A framework (with software) for assessing the health of, and risk to, Queensland's estuarine wetlands: examples of outputs and outcomes from the Burnett Mary NRM region

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ABSTRACT

An estuarine assessment framework has been developed by the Qld EPA and trialled in the Burnett Mary NRM region through a collaborative project with the Burnett Mary Regional Group. The framework assists in the effective management of estuaries by monitoring indicators of human activities and management practices, estuarine vulnerability, physical-chemical state and biological impacts via a stressor framework. In short, it assesses 'cause and effect' by monitoring the current pressures, vulnerability and condition of estuaries. The major benefit of this framework is that the link between human activity and estuarine health is clearly identified, thus helping managers establish appropriate management actions and priorities. The framework also allows manager to relatively easily and inexpensively examine the risk to a specific area from the local pressures and therefore determine what condition indicators (if any) should be monitored in that particular estuary – making indicators locally relevant and cost effective.

To assist in applying the framework we have developed a user-friendly computer package which enables the user to easily determine the data required for the assessment and calculate all the relevant 'scores' and confidence/dependability results to be reported for an individual estuary. The software is currently undergoing testing through a partnership with Qld EPA, NT NRETA and SA DEH. The package produces a colour coded and numeric report card which is designed to be easily understood and interpreted by users from a variety of backgrounds.

Report cards for the 18 estuaries included in the Burnett Mary trial have been published and specific management actions identified to reduce the risk of human activities impacting a particular estuary. The outputs and outcomes of this project are discussed.

INTRODUCTION

Coastal areas are continuing to be the focus of a population shift as many Australians seek a change in life style. In addition, these areas support a diverse range of economically and culturally important land uses, including agriculture, forestry, grazing, aquaculture, urban/residential and industrial. They are also often popular tourist destinations and fishing areas. All of these uses place some pressure on the health (condition) of our coastal waterways.

So the question is how can we protect, maintain or improve the coastal waters we love and need so much? To do this effectively we need to understand:

- the condition of the coastal ecosystem,
- the pressures impacting the system,
- the system's vulnerability to those pressures,

- the current management practices occurring,
- the likely changes or future condition, and
- the communities aspirations, uses and needs for the system.

To effectively manage the impacts of human activities, an assessment framework is needed which monitors condition information that can be directly linked back to pressures and hence to management actions.

Many monitoring and reporting programs have been developed for coastal ecosystems, using a variety of frameworks. The pressure-state-response (PSR) framework and variants has been widely used for environmental reporting (OECD 1993, Turner 2000, Bowen and Riley 2003, Bidone and Lacerda 2004). Pressures are defined as those factors that act directly on the ecosystem and may cause it to change, state indicators relate to the condition (health) of the ecosystem itself, and responses are human management or policy actions that aim to address (reduce) the pressures.

In Australia, regular national (and state) State of Environment (SoE) reporting, which is based on the PSR model, has occurred since the late 1990s. Although the PSR framework is designed to be cyclic, in that pressure indicators affect state indicators, which affect responses, which affect (decrease) pressures; the SoE condition, pressure and response indicators are not explicitly linked. Therefore, it is not possible to interpret changes in individual indicators in relation to the condition of the whole system, nor to assess potential management actions – a key requirement of managers.

The framework discussed here attempts to meet the information needs of managers and is based on the framework developed by Scheltinga *et al.* (2004), but has been further developed (Scheltinga and Moss 2007). As the framework explicitly links pressure to condition it provides sufficient information to interpret changes in condition and recommend appropriate management actions and priorities (and assess their success). The framework also allows users to select only indicators that are appropriate to local systems and pressures, and provides information on acceptable values (scoring) for each indicator monitored.

The framework has strong links to the National Natural Resource Management Monitoring and Evaluation Framework (National M&E Framework 2003) to assess progress towards improved natural resource condition through Commonwealth Government funded programs and the Queensland Government's Stream and Estuary Assessment Program (SEAP), SoE Online and Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) programs.

