cannibalism (a behaviour used to enhance the survival and longevity of egg guarding parents) being observed.
Harem polygyny appears to also exist with spawning sites commonly being shared. This may be energetically advantageous for adults. Aggregations of broods on individual rocks could also reduce the impact of cannibalism on distinct broods. To date, field observations have shown that the reproductive strategy of Paragalaxias species is complex and that these fishes may be suitable candidates for more detailed behavioural studies.

Poster abstracts

312 The likelihood of floodgate opening *(saline intrusion)* causing conditions that promote algal blooms and fish kills in a coastal lagoon

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The Vasse Wonnerup wetlands in south-western Australia are a Ramsar-listed, shallow barrier wetland that has been highly modified with the construction of floodgates to reduce seawater input. Within the community, it is perceived that reoccurring algal blooms and fish kill events are caused by eutrophication and opening the floodgates will dilute the water body, thereby reducing their occurrence. While nutrients fuel algal blooms, research has shown that other factors such as light penetration and stratification may be the key drivers that trigger a particular bloom. This study will determine what combinations of physiochemical variables are most likely to promote algal blooms or fish kill events. This will be done by measuring a suite of physiochemical profiles of the water column during summer, before and after the floodgates have been opened and relating it to chlorophyll a measurements, phytoplankton community species composition and fish kill events. This will inform the development of different scenarios of combinations of physiochemical variables, which will be tested in a structural equation model. These scenarios can be used to inform managers of the conditions that promote algal blooms and when it is appropriate to open the floodgates.

313 Murray River crayfish: could they be a key surrogate species for freshwater conservation?

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Conserving freshwater ecosystems to protect biodiversity and critical ecosystem functions is needed if we are to continue to receive the essential goods and services we require from our catchments in arid countries such as Australia. However, the complexity of freshwater ecosystems and their response to various pressures (e.g., water extraction, species loss, changing hydrology, urban development) has posed some major challenges for management. One approach to the problem has been the use of surrogate species as a focal point for conservation planning and monitoring. Here, I explore the prospect of using Murray River crayfish (Euastacus armatus) as a key surrogate species for monitoring and management of upland catchments within the Murray-Darling Basin of southeast Australia. By introducing all the elements of an effective surrogate species, and how Murray River crayfish may fit these criteria, we look to provide a solid basis for future planning and investment in freshwater conservation and management.

314 Mapping giant clams *(Tridacnidae)* in the Northern Territory, Australia using a novel remote video system

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Giant clams (conventionally family Tridacnidae) are a conspicuous inhabitant of coral reefs throughout the Indo-Pacific region. Surprisingly, anecdotal reports, and museum voucher specimens, suggest that the fluted giant clam Tridacna squamosa may be species of giant clam inhabiting rocky coral reefs in the Northern Territory (NT), despite a possible 10 being known from the Indo-Pacific. Our research is the first to investigate the abundance, distribution, and phylogeography of giant clams within the coastal reefs of the NT. The NT is a sparsely populated area of northern Australia, with limited infrastructure in the mostly remote coastline. Travel relies on planes or boats, subject to prevailing weather conditions. In these circumstances, underwater survey using SCUBA is an expensive and time consuming exercise, carrying a significant risk of attack from sharks and estuarine crocodiles. We developed a novel underwater video system to survey reefs in three remote regions of Arnhem Land, NT. Using a commercially available GPS, depth sounder, video lens, and text overlay box we built a relatively cheap, portable and easy to use georeferenced video system to survey reefs in shallow water. The equipment was tested and calibrated before it was used in the field. After each survey, image frames were extracted from the video transects and calibrated before virtual quadrats were overlaid and measurements taken. Multivarate analysis was used to compare the percentage of habitat coverage within sites with and without clams, and between sites, areas and regions. Length frequency was estimated from calibrated video frames, and abundance from transect observations.

