National Estuaries Network Science Forum

ABSTRACT BOOKLET

(in Alphabetical Order)

Barrier estuaries:

Science for restoring and enhancing estuary values

Vasse Wonnerup Wetlands System

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Aquatic plants, macroalgae and phytoplankton: a crucial balance

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Scheffer and Nes (2007) suggest that shallow lakes may be dominated by submerged charophytes, angiosperms, green algae or cyanobacteria at different points along a gradient of eutrophication. The implications of this for management are that different levels or thresholds of a controlling variable (such as nutrients) may be necessary to cause a shift in dominance depending on the characteristics of the dominant taxa. The relative dominance of these plant groups significantly affects the functionality of the ecosystem. For example, the maintenance of bird populations on which the Vasse Wonnerup RAMSAR status is based requires dominance of *Ruppia megacarpa,* while cyanobacteria may be toxic and result in fish kills. Importantly each of these groups are ecosystem engineers, modifying the environment to maintain their populations. Understanding the drivers of this dominance is then key to ensuring a healthy, resilient ecosystem. This study investigates the role to which nutrients or other parameters such as salinity, flow or sediment quality drive plant community dominance. Nine years of time series data, at a fine spatial resolution across the estuaries, comprising plant species distribution and biomass, water and sediment quality are synthesised. Each of the plant types listed above occur simultaneously in spring in different locations, with small scale variation maintained by local processes resulting in high levels of site fidelity. The implications to management of this small-scale variability and drivers of community dominance are discussed.

How does seasonal drying affect sediment and submerged macrophyte community dominance in the Vasse-Wonnerup Wetlands of South-Western Australia?

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Drying of wetland sediments can result in compaction and oxidisation, resulting in sediments with an increased rate of organic matter decomposition and that are resistant to resuspension on reflooding. These qualities may be important in maintaining the seagrass meadows present in the Vasse Wonnerup wetlands. Macrophytes require a stable substrate in which to anchor their roots and therefore would be expected to favour sediments that have been dried, whereas areas of fine, flocculent and anoxic sediments associated with permanently inundated, turbid, nutrient-rich waters would be more likely to favour the proliferation of floating macroalgae and phytoplankton. The aim of this project is to determine the effect of seasonal drying on both sediment composition and subsequent macrophyte community dominance at the Vasse Wonnerup wetlands. This will be achieved by testing the following hypotheses: (1) The submerged macrophytes *Ruppia megacarpa*, *Lepilaena cylindrocarpa* and the charophyte *Lamprothamnium macropogon* will have higher density

in sediments that are seasonally dried than in sediments that are constantly inundated; and (2) Seasonally drying sediments will result in lower proportions of organic matter and fine particles, higher redox potentials and be more compact compared to sediments that are constantly inundated.

Water and nutrients in the Geographe landscape – catchment modelling

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In order to understand the current hydrological, hydrodynamic and biogeochemical state of the Vasse Wonnerup estuary we need to first understand the history of the catchment that has resulted in the heavily modified system that we see today. This presentation explores a century of hydrological change in the Vasse Wonnerup catchment, including land clearing, intensification, flooding, nutrient enrichment and the significant associated engineering solutions. We will then discuss how this has led to the projects that the Water Science Branch is undertaking in the Vasse-Wonnerup catchment.

Canning River Management: Understanding and Overcoming Barriers

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The Canning River, located in the Perth Metropolitan Area, has had a long history of management and being a highly urbanised catchment area, has a number of pressures placed on it. The Kent Street Weir forms a barrier within the Canning Estuary and has been in place in one form or another for over 100 years maintaining an estuarine ecosystem downstream and a freshwater ecosystem upstream. As a result of the weir being in place, the weir pool exists as a static water body during summer and autumn that endures some significant issues. Excessive nutrient and sediment inputs, accumulation of contaminants, algal blooms and associated fish kills, reduced freshwater flows and increasing tidal incursions as a result of sea level rise are some of the issues that affect the weir pool at various times. Effective management of estuaries with barriers requires an understanding of the system and pressures placed on it in order to provide a management response to overcome them. Monitoring of water quality, flows, sediments and aquatic biota provides a better understanding of the pressures and interventions that will assist in maintaining a healthy ecosystem and measuring the success of the management interventions in place. Some of these interventions include artificial oxygenation, application of phosphorus binding clays (Phoslock^{TM}), nutrient stripping wetlands, provision of environmental water releases and upgrading of the weir to prevent tidal incursions. This case study looks at the issues and management strategies put in place in an urban estuary with an artificial barrier.