THE ASSESSMENT FRAMEWORK

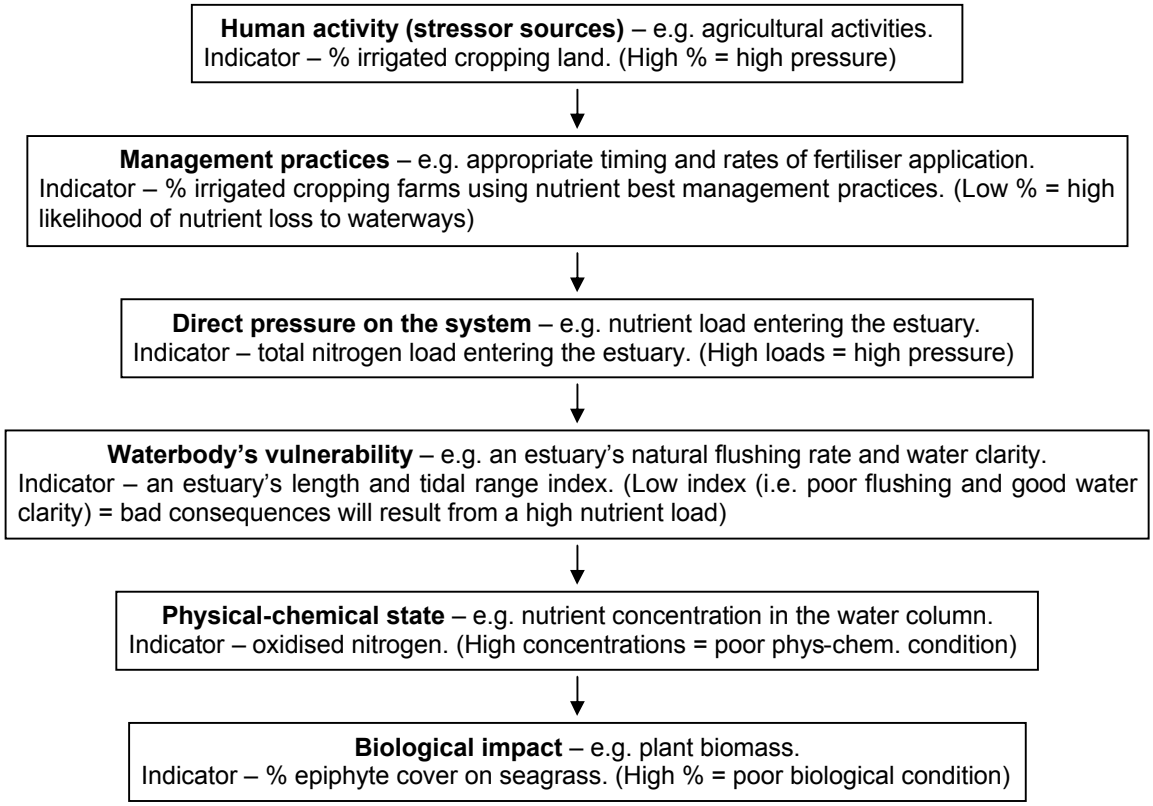
The objective of the assessment framework described here is to define a set of indicators that can be used to assess the condition of, and risk to, coastal waters at local, regional, state and national scales. The information on condition and risk can then be used to direct, prioritise and assess management actions. Implicit in this approach is that condition information can be directly linked back to pressures and hence to management actions. Therefore, we have developed an assessment framework that makes these implicit links quite explicit.

The basis of the framework is the identification of a set of key stressors that can potentially impact on estuarine, coastal and marine waterbodies. Stressors are

defined as components of the environment that when changed can affect the condition of the ecosystem. These can be natural components such as nutrients or entirely anthropogenic components such as pesticides or biota removal/disturbance (e.g. fish catch).

Different stressors are affected by different pressures and their change will result in different condition responses. Once the aspects of cause and response to a changed stressor is conceptually understood then the links between human activities and waterway condition can be examined.

The basic principle of the framework logic is: for each individual stressor there are human activities that cause a change to an actual pressure acting on a system which in turn cause a change to the physical-chemical state of the system. This physical-chemical change results in a corresponding change (impact) to the biological condition of the estuary. There are pressure mediating factors (i.e. management practices) which reduce the likelihood of human activities impacting an estuary, as well as intrinsic mediating factors (i.e. an estuary's vulnerability to a stressor) which determines the consequence of any change to a stressor. For example, for the stressor 'nutrients':



These elements provide a logical framework for the selection of indicators. For each stressor, one or more indicators of each element can be identified (Table 1).

