

## **A Systems Approach to Coastal Research and Management**

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### **Abstract**

Coastal research and management often has an issue-specific focus, with little attention paid to the interdependencies of various issues. A systems approach to coastal research and management consists of: (i) identifying the underlying drivers of change and potential management leverage points for maximum impact; (ii) development of potential strategies for ecosystem-based management; (iii) evaluation of the consequences of potential solutions and comparing solution outcomes; and (iv) reflecting on potential short- and long-term implications of potential management strategies. This paper presents examples of systems approaches to coastal research and management, and describes the potential application of a systems approach to the Sydney region.

### **Introduction**

Past approaches to coastal research and management have largely been *ad hoc* and issue-specific (Smith *et al.*, 2001). These approaches create challenges when: (i) managing sustainably for multiple uses and benefits; (ii) working with communities and partners using a participatory approach and with a view to capacity building; (iii) dealing with complex interactions and feedbacks across atmospheric, terrestrial and marine, and across biophysical, economic and social components; and (iv) dealing with uncertainty. These challenges require adaptive management approaches and explicit treatment of uncertainty and risk; as well as, integrative approaches to research and management. Understanding leverage points in a system can help identify high leverage interventions – getting more effect for money and time invested. The implications of not being adaptive or integrative may include unintended consequences of short-term actions exacerbating problems in the long term.

### **A New Approach to Coastal Management Research**

Australia's State of the Marine Environment Report (Gibbs *et al.*, 1995) and State of the Environment (SOMER) (Zann, 2001) reports describe a broad range of adverse effects that human activities are having on Australia's coastal systems including nutrient and pollutant runoff, habitat loss, coastal modification, introduced species, and harmful algal blooms. Ultimately, these externalities contribute to the loss of human amenity and a reduction in the ecosystem goods and services. The sustainable use of the coastal zone is dependent on maintaining desired human activities, but managing them in such a way as to minimize the risk of adverse consequences. Coastal management, in this sense, is therefore fundamentally an application of risk management – decision-making that reduces the likelihood of undesirable consequences (Australian Standard, 2004).

The recognition that a new approach is needed to decision-making in the coastal zone is apparent from the shift in government coastal policy over the past decade. For example, the SOMER report concluded that the lack of national policy and coordination on coastal

management as well as gaps in scientific knowledge of the marine environment were major impediments to sustainable management (Zann, 2001). In the wake of this criticism, the federal government developed a national oceans policy, announced in 1998. In addition, Australia's Framework for a National Cooperative Approach to Integrated Coastal Zone Management (NRMMC, 2003), provides guidelines for cooperation among communities, governments, and industries in pursuit of integrated coastal zone management. Yet national initiatives have yet to trickle down (in terms of funding or implementation) to the local area where management decisions are made, and they tend to overlook the necessary collaboration between researchers and communities in achieving management goals.

Successfully managing risk in coastal Australia requires developing a research framework that enables the interactions among diverse drivers of social and environmental change to be assessed holistically. Although many of the challenges facing coastal systems can ultimately be traced to the presence of humans (Vitousek *et al.*, 1997), the downstream consequences of human activities manifest via physical, chemical, biological, political and economic drivers. The quantification of risk cannot be performed adequately considering only singular drivers of environmental change. To provide the foundation for integrated risk management, research frameworks are required that are capable of identifying how a suite of drivers interact to yield undesirable outcomes. Furthermore, that research framework must also be able to evaluate how well alternative management strategies address management goals. This necessitates interdisciplinary research teams representing a broad range of expertise.

Although researchers can provide information on how systems behave and the key interactions that result in negative outcomes, to adequately inform decision-making, such objective analyses must be integrated with the subjective preferences of individuals within coastal communities. How do individuals see their community developing in the years ahead? What are their goals, key challenges, and preferred strategies for managing risk? What kind of conflicts exist over coastal activities and potential management decisions and how might they be resolved? These critical questions form the context in which research efforts are undertaken. Thus, rather than view coastal management research as a purely a technical task undertaken by natural and social scientists, it should be viewed as a partnership between communities and researchers.

As research partnerships develop strategies for coastal risk management, they also must be cognisant that social and environmental change will continue to evolve decades to centuries into the future. New activities will undoubtedly emerge, such as the burgeoning aquaculture industry, and new technologies with potentially beneficial and harmful effects are likely to be developed. Careful consideration must be given to ensure that management strategies are effective at reducing risk over the near-term, while preserving options over the long-term in recognition that future preferences cannot be forecast with confidence. Management decisions should be treated like policy experiments that are monitored, evaluated, and periodically revisited to ensure they remain effective means of achieving desired outcomes.

