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National Marine Environmental Condition Assessment Framework Round Table

26 – 27 February 2008

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Natural Heritage Trust

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1.0 National Marine ECA Framework Round Table Report

This draft report summarises discussions from a two-day round table held in Melbourne on 26 and 27 February, 2008. The national round table was convened to facilitate discussion with key marine researchers and managers (Appendix1) and provide a range of opportunities for participants to assess and provide feedback on the feasibility of developing a practical national marine assessment framework. A background briefing paper (see Appendix 3), provided to participants prior to the round table, was presented in three sections. Section 1 of the paper presented information on the role of the NLWRA (the Audit) and provided details of a model National Environmental Condition Assessment (ECA) Framework and a supporting information model. The model National ECA Framework was refined in a similar round table held to determine the feasibility of using the ECA Framework for assessment of estuarine areas. Section 2 of the paper focused on the aims and questions to be addressed in the round table. Section 3 provides an overview of some approaches used in current assessment programs for marine and estuarine systems in Australia and overseas.

1.1 Objectives of the Round Table

Specifically the objectives of the National Marine ECA Framework round table were to:

- **Identify the structure and potential core components for a viable national marine environmental condition assessment framework.**
- **Identify what needs to be done to produce and implement a national marine environmental condition assessment framework.**

Activities at the round table were designed to provide further information about the Framework and address the following questions (see Agenda Appendix 2)

- What value is the Framework to you?
- Does what you are doing in your state or territory fit with the Framework?
- What are the main requirements of a national Marine ECA Framework?
- What aspects of the Framework need to be resolved to improve its value?

It should be noted that participants at the workshop were not representing particular States or Territories. They were using their perspective and/or experience to assess how a National Marine ECA Framework can add value, what it needs to include and what improvements need to be made.

1.2 Roundtable summary

The participants' responses from discussions during the roundtable were collated and presented in Figures 1-4. Comments were captured verbatim, where possible, and broad headings to group the ideas and comments were added after the workshop.

The roundtable summary draws on and consolidates ideas that arose in different sections of the round table agenda to focus on the round table objectives. Overall summary comments and/or recommendations are italiscised and presented in boxes throughout this section of the report.

Marine Environmental Condition Assessment Framework

The structure and logic of a model National Environmental Condition Assessment Framework (ECAF) was presented at the round table by Richard Mount (also summarised in Section 1 of Appendix 3) as a basis for subsequent consideration by participants of its applicability to assessment of marine environmental condition.

Participants were asked for an initial 'gut reaction' to the model Framework – from their perspective and/or experience in marine environmental assessment processes- and a further, more detailed response, which was guided by the questions

- What are your needs?
- What is the 'state of play' as you see it?
- How does close is the fit (of the Framework to needs)?

The questions and subsequent discussion elicited responses which were collated and presented in figures 1 & 2 under the following headings.

- Value of a National Marine ECA Framework (Fig 1)
- Issues and recommendations for improving the Framework (Fig 2).

Any relevant additional comments and/or suggestions arising from subsequent discussions at the round table were also included in these figures.

There was some discussion of existing marine assessment programs within Australia (also see section 3 of the round table background briefing report (Appendix 3)). However, no impediments to incorporating these into the Framework were identified by participants.

1.2.1 Value of a National Marine ECA Framework

Responses to the framework indicated strong support for a national framework to guide assessment of marine condition.

Individual responses could be grouped in many ways and there is unavoidably some overlap in the categories ultimately selected. The main values of a national marine ECA framework identified by participants were that it:

- Provides a practical and logical structure;
- Directs research;
- Enhances communication;
- Facilitates co-ordination between jurisdictions; and
- Guides identification of indicators.

Summary of participant responses within these categories

Provides a practical structure. The hierarchical or layered structure of the framework was particularly well received as it clearly identifies the steps required to undertake an assessment and formally acknowledges the activities and reports possible at each pass with differing levels of information. The structure focuses assessment activities and enables prioritisation so that, although increased information is required at each pass, the focus will be on fewer assets and/or threats (interactions).

At each pass different types of assessment reports are possible, for some assets 1st pass reports will be adequate to meet the objectives. The layered structure also encourages a ‘reality check’ at each level to determine whether the information required to support the assessment at each pass is available.

Participants agreed that a basic understanding of the form and function of the system or asset being assessed was a necessary first step underpinning all assessments.

Facilitates coordination between jurisdictions. It was noted that marine assessment often involves a range of agencies with different expertise and experience. The framework would allow agencies with management responsibilities for areas, such as fisheries, marine conservation and the catchment, to work within a recognised framework.

The Framework, which is flexible enough to apply at a range of spatial scales, facilitates coordination of (local, regional, state and national) activities within a common structure.

Enhances Communication. In particular, participants noted that the Framework will help manage expectations and explain, given the information available, what is and isn’t possible. For example, developing resource condition targets for system without a basic understanding of its functions was considered to be unrealistic expectation. The value of the Framework as a communication tool was seen as a particular advantage in the marine environment given the range of agencies involved.

Directs Research. The Framework provides a structure for better directed research programs. Knowledge gaps, which are identified at each pass, provide a context for developing research priorities. Support for research programs by Commonwealth research agencies was considered more likely, if the information needs were identified within a nationally recognised Framework.

Guides Identification of Indicators. The Framework was thought to provide a consistent and logical method for identifying relevant indicators of environmental condition of the asset under consideration. Indicators supported by relevant information could be incorporated into condition assessment reports at each of the three passes.