Poster abstracts

315 Spatial, temporal and size-based trophic analyses of albacore tuna using stable isotopes and fatty acids

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We examined the trophodynamics of albacore tuna in the south-west Pacific Ocean using novel numerical and biochemical tracer approaches. Specifically, General Additive Models (GAMs) were used as an exploratory and predictive tool to assess the influence of collection site and time, and individual length and age on bulk carbon and nitrogen isotopes and on fatty acid biomarkers. Interpolated results were relayed on a landscape map of the south-west Pacific Ocean to show the spatial distribution of these biochemical tracers. Clear spatial differences in δ15N and δ13C, and in fatty acid markers 20:5n3, 16:1n7 and 22:6n3 were detected and related to distinct biological (diatom vs dinoflagellates) and oceanographic (temperature and eddy) features off east Australia. Stable isotopes with slower turnover rates, were shown to vary seasonally for carbon and annually for nitrogen, whereas fatty acids varied monthly and/or seasonally. Ontogenetic patterns of biochemical parameters were also detected and related to migration and related feeding trends known to occur in the species. Detection of spatial and temporal trophic differences supports the use of stable isotopes and signature fatty acids as tools to detect within community changes over space and time. Our findings also suggest that, these biochemical tracers can be used to monitor bottom and top order processes in respect to fisheries and climate change.

316 Ecogenomic tracing of trophic connectivity in tropical coastal and freshwater fish communities

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Fish play an important role in the transport of energy through tropical food webs. This project proposes a novel method, based on next-generation sequencing, to reconstruct feeding links by examining DNA of gut bacteria. Paired isotope and 16S rRNA gut bacteria sequence data were generated for 61 fish of 10 species, with omnivorous, herbivorous and carnivorous diets, collected from a billabong in Kakadu National Park. This area is of significant social and environmental value for indigenous and non-indigenous peoples. A stepwise distance-based linear model procedure was then used to determine the variation in gut bacteria community composition explained by isotope signatures of basal food sources. Diversity of gut bacteria phyla was higher in fish with omnivorous and herbivorous diets than fish with carnivorous diets. However, bacteria from two phyla (proteobacteria and firmicutes) represented over 50% of the total richness within each fish trophic guild. Stable isotope source data explained ~ 25% of overall gut bacteria community structure, with savanna and planktonic sources explaining most variation. The results confirm previous studies emphasising the role of diet in shaping host gut bacteria. However, the approach could be improved through greater replication of each guild and species, analysis of connectivity between sites and examination of patterns at higher levels of taxonomic resolution. A critical next step will be to incorporate data from another 20 sites that were sampled, to test if bacterial species, functional guilds and communities can be traced through the aquatic food chain.

317 Integrated Ecosystem Condition Assessment

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The intent of the Integrated Ecosystem Condition Assessment (IECA) Framework is to provide a methodology for development of aquatic asset-based condition assessments that are capable of incorporating different connected aquatic ecosystem types (e.g. rivers, floodplains, lakes, marshes and estuaries), and the key ecosystem functions that support them. It aims to allow transparent comparisons of the condition of diverse aquatic ecosystems with different values and management objectives. The Framework builds on current approaches to broad-scale and asset-based condition assessments based on the functional processes and ecological characteristics (e.g. components and processes) that underpin the aquatic asset's key ecological values, and scopes new ground by taking into account connectivity, resilience, natural variability and where appropriate, threats and pressures. The Framework allows for condition to be evaluated and reported in relation to risks, thresholds and management actions to aid adaptive management. As such a key step is to relate ecosystem condition to identified values of the nominated aquatic ecosystem.
IECA has the challenge of addressing a water manager's capacity to identify and prioritise the threats and impediments which cause decline or prevent recovery. The Framework will assist in identifying critical knowledge gaps and in prioritising management actions and research needs. It aims to provide a systematic, cost-effective and repeatable process that can fit into existing Monitoring, Evaluation and Reporting Frameworks. IECA is explicitly a value-based assessment and this has challenges from a science perspective.

Poster abstracts

318 Comparative phylogeography of four aquatic species from the Murray-Darling Basin

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The Murray-Darling Basin (MDB) has a complex biogeographic history as it is surrounded by more independent river basins than any other Australian basin. As a result portions of the aquatic fauna have a mix of relationships to all surrounding regions, as well as an endemic component. Our project has three principal goals. 1) Is there an historical signature on biodiversity in the MDB and adjacent drainages that remains evident in the genetic structure of widespread species? 2) Are there concordant patterns of genetic structure across disparate aquatic and water-dependent organisms? 3) What are the impacts of dams on dispersal and degree of erosion of local genetic diversity of aquatic organisms? We chose four unrelated aquatic species that were widespread acorss the MDB, but that lacked known complications due to introgression or presence of cryptic species: the fish Australian Smelt (Retropinna semoni), river turtle (Emydura macquarii), yabby (Cherax destructor) and shrimp (Macrobrachium australiense). We are exploring patterns of genetic diversity using SNP variation from thousands of loci to address these three questions.