Various projects within CSIRO reflect the approach of researchers assisting communities to manage their surroundings to achieve preferred outcomes. CSIRO's Regional Development Futures Framework helps communities, local government and other stakeholders identify and understand the issues and drivers associated with future planning and development, and evaluate strategies to achieve a shared vision for the future. In addition, several studies into coastal hazards have assisted the Gold Coast City Council to devise planning schemes and risk management practices for the extensive flood plain development of the Gold Coast (Walsh *et al.*, 1998, 2004; McInnes *et al.*, 1998). Meanwhile, partnerships between CSIRO and relevant state governments are facilitating the application of sophisticated decision-making methodologies and science to Westernport in Victoria to demonstrate how such tools can be used to improve the catchment health (Savina *et al.* 2005). Similar approaches have

been employed off the northwest shelf of Australia to assist with managing the increased demand for development in this region and to gain further understanding of marine conditions and processes (NWSJEMS, 2005).

## **Application in the Sydney Region**

### ***Challenges***

The Sydney region currently supports approximately 4.2 million people, sprawling over approximately 12,000 sq km (ABS, 2003). The coastal zone of Sydney extends from Broken Bay in the north to Port Hacking in the south, and contains approximately 86 km of ocean shoreline and over 340 km of estuarine frontage. There are both marine and terrestrial protected areas in the coastal region of Sydney. There are seven National Parks with foreshore access and ten Aquatic Reserves. There are also eight Intertidal Protected Areas and six aquatic reserves along Sydney's coastline where the collection of intertidal invertebrates is prohibited. There are approximately 1500 Aboriginal heritage sites within Sydney's coastal local government areas; including rock engravings, drawings and stencils, shelters, shell middens, camp sites, burial sites, axe grinding grooves, waterholes and scarred trees (Council for Aboriginal Reconciliation, 1992).

There are a number of management issues facing the Sydney coastal region such as: (i) water management; (ii) waste management; (iii) coastal processes; (iv) nature conservation; (v) public access; (vi) climate change; (vii) loss of cultural heritage; and (ix) development and population pressures (Sydney Coastal Councils Group, 1998). Added to the complexity of management arrangements is a complexity of institutional arrangements. Any management issue may be subject to management interventions by various local governments, various State government departments, and a range of other formal and quasi-formal management groups (eg. the Sydney Catchment Management Authority). Currently, many issues are managed in isolation, both between and within management institutions.

### ***Rapid Conceptualisation of Critical Issues***

On the 23<sup>rd</sup> March 2005, the Sydney Coastal Councils Group and CSIRO conducted a joint workshop on Integrated Coastal Research Frameworks. Participants included representatives from 10 member councils, four CSIRO Divisions, Sydney Catchment Management Authority, NSW Department of Conservation and Environment, NSW Department of Infrastructure Planning and Natural Resources, and Commonwealth Department of Environment and Heritage. The workshop was designed to allow a rapid conceptualisation of coastal issues (and their interdependencies) affecting the Sydney region. The objectives of the workshop were to: (i) to assist Sydney coastal councils identify and articulate coastal issues and problems that they want to solve; and (ii) to assist Sydney coastal councils think about those issues in terms of an integrated research framework.

### ***Summary of Issues***

After introductions and an outline of the workshop, CSIRO gave a presentation on "systems approaches" to coastal research and management, and also provided some examples of integrative research frameworks that are currently being implemented in Wollongong and Central Coast (NSW), North West Shelf and Margaret River (WA), and Western Port (Vic).

Workshop participants were then asked to brainstorm key issues for coastal management in the Sydney region (table 1).