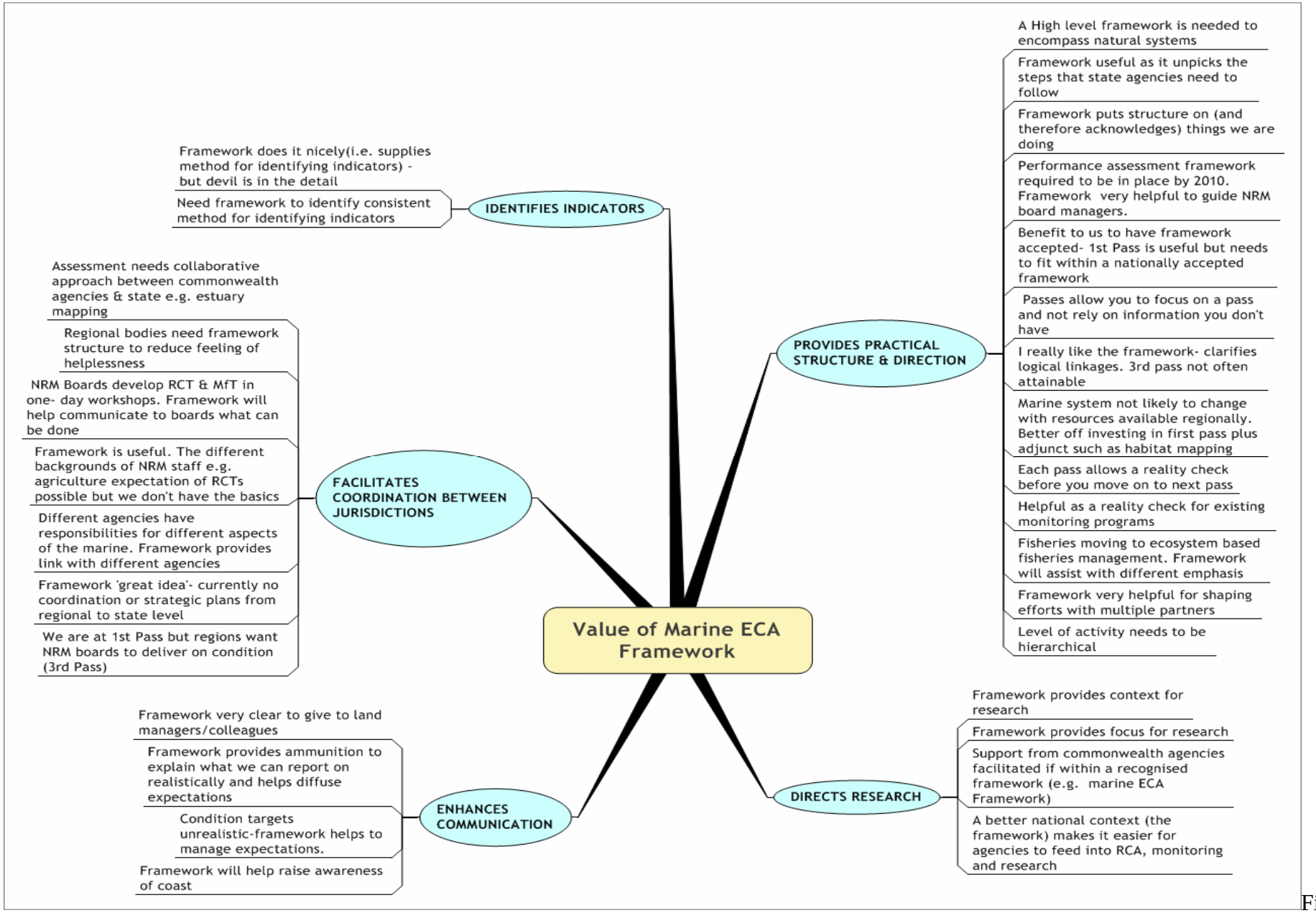

Figure 1. **Value of the National Marine ECA Framework**

1.2.2 Issues and Recommendations for improving the Framework

Figure 2 summarises both recommendations made by participants for improving various aspects of the Framework and issues identified by participants, particularly relevant to undertaking marine condition assessments.

Issues identified related to:

- Detecting change; and
- Scale.

It was noted that in the marine environment it was often difficult to detect, using monitoring programs, the level of change likely to result from a particular investment program. Yet this is the objective of monitoring programs focusing on marine condition indicators.

It was also recognised that what to measure (as an indicator of ecological integrity) is not well established in the marine environment. However the framework was considered to provide a logical framework for selecting meaningful indictors for assets, at various scales, under consideration.

Defining the asset and scale to which the framework would be applied was recognised as more problematic in marine systems, which don't have the natural spatial boundaries of wetlands and estuaries. The use of different boundaries (e.g. 3 nm and 200 m) by agencies was seen as a limitation for some marine assessment, particularly for assets such as fish populations that may extend beyond jurisdictional boundaries. The framework was considered sufficiently flexible to apply at a range of scales and to a range of possible assets. Where possible it was suggested that assets should be selected that allow for reporting at different spatial scales. It was also noted that boundaries for some assets could move inter-annually or seasonally in response to factors such as oceanographic currents.

Recommendations for improving the Framework related to:

- Structure and format
- Language
- Research
- Linkages

Many suggestions from the round table related to improving the structure or format of the Marine ECA Framework. Many of these recommendations were also noted in participant responses to the schematic representation of the Framework and are documented in more detail in 'Further Recommendations'.

Participants recognised the need for more detail before the framework could be properly assessed. However, some general recommendations included:

- The rationale for selection of particular assets should be clearly articulated;
- Identification of threats should be evidence based;
- Principles should be developed to guide movement between the three passes.
- Assessing and communicating the level of confidence in the data applied to assessments should be an explicit element of the Framework.

- The structure of the Framework should reflect its purpose that is, to provide guidance about assessments, and that management interventions are a different process outside the framework.

It was considered that some terms used in the framework, for example asset, vulnerability and condition need to be more clearly defined, particularly in the context of a marine system.

Participants noted that further research was required for development of conceptual models. The models were seen as a key tool and should therefore be the focus for research investment with the objective of identifying key ecological features and/or processes at various scales. It was noted that conceptual models could be developed with varying levels of knowledge and therefore the level of confidence should be clearly documented. Research was also recommended to explore the concept of vulnerability and risk and how each could be measured and applied to marine assessments.

It was considered that an effective marine assessment framework would recognise links of marine condition with activities and processes in the catchment. Participants also noted that alignment of the Framework with national policies e.g. Oceans Policy, would facilitate greater participation by commonwealth agencies in its implementation.

