TRaCK

Tropical Rivers and
Coastal Knowledge

Project Updates

TRaCK consortium workshop
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Griffith University, Brisbane



Australian Government
Department of the Environment, Water, Heritage and the Arts
Land & Water Australia
National Water Commission

“TRaCK brings together leading tropical river researchers and managers from Charles Darwin University, Griffith University, University of Western Australia, CSIRO, James Cook University, Australian National University, Geoscience Australia, Environmental Research Institute of the Supervising Scientist, Australian Institute of Marine Science, North Australia Indigenous Land and Sea Management Alliance, and the Governments of Queensland, Northern Territory and Western Australia.”

TRaCK receives major funding for its research through the Australian Government’s Commonwealth Environment Research Facilities initiative; the Australian Government’s Raising National Water Standards Program; Land and Water Australia and the Queensland Government’s Smart State Innovation Fund

Contents

TRaCK
Tropical Rivers and Coastal Knowledge

Scenario Evaluation

Theme 1 Scenario evaluation

The function of the TRaCK research themes will be to inform decision-making about tropical rivers and coasts. This will require the exploration of the environmental, social, cultural and economic consequences for the rivers, coasts and communities of potential development and climate change. Theme 1 will address this task by bringing together information from the other themes to develop predictions based on realistic scenarios. These predictions can inform public debate, stimulate community action and help policy makers explore solutions to conflicting stakeholder needs.

Project 1.1 Scenarios for Tropical Rivers and Coasts: Integrating the TRaCK Research

Key findings or observations to date

- The Daly River Management Advisory Committee were readily able to manipulate scenario models to explore the implications of water use policy decisions.
- Integration of TRaCK projects will require greater investment in both programming and in communication between projects than has been allocated so far

Implications of the findings

- Scenario modelling can provide a platform for communities to understand the implications of water policy decisions if conveyed through appropriate communication channels
- Systems models are only really possible where there is an adequate level of fundamental research. For TRaCK this means that only the Daly is likely to have a system model of sufficient information density to allow evidence-based policy to be derived.

Opportunities for integration

- As an integrating project within TRaCK, this project has been identifying the opportunities for improved integration across the entire consortium. This has led to the development of Project 1.4 where more resources will be put into integration processes than were initially envisaged with 1.1.
- The biggest challenges/opportunities for integration are between the social/economic research and the biophysical projects to provide results relevant to policy makers.

Where to next?

Development of project 1.4 based on outputs of this project. By adopting a broader integration framework such as the Catchment-to-Coast Management Strategy Evaluation, we will also include information about management actions, monitoring, assessment and learning and decision-making in our view of the world.

Project 1.2 Capacity Building Tools for Effective Planning and Decision-Making in Indigenous Contexts

Key findings or observations to date

There is limited on-ground support for Indigenous groups in relation to:

- Understanding of/input into water plans & policies affecting their catchments;
- Clear direction as to the role/responsibility of established Indigenous groups and their members
- Current limit in resources and opportunities being recognised for collaboration regarding 'country'/language group level planning (by Indigenous groups) and government bodies in charge of water planning/water policy making processes.

Research agreements between a project, language group/s and key organisation/s (e.g. land councils) need to be clearly understood by the majority of parties involved. Regular feedback needs to be provided to the language group/s and other relevant stakeholders on the role of the project, it members and perceived use of the information collected.

Successful Indigenous engagement in research is primarily dependant on adequate funding being provided and opportunity for flexible reporting arrangements. These are things which need to be accounted for in the development phase of a project, especially in relation to expectations identified through milestones.

Implications of the findings

- Increased direction and support from organisations wanting input from Indigenous groups regarding water plans/policy processes need to be facilitated.
- Resources should be allocated to assist preparation/ establishment of research agreements before projects come on board.
- Training of Indigenous researchers is resource intensive (for all involved especially the trainers and trainees). Important discussions regarding opportunities for continued development of Indigenous researchers (after the project lifespan) need to take place between interested Indigenous researchers, research organisations and relevant stakeholders re: Indigenous researchers' role in facilitating Indigenous engagement in water plans/policy processes into the future.

Opportunities for integration

- How can the role of the newly established Indigenous Community Water Facilitators' Network assist in facilitating increased and stronger Indigenous engagement in water plans/policy processes across northern Australia?
- Lessons learned about Indigenous engagement in different catchments & contexts – some principles/issues to consider
- Levels of Indigenous engagement in water planning/policy processes – Experiences from Indigenous language group/s on opportunities and challenges

Where to next?

- River change stories for Daly River catchment to be collected by selected members of the Daly River Aboriginal Reference Group
- Continue discussions regarding facilitation of change stories project in the Fitzroy River catchment
- Continue discussions regrading facilitation of power tools and change stories project in the Mitchell River catchment

Workshop outputs (photo courtesy Hmalan Huner-Xenie)

Project 1.3 Collaborative water planning

Key findings or observations to date

1. Our case studies so far show that it is important to consider the context of the broader planning landscape for the region, including the capacity of the community to become and remain involved. They also show that it is important to design a transparent, flexible planning process that can accommodate a diversity of knowledge, interests and values. More specific findings include:

- There are high community expectations of their participation in water planning. Respondents indicated they wanted a greater level of transparency in the relationship between their contributions and the planning outcomes.
- Seeking feedback from the community is not the same as collaboration. Water planning processes in Australia is currently more accurately described as 'advisory' rather than 'collaborative'.
- Participant commitment to the process depends on the extent of input into actual decision-making.
- Integrating knowledge is complex, particularly in making sense of local, cultural and scientific forms of information.
- The research in phase one has identified the top ten barriers to collaborative water planning.

2. Our legal and policy report makes a total of 17 proposals in relation to eight major areas for improvement in collaborative processes in water planning. These include:

- Collaborative water planning requires the development of clear legislative objectives

- There is a lack of reference to or requirement for deliberative participatory processes within Australian water policy and law. Regulatory design in water planning requires a greater emphasis on such processes.
- Decision makers are now guided by a number of principles or objectives laid down in legislation but discretionary powers remain available. These discretionary aspects of the process provide for flexibility but may also introduce confusion and uncertainty into planning.
- Attention should be given to clear and concise writing of water plans. At present, they are often difficult to understand and expressed in an overly complex manner.
- An area for improvement repeatedly noted is that Indigenous interests are not adequately provided for in planning practice. There is qualified recognition of Indigenous rights to water in the NWI, the provisions of which are attempting to steer a difficult course between the strict legal requirements of native title, and the wider approach that Indigenous social, spiritual and customary objectives have intrinsic value and should be considered in planning.

Implications of the findings

The findings of both case studies confirm the need to advance development and application of collaborative methods in water planning, including:

Clear processes and standards for community engagement, particularly for participants in a community reference panel/group, to understand the role, timing and purpose of involvement

1. Processes and standards adapted to address issues in Northern Australia catchments which are socially complex, with relatively small settlements, and are invariably remote
2. Communication strategies and techniques to address the specific information requirements of diverse stakeholder groups
3. Tools that can increase the capacity for community's understanding of water planning, and their ability to contribute meaningfully to the planning process
4. Training and professional development for agency staff and science providers to better facilitate community collaboration in planning and research
5. Indigenous-specific engagement strategies to identify the implications of water plans for cultural heritage, values and practice and the economic development opportunities provided by water planning
6. Participatory planning and impact assessment methodologies with best-practice scenario projections and predictive modeling
7. Data, knowledge and information systems that have capability to handle multiple types of knowledge
8. Decision-support systems for rigorous and transparent trade-off analysis in decision-making.

Opportunities for integration

1. Work with scientists to better integrate local knowledge into scientific research results.
2. Collaborate with hydrologists, hydrogeologists to present scientific knowledge to local communities

3. How to better link and present scientific report to support their uptake by agencies in water planning processes.

Where to next?

In the second phase of the project, we will build on the findings of the literature review and case studies to develop a strategy for piloting new approaches to planning. The project team will be working in consultation with water agencies and sectors of the community to trial two alternative approaches for collaborative planning in tropical river regions. These will be the rural areas surrounding Darwin as well as the Archer River on the Cape York Peninsula, which has recently been proposed a Wild River under Queensland Wild Rivers legislation.

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Tropical Rivers and Coastal Knowledge

Assets and Values

Theme 2 Assets and values

Valuation of riverine and coastal assets is essential for decision-making about the allocation of these resources to different and sometimes competing uses. Value, however, is contingent on cultural, economic and geographical perspective.

Researchers from Theme 2 are working closely with landowners, land managers, industry and community groups, examining the full range of values associated with tropical rivers and coasts. They are assessing the effects of water use decisions on social, cultural, economic and ecological values and exploring ways to better incorporate these values in decision making.