319 The gill net selectivity of four teleost species in south-western Australian estuaries

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An understanding of fishing gear selectivity is crucial for managing fisheries appropriately. This study examined the gill net selectivity of four teleost species that are recreationally and/or commercially fished with gill nets in south-western Australia; Black Bream (Acanthopagrus butcheri), Sea Mullet (Mugil cephalus), Perth Herring (Nematalosa vlaminghi)and Tailor (Pomatomus saltatrix). Sampling was undertaken in five south-western Australian estuaries using gill nets with mesh sizes ranging from 38 to 127 mm. The total length of all four species increased with increasing mesh size. Linear relationships between maximum girth (Gmax) and opercular girth (Gope), and total length (TL) varied markedly among species. Selectivity curves, i.e. the relative retention probability of a fish at a given length within a mesh, were estimated using the SELECT method. The spread and mode of these curves varied extensively among species due to their morphological and behavioural characteristics. Modes for the selectivity curves of A. butcheri, the species with the greatest girth at any given length, were less than those of the other three species across all mesh sizes. The selectivity curves were broadest for P. saltatrix due to the far greater proportion of tangled fish than meshed fish, i.e. gilled and wedged. The gill net selectivity of A. butcheri differed among estuaries, which reflects significant differences (ANCOVA, $P < 0.01$) in body condition, and thus girth-length relationships, of fish among the five estuaries. These results have the scope for use by fisheries managers in determining the most suitable mesh size regulations for estuarine gill net fisheries.

320 May the flow be with you – Modelling Hydroecological Risk

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Due to the lack of empirical data, expert derived metrics have been used to inform environmental water requirements for water allocation planning in South Australia. The number of these pass/fail metrics that fail has been used to inform the level of risk to ecological assets. This lack of quantitative relationships prevents explicit demonstration of the reduction in risk by returning water. We sought to use fish and macroinvertebrate monitoring data to construct hydro-ecological models to inform the risk to fish and macroinvertebrate populations. Flow response models were developed for Galaxias olidus, a known flow responder, by examining data collected across the Eastern and Western Mt. Lofty Ranges. This population data was compared to multiple ecologically relevant flow metrics and models were developed for those that showed a response. Four models were developed, two based on the number of riffle flow days, one on the number of zero flow days and one on the average daily runoff. Macroinvertebrate trait and species data was compared to multiple flow metrics. Species richness was used as a representative of the response observed in the mean daily flow for the antecedent 90 days. All of the models developed showed a positive response to increasing flow and these responses were used develop risk levels for various flow management scenarios. This work represents an important step forward for water allocation planning as they allow for empirical analysis of changes to populations based on different modelled flow scenarios.

Poster abstracts

321 Saving native Dwarf Galaxias while controlling invasive Mosquitofish: Taking advantage of local adaptations to variable habitats

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The dwarf galaxias, Galaxiella pusilla, is a small freshwater fish of national conservation significance from south-eastern Australia. Anecdotally it has been suggested by a number of authors that dwarf galaxias are able to survive extended periods of habitat drying (e.g. aestivation, refuge in cray burrows), but it has not been rigorously tested. A series of experiments were conducted to understand the capacity for dwarf galaxias to persist without surface water, including the influence of particular habitat types (sediment only, vegetation, detritus, artificial crayfish burrows) on survival rates, as well as measurements of respiration rates in both water and air. In parallel, we tested the responses of the invasive eastern mosquitofish (Gambusia holbrooki), a major competitor and predator that often threaten dwarf galaxias populations.

Dwarf galaxias survived significantly longer than eastern mosquitofish without surface water, with survival rates strongly influenced by the moisture retention capacity of specific habitats. There were also distinct changes in the physiological response of dwarf galaxias to habitat drying, with transition to a mode of air-breathing clearly evident as water levels receded. On the other hand, eastern mosquitofish appeared to change their breathing rate but not their breathing technique. The enhanced ability of dwarf galaxias to cope with habitat drying was also demonstrated by differences in respiration rates – where oxygen consumption was similar between dwarf galaxias and eastern mosquitofish in water, but significantly lower for eastern mosquitofish in air. This research will help inform dwarf galaxias conservation efforts in regards to the potential risk of local extinction due to extended dry conditions or predicted changes in future climate, and the management of invasive species such as eastern mosquitofish.

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