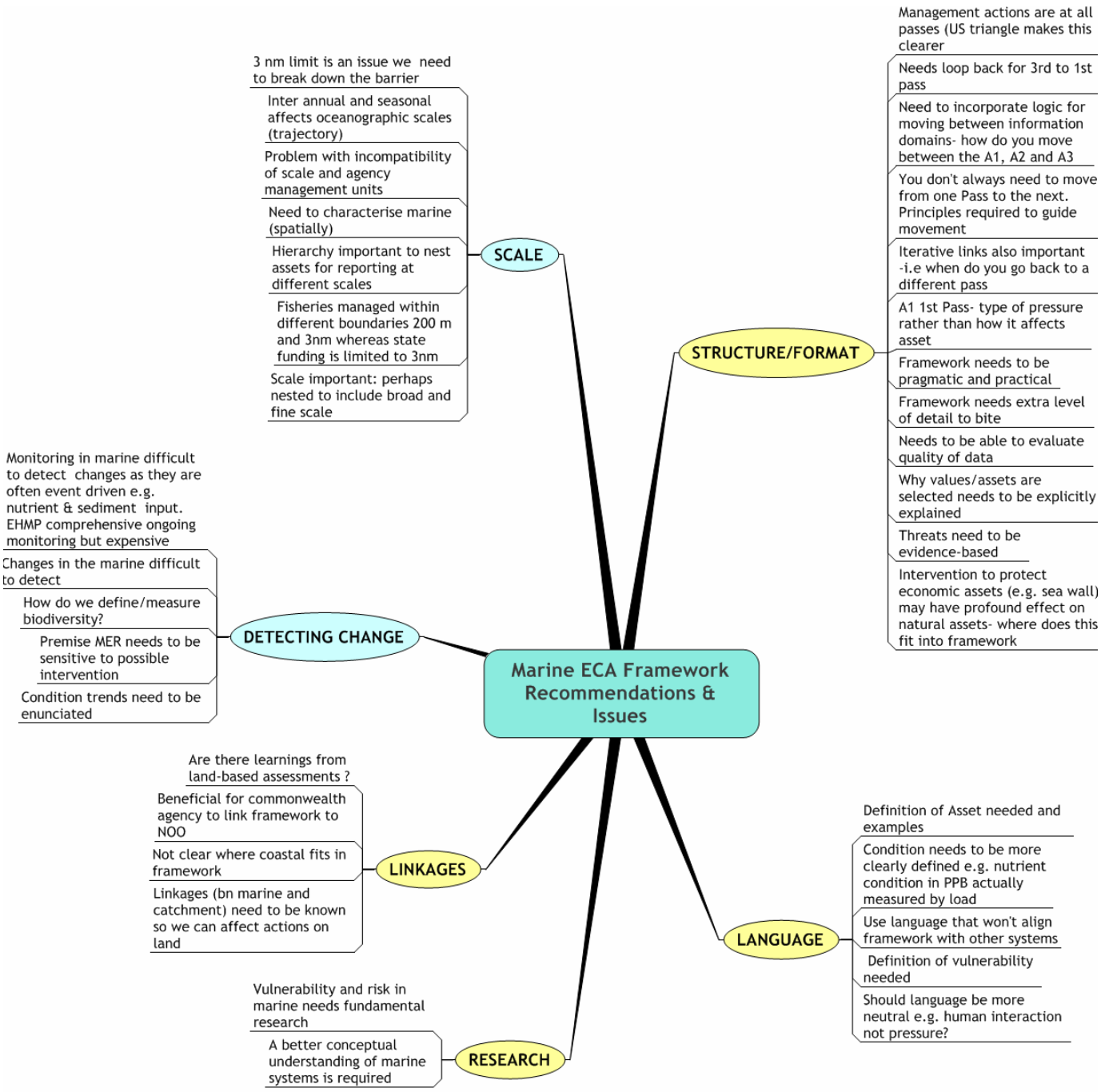

Figure 2. Recommendation for improving the National Marine ECA Framework and issues identified as affecting marine condition assessment. Blue bubbles represent issues and yellow bubbles represent recommendations.

1.2.3 Further Recommendations

The schematic representation of the Framework was used as a prompt for a brief discussion of: **What reports are possible and applicable to marine condition assessment?** This discussion initiated a general response to **how well the schematic diagram depicts the logic and details of the ECAF approach** as described in the presentation by Richard Mount (also see Section 1 of Appendix 3)

The main points from these discussions are summarised below and presented in Figure 3.

It was considered that the language and structure of the framework did not clearly distinguish the ECAF as an assessment and not a management framework. The Framework should provide assessments that are useful for guiding management actions by providing a structure for identifying what is known, further information that is required and point to management gaps or issues. To this end it was suggested that a 'Management World' column be included outside the framework to note broad management processes, which could be advised by the assessment outputs from each Pass. It was also suggested that the names of the passes be changed to reflect the supporting role of the Framework, that is the role of the 1st Pass 'understand' change to 'support understanding' and the 2nd Pass 'focus and prioritise' change to focus and enable prioritisation'. Similarly the aims at the 1st Pass should note they are the existing or given aims for a particular asset, and at the 2nd and 3rd Pass the aims will be established by management, using information from the previous pass.

Participants thought the Framework did not clearly communicate the hierarchical structure of the Framework. That is, although the level of information required increases moving from 1st to 3rd Pass, the focus will be on fewer and fewer assets. For many assets there is no need to move to the 3rd Pass. It was also considered necessary to include guidelines or principles that help guide a manager's decision about whether to move to the next pass, why they wouldn't and in what circumstances would they return to a previous pass. When a manager identifies priority assets, resources are allocated to some assets over others.

Participants suggested there was a need to more clearly differentiate reports from both other outputs and also the process of generating the outputs. For example, at the 1st Pass conceptual models and inventories could be considered outputs, a vulnerability assessment - a report, and a meta analysis - a method or process for generating outputs.

Participants did not identify any of the listed assessment reports namely, pressure, vulnerability, risk and condition as not relevant in the marine environment. However, in earlier discussion (see 'Issues and Recommendations'), some concerns were raised about the feasibility of generating these reports given our current level of understanding of marine systems.

In Summary recommendations of participants for improving the marine ECA Framework included:

Structure of Framework

- *Modify schematic representation to stress the Framework:*

  - Is an assessment and not a management framework;

- Is hierarchical with regard to the level of assessment activity and number of assets at each Pass

Components of Framework

- *Develop broad definition of marine asset (should include issue of scale)*
- *Develop definitions for vulnerability and risk.*
- *Develop principles to guide movement between Passes.*

Research

- *Develop comprehensive conceptual models that include direct and indirect human interactions and cumulative impacts*