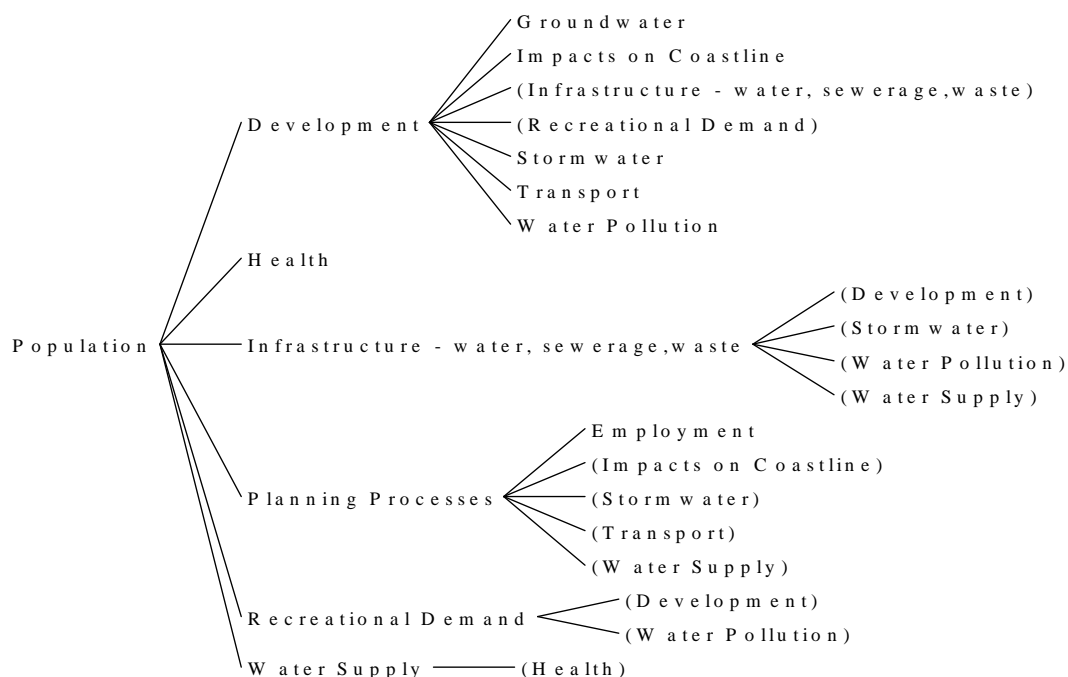
**Table 1: Key issues for coastal management in the Sydney region**

Development	Transport	Coastal ecology	Climate change
Coastal processes	Education	Attitudes and values	Water pollution
Stormwater	Coastal ecology	Water supply	Infrastructure
Population	Migration	Tourism	Impacts on coastline
Planning processes	Social inequity	Financial resources	Energy supply
Air quality	Health	Recreation demand	

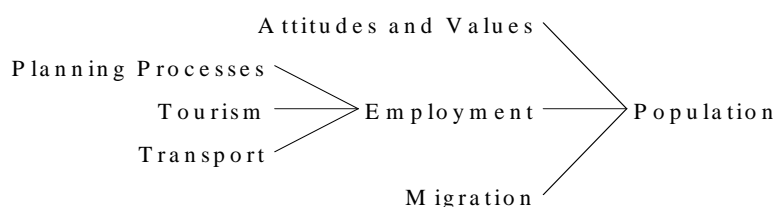
Participants were then asked to create a systems diagram by linking the issues in terms of causes (drivers) and effects (consequences) (figure 1).



Through understanding some of the critical interactions affecting coastal management, participants were able to see where critical interventions in the coastal zone may be prioritised for maximum impact (eg. population growth impacts, figure 1; and drivers, figure 2).



**Figure 2: Examples of direct and Indirect impacts of population growth**



**Figure 3: Examples of direct and Indirect drivers of population growth**

Participants were then asked to break into four groups to focus on some of the key interactions (eg. development, water pollution, and coastal ecology) and what research was needed to understand those issues and interactions.

Through group work, the participants identified the following areas of the coastal system that were currently not well researched:

- Interdependencies between issues
- Critical drivers and intervention points
- Cumulative impacts over various time frames
- How to build capacity with local councils and government agencies
- How to involve communities in decision-making and implementation

- Science to justify planning decisions
- Risk
- Uncertainty
- Dynamic planning structure that supports integrated decision making
- Adaptive management
- Baseline data on all issues
- Comparative baseline data
- Temporal variability of baseline data and long term trends
- Limits of the system
- Decision-support systems
- Future predictions about how the system might change
- Quantification of the links between issues

The groups re-convened and together discussed a ways to progress an integrated research framework for the Sydney region, recognising a need for a framework that identifies the key drivers and consequences of coastal management issues, and that management of issues in isolation (eg. stormwater) is ineffective if the key drivers are poorly understood and unmanaged.