Project 2.1 The Value of Tropical Rivers

Key findings or observations to date

Australia's tropical rivers provide many ecosystem services that underpin much economic and other activity in the tropical rivers region:

- The aquifers, river channels, waterholes and wetlands store ground and surface water that is used as drinking water for people, cattle and wildlife; and water for native vegetation, horticulture, agriculture, aquaculture and mining.
- The native vegetation supplies shade, aesthetic benefit, habitat, medicinal resources, fuel, building material and subsistence nutrition; and stabilises river banks.
- The water, wildlife and native vegetation provide water, nutrition and habitat for species that play a role in tropical river food webs, have conservation value and/or are harvested in recreational and subsistence hunting and gathering.
- The river channels, waterholes and wetlands have conservation value and provide: (a) habitat for vegetation and wildlife, including aquatic species harvested in commercial, recreational and subsistence fishing and species with conservation value, such as certain waterbirds; (b) places for people to relax, swim, bathe, socialise and learn.
- The cycles of the river systems help to regulate the local climate, provide water and runoff (especially to sites distant from the river channels via flood pulses), help to retain and form soil, regulate water quality (through regulating nutrients and wastes) and support habitat for species harvested off-shore.
- The tropical river systems as a whole provide for scientific and educational benefit.
- The landscapes and experiences of tropical river systems have aesthetic benefit and attract tourists.
- The country in and around tropical rivers is the source of important cultural stories, responsibilities, identities and relationships for local Aboriginal people.

This project has assisted in introducing the challenging concept of ecosystem services into discussion about Australia's tropical rivers.

Preliminary analysis of responses to the valuation questionnaire indicates that Australians place a value on tropical river ecosystem services (through their willingness-to-pay) whether they get direct use out of them or not, i.e. they value their existence as well as their direct use. There are differences in willingness-to-pay for ecosystem services depending on whether a person lives in the river catchment or a reasonable distance from the river, or in a city much further away.

This project has further introduced the challenging concept of economic value into discussion about Australia's tropical rivers and will provide estimates of the non-market economic value associated with some direct, indirect and non-uses of Australia's tropical rivers in ways that have not been used before in northern Australia.

The overall value of Australia's tropical rivers depends on both the ability of tropical rivers to provide ecosystem services and the values people hold for tropical rivers and their ecosystem services. There have been a number of key events that have significantly impacted on (a) the ability of tropical rivers to provide ecosystem services, and (b) the values people hold for tropical rivers and their ecosystem services. An example of the former is where overstocking of pastoral lands and poor stock management have lead to erosion on riverbanks, which has increased the sediment in water bodies making some pools unsuitable for fishing and modifying the flow of water. An example of the latter is how people are now much more concerned with conservation and good planning than in the past due to a greater level of awareness of the environment, among other things. Changes in these two factors have also impacted on each other: people's values for tropical rivers have changed through time and this has influenced our land and water use practices, which in turn has impacted on the physical capability of tropical river ecosystems to provide the things people value. It is the combination of all of these changes and interactions that impacts on the overall value of Australia's tropical rivers and the sustainability of their use into the future.

Geike Gorge (WA) (photo courtesy of Anna Straton)

Implications of the findings

- Ensuring that the economic and other activities underpinned by tropical river ecosystem services can continue into the future requires that these services and the ecosystems that produce them are recognised and accounted for in decision-making.
- Development scenarios that enhance certain ecosystem services will increase Australians' welfare.
- Combinations of people's values, land management activities, government policy and natural events impact on the overall value of Australia's tropical rivers, sometimes in unexpected ways. Understanding these interactions is key in managing for sustainable use into the future.

Opportunities for integration

- How do the economic values estimated by this project compare and complement those estimated by Project 2.2 (Indigenous values)?
- What are other projects revealing about the combinations of land management activities, government policy and natural events that may impact on ecosystem capacity and values in the future?

Where to next?

- Finalise data analysis
- Consider implications
- Write up reports and papers
- Present findings to stakeholders

Project 2.2 Indigenous Socio-Economic Values and River Flows

Key findings or observations to date

1. Preliminary results suggest that Indigenous household harvest of aquatic species is substantial (one valuation method indicates a fortnightly equivalent to about 17% of median household income).

2. Species use varies between communities. Plant species are more popular in Nauiyu in comparison to Fitzroy Crossing. In the Daly River (Oct/Nov 08), the 5 species most commonly harvested by the Indigenous households surveyed were

- Magpie Geese (*Anseranas semipalmata*),
- Long-neck Turtle (*Macrochelodina rugosa*),
- Lotus Lily (*Nelumbo nucifera*),
- Black Bream (*Hephaestus fuliginosus*) and
- Barramundi (*Lates calcifer*).

The first two weeks of Fitzroy River surveys (Feb 09) suggest that the 5 aquatic species most commonly harvested were

- Spangled Perch (*Leiopotherapon unicolour*),
- Catfish (*Arius* sp.),
- Bony Bream (*Nematalosa erebi*),
- Freshwater Crabs (*Holthuisana transversa*) and
- Black Bream (*Hephaestus jenkinsi*).

3. Preliminary analysis of Daly River surveys (Fitzroy not yet fully analysed) shows that during the late dry season billabongs were the most commonly utilised habitat (66.9% of trips), followed by locations on the main river channel (12.5% of trips).

Harvest of Lotus Lily (photo courtesy of Marcus Finn)

Implications of the findings

1. Dramatic changes to river flow that results in changes to plant and animal populations may significantly affect Indigenous household income and diets. Other components of the project will describe some of the social and cultural implications of such change.
2. Water resource assessments will need to take into account variations in resource use and significance in order to address local concerns and priorities.
3. Knowledge of people's habitat preferences should assist in the identification of the flow regime required to sustain people's use of resources.

Opportunities for integration

1. Economic data can be used to model scenario impacts
2. Social assessment integrated into e-flow tools
3. Indigenous knowledge outputs (e.g. seasonal calendar with ecological cues related to flow characteristics) can inform biophysical research

Where to next?

The household surveys will continue throughout the year in the Daly River and Fitzroy communities. A plan for the participatory monitoring trial will be developed and monitoring will commence by September.

A number of Indigenous knowledge activities will be completed in time for the Merrepen Arts Festival in Daly River in May, including the production of a seasonal calendar and science collaborations with Indigenous experts.

(photo courtesy of Marcus Finn)

A study of Malak Malak customary relationships to water and Indigenous hydrological knowledge will be undertaken. It will describe the social arrangements and cultural practices relating to water, document knowledge of groundwater and surface water sources held by Malak Malak in the vicinity of the regional centre of Nauiyu and examine how rights to water and management responsibilities are conceived and applied both in context of the land use history of the area as well as present and future economic and commercial use of water supplies.

TRaCK
Tropical Rivers and Coastal Knowledge

River and Coastal Settings

Theme 3 River and coastal settings (Classifying tropical rivers)

The rivers and estuaries across northern Australia can differ substantially between catchments. Differences in riverscape setting - primarily their flow patterns and how they form and evolve - are likely to influence ecosystem processes, the potential types of developments and the likely response to development and climate change. In Theme 3 a physical classification system is being developed so we can determine the degree to which information is transferable from one catchment to another.

We are also seeking to understand the demographic and economic character of local communities in nominated catchments, and how this relates to the physical classification.