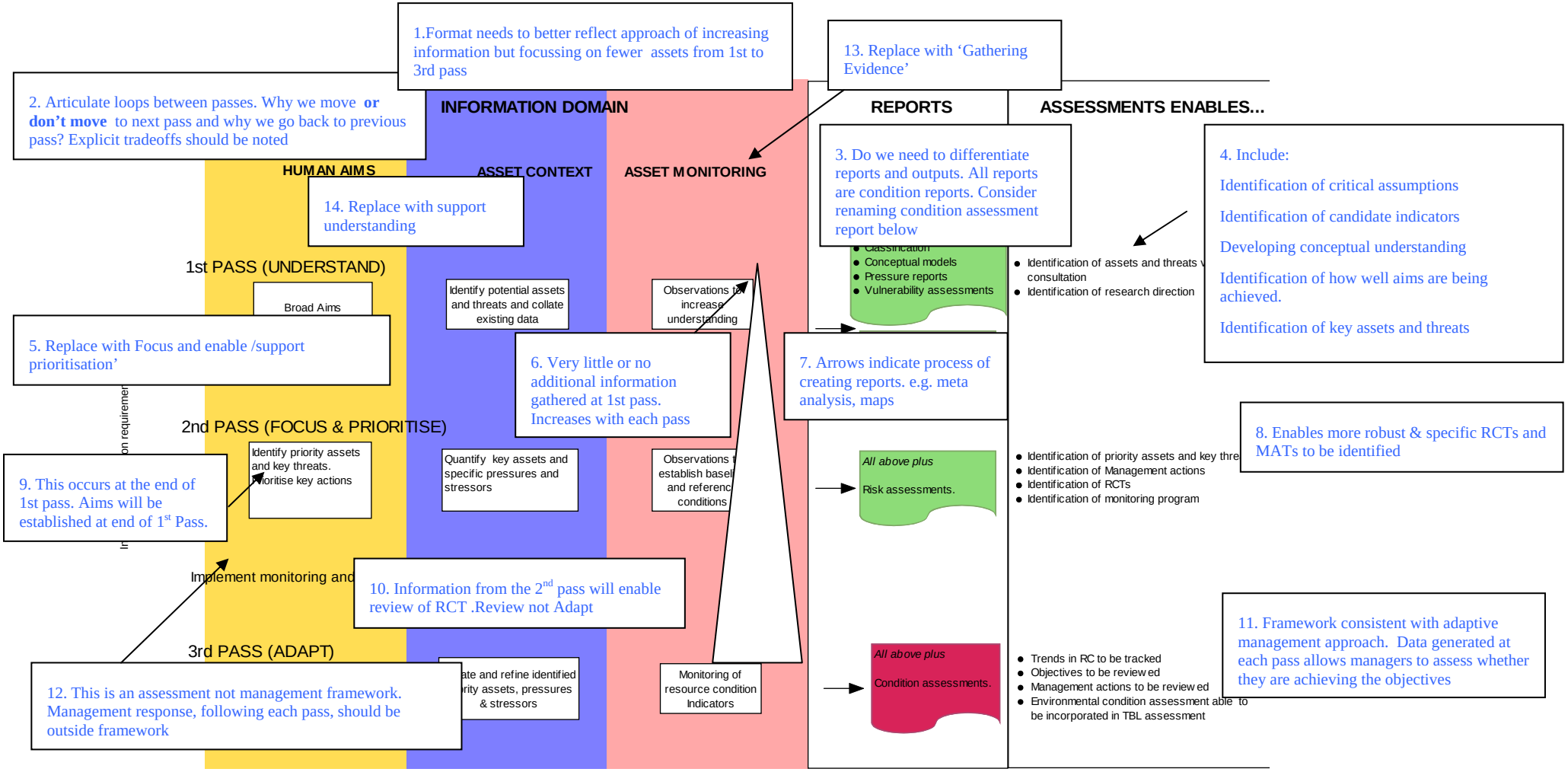

Figure 3. Recommended changes to the National Marine ECA Framework

1.2.4 Information Domain Conceptual Model

Undertaking an environmental condition assessment of an asset requires information from each of three domains (see Appendix 3 Section 1.). Each information domain; Asset Context, Human Aims and Gathering Evidence was examined in detail to determine the contribution of the domain to the Framework and the assessment of marine condition. To this end, participants addressed the following questions:

- What information is provided by each domain?
- Why it is required?
- What products or outputs can be generated with the information? and
- How do the information domains relate to each other?

The results of the roundtable discussion are presented in Figure 4 and summarised below. Aspects of the Domains, which were not noted in the 'Information Domain Conceptual Model' presented in Section 1 are highlighted. This information will be used to review and possibly revise the Model.

Participants considered the information provided by each domain. The results of the discussion are summarised as:

- the Asset Context Domain provides information about where the asset is and how it works and also identifies the direct and indirect human influences and impacts acting on the asset;
- the Human Aims Domain articulates what we value about the asset and identifies any existing management intentions that are relevant to the asset; and
- the Asset Monitoring Domain includes further observations or evidence that is required to inform the assessment. It was recommended that Asset Monitoring Domain be renamed 'Gathering Evidence' to better reflect the range of information gathering activities that are included within this domain

The Asset Context Domain includes information about the function and physical form of the asset and the direct and indirect human influences and impacts on the asset. There was no agreed definition of a marine asset but the general discussion considered it could be either a living or non-living object or process. Depending on the type of asset, the domain encompasses a range of physical characteristics and population attributes and should also include historical information. This domain identifies the range of ecosystem services provided by the asset.

Information about human influences and impacts points to actions that we have some control over and hence is the basis for the development of management strategies. This information also assists in identifying relevant stakeholders to participate in assessment programs. The need to include indirect human influences and cumulative impacts was also stressed.

The Domain provides a 'common understanding' of the asset and should incorporate many 'ways of knowing' including research, expert opinion, and local and indigenous knowledge. The domain is also useful for identifying what we don't know i.e. knowledge gaps.

Developing an understanding of the asset and the influence of human activities was seen as critical to the other domains, namely, identifying further evidence that might be required to assess the condition of the asset and identifying human values associated with the asset.

It was acknowledged that the quality of information will vary and a 'level of confidence' should be applied to all information in this domain.

The **Human Aims Domain** identifies both why we care about the asset and the management intentions which exist to protect it.

This Domain includes all values (i.e. economic, social and cultural) assigned to an asset by a range of stakeholders. It also recognises the standing (e.g. community opinion or legislation) and specificity (e.g. from general policy protecting biodiversity to recovery plan for particular species) of the value. It was recommended that management intentions should encompass all arrangements including community and indigenous values, regional policies and plans, legislation, treaties and established principles such as the precautionary principle.

This Domain (together with the insights from the Asset Context Domain) allows responsible stakeholders to be identified and hence provides a link to resourcing requirements. Information in this Domain allows areas where values are not expressed or management intentions are absent or unclear, to be identified.

The **Gathering Evidence Domain** identifies information, additional to that in the Asset Context Domain, required for environmental assessment of an asset at any Pass. The level of information required will vary depending on the gap between existing information and that required to meet the stated management intention or objectives for the asset. Types of information could include for the 1st Pass, last minute incidental observations and supplementary rapid assessment observations; for the 2nd Pass, collecting baseline observations and measurements; and for the 3rd Pass results of extensive monitoring programs.