The Southwest Recreational Crabbing Project

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Blue swimmer crabs represent one of the most important recreationally fished species in terms of catch and participation rate in southwest Western Australia. The South-west Recreational Crabbing Project provides a valuable opportunity for the Department of Fisheries, Western Australia (DoF) to engage with the local crabbing community to develop ongoing, cost-effective programs that will deliver annual information on recreational crabbing and stock dynamics in the recreationally important blue swimmer crab fisheries of the Swan-Canning Estuary (SCE), the Leschenault Inlet (LI) and Geographe Bay (GB). This information could not otherwise be collected by DoF, as these areas do not have substantial commercial fisheries like Cockburn Sound and the Peel-Harvey Estuary, where information is available to assess the annual status of these stocks.

Specifically, the project aims to:

1. establish a program for providing recreational crabbing information on SCE, LI and GB by implementing a Recreational Angler Program (RAP) daily logbook to be completed by targeted recreational crabbers.
2. develop methods for the ongoing assessment of blue swimmer crab recruitment and breeding stock in SCE, LI and GB.
3. determine the effectiveness of tagging methods to provide information on the movement of blue swimmer crabs that occurs between SCE, LI, GB and their adjacent marine environments (including Cockburn Sound and Koombana Bay).

Funding for the project comes from Recreational Fishing from Boat Licence (RFBL) fees, via the Recreational Fishing Initiatives Fund which is overseen by Recfishwest.

Hydrodynamic-biogeochemical modelling to support decision-making in estuarine lagoons

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A particular concern for the management of estuaries within Australia is understanding how changes to hydrological regimes, due to both water diversions or climate variability, may amplify the effects of existing stresses such as eutrophication, acid sulfate soils, hypoxia and anoxia, and loss of habitat and fish nurseries. Models of estuary dynamics have become widespread, but developing reliable models able to connect hydrological change to water quality and ecosystem “health” remains

challenging. It is the aim of this presentation to document examples of modelling inland estuarine lagoon systems where we have been using coupled 3D hydrodynamic-biogeochemical models to assess to assess the above management challenges. For many of the areas outlined above it is critical to model the interaction of estuaries with the terrestrial margin and surrounding wetlands, however this capability is currently poorly captured in model systems. Further, the need for more rigorous assessment of the accuracy of biogeochemical processes and system-scale response dynamics of model predictions is outlined. Finally, the use of models to compute simple proxies of ecosystem services is discussed as a way to provide more relevant outputs to decision-makers about management benefits and priorities.

Vasse Wonnerup Wetland System Investigation Node

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The Vasse Wonnerup Wetlands System (VWWS) is a Ramsar listed site and a wetland of national significance which suffers from high levels of nutrient enrichment affecting all aspects of wetland ecosystems. To conserve the wetlands to meet ongoing and future habitat requirements of migratory birds especially, it is critical that the quality of the habitats, ecosystems and associated food sources are sustained and/or improved.

A better understanding of the VWWS's resilience is required to determine and develop adaptive management of coastal wetlands. Management needs to be underpinned by a sound scientific understanding of ecosystem structure and processes whilst aligning with social and political realities and community expectations. An innovative and collaborative research program initiated by South West Catchments Council and led by Murdoch University and Edith Cowan University is part of a larger multi-institutional and inter-disciplinary program, funded by the South West Catchments Council (SWCC) through funding from the Australian Government's National Landcare Programme. The program enmeshes the ecological and social sciences and advances our knowledge to provide an integrative solution to the management of this wetland system. The research is primarily undertaken by PhD and Master students with supervisory teams from across the collaborating organisations.