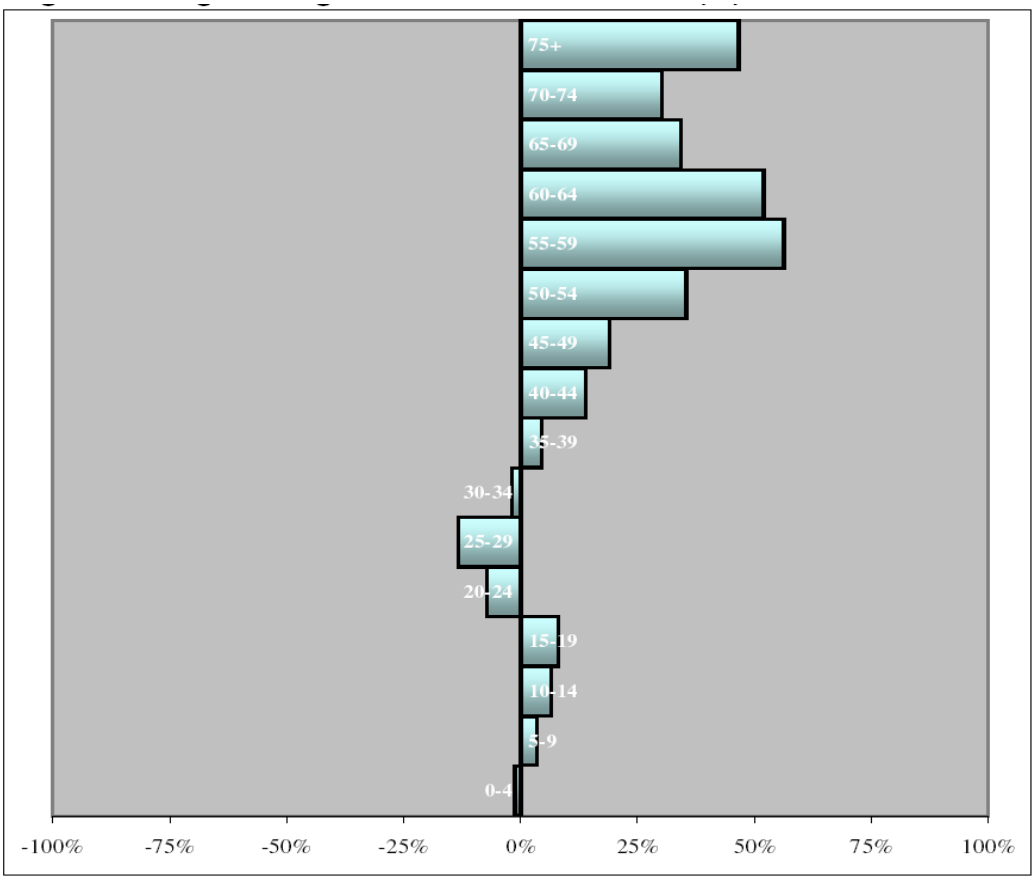
Project 3.1 People and the economy

Key findings or observations to date

- Populations are growing, aging, becoming more Urbanised and becoming more Indigenous
- Population growth rates are slowing down, and the region is 'losing' people in the 20 – 34 year age bracket
- Government Admin & Defence, Health and Education sectors provide most employment (25% of people). Then Agriculture (11%), the Mining, Retail and Construction (each with 4%).
- There is vast diversity in the region: significant gaps between rich and poor; many communities a long way from key 'services' with no schools, no permanent water, and no year-round road-access to other communities. Other communities well served, and comparatively 'rich'.
- Persons in different regions are also likely to face very different set of 'opportunities' for income/employment: tourism is largely confined to urban(ish) areas; mining, manufacturing and processing are only in isolated areas; many regions are not suitable for particular types of agriculture, etc.
- The socio-economic characteristics of the catchments in and around Darwin are very different to those of remote areas. But there are also significant differences in the socio-economic characteristics of rural/remote catchments: some rely on agriculture, some rely on mining; some have a high percentage of Indigenous persons (generally with relatively low levels of education, low mobility and high

fertility rates); and other rural catchments have a high percentage of Non-Indigenous persons (often highly mobile, and employed in the mining sector).

- Some catchments appear to be socio-economically 'similar' in many respects; but the definition of 'similar' changes according to the data used. Existing data sets are very poor – this suggests the need for more background socio-economic information.



Changes in age cohorts, 1996 to 2006 (%)

Implications of the findings

- (Skilled) labour shortages could be significant constraint on future development
- The aging population could place strain on existing workers to support
- If the trend of out-migration amongst 20 – 34 year olds continues, the region could face loss of human and social capital
- Many regions are likely to have only a limited number of options for earning an income –any NRM plans which limit those options will need to step cautiously; perhaps seeking to find ways of providing alternative income/employment options if truly wishing to be successful.
- The vast diversity of opportunities and socio-economic characteristics => different catchments, even if geographically close, may need quite different NRM strategies. Top-down, one-size fits all strategies are likely to be VERY difficult to implement. Not just because one-size won't fit all, but also because may need to develop community capacity when implementing NRM strategies (because of dot points above)

Opportunities for integration

- Population and Tourism projections could help inform scenarios; can help define base-line 'continue as usual' scenarios for subsequent comparisons to alternatives.
- Scenarios will be 'modelled' in economic modelling activity so can explore income, employment and water-use impacts of different development paths.
- Socio-economic profiles can be used to gauge representativeness of data collected in other socio-economic studies (do we have data from a full range of people?).
- Outputs from 'clustering' analysis can be used to try and draw inferences about the way in which changes that are occurring in ONE catchment, MIGHT also occur in other, socio-economically 'similar' catchments.
- Expanding characterisation so can look for similarities/differences between catchments using socio-economic data and also biophysical data.
- Combine data from the indigenous values project (2.2) on environmental 'resources' used by Indigenous communities with information about consumptive water use --- effectively expanding the water-use IO model to also look at other resource uses.

Where to next?

Final reports plus publications

- Finish collecting primary data and organising secondary data
- Enter, clean-up, organise and analyse expenditure and water use data so can build model
- Create list of variables related to scenarios which can be 'shocked'
- Use model to analyse impacts of those 'shocks'
- Consult with end-users, write-up and disseminate findings

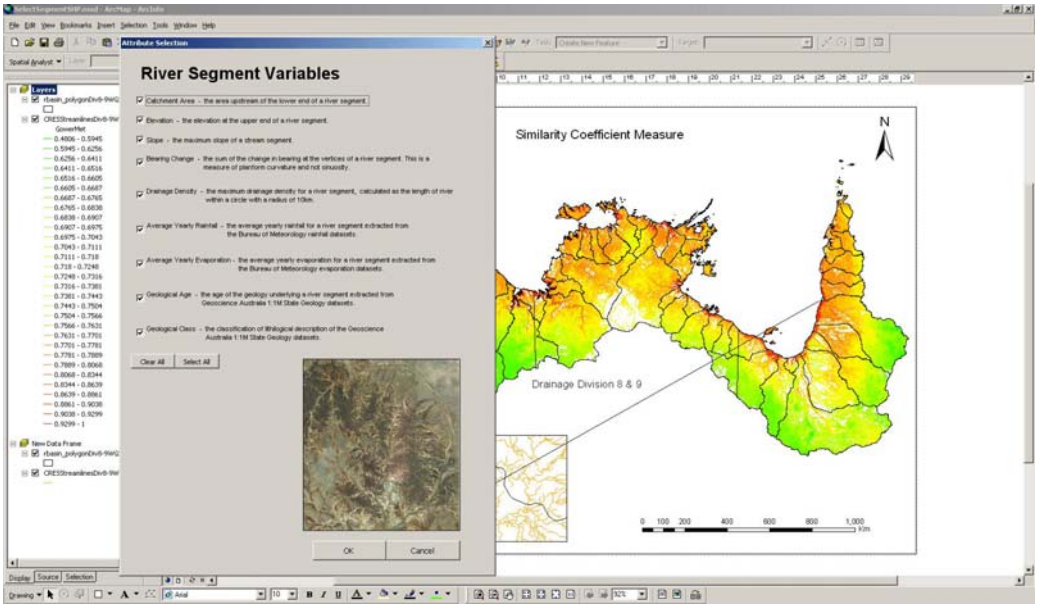
Project 3.2 Classifying river landscapes

Key findings or observations to date

In this project we have developed a universal classification tool which provides a means of readily characterising the similarities and differences between the study reaches and subcatchments and the rest of the northern Australian rivers. The tool is in the form of an interactive GIS based system that allows a user to define the input variables to their classification and produce a tailor made output that suits the individual users needs. Importantly, this now enables the classification tool to be constantly updated as new and improved data becomes available. This takes us away from the concept of producing yet another subjective classification, fixed in time, but instead it allows users to explore the range of available geophysical data to gain an understanding of the relationships between rivers. .

Implications of the findings

The development of this river classification tool is a significant advance in the quest for a river classification system that is completely objective but meaningful. The development of this tool has applications well beyond TRaCK, as it provides a method which should significantly improve the objectivity of all approaches to river classification.



The variable selection window in the classification tool. Additional input layers are still being developed and will be added as they are developed.

Opportunities for integration

There is significant room for further developing this tool to aid in the scenario development modelling. New input layers could be generated (based on altered vegetation, climate, runoff etc) and the effects on river reach classes analysed.

There is also great potential for incorporating socioeconomic input layers to the database and generating hybrid socio/physico river classifications.

Where to next?

At this time a fairly simple prototype of the tool is near to completion. The focus now will shift towards the development of more input layers, and on improvements to the functionality of the system. In particular we will be developing various options for exporting data underlying the classification.