This information could provide for standards to be set and changes in either the condition of the asset or the level of impact on the asset to be detected. It also allows conceptual models and underlying assumptions to be tested.

1.3 Next Steps

The results of this roundtable will:

- Provide input to a scoping report which will recommend to the Audit a suitable assessment framework and mechanisms for conducting the national estuarine, coast and marine assessment (Scoping report due April 2008)
- Provide the foundation for a national workshop on NRM ECM report carding (March 2008)

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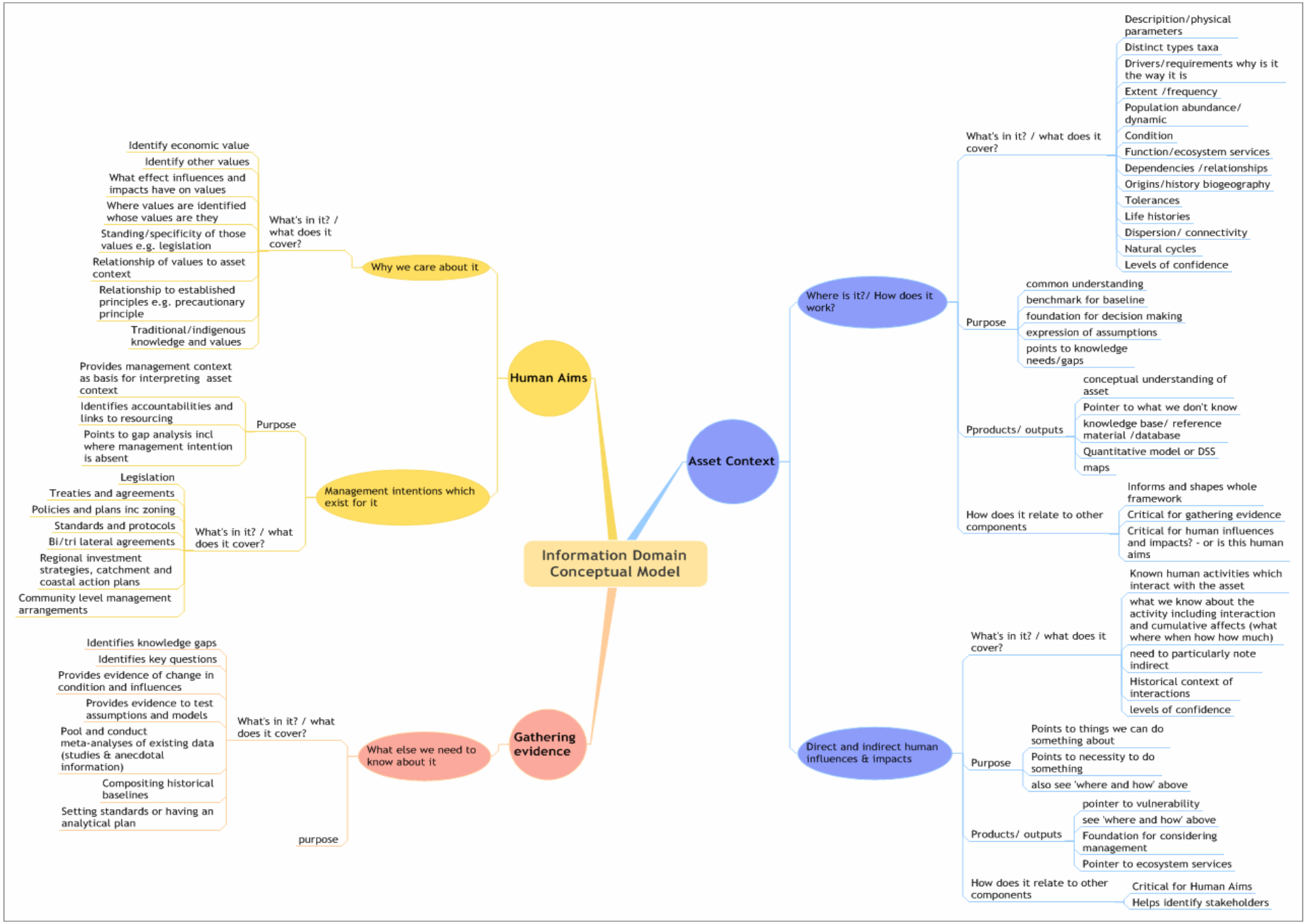

Figure 4. Components of the Information Domain Conceptual Model

Appendix 1. National Marine ECA Framework round table participants -final list

Name	State	Agency	Email
Peter Fairweather	SA	Flinders University	peter.fairweather@flinders.edu.au
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Mark Butz		Facilitator	

Appendix 2. National Marine ECA Framework round table agenda

Time	Item	Round table aims	Comments
11am			
	1	Introductions & Welcome	
	2	Familiarise participants with roundtable aims and scope	Agenda; what's in /what's out
	3	Review current audit approach to condition assessment	What's happened in the past? Why do we need a framework?
	4	Familiarise participants with the information domain conceptual model & the Framework	Presentation: Richard Mount
12.30-1.30		**Lunch**	
	5	Determine the value of the Framework to participants	Initial response, what are your needs? What is the state of play? How close is the fit?
	6	Determine whether each state/NT approach fits with the Framework?	
3.30-4 pm		**Break**	
	7	Measuring marine biodiversity	Presentation: Brendan Brooke
		Selecting marine assets	Presentation: Chris Marshall
	8	Identify potential core components for a marine ECA framework	Examine the information domains within the conceptual model
6 pm		**End Day 1**	
		DAY 2	
9 am	9	Recap Day 1	
	10	Identify potential core components for a marine ECA framework (cont'd)	Examine the information domains within the conceptual model
12.30pm-1.30		**Lunch**	
	11	Identify ways to improve Framework	A more detailed look at the framework and reports posssible
3.15-3.30	12	Wrap up. Where to from here?	Richard Mount
3.30		**END Day 2**	

Appendix 3. National Marine ECA Framework round table background paper

National Marine Environmental Condition Assessment Framework Round Table

Background Briefing paper

University College, Melbourne University, February 2008

Authors: Helen Arundel[1] and Richard Mount[2,3]

[1] Deakin University, Warrnambool

[2] National Estuarine, Coastal and Marine Information Coordinator, NLWRA and

[3] Spatial Science Group, School of Geography and Environmental Studies, University of Tasmania

1.0 National Marine ECA Framework Round Table Background Briefing Paper

The round table is an opportunity to explore the potential for developing a national marine assessment framework

This briefing paper, which supports National Marine ECA Framework round table, is divided into three sections.