Nutrient sources and sinks within the wetlands, quantitative food-web, community values and adaptive management will all be investigated as part of this program. It is anticipated that the research outcomes will assist managers in developing appropriate adaptive management strategies, mitigation measures and onground actions as well as; identify key indicators to be monitored that will inform management and promote increasingly informed decisions. Importantly, whilst focussed on a single ecosystem, the integrative nature of these research projects will be broadly applicable to other estuaries and wetlands.

Keeping Watch on seagrass health in Geographe Bay

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Keep Watch is a seagrass health monitoring program funded by GeoCatch and the Water Corporation with in-kind support from Department of Parks and Wildlife and Department of Fisheries. Nationally, the Geographe Bay catchment is a nutrient hotspot due to catchment activities. If high amounts of nutrients enter the marine environment there is potential for negative impacts to seagrass. This program aims to assess the health of seagrasses in Geographe Bay from nutrient increases. Since 2012, seven sites have been monitored every summer (seagrass density, nutrient content, algal cover). The health of the meadows are determined annually by assessment against Trigger values, a significant decline in the density indicates poor health. Other measures such as algal cover and nutrient content help us understand if the seagrasses are exposed to higher levels of nutrients and the potential sources. To date, none of the seven sites have shown significant declines as determined by the Triggers. There are variations among sites, with the lowest abundance near Vasse-Diversion drain, and the highest near Dunsborough. There are also variations over the years, although this is not consistent across sites, some sites decline in some years, but increase in others. The nutrient content is very low, indicating they are not exposed to high nutrient levels. Seagrass shoot density in Geographe Bay is higher than other locations in the south-west of WA where similar monitoring is carried out. Overall, this monitoring program indicates that in the last four there have been no major declines in seagrass health.

A nation-wide assessment of current and future-risk due to climate-change for seagrass meadows in Australia

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Seagrass habitat provides many significant ecosystem services, yet it is threatened due to human activities and declining globally. Highlighting hotspots of risk is a useful management tool supporting decision making such as where and what threats to focus management effort. This project assessed

risk to seagrass habitat in Australia. Firstly, an Australia wide potential seagrass habitat map (10 x 10 km grid size) was generated. Then we identified 12 threats due to current human activities and 3 due to future climate change predictions. We attempted to collate spatially explicit layers for each threat, and were successful in generating 7/12 current and 3 future threats. Finding appropriate variables to reflect the threat at the national scale was challenging. In some cases, we combined a number of variables from different sources to generate the risk layers. For each threat, we categorized the risk into low, moderate and high. We then weighted each risk and ran a cumulative risk-analysis for both current, and future threats. Under current conditions, there are hotspots of cumulative high risk in all coastal states and territories of Australia. When assessing future risk, southern Queensland and NSW, as well as the Gulf of Carpentaria in NT were the hotspots of high risk. With this information, we can prioritise management on a national scale to help make decisions on the most effective way to manage seagrass habitat. In this talk I will present the findings of this risk assessment, and with particular reference to Geographe Bay.

Opening the fish gates: can saline inflow prevent algal blooms and fish kills in the Vasse lagoon?

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The Vasse surge barrier has reduced the inflow of saltwater into the Vasse wetlands, and the reduced flushing may have contributed to eutrophication, contributing to the occurrence of harmful algal blooms. This in turn has led to deoxygenation events and fish kills, particularly in the vicinity of the lagoon which lies upstream of the surge barrier. This study looked at the effects that opening the fish gates had on the hydrodynamics of the lagoon. This research investigated the availability of nutrients and light under fish gate opening scenarios, and what effects these had on algal growth and the presence of oxygen. This is essential for the management of the fish gates.

GeoCatch and the Community – leading the challenge

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The Geographe Catchment Council (GeoCatch) is a local community NRM group in the Geographe Catchment. Formed in 1997 after growing community concerns for the health of Geographe Bay, GeoCatch has 18 years of catchment management experience working for many years to reduce excess nutrients in the Geographe Catchment.