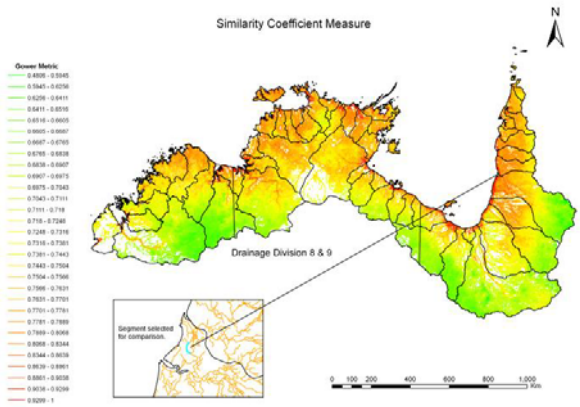


Figure 2: All Variables

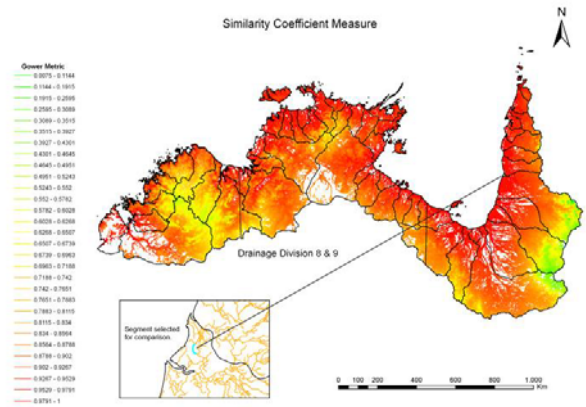


Figure 3: Elevation

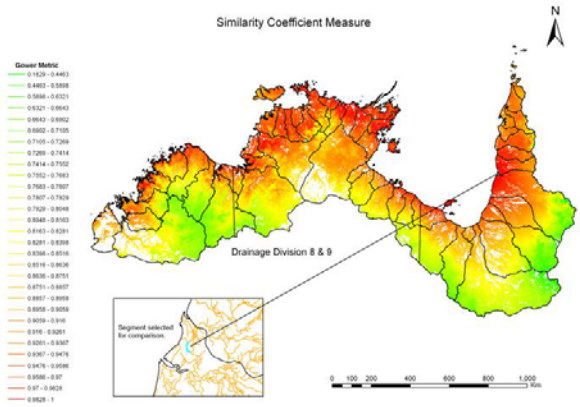


Figure 4: Rainfall and Elevation

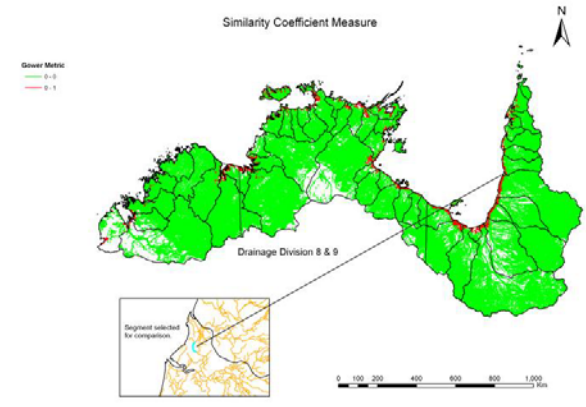


Figure 5: Geological Class

These images provide examples of the type of output that can be generated using the similarity coefficient tool. In this case a single river segment is selected (this could also be a subcatchment) and an analysis performed to show the similarity of all other river segments to the selected segment on a scale of 0 – 1 (green to red), for the selected input variables.

Project 3.3 Classification of Northern Australian Riverine Flow Regimes

Key findings or observations to date

1. There are 12 distinct flow regime types present in Australia's rivers.
2. Six of the flow regimes occur in northern Australia.
3. Flow regimes of northern Australia are generally typified by degrees of intermittency except in distinct regions where high baseflow contributions originate from groundwater.

Implications of the findings

1. We now have the ability to place individual rivers into a spatial context and validly transfer the findings from studies in one catchment to another.
2. the classification enables identification of particular components of the flow regime that distinguish individual rivers. We can now formulate strategies to protect or maintain those components in management actions
3. the classification provides capacity for identification of areas of particular distinctiveness (ie. high flow diversity) with ramifications for biodiversity

Opportunities for integration

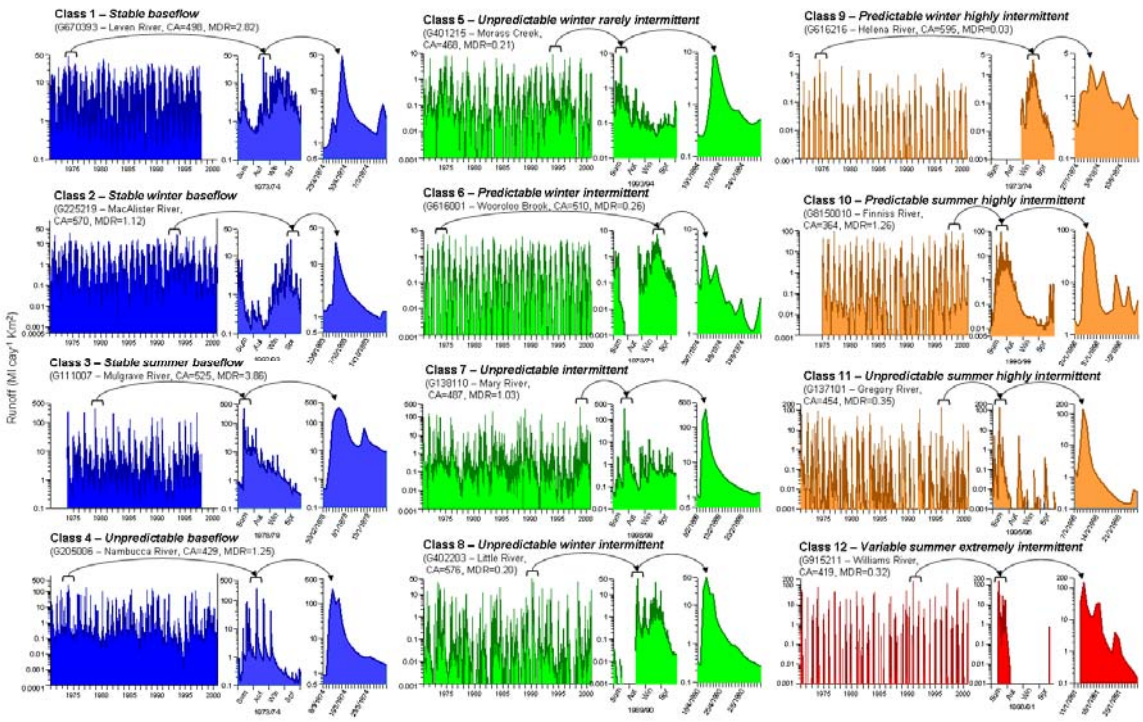
1. Could be linked with studies on production to identify areas or regions likely to support high production.

2. Can be linked with landscape classifications

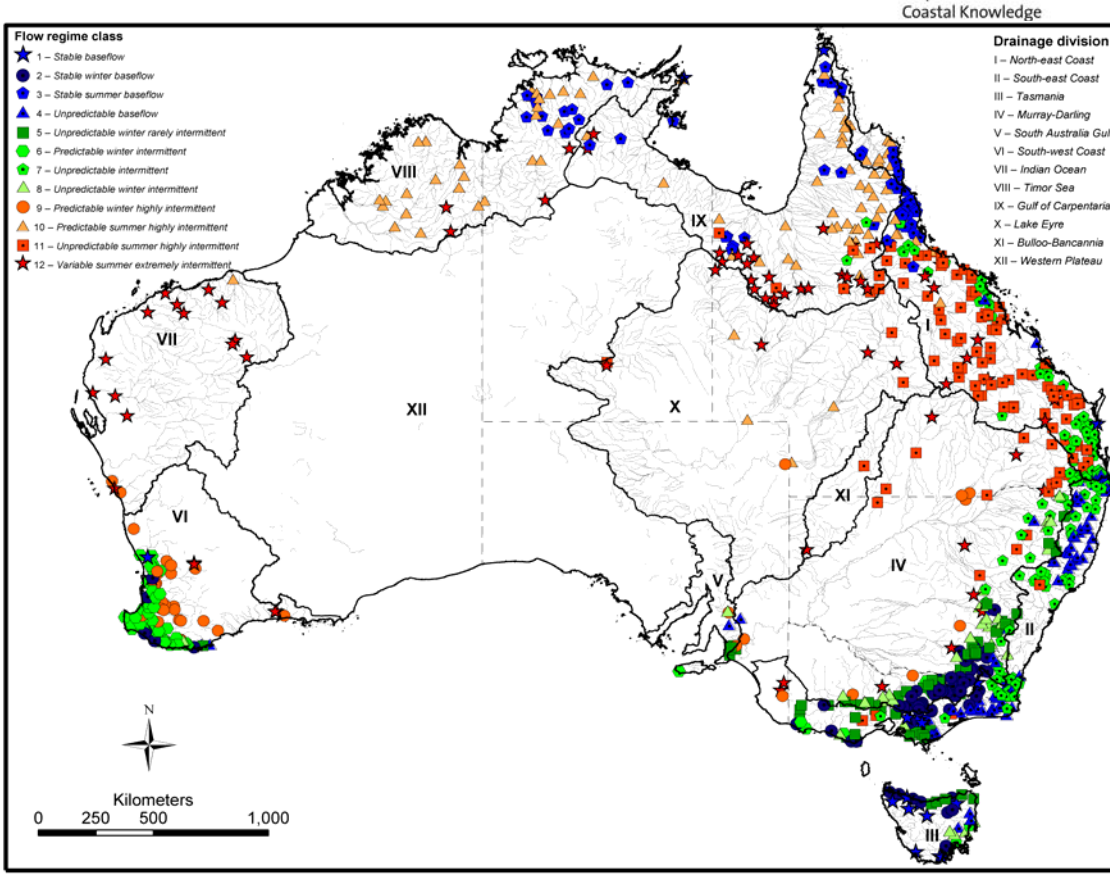
3. Provides spatial framework for formulation of flow rules in environmental assessments.