Table 1. Example of indicators identified for a stressor.

Stressor	Pressure indicators		Condition indicators	
	Human activity	Direct pressure	Physical-chemical	Biological
Aquatic sediments	Catchment land-use. Percentage of catchment cleared. Percentage length of river system	Monitored or modelled sediment loads entering the estuary	Secchi depth. Turbidity.	Change in seagrass extent. Percentage cover of

	with no riparian vegetation. Presence of point sources. Boating activity within the estuary. Unsealed road density. Intensive agriculture on steep slopes. Percentage ground cover. Occurrence of dredging in river system.	(total diffuse and point sources).		seagrass. Change in mangrove extent.
Bacteria/ pathogens	Occurrence of sewage treatment plants. Occurrence of sewage overflow events. Percentage of catchment under intensive animal production. Number of septics within catchment. Presence of stormwater outflow.	None.	Intestinal enterococci counts.	Number of mass mortality events caused by pathogens.
Etc.	…	…	…	…

Stressors and related indicators

In Queensland, the following 'components of the environment' have been identified as major stressors important in our estuarine, coastal and marine ecosystems:

- Aquatic sediments
- Bacteria/pathogens
- Biota removal/disturbance
- Connectivity
- Freshwater flow regime
- Habitat removal/disturbance
- Hydrodynamics
- Litter
- Nutrients
- Organic matter
- Pest species
- pH
- Toxicants

For each of these stressors we have developed pictorial and text conceptual models of our current understandings which has allowed the identification of at least one indicator of pressure and condition. Exceptions to this are the stressors 'freshwater flow regime' and 'hydrodynamics' for which we have not been able to identify any appropriate condition indicators (e.g. because of complexity, lack of ecosystem understanding, costs, etc.). In total, we have identified 49 pressure and 38 condition indicators for monitoring, though not all of these would be monitored in a particular area. Through a process described below only indicators relevant to a region would be monitored.

Information provided in the full report (see Scheltinga and Moss 2007) describes the stressor itself, shows our current conceptual understanding and lists the relevant pressure and condition indicators to monitor. A description of the aspects of the waterway (i.e. mediating factors) effecting its vulnerability to that stressor as well as management practices used to reduce the pressure is also discussed. Information on the specific aspects of the pressures to be monitored and how to monitor each of the condition indicators is also provided.

Identifying indicators

In order to determine what indicators to monitor the user first needs to identify what the key stressor in their area are. This can be done in two ways.

The first way is to determine the key stressors through a consultation process and using the information provided in the full report, local knowledge and regional planning programs. The second way is to monitor all the pressure indicators listed and thus score all the stressors on the information obtained. This will identify the key stressor in an unbiased way.

To allow the best possible understanding of a stressor as well as the links between indicators and the data obtained, whenever possible, all indicators relevant to a stressor should be monitored. The use of multiple indicators for each stressor will improve the users' ability to relate observed changes in condition to changes in the stressor/pressures caused by management actions.

Software

To assist in applying the framework a user-friendly computer package (VPSIRR) has been developed which enables the user to easily determine the data required for the assessment and calculate all the relevant 'scores' and confidence/dependability results to be reported for an individual estuary. The package produces a colour coded and numeric report card which is designed to be easily understood and interpreted by users from a variety of backgrounds.

Reporting

The primary purpose of a monitoring program using indicators identified through the processes described in this document is to provide information about the pressures on (or risk to), and condition of, estuarine, coastal and marine natural resources. To report on each indicator the assessment framework uses a five point scoring scale with appropriate values for each level identified. A score of 1 being the 'best' and 5 the 'worst'. The scores applied to condition indicators are generally based on how they compare to the guideline/reference or baseline value, or to the value obtained from the previous sampling period (trend/change data).

It is important that the results obtained from any monitoring program are reported in such a way that all stakeholders obtain information in a way that is relevant to them (i.e. useful). Reporting of the assessment framework is sufficiently flexible to meet several levels of information needs from local to national. The framework allows the reporting structure to be hierarchical, with several levels of detail that may be accessed. The broadest level (with least detail) is an integrated scorecard, where the condition of each system is rated on a basic scale from A+ to D- with a score of F being the highest risk/worst health score possible. The next level of detail includes an overall rating for condition and risk for each stressor (Table 2), whereas the third level of detail would incorporate assessments of individual indicators within a stressor (Table 3).