### **Ways Forward**

The SCCG workshop represented the first step in establishing the necessary collaborative relationship between researchers and coastal communities. Building upon this interaction to enable research to be undertaken that addresses the needs of the community and enhances decision-making may be achieved through a number of actions. First and foremost, an active communication plan must be developed that secures political commitment among community decision-makers to the process. Second, a research and management framework must be developed for the Sydney region that maps challenges, drivers, interactions, as well as viable management and learning strategies and potential outcomes. Third a master plan for implementation of the framework must be developed which includes funding mechanisms and partnerships that ensure continued support of the plan over the course of its expected lifespan. Successful initiation of such an integrated research and management agenda would create the opportunity for exporting the overall approach to other communities.

Other communities within New South Wales as well as other jurisdictions are already challenged to successfully manage the various pressures within the coastal zone. Future trends are likely to bring substantial additional growth to these areas. This means further challenges for already stressed communities, and new challenges for previously pristine areas. Relationships between researchers and communities are burgeoning as communities attempt to obtain information about growing pressures to sustainable use of coastal resources. Such relationships must be cultivated and expanded with the goal taking a more holistic approach to coastal zone management to reduce the risk of undesirable management outcomes and steer a path among multiple drivers to the preferred future.

### **Conclusions**

Coastal management remains largely *ad hoc* and issue-specific, with unintended consequences of short-term actions potentially exacerbating problems in the long term. A workshop held by CSIRO and the SCCG in March 2005 provided a mechanism to highlight the importance of a systems approach to developing an integrative research and management framework. This approach enables a rational basis for prioritising management

and research activities through understanding leverage points in a system, where key interventions can maximise impact for the money and time invested.

## References

Australian Bureau of Statistics, 2003, Australian Demographic Statistics. ABS, Sydney.

Australian Standards: 2004, *Australian Standard: Risk Management*. Council of Standards Australia and Council of Standards New Zealand, AS/NZA 4360:2004, Standards Association of Australia, Strathfield, NSW, Australia.

Clark, J.R.: 1992, *Integrated Management of Coastal Zones*, Food and Agriculture Council for Aboriginal Reconciliation and Aboriginal and Torres Strait Islander Commission, 1992, Aboriginal Australia. Commonwealth of Australia, Canberra.

Organization of the United Nations, FAO Fisheries Technical Paper 327, Rome, Italy.

Gibbs, C., Fabris, G., Gason, A., Gibbs, H., Gunthorpe, L., Longmore, A., Parry, G., and Porter, C.: 2001, *Australia State of the Environment Report 2001: Coasts and Oceans Theme Report*, Australian State of the Environment Committee, CSIRO Publishing on behalf of the Department of the Environment and Heritage, Commonwealth of Australia.

North West Shelf Joint Environmental Management Study (NWSJEMS) 2005: <http://www.marine.csiro.au/nwsjems/index.html>.

McInnes, K. L., Hubbert, G. D., Oliver, S., and Abbs, D. J. 2000: Storm tide return periods and 1974 floodwater modelling: for Gold Coast City Council. Aspendale, Vic.: CSIRO Atmospheric Research. 45 p. [http://www.dar.csiro.au/publications/mcinnnes\\_2000b.pdf](http://www.dar.csiro.au/publications/mcinnnes_2000b.pdf)

Natural Resource Management Ministerial Council (NRMMC): 2003, *Framework for a National Cooperative Approach to Integrated Coastal Zone Management*. NRMMC Secretariat, Canberra, Commonwealth of Australia.

Smith, T. F., Sant, M., and Thom, B. 2001, *Australian Estuaries: A Framework for Management*, Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, Brisbane.

Sydney Coastal Councils Group, 1998, Sydney Regional Coastal Management Strategy. Regional Steering Committee. Sydney Coastal Councils Group.

Vitousek, P.M., Mooney, H.A., Lubchenco, J., Melillo, J.M.: 1997, Human domination of Earth's ecosystems, *Science* 277, 494-499.

Walsh, K.J.E., Betts, H., Church, J., McInnes, K., Pittock, A.B., Jackett, D.R. and McDougall, T.J. 2004: Using sea level rise projections in urban planning in Australia. *J. Coastal Res.*, 20 (2):586-598.

Walsh, K.J.E., Jackett, D.R., McDougall, T.J. and Pittock, A.B. 1998: Global warming and sea level rise on the Gold Coast. Report for Gold Coast City Council, 34pp.

Zann, L.P.:1995, *Our sea, Our Future: The State of the Marine Environment Report for Australia*. Department of Environment, Sport and Territories, Commonwealth of Australia.