Where to next?

This project has been completed. The technical report is available via LWA website http://lwa.gov.au/products/PN22591. Publication of findings is underway (2 papers in print). Integration within environmental flows programs within TRaCK underway.



The twelve types of flow regime in Australian rivers



Distribution of the twelve types of flow regime across Australia

Theme 4 Material budgets (Water, carbon, sediments & nutrients)

Catchment development typically results in altered river flows and increased nutrient and sediment loads. Such changes in rivers and estuaries can have impacts on aquatic ecosystems and processes. Researchers in Theme 4 are developing models to predict the effects of land use and climate change on the sources, amounts and movement of water, carbon, sediment, and nutrients. Indicators for monitoring and assessing water quality and quantity are also being developed.

Project 4.1 Catchment Water Budgets and Water Resource Assessment

Key findings or observations to date

The project is using a range of data (vegetation, soil, climate, water use) and models to construct a water balance at a catchment scale. To date we have found:

- Pastures use more water in the wet season but show rapid decline in water use through the dry season whereas uncleared vegetation maintains water use through out the dry season. This appears to dry out the soil profile to a greater extent than pasture sites.
- In the Fitzroy sample there may be local connections between alluvial aquifers and regional aquifers.
- Involving the community can build capacity and local ownership of research as well as providing research teams with more data e.g. Kulkarriya School at Noonkanbah and Fitzroy Community School at Fitzroy Crossing have volunteered to take fortnightly water samples from the river. In return the project has talked with students and provided the schools with information on groundwater and the water cycle for use in their classroom lessons.
- The rate at which the water stored in river banks was returned to the river varied depending on the slope of the bank and conductivity of the aquifer. In this case, the bank storage volume was returned to the river more rapidly for less sloping rivers. It is thought that as the water is deposited further away from the river where banks are more sloping, it will take longer for this flow to return.

Implications of the findings

A more comprehensive water balance for the Daly catchment will be developed plus a better understanding of the hydrological implications of land use change. Water resource managers will be able to set sustainable allocations with more confidence of the long-term impacts of their decision making.

Where to next?

Runoff measurements for uncleared and cleared sites, maintaining evapotranspiration, soil moisture and stream flow monitoring (Stray Creek), assess soil hydrological properties across the catchment, modelling and use of remote sensing products to help scale patch scale processes to broader scales.

Project 4.2 Regional Scale Sediment and Nutrients Budgets

Key findings or observations to date

- Channel bank and gully erosion are the dominant sources of fine sediment in the Daly and Mitchell River catchments.
- Hillslope erosion is only a minor contributor of fine sediment in these catchments.

Implications of the findings

- We infer that land use change is not likely to have a significant impact on sediment delivery to the Daly and Mitchell Rivers because hillslope erosion is (currently) only a minor of sediment source relative to gully and channel bank erosion.
- An increase in rainfall and runoff resulting from climate change could increase the severity of gully and channel bank erosion.

Opportunities for integration

Project 4.2 has close linkages with aspects of research in Projects 4.3 (primary productivity) and 4.4 (bedload transport).

Where to next?

The whole-of-catchment sediment and nutrient budgeting will be developed in the second half of 2009 when more sediment load estimates and sediment tracing data becomes available to test and calibrate the budget modelling. We will also be able to link this modelling with the channel and floodplain model to improve estimates of floodplain deposition and channel bank erosion.

Bank erosion along the Daly river (photo courtesy of Gary Caitcheon)

Project 4.3 Towards Understanding the Impacts of Land Management on Productivity In The Daly and Flinders Rivers

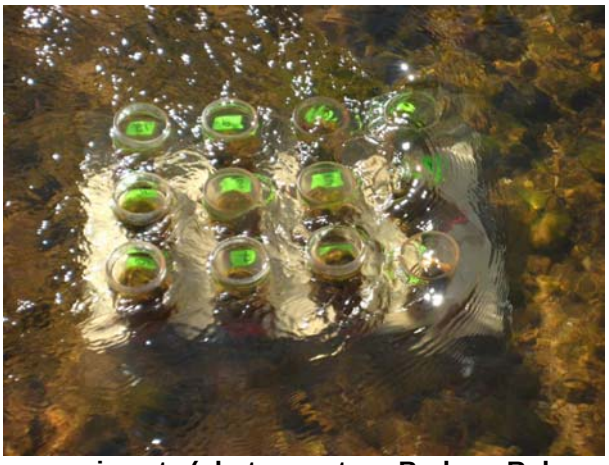
Key findings or observations to date

1. Photosynthesis and respiration were higher in September than in July, though nutrient concentrations did not generally increase. There is evidence of considerable EPS production, indicating that much of this photosynthesis does not produce algal biomass that will be passed up the food-chain.
2. Growth of phytoplankton and benthic algae in the Daly River is limited by both nitrogen and phosphorus.
3. Sand beds in the Daly River migrate down-river during the dry season.

Implications of the findings

1. Algal growth in the Daly River is likely to be particularly sensitive to increased nutrient loads.

2. Benthic habitat is the Daly River is dynamic, regardless of the season.



In stream experiments (photo courtesy Barbara Robson

Opportunities for integration

1. Link with water budget / hydrology project (4.1) to get a better understanding of groundwater inputs.
2. Can we better link this project (nutrients and primary production) with theme 5 (foodweb and ecology) work?
3. Need to define links between land use and nutrient loads to Daly River.

Where to next?

1. Completion of chemical analyses and interpretation for the Daly River
2. Modelling of primary production in the Daly River
3. Fieldwork in the Flinders River

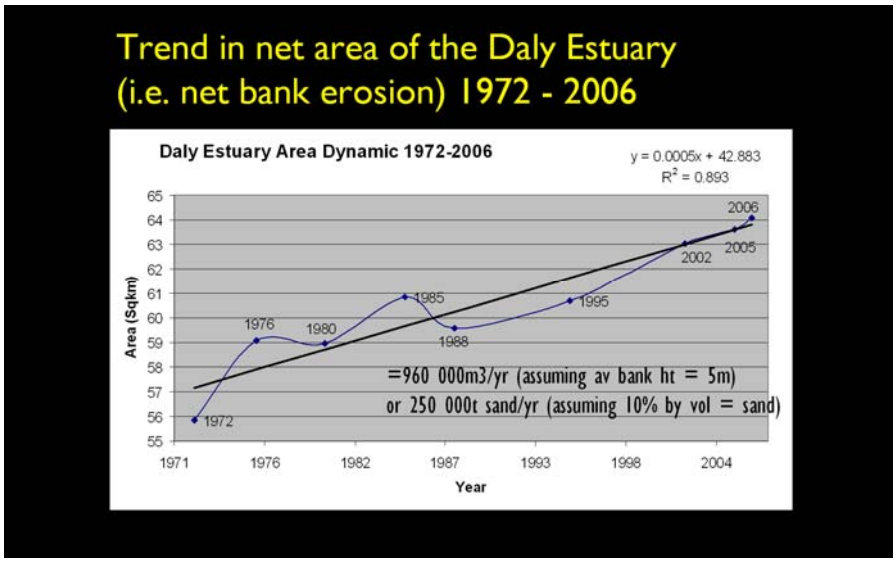
Sampling in the Daly River (photo courtesy of Barbara Robson)

Project 4.4 Bedload Transport in large tropical rivers

Key findings or observations to date

Daly River

1. Preliminary results from historical aerial photo analysis in the Daly River between Oolloo crossing and Daly River Crossing, suggest there is no evidence for sustained sand accumulation within the bed of the river between the late 1940s and the present day.
2. Commencing in the 1970s, but rapidly increasing from 1990s onwards, there is evidence for extensive bank erosion (channel expansion) along the entire Oolloo to Daly River reach, which takes the form of both channel marginal stripping and large rotational bank slumps. It is unlikely, however, that this channel expansion has contributed much by way of the coarser sediment fractions that typically comprises the bedload in this reach. It is evident that the sediment contributed from bank erosion has been exported from the reach.
3. A major woody debris recruitment episode has accompanied the extensive bank erosion.
4. The Daly River estuarine reach demonstrates substantial and sustained channel expansion over the period 1972 – 2006. Average net annual increase in estuary area (i.e. net bank erosion) is in the order of 19 ha/yr for this period. This sediment source alone could be contributing as much as 250000 t/yr of sand to the estuarine reach, and may account for some of the shoaling observed in the estuary over the last few decades.
5. The Daly River is not a freely adjusting alluvial river. Instead its geomorphology and hydraulics are strongly controlled by bedrock (in the bed and banks) and tufa dams.