Recommended management actions, priorities and responses can then be reported in relation to each stressor. At the most detailed level, information is available at the individual indicator level. Although this reporting framework may appear unnecessarily complicated at first, the several levels of reporting are required to meet the varying information needs of a range of stakeholders.

Reporting by stressor allows managers and scientists to assess condition in terms of relevant pressures (in order to identify the most appropriate management actions for success), assess the human impacts of this condition (and therefore management priority), and the actions (responses) being undertaken to date. This also allows the effectiveness of management actions to be assessed over time, as pressure indicators will change first, followed by physico-chemical and then biological indicators.

Table 2. Summary of the stressor risk and condition scores for Eurimbula Creek estuary.

Stressor	Risk	Condition
Aquatic Sediments	Low	Good
Bacteria/Pathogens	Negligible	Excellent
Biota removal/ disturbance	Low	Excellent
Connectivity	Negligible	Excellent
Freshwater flow regime	Negligible	Excellent
Habitat removal/ disturbance	Negligible	Excellent
Hydrodynamics	Negligible	Excellent
Litter	Low	Poor
Nutrients	Negligible	Excellent
Organic matter	Negligible	Excellent
Pests	Negligible	Excellent
pH	Negligible	Excellent
Toxicants	Low	Excellent

Table 3. Indicator information for the stressor 'litter' for Eurimbula Creek estuary.

Litter (rubbish)

Low risk	Very high confidence	100% dependability
Poor condition	High confidence	100% dependability

Risk

Indicators of litter sources	Raw data	Risk score	Confidence
PI5: boating activity within the estuary	Commercial vessels or 'anchorage' sites identified	Moderate	Very high
PI20: recreational usage index (value between 8 and 40)	14	Low	High
PI21: 'estuary' population size (people/km^2)	2.852	Negligible	Very high
PI38: % of estuary adjoining urban area	0	Negligible	High
PI15: number of stormwater inflows per km estuary	0	Negligible	Very high

Condition

Physical-chemical condition indicators	Raw data	Condition score	Confidence
CI16: presence (standing crop) of litter (per m^2)	0.0105	Poor	High
CI17: litter accumulation rate (per m^2 per day)	0.000071	Fair	Moderate

TRIALLING THE FRAMEWORK IN QUEENSLAND

A project to trial the framework has been completed in partnership between the Qld EPA and the Burnett Mary NRM Group (BMRG). Both parties have benefited from the collaboration and sharing of resources to trial all the indicators in 18 estuaries within the region.

Of the 18 estuaries, eight were already being monitored for several indicators by the EPA. As part of the BMRG's State of the Estuarine Environment (SoEE) project, the BMRG has contributed funds to cover analysis costs of extra sites within these estuaries. The remaining estuaries are being monitored by staff from BMRG and community groups.

As at the end of January 2009 draft report cards for all the estuaries have been completed and are awaiting finalisation. Final products from the BMRG SoEE project include:

- A main report which fully documents the SoEE project and results
- An A3 regional summary report (for all estuaries)
- A4 report cards for each estuary
- A website (see www.bmrg.com.au)

TAKE HOME MESSAGE

In order to assess the underlying causes of changes in condition and identify suitable management actions it is essential to incorporate linked condition and pressure indicators in an environmental monitoring program.

The major advantages of this framework are that it:

- allows locally relevant indicators to be identified and monitored (rather than a static list of sometimes irrelevant indicators),
- explicitly links pressure and condition indicators to facilitate data interpretation and resource management,
- increases the likelihood of being able to identify the causes of any observed changes in condition
- provides information to identify appropriate management priorities and actions, and can be used to justify why and where actions were done,
- can be used to assess the success of management actions performed,
- has a focus on pressure indicators that will respond to management action much earlier than biological condition indicators, and
- is suitable for use/reporting at a variety of scales, from subcatchment to regional, state or national.

The framework is being recommended for use by regional, state and national bodies.

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