GeoCatch projects have been achieved in partnership with government agencies, local government, industry groups, research bodies, other NRM groups, local businesses, farmers, schools, residents and the general community.

After an independent review into the management of key water assets in the Geographe Catchment and the establishment of the Vasse Taskforce in 2014 a range of new initiatives are being developed to improve water quality. These are exciting times for waterways management if Geographe, building on the past work and investment by GeoCatch and the community to improve water quality.

GeoCatch water quality improvement projects have worked to reduce nutrients in both urban and rural areas. Projects include riparian management working with our farmers to fence off and re-vegetate waterways on farms, improving dairy effluent and fertiliser management on farms, partnering with local government to retrofit water sensitive urban design in urban areas, fertiliser audits for managers of recreational turf areas, Bay OK behaviour change program working with local businesses, schools and community to increase water efficiency and reduce nutrient export and working with developers and residents to promote sustainable low nutrient gardening principles in the Bay OK gardens program.

Strategy for revitalising the Vasse Wonnerup estuary

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The Vasse Geographe Strategy (Strategy) is a bold initiative by the State Government to tackle water quality problems in the Geographe Bay catchment. The Strategy integrates a range of actions and initiatives aimed to improve water quality and management of local water assets incorporating recommendations from the Independent review of Waterways Management in the Geographe Catchment (2014). The Strategy provides a framework for undertaking best-practice water quality and waterways management based on sound science and community input. Activities will occur in the rural drainage network, Geographe catchment, Vasse-Wonnerup wetlands, Toby Inlet and the lower Vasse River.

The implementation of the Strategy will be overseen by the Vasse Taskforce chaired by the Minister for Water for the first year. The Taskforce will ensure effective partnership from the relevant agencies, local government, the community and water service utilities. The key outcome will be to reduce eutrophication in the Vasse-Wonnerup estuary and Vasse river and diversion drain systems. Success in this region will indirectly provide the capacity and knowledge necessary to address eutrophication issues in other at-risk waterways including the Blackwood, Harvey and Collie rivers.

Estuary management and the role of science

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Decisions made on natural resource management without good science supporting them will ultimately mean objectives are not achieved.

We have been fortunate that the judgement of experts has allowed our Western Australian estuaries to be managed to maintain their function through several decades of increasing cumulative pressures. However as pressures continue to increase, the margin for error in decision making is smaller meaning that even experts require a better feed of evidence to support their decisions, or their advice to policy makers.

Governance of estuaries must be aligned to allow new information developed to influence timely and appropriate decisions. But to provide that new information, there are several key challenges we face.

Firstly, several southwest estuaries are showing symptoms of pressures and it is likely that action is needed sooner rather than later. But actions are often expensive or contentious so the evidence to ensure the right combination of mitigation measures are taken must be defensible yet is not readily available.

Secondly, estuaries and the pressures upon them are diverse, dynamic and complex. Developing the necessary evidence with any certainty is a multi-disciplinary and complicated exercise that in particular requires great baseline level data to support further science.

Thirdly, the resources and people available to develop this information is limited and not always aligned.

WAMSI, the Department of Water and Swan River Trust are working together to provide a clear priority for the knowledge required by the estuary managers from many government departments and other groups.

This process will provide a compelling case for investment in new priority knowledge to address these complex issues, and help align the disparate capabilities from government, the research sector, and other groups that will enable us to collaboratively deliver the defensible information and advice necessary to maintain our healthy estuaries.