Trend in net area of the Daly River estuary between 1972 – 2006. The net increase in estuary area reflects significant channel expansion within this timeframe.

Mitchell River.

1. Preliminary remote sensing results indicate there is evidence for sustained sand accumulation within the lower reaches of the Mitchell River over the last 2 decades. In the period between 1988 and 2005, there was a net increase of 17.1

km^2 in the area of sand bodies within the 515 km^2 of channel network analysed. Based on a conservative estimate of the average depth of sediment turnover (3m) this equates to ~ 3.1M m^3 of net annual sediment accumulation within the Mitchell channel network (or 500,000 truckloads). The increase in sand bars is largely at the expense of dry season pools

2. Bedload transport during the waning stages of the 2009 floods on the Mitchell recorded rates of 250,000 t/day (25,000 truckloads/day), with similar rates recorded for suspended sediments.
3. Up to 40% of the measured suspended sediments consisted of sands.

2009 trip down the flooded Mitchell River measuring suspended sediment concentration and bedload transport (photo courtesy of Jeff Shellberg).

Implications of the findings

Daly River

1. These findings support the assertion that the bank erosion observed within the same reach is not the primary source of bed sediments in this reach. This sediment is likely sourced from the granitic catchments in the Daly headwaters.
2. The observation of no net sand accumulation in the Oolloo – Daly R reach over the last 60 years does not discount the idea that there are highly mobile sand slugs moving through this reach. Nor does this observation preclude the possibility that there is an elevated supply of bedload material in the upper catchment that is yet to work its way through the lower channel system.
3. These initial findings have identified some key knowledge gaps in the Daly:
   i. The mechanics of bank erosion in the Oolloo – Daly R reach, particularly the role of a higher water table on bank cohesion, and hence mass failure.
   ii. The hydraulic, geomorphic and ecological effects and feedbacks of a major wood recruitment episode.
   iii. The relationship between bank slumps and bank gullies.
4. The observation that there has been widespread channel expansion in the Daly river over the last couple of decades supports the notion the channel might be adjusting to a new, higher discharge, flow regime.

5. The observations of extensive bedrock control on channel geomorphology and associated local-scale hydraulic control, has important implications for modelling both channel evolution and bedload transport in the Daly.

Mitchell River

1. Preliminary results support the anecdotal evidence that there have been significant increases in sand accumulation within the Mitchell River within living memory in the lower Mitchell River.
2. It is too early to say what the key drivers are of the apparent increases in coarse sediment supply to the Mitchell. However, there is increasing circumstantial evidence for a land-use driver of alluvial gully erosion – one of the dominant sediment sources to the river. A this stage we cannot rule out climate as a key driver of the observed changes. Resolving this issue will be subject of ongoing future research, at a much higher resolution than studies thus far.

Opportunities for integration

There is a clear need for much greater integration between this project and the sediment/nutrient tracing and budgeting research within project 4.2.

Where to next?

- Additional ground mapping work in the Daly to better validate the remote sensing and airphoto analysis.
- Ongoing OSl dating of channel sediments in the Mitchell to better understand timescales of sediment turnover.
- Ongoing remote sensing of channel dynamics and ground validation
- Ongoing hydrodynamic modelling

Theme 5 Foodwebs & biodiversity

Foodwebs describe 'who eats who' in ecosystems. Many human activities affect aquatic food web structure and hence important ecosystem processes. In tropical aquatic systems, the sources of organic matter that drive the foodwebs are largely unknown. In Theme 5 we are:

- identifying sources of organic matter
- developing models that predict the effects of land use change on foodwebs and aquatic biodiversity
- developing tools for determining environmental flows and monitoring biodiversity and ecological condition

Project 5.1 Bottom-Up and Top-Down Control of Riverine Food Webs

Key findings or observations to date

1. Fish do not match isotopically with algae growing on river bottom when sampled in the early dry season, suggesting a seasonal shift in food resources between the wet and dry seasons

2. A peak in primary (plant) and secondary (herbivore) production has been observed in tributaries at the end of the wet season

3. Fish and vegetation assemblages differ among river settings (tributary, waterhole, main-channel) and systems (Daly, Fitzroy, Mitchell) while invertebrate assemblages correspond to local habitat differences (pool vs. riffle).

Implications of the findings

1) The mismatch between fishes and food resources at the time of sampling could be explained if fish: a) have arrived from elsewhere, b) are feeding on terrestrial C4 carbon (e.g., via terrestrial insects?), or c) have a temporal lag due to floodplain feeding on aquatic production that is isotopically distinct.

2) Impoundments and water extraction may alter seasonal flow patterns and corresponding patterns in productivity.

3) Conservation of representative habitats needs to account for community differences related to position in the catchment and to differences across catchments

Opportunities for integration

1. Links with floodplain project (5.3) to determine the wet season diet of fish and assess connectivity between rivers and floodplains.

2. Links with flow-ecology project (5.5) will examine implications of changes in flow

3. Links with biodiversity project (5.8) will examine dispersal patterns of fish within and among catchments

Where to next?

Consumer exclusion experiments will assess top-down control of primary producers and lower levels of the food web by herbivory and predation. These will be conducted in the Daly River catchment during the 2009 dry season.

Data are being analysed from the Mitchell River sampling conducted in the late dry season (2008) to better understand seasonal shifts in use of organic carbon sources by consumers.

Late wet season stable isotope sampling is being conducted in the Daly and Fitzroy Rivers at a subset of sites sampled in the mid-dry 2008 to further evaluate seasonal changes in diet.

Project 5.2 Importance of Waterholes as Aquatic Refugia and the Biophysical Processes that sustain them

Key findings or observations to date

1. Waterholes in the tropical catchments under study tend to be less turbid than those in central Australia (e.g., Cooper Creek), where most previous waterhole research has been conducted.

2. Food chains are of typical length (based on stable nitrogen isotopes), but fish communities are often dominated by herbivores (e.g. rainbowfish, bony bream).

3. Macrophytes (aquatic vascular plants) are heavily grazed by late in the dry season, apparently due to terrestrial animals (cattle, pigs, wallabies) as well as aquatic consumers.

4. There is little evidence for the importance of groundwater inputs in sustaining waterholes through the dry season (except possibly waterholes situated in large sand bed channels)

Implications of the findings

1. Primary productivity is potentially less limited by light (and therefore may be more limited by nutrients and grazing)

2. Top-down control of primary productivity is highly likely, and this may be partly due to introduced animals

3. Impacts of cattle, pigs, wallabies may be severe; suppression of macrophytes may enhance the relative importance of algal growth in sustaining aquatic food webs

4. Surface flows are necessary for sustaining waterholes as refugia (i.e., local inputs of water are not enough)

Opportunities for integration

1. Measurements of primary productivity and factors that control it in 4.3

2. Exclusion of herbivores (projects 4.3, 5.1) will reveal strength of top-down control

3. A new project with Kowanyama Aboriginal Land and Natural Resource Management Office (KALNRMO) will use a combination of time-lapse photography, rapid assessments of riparian condition and macrophyte biomass, and exclusion fencing to evaluate the effect of pigs and cattle on floodplain waterholes.

4. Links with the Department of Environment and Resource Management, whose staff will be doing waterhole bathymetry measurements and hydrological analysis in collaboration with TRaCK. This will allow us to generate models of waterhole persistence by analysing evaporation rates and changes in water depth.

Where to next?

Our work on food web structure and sources of organic carbon for consumers is being extended from the Mitchell River to the Flinders River in 2009 to broaden the spatial scope and include a catchment with greater potential for agricultural development. Depth logger installation and detailed bathymetric surveys in selected waterholes will generate the data needed to develop persistence models. Time lapse cameras will be installed in August.

