A framework for monitoring the risk to estuarine, coastal and marine areas and its current condition: assisting management

David M. Scheltinga and **Andrew Moss**
Environmental Protection Agency 80 Meiers Rd Indooroopilly QLD 4068

ABSTRACT

Coastal waters are under increasing pressure from human activities. To be able to effectively manage these waters we need to truly understand the relationship between the pressures impacting them and the resulting effects on waterway condition. In an attempt to gain this understanding, we have developed a monitoring and assessment framework that reports on the current pressures, vulnerability and condition of coastal waters. The major benefit of this framework is that the link between pressure and condition is clearly identified, thus helping managers establish appropriate management actions and priorities. The framework also allows managers 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 waterway – making indicators locally relevant and cost effective. The framework has been designed to allow users to report at a variety of levels and aspects depending on the 'audience' targeted. For example, reporting can be done for a specific waterway or region as a whole, it can be on specific stressors (key component of the environment impacting waterway health) or on overall condition and pressures. It is envisaged that the framework will also allow NRM bodies to examine (and report on) changes to resource condition as a result of their management actions.

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 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

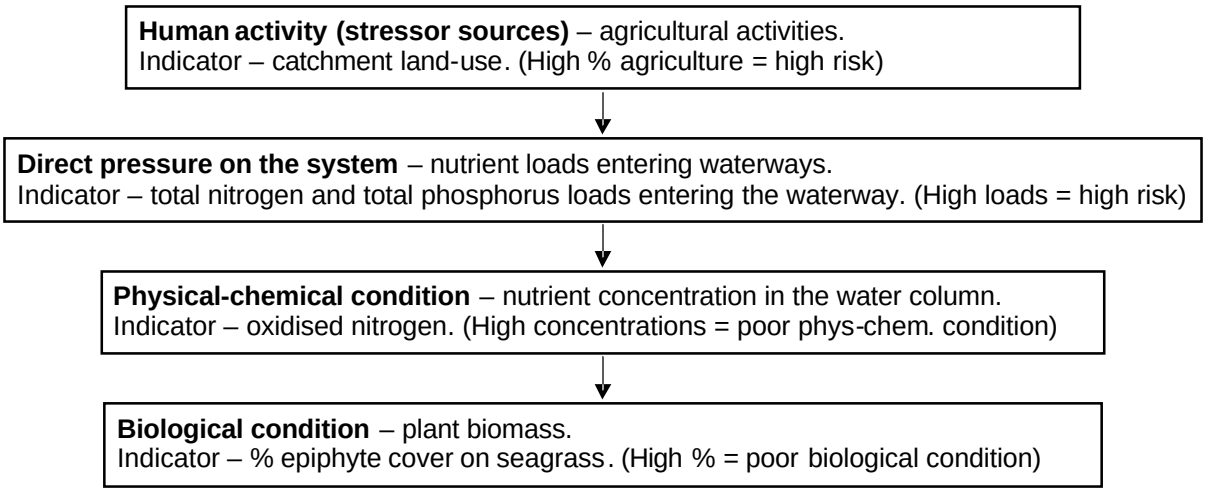
The objective of the assessment framework described here is to define a set of indicators that can be used to assess the condition of, and risk to, coastal waters at local, regional, state and national scales. The information on condition and risk can then be used to direct, prioritise and assess management 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 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 condition of the system. This physical-chemical change results in a corresponding change to the biological condition of the waterway. We can monitor indicators for each of these components which then help

determine what is the risk of a waterway being affected by pressures and what is the current condition of the waterway. Therefore, links between human activities and biological condition can be closely examined and management activities determined. 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 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.	Monitored or modelled sediment loads entering the estuary (total diffuse and point sources).	Secchi depth. Turbidity.	Change in seagrass extent. Percentage cover of 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
- 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 50 pressure and 33 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 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.

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 E. The next level of detail includes an overall assessment of condition and pressure for each stressor (Figure 1), whereas the third level of detail would incorporate assessments of all subcategories within these (Figure 2).

Recommended management actions, priorities and responses could also be reported in relation to each stressor. At the most detailed level, information would be 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.

Stressor	Pressure	Condition
Aquatic sediments	High	good
Bacteria/pathogens	Low	Excellent
Biota removal/disturbance	Extreme	Poor
Freshwater flow regime	Extreme	No indicators currently available
Habitat removal/disturbance	Extreme	Very poor
Hydrodynamics	Moderate	No indicators currently available
Litter	Negligible	Not monitored – assumed okay
Nutrients	Moderate	Good
Organic matter	High	Fair
Pest species	Negligible	Excellent
pH	Low	poor
Toxicants	Moderate	Fair

Figure 1. Example reporting of 'overall assessments' of condition and pressure for each stressor.

Pressures					
P1: Moderate	P2: Low	P3: Extreme	P4: High	P5: High	P6: Moderate

Vulnerability
V1: Moderate

Condition		
C1: Fair	C2: Good	C3: Very poor

Figure 2. Example of reporting on individual indicators for the stressor 'aquatic sediments'.

TRIALLING THE FRAMEWORK IN QUEENSLAND

A project to trial the framework has been undertaken in partnership between the Qld EPA and the Burnett Mary NRM Group (BMRG). Both parties will benefit from the collaboration and sharing of resources to trial all the indicators in 16 estuaries within the region.

Of the 16 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 June 2007 data for many of the pressure indicators (and some of the condition indicators for which data was already available) had been collected and recorded for most of the estuaries. With respect to the remaining condition indicators, monitoring of these parameters in the remaining estuaries has started and will continue until April 2008.

At the present time it appears that all the indicators will be practical and useable in Queensland.

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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