Section 1 presents background information about development of the framework (modified from Arundel & Mount 2007) and includes:

- the role of the NLWRA (the Audit) in undertaking estuarine coastal and marine assessments; and
- a model framework - the National Estuarine Environmental Condition Assessment Framework (NEECAF) - and an information model which supports the framework;

Section 2 focuses on the round table and includes

- the aims of the round table; and
- key questions to be addressed at the round table.

Section 3 presents some approaches used in current assessment programs for marine and estuarine systems in Australia or overseas.

1.1 Background

The Natural Resource Management Ministerial Council, which includes representatives of the Australian Government and all states and territory governments, was established to develop a coordinated approach to issues affecting natural resource management in Australia. The Council endorsed two national level documents to help set targets, monitor, evaluate and report on natural resource management. These are the:

1. National Natural Resource Management Monitoring and Evaluation Framework (NRM M&E Framework)
2. National Framework for Natural Resource Management – Standards and Targets

This framework sets broad aspirational natural resource outcomes and identifies matters for which regional targets must be set. Several targets are relevant to assessment of estuaries, in particular Estuarine, Coastal and Marine habitat integrity but also those related to, significant species, invasive species and water quality (Appendix 1).

To provide more detail on how to assess each 'Matter for Target', a set of Resource Condition Indicators was developed for the National Natural Resource Management Monitoring and Evaluation Framework (2003).

Two indicator headings are identified with regard to estuarine, coastal and marine habitat integrity:

- Estuarine, coastal and marine habitat extent and distribution
- Estuarine, coastal and marine habitat condition and

A users' guide to these documents (Scheltinga *et al*. 2004) helps interpret the national framework for estuarine coastal and marine systems. It provides a list of stressors on these systems and identifies potential indicators to measure the affect of the stressors on ecosystem condition (physicochemical and biological) and habitat extent

A national workshop convened in Hobart in February 2006 reviewed the ECM indicator headings issues and indicators (Souter and McKenzie 2006) and identified 19 nationally agreed indicators (Appendix 2).

It should be noted that at the workshop strong views were expressed with regard to both management issues and objectives and the need to encourage the development of, among other things, "more comprehensive" condition indices and pressure indicators (Souter and McKenzie 2006). It was identified that further work is required to:

1 Identify which indicators, or combination of indicators, should be used to provide a meaningful assessment of resource condition.

2 Develop pressure indicators to provide context for the resource condition indicators and guidance for management action.

3 Develop climate change indicators, such as alkalinity, shoreline position and biological indicators

The round table and resultant scoping report is one initiative designed to progress the development of improved assessment methods, in this case for the marine environment.

1.2 Purpose and Benefits of an Assessment Framework

The NLWRA (the Audit) has a role in delivering national level assessments. The quality of the broad-scale information required for these assessments is dependent on the interpretation of valid, accurate information, which is typically sourced from state agencies, regional bodies or local councils. For this reason, the Audit has been tasked with the role of supporting the development of natural resource information systems, including an information infrastructure and resource condition indicators, that are, ideally, consistent at regional, state and national levels.

A National Estuarine Environmental Condition Assessment Framework (NEECAF) (Arundel and Mount 2007) was developed to provide direction for reporting on the broad ecological integrity of estuaries at a national level. The NEECAF was based on a generic **Environmental Condition Assessment Framework (ECAF)**, which is designed be used in other thematic area including the marine environment. The NEECAF focuses on national level reporting, and any similar system is clearly dependent on the states, Northern Territory and regions as they are the primary sources of ecological information.

The alignment of assessment frameworks across jurisdictional levels allows for effective allocation of resources to satisfy assessment and reporting requirements at each level. This approach is consistent with the principles of the National NRM M&E Framework (Appendix 3)

In summary, a nationally agreed marine ECAF would enable:

- Comparison of the condition of natural assets through standards-based reporting at the regional, state and national levels,

- The Australian Government, states/NT and regions to address their reporting and management needs more efficiently through closer alignment of management and reporting activities, and
- Cross-jurisdictional collaboration via multi-regional research, management solutions and information exchange.

1.3 Audience

The National Marine ECAF (Framework) is designed to deliver assessments of broad resource condition at the national level to all parties interested in national scale reporting. These include national policy makers, such as politicians and natural resource managers, and the general public. A wide range of industrial and national development interests intersect with estuarine and marine ecosystems including emergency management, key national infrastructure (e.g. ports, refineries, desalination plants), shipping and transport, urban development, water and sewage management, recreation, tourism, conservation, agriculture, aquaculture and fishing.

The reports and assessments are useful for people who need to make comparisons of regions or states with other regions or states or with the national perspective. For example, this information will assist with evaluating the effectiveness of programs such as the NAP and the NHT.

Multi-scale reporting requires specific interpretation of the data for the intended audiences. Information important to local and regional managers needs to be collated, aggregated and reinterpreted for larger scale reporting. The ecological processes of interest often changes with the jurisdictional interests of the specific report reader. For example, a regional manager may be interested in the number of algal blooms in an estuary, but a report that aggregates this information for a national audience will be difficult to interpret because records will vary greatly with monitoring effort

1.4 Scope

The current nationally agreed Estuarine, Coastal and Marine (ECM) Indicators include the extent and distribution of key habitat types and also a range of indicators assessing habitat conditions.

Unlike estuaries and wetlands, which are relatively discrete spatial units, defining the aspects of the marine environment of interest for an assessment is more challenging as there are not usually well-defined boundaries between recognisably different parts. Further, some aspects of interest are better characterised as flows or processes rather than spatially discrete objects. Spatially, the Australian marine environment is divided into 60 Interim Marine and Coastal Regionalisation for Australia (IMCRA) bioregions. The Bioregions reflect common environmental features or regions and could be used as reporting units. Alternatively, the criteria used to define an area could depend on the indicator selected for assessment. For example, if a pressure indicator is selected the area of impact may be relevant whereas for the condition of a particular species, the extent of the population may be more meaningful. Flows of genetic material (e.g. puerulus recruitment) or episodic events such as breeding aggregations may be regarded as key ecological features, yet be difficult to define precisely. The units of interest could, therefore be defined as static spatial areas or as dynamic processes that may not occur in a fixed location or even at fixed times.