Fish caught in the Mitchell (photo by Tim Jardine

Project 5.3 River-Floodplain Food Web Subsidies

Key findings or observations to date

1. Coastal floodplains (e.g. Mitchell River delta) appear to have lower primary productivity than expected

2. Large numbers of predominantly marine fish were present in freshwater reaches during inundation

3. Seawater intrusion in combination with the strong dry season limits plant productivity on floodplains in the coastal plain, in extreme cases producing extensive barrens

Implications of the findings

1. Inundation may be important as a migration, dispersal and spawning phase for fish and other aquatic animals rather than a stimulus to aquatic primary production that supports a major growth phase for consumers

2) Despite low apparent productivity, there must be sufficient food in inundated reaches during floods to attract large numbers of marine fishes

3. Climate change (sea-level rise) and changes in flow regime may affect the ability of seawater to penetrate further inland:
"Every year it (the tide) comes in, it goes a bit further up….once it hits the swamps, that will kill all the plant life, and the waterways."
-Stanley Budby, KALNRMO Ranger

Opportunities for integration

1) Links to the biodiversity theme (5.8) which will examine dispersal of fishes using genetic and stable isotope indicators

2) Links with Theme 5.6 will examine the use of freshwater and marine feeding sites by barramundi

3) Links to Themes 1 and 2 because climate change impacts have major cultural and socio-economic implications for Indigenous communities, such as Kowanyama, that are located in coastal regions but benefit from a diversity of freshwater wetlands and floodplains.

Where to next?

Analysis of stable isotope data will determine the relative contribution of marine, freshwater and terrestrial carbon to the diet of the 20 fish species collected in the Mitchell River delta during flood. This will then inform future sampling efforts in the 2009-10 wet season, which may include work in the Flinders River.

Depth loggers deployed over the Mitchell floodplain in October 2008 will be collected in May 2009 and data analysed to evaluate the extent of surface flooding and validate remotely sensed imagery.

Project 5.4 Assessing the Effect of Urbanisation and Catchment Development on Ecosystem Health in Estuaries

Key findings or observations to date

The effect of sewage on the ecological health of the tidal creeks in Darwin Harbour depended both on how much sewage was entering the creek and how well flushed the creeks were.

- One of the creeks, Buffalo Creek, sewage had major impacts on ecological health of the system, as measured by a range of biogeochemical processes and markers.

A study of the response of biota to freshwater flow in estuaries found that the major sustained flooding in the southern Gulf of Carpentaria dropped the salinity dramatically and resulted in migration of all banana prawns out of the estuary.

Implications of the findings

Further expansion planned for sewage plants in Darwin is likely to deteriorate ecological processes and have flow-on effects to the animals and plants living in the creek.

Opportunities for integration

- Linking the nutrient and sediment loads exiting the Norman River estuary with river and catchment conditions in southern Gulf rivers
- Using flow-fisheries data in integration studies of the effect of changes in freshwater flow on rivers and estuaries.

Where to next?

- Analysis of samples and data from 6 months of wet season sampling in a Gulf estuary to determine how flow affects nutrient concentrations, algal biomass and a range of other parameters. Continue field work commencing October 2009.
- Data analysis and writing publications on the effect of sewage on tidal creeks

(l) Buffalo Ck (Darwin Harbour) (r) Buffalo Ck mud (photos courtesy Michele Burford)

Project 5.5 Flow-Ecology Relationships for Biodiversity and Ecosystem Processes

Key findings or observations to date

1. In the Daly, most fish species are fairly widespread throughout the catchment, probably due to the predominance of perennial flows, but some species do not occur in seasonally intermittent streams. There are also no exotic fish species. These findings have been used to construct a model to predict effects of flow alteration on barramundi and sooty grunter abundance.

2. There appears to be large upstream movement of fish, particularly rainbowfish, in tributaries during the early wet season.

3. Algal biomass appears to peak after high flow events such as storm events in headwaters, and after high wet season flows in larger tributaries.

Implications of the findings

1. Changes to natural flow regimes, particularly from intermittent to perennial, may homogenise regional fish assemblages. Modelling can predict effects of future flow scenarios on fish species.

2. Instream structures and water extraction may delay and reduce upstream movement of biota.

3. Storm and flood events may provide nutrients for algal production throughout the river catchment, potentially providing a boost to aquatic food webs to last them through dry season conditions.

Opportunities for integration

Links with the food webs Projects (5.1, 5.2 and 5.3) will examine key food sources and consumers between seasons and across riverine landscapes.

Links with Project 5.8 to relate the hydrology and biodiversity of northern rivers.

Where to next?

Quantitative sampling of algal, invertebrate (both aquatic and terrestrial) and fish biomass is happening over the year to identify flow triggers for movement and peak production.

Analysis of instream experiments looking at the effects of nutrients and velocity on algal biomass and production.

Project 5.6 Flow Impacts on Estuarine Finfish of the Gulf of Carpentaria

Key findings or observations to date

Coastal finfish production in terms of catch is positively correlated with flow through increased catchability within the year of the flow.

Recruitment of barramundi is positively influenced by the timing of flows. Early wet season flows (during December) in the Flinders River catchment provide the right conditions for strong recruitment of juveniles spawned near the end of the previous dry season.

Mercury levels from barramundi and king threadfin from the Mitchell and Flinders Rivers are below recommended levels for food.

Implications of the findings

Altered flow regimes through anthropogenic effects such as water infrastructure development may impact of estuarine fisheries resources

Altered timing of flow (for whatever reason) may decrease the potential recruitment strength of barramundi.

Opportunities for integration

Flood plain inundation is considered one of the important aspects of barramundi production. The length of time that flood plains are inundated is an important component of this. Combining digital elevation models, food web work and otolith microchemistry may improve our understanding of importance of these inundation events.

Improvements in conceptual models of the likely impacts of flows on the life histories of fisheries species taking into account the above would help elucidate the potential impacts of various changes in the flow regime.

Why are flows correlated with fisheries production? Catchability through the movement of animals, growth of animals, nutrient delivery, habitat expansion, connectivity to habitats offstream and many others.

Where to next?

Yearly collections of samples will continue in the Mitchell, Flinders, Roper and Daly river estuaries during 2009.

Project 5.7 Environmental Flow Tools for Northern Rivers

Key activities to date

1. To draw together the key findings relating to flows from all TRaCK projects.

2. To deliver guidelines, rules and tool to support the determination of environmental flows in rivers and estuaries across northern Australia.

Implications of the activities

A resource for water managers and planners to draw on relevant findings from the TRaCK research program, incorporating:

1. a set of flow guidelines and flow rules to guide environmental flows assessments

2. a map-based database providing information on specific TRaCK projects and data custodians

3. generalised scenario-evaluation models for northern rivers and estuaries, to provide the basis for future catchment-specific water management plans.

Opportunities for integration

- Integration of flow-related findings from all TRaCK projects.
- Convergence with the scenario-evaluation Project 1.1 as well as Knowledge and Adoption Theme.
- Engage with relevant water management planning agencies to ensure appropriate and useful delivery of TRaCK's research.

Where to next?

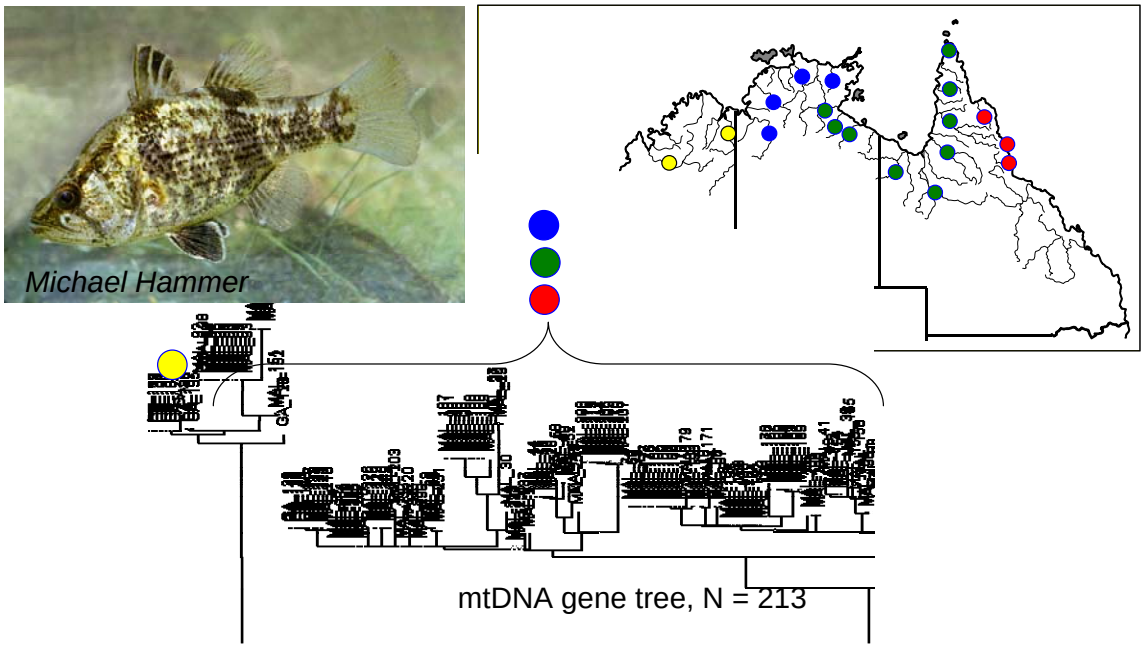
Workshops are being held with each state and territory agency responsible for conducting environmental flows assessments and water management planning. These workshops will provide feedback to TRaCK on the best means of delivering the research findings so that they will be used and incorporated into agency activities in the future.