Sediment accumulation dynamics in the Vasse-Wonnerup system

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The Vasse-Wonnerup system is a highly modified waterway and recent findings suggest that the water column depth may have decreased between 0.25 and >3 m in some areas over the past 40 years. These wetlands are Ramsar-listed and maintain significant estuary values, but the potential increase in sedimentation could lead to the collapse of the Vasse-Wonnerup wetlands and the subsequent loss of the ecosystem services provided. In this study we collected seven cores along the Vasse and Wonnerup wetlands to reconstruct past and present sediment accumulation rates (SAR) in this system by the analysis of ^{14}C and ^{210}Pb. ^{210}Pb-derived SAR at stations 1 and 2 (Vasse) were 0.5-1 cm yr^{-1} for the last 25-30 years, and around 210 kg m^{-2} of sediments have been accumulated over this period. These recent sediments (top 20-30 cm) overlie old (1,000-13,000 yr) material accumulated at 0.006-0.06 cm yr^{-1}, suggesting that erosive processes occurred in the Vasse ca. 30 years ago. At station 3 (upstream the Vasse flood gate), the data is too preliminary to be conclusive, but suggest recent SAR of about 0.5 cm yr^{-1} and pre-anthropogenic SAR of about 0.02 cm yr^{-1}. Estimates of SAR in the Wonnerup are still preliminary, but of the order of 0.4 cm yr^{-1} for the last decades at middle Wonnerup (station 5), and are likely significantly higher at south Wonnerup (station 6). On-going dating and biogeochemical analyses shall provide with further information on the dynamics (marine vs river influence) and the time-course of natural- and human-induced changes in this system, which could aid in management decision-making.

The fish fauna of the Vasse-Wonnerup: life in an extreme estuarine environment

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Despite the high ecological and community values placed on the Vasse-Wonnerup and its well-publicised anthropogenic perturbations, little was known about the biology and ecology of its fish fauna until recently. This presentation summarises spatial and temporal differences in the fish faunas throughout the system and the biology and ecology of a key recreationally-important species, Black Bream. The fish fauna in the shallows was found to comprise 31 species, including two introduced freshwater species. This assemblage was dominated by small species (mainly atherinids and gobies) that complete their life cycle within the estuary, but also included 18 species of marine-spawning fish which utilise the system as a nursery area. The abundance and distribution of fish changed markedly throughout the year in response to massive changes in salinity. Fish species richness and density also decreased with increasing distance from the ocean (*i.e.* in an upstream direction). The fish fauna in the deeper waters comprised predominantly marine-spawning species, with the notable exception of Black Bream which is solely estuarine. This species, together with two mullet species, largely dominated these fish faunas and remained relatively consistent throughout the year. However, the prevalence of other species in the deeper waters varied with changes in salinity and/or the frequency and duration of bar openings. Acoustic tagging of Black Bream demonstrated that this species was highly mobile, travelling on average 14 km per day throughout the estuary. Assessment of its growth characteristics, however, revealed that it grows far slower in the Vasse-Wonnerup than in other estuaries in south-western Australia.

Vasse Wonnerup: Wetlands of International Importance

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The Vasse Wonnerup wetland system, listed in 1990 is one of 11 RAMSAR wetlands in Western Australia. Covering approximately 1115ha the Ramsar area includes two lagoonal water bodies and portions of adjacent nature reserve and national park lands. The wetlands are important seasonal water bird areas, with over 90 species recorded and up to 37,000 birds present on one day. Four species have recorded at least 1% of their south west, national or Australasian populations occurring at Vasse Wonnerup. The area supports the largest regular occurrence of breeding Black Swans in Western Australia. Thirty one species are included on three international migratory bird agreements including many species of trans-equatorial migratory shorebirds who use the system as an important feeding and recovery site prior to breeding in the northern hemisphere. The system contains important vegetation communities including a nationally listed Coastal Saltmarsh TEC and a state listed Tuart Forest PEC and priority listed flora species.

However the system is far from pristine and many management challenges including declining bird numbers, extensive weed invasion and vegetation degradation resulting from 100+ years of farming activities, stock grazing and changed fire regimes are evident. The natural hydrological regime has been extensively modified and expanding urbanisation and resultant pressures, many not sympathetic to the conservation requirements of the system are significant threats to the future of the wetlands. Though partnerships with regional NRM bodies have progressed vegetation restoration programs, attracting funding for nature conservation actions remains a challenge.