Within a spatially defined marine unit or region of interest, decisions also need to be made about describing the physical extent of habitat types. How this occurs may be guided to some extent by the mapping protocols utilised. Classification systems are generally hierarchical. Broad scale categories, particularly those that don't change over short time scales such as reef and sand substrata, are described at one level and habitat characteristics, which are more dynamic described at a lower level.

In terms of triple bottom line (environmental, social and economic) reporting, the framework will be limited to the assessment of environmental integrity. Reports generated through implementing the Framework will contribute, the environmental component, to triple bottom line assessments of estuarine, coastal and marine condition.

1.5 A National Environmental Condition Assessment Framework (ECAF)

1.5.1 Establishing the Information Base for Resource Condition Assessments

For the purposes of better understanding reporting and assessment needs under the National NRM M&E Framework, an analysis of information requirements was conducted. The analysis led to the development of a NRM reporting "Information Domain Conceptual Model" (Mount 2007) (the Model), which is summarised here and presented more fully in Arundel & Mount (2007).

The Model is presented as a way of thinking about the 'types' of information required for ECM reporting and types of reports possible. The Model has underpinned the development of a flexible, layered ECAF.

The three information domains required for a comprehensive resource condition assessment are represented diagrammatically in Figure 1. In summary, the domains are

- Asset Context i.e. information about the biological and physicochemical form and functioning of the system and the pressures acting on the system;
- Human Aims i.e. what we value and our objectives for the system; and
- Asset Monitoring i.e. our current understanding from observations and measurements of various attributes of the system.

Asset Context: The assets context domain includes information about the estuarine system (i.e. form and function of the estuary) and factors that impact on the system. The form and function of the estuary (e.g. habitat, biota, and water quality) is influenced by pressures (e.g. fishing, land use in the catchment and modifications to hydrology) and consequent stressors (e.g. reduction in species numbers, increases in sediment & nutrients). The impact of the stressors on the estuary is in turn modified by the vulnerability of the system to a particular stressor.

- System (Sy)
    - Typology:
        - Form: size, shape, energy characteristics (tidal, fluvial, wave)
        - Function: biota, ecology, flushing rate, hydrodynamics, chemistry.
    - Trajectory/Phase e.g. wet/dry season, open/closed
- Vulnerability (Vu) (or Susceptibility)
    - System resilience (fragile to robust) e.g. large open well flushed system vs. periodically closed low flush system
- Pressures (Pr) (or Drivers)
    - Disturbance to form and/or function such as changes in land cover, land use, land practice, population and harvesting of species.
- Stressors (Str)
    - A component of the natural environment that is changed from its natural state by the effect of pressures (e.g. increased turbidity, changed salinity levels, reduced number of target species)

Human Aims: The human aims domain recognizes the influence of societal, political and jurisdictional objectives on the assessment of estuary condition. The aims relate to

both broad human use values (Va) and specific management objectives (Mo). Values of particular estuaries will vary depending on how an estuary is utilized. For example, whereas economic and recreational values may be highly valued in urban estuaries, protecting the conservation values may be a primary objective for pristine estuaries. These differences may be reflected in specific management objectives, such as, NRM resource condition targets and water quality objectives established for an estuary.

Asset Monitoring: The asset monitoring domain includes the use of measurements and observations of resource condition (Ob) in the assessment of current estuary condition. A range of indicators can be monitored to assess condition, for example, ECM Habitat Integrity Resource Condition Indicators; Habitat extent and distribution; Physical/Chemical Condition Indicators; and Biological Condition Indicators.

Assessment (Report) Types

The model also depicts four types of assessments or reports (A1- A4) that are possible given different combination of the information domains.

An **A1 Assessment** evaluates the management objectives or values assigned to that estuary against an understanding of the system type. This does not require information about current estuary condition gained by monitoring. An A1 report can be a simple descriptive report that relies on collation of existing data from the assets context domain, to a detailed risk assessment.

Applications: Assessments of vulnerability and risk (*sensu* Moss *et al.* 2006); identification of 'priority' estuaries; mapping; inventories; and conceptual models.

An **A2 Assessment** reports on aspects of the estuary that the community values or are recognised as of potential interest without reference to, or understanding of, the estuarine system.

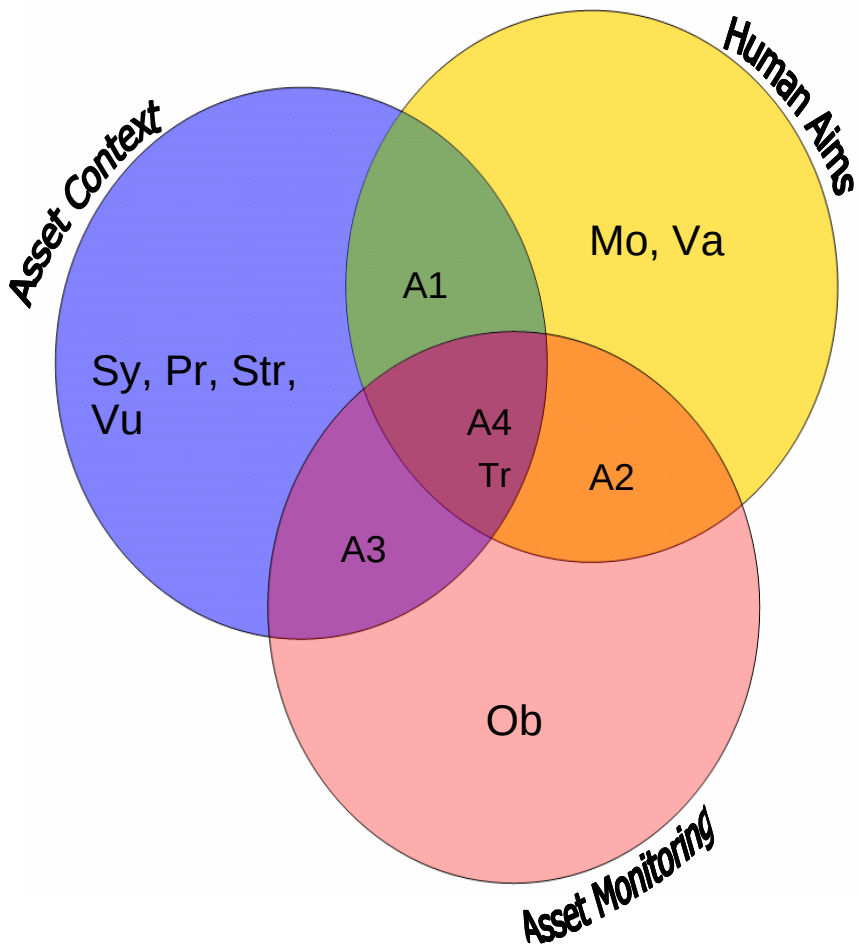
Applications: Developing information base; surveillance; community engagement/capacity building projects

An **A3 Assessment** provides information gained by monitoring various estuarine components. Enables an understanding of the system to be developed but the results are not related to management objectives.