Project 5.8 Biodiversity and HCVAE: Bioregionalisation, Conservation Priorities and Predictive Models of Aquatic Biodiversity

Key findings or observations to date

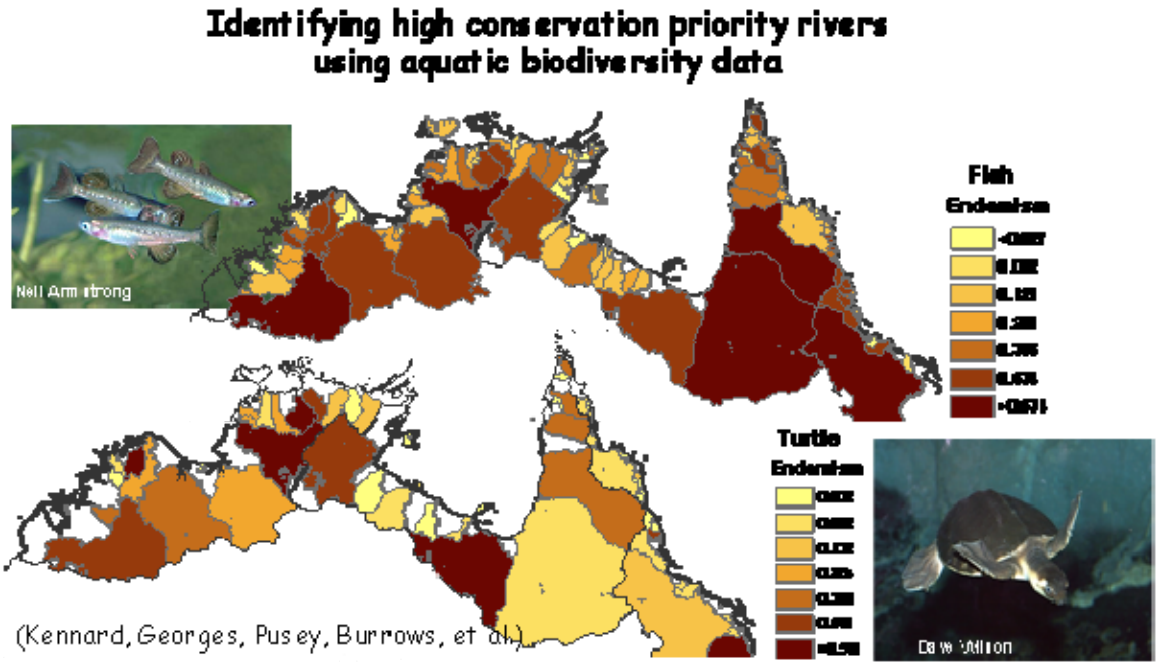
- Freshwater biodiversity attributes identified using molecular methods indicate stronger patterns of alpha and beta diversity than currently appreciated (alpha diversity = no. species in an area, beta diversity = change in species diversity between these ecosystems)
- Numerous freshwater species throughout northern Australia have been identified as having sub-species
- The Kimberley, as a region, is genetically distinct from the other regions of northern Australia, and rivers within the Kimberley may be more genetically distinct from one another for a number of species than rivers within other regions

Genetic variation among populations of Mouth almighty (*Glossamia aprion*)



A predictive model of fish species distributions throughout the Daly River catchment has been developed. It predicts the distribution of 41 fish species based on relationships with key environmental descriptors (e.g. describing hydrology, catchment topography and geology, climate, etc). The model helps us to understand the important environmental drivers of species distributions. The model will also be used in a conservation priority assessment of the Daly River (using systematic conservation planning methods) and contribute to a river health assessment (through FARWAH). Predictive models are also being developed to model basin-scale fish species composition throughout the tropical rivers region.

We are identifying rivers with high conservation values based on key biodiversity attributes (e.g. richness, rarity, endemism). This data is based on high quality data sets currently being assembled on freshwater species distributions (fish, turtles, aquatic macroinvertebrates) in tropical rivers.



A conservation priority assessment for eastern Australian rivers has been undertaken. We evaluated a number of planning scenarios in which the costs (i.e. management and restoration costs) of including particular basins in a freshwater reserve design were estimated according to basin area, intensity of human disturbances, or number of introduced fish species in each basin. This work will be extended to include all tropical river basins.

Implications of the findings

- The present reserve system (National Parks, Declared Wild Rivers) may capture only a subset of the major elements of freshwater biodiversity in Northern Australia
- Proposals to transfer water among some catchments represent extremely high risks to biodiversity values of rivers in Northern Australia
- Stocking programs for some key recreational species, eg sooty grunter, need revising due to the presence of multiple species as detected using molecular methods

Opportunities for integration

- Water planning (especially proposals for Inter Basin Transfers) and northern Australia Sustainable Yields project (NASY)
- Conservation planning and identification of High Conservation Value Aquatic Ecosystems (e.g. though NAWFA); contributions to DEWHA National Heritage Assessments
- River Health Assessment (e.g. though FARWH)
- Riverscape classifications :
    - do geomorphic classifications relate to classifications based on biodiversity attributes
    - do particular geomorphic classifications contain more biodiversity than others (eg Kimberley versus gulf?)

Theme 6 Sustainable enterprises

There are many impediments to the development of enterprises in riverine and coastal environments across northern Australia. Principal among these are: policies, legislation and provision of services or lack thereof that often, inadvertently, remove the rights of landowners in particular and reduce service delivery or access to; governance of enterprises at community, clan and family levels; a lack of recognition, use and application of the customary knowledge held by resident Indigenous peoples; realistic assessments of production capacity and markets for natural products; basic training and education; communication with audiences that speak English as a second and sometimes third language; development of leadership structures around aspiring remote peoples; and logistic and technical difficulties arising from tropicality and remoteness.

The theme comprises 3 elements to provide knowledge for supporting economic development in the TRaCK region:
1. Review of Water Markets
2. Review of Property Rights – legal framework
3. Case Studies (practical initiatives and linkages to regional and local projects)

Key findings or observations to date

There are no findings available from projects themselves yet. But some analysis of the process of getting this far is perhaps relevant:

- Indigenous participants require opportunities to influence the questions asked and the way they are addressed
    - empowers local Indigenous participants to seek & build long term relationships with research organisations.
- bodies like the Indigenous Water Policy Group perhaps provide a model for agreement on studies of broad interest
    - but for community-based work there is no reasonable substitute for long-term relationships.
- time frames are often too short for full consultation and negotiation, unless based on existing and preferably longstanding relationships.
- Future work linked to TRaCK should build on the relationships established through the existing projects.

Implications of the findings

- Consortium members wishing to work with Indigenous communities on Indigenous lands in the future should respond positively to present invitations.
- Planning for future work linked to TRaCK should build on existing relationships, while leaving open options for forming new ones.

- Indigenous Community Water Facilitator Network (ICWFN) will assist in establishment of community research protocol document through Land Council partners.
- ICWFs are also developing/investigating future priority case studies in catchment regions.

Opportunities for integration

- Case studies provide opportunities for a range of researchers to connect their work to community development issues.
- All contracts so far envisage participation of researchers in synthesis workshops towards the end of the present TRaCK program. However funding for workshops has yet to be identified.

Project 6.1 Establishing water markets in northern Australia: a study to assess feasibility and consequences of market-based mechanisms of water delivery

Key activities to date

The project is made up of three tasks:

Task 1: First phase analysing institutional arrangements and constraints will utilise structured interview questions with key decision makers and experts in field.

Task 2: Second phase will use surveys to look at stakeholder attitudes and values, and how this might inform design of markets.

Task 3: The above two tasks will feed into an assessment of costs and benefits of water markets in the study region.

Work has commenced on task 1

Implications of the activities

- Decision support framework for regulators and policy makers.
    - Aid policy and planning.
- Improve information available to water users, Indigenous groups, stakeholders and public interest groups.