Applications: Research reports; monitoring of estuarine systems to establish management objectives and identify potential indicators

An **A4 Assessment** provides information about the condition of the estuary, informed by information about the monitoring data and evaluated against specific management objectives.

Application: Full resource assessment; establishment of trigger levels and /or reference conditions



Domain Component		Example
Sy	system type	Tidal, tropical estuary, large fluvial flows
Vu	vulnerability	High resilience due to high flushing rate
Pr	pressure	Catchment clearance, farming land uses, increasing population
Str	stressor	Increased nutrients
Ob	observations	Turbidity measurements
Mo	management objectives	Water clarity objective
Va	values	Ecosystem (biodiversity) and human use (aquaculture, tourism)
Tr	triggers/alerts (reference)	Set to 90th percentile

Figure 5. Information domain conceptual model for NRM ECM reporting and assessments. Information domains (Asset Context, Human Aims and Asset Monitoring) provide the basis for various types of assessments, here represented by the overlaps between the information domains (See Table 1 below). For example, full resource condition assessments (A4), such as indicator reports; require information from all three domains

Table 1.Assessment (Report) types (A1-A4) that are feasible with any given combination of information domains as shown by the overlaps between the domains presented in Figure 1. Weaknesses of each type are also identified.

	Examples	**Weakness**
A1	Capability, suitability, vulnerability, perturbation, hazard, risk, inventory, conceptual models	Current condition and trends not available
A2	Surveillance, early warning	Poor causal linkages
A3	Knowledge quest, research reports	Lack of management relevance
A4	Full assessment including A1-A3 (with trigger levels)	Complex, long time frames, expensive

1.5.2. The ECA Framework

The Information Domain Conceptual Model demonstrates that reporting on resource condition is a "high level" activity (i.e. A4 type assessment) and requires a significant amount of information from all three domains (i.e. information about the form and function of the system, results of monitoring and clearly established objectives). The analysis also identified that much of the contextual (e.g. form and function) information is more readily available and is also highly pertinent to management.

For most Australian natural resource systems, information is not available to undertake a comprehensive resource condition assessment. A flexible, layered assessment framework is proposed to enable reporting at different stages of the management cycle with varying levels of information. The Framework does not prescribe aims nor identify specific asset or threats to be monitored (this occurs at a regional or state level) but ensures that assessments occur within a common structure, thereby facilitating consistency in approach, data collection and reporting.

The draft framework presented here is synthesised from the reviewed frameworks and incorporates comments and discussions with key estuarine managers and researchers from around Australia and builds on the learnings from the National Indicators Workshop held in Hobart in February 2006.

The logic of the draft Framework is presented in Figure 6. It introduces the concept of a multi-layered system The layers in the system are referred to as "First Pass", "Second Pass" and "Third Pass" to align with the notion that these are **activities** likely to be conducted by those with NRM reporting responsibilities.

An increasing level of information is required moving from First to Third Pass assessments. At the end of each Pass, priority estuaries can be identified so assessments that require more intensive data collection are focused on progressively fewer estuaries. For some estuaries, movement to second or third passes may not be necessary.

Monitoring programs are only implemented once key assets and stressors are known and appropriate indicators identified.

The approach outlined is consistent with, and provides a method and reports for, each phase of policy development. In summary, the "Passes" are:

First Pass: Understand. Characterise the assets and threats (pressures). Assess vulnerability (susceptibility). Key aims of this pass are:

To assess what we have got and how it works

Second Pass: Prioritise. Focus on key issues and locations. Identify causative linkages. Identify and implement actions. Key aims of this pass are:

To prepare for action via prioritising and identifying actions and their associated monitoring programs.

Third Pass: Adapt. Assess performance of policy and actions i.e. adaptive management. Key aims of this pass are:

Assess how things are going and identify what we need to change.

1st Pass Assessment (Understand)

A 1st Pass focuses on increasing our understanding of the estuary by assembling what is known about an estuary, including the catchment. This requires collating existing data and/or some limited data collection but is not reliant on the results of a monitoring program. Human Aims may not be explicitly stated but the value assigned to particular estuaries will to some extent drive data collation. Reports produced at this stage are A1 type assessments.

The 'Estuary Description Assessment' identifies characteristics of the estuary (potential assets) and its pressures (potential threats) and resultant stressors on the assets. A 1st Pass assessment would also enable the vulnerability (*sensu* Moss *et al.* 2006) or susceptibility of estuaries to be determined. While the vulnerability of an estuary varies depending on the particular stressor, factors such as flushing rate and entrance status modify the threat from several stressors, such as toxicants and nutrients, and will be relevant to many estuaries.

A 'Vulnerability Assessment' allows priority estuaries to be identified and management effort and further data collection to be better targeted.

A 1st Pass assessment enables more specific 'Human Aims' to be established. For example, input into the identification of assets and threats by experts and stakeholders, identification of suitable levels and types of use (e.g. multiple uses vs. conservation) and setting of broad resource condition targets (e.g. 10-20 yr time frame).

2nd Pass Assessment (Prioritise)

A 2nd Pass assessment uses the information collected in the 1st Pass to prioritise key assets and threats. While the vulnerability assessment identifies the susceptibility of the system to various stressors, the level of pressures and/or stressors is required to ascertain risk (Moss *et al.* 2006). For example, an estuary (or estuarine asset) is at high risk if it is subject to a high level of pressure (e.g. high nutrient load) and also highly vulnerable to that pressure (e.g. intermittently closed).

A 'Risk Assessment' enables prioritising of the assets, specific management actions to be identified and resource condition targets set. The resource condition indicators selected for inclusion in a monitoring program will depend on the stressors present in the estuary. For different stressors, Scheltinga et al. (2004) suggests physicochemical and biological indicators to assess condition and others as indicators of habitat extent.

Both 1st and 2nd Pass assessments are A1 type assessments.

3rd Pass Assessment (Adapt)

A 'Resource Condition Assessment' is a comprehensive A4 type assessment undertaken following implementation of management actions and incorporating the results of monitoring programs. It enables trends in the resource being monitored to be tracked. This information can be used to assess and refine management actions, evaluate resource condition targets and where required set trigger or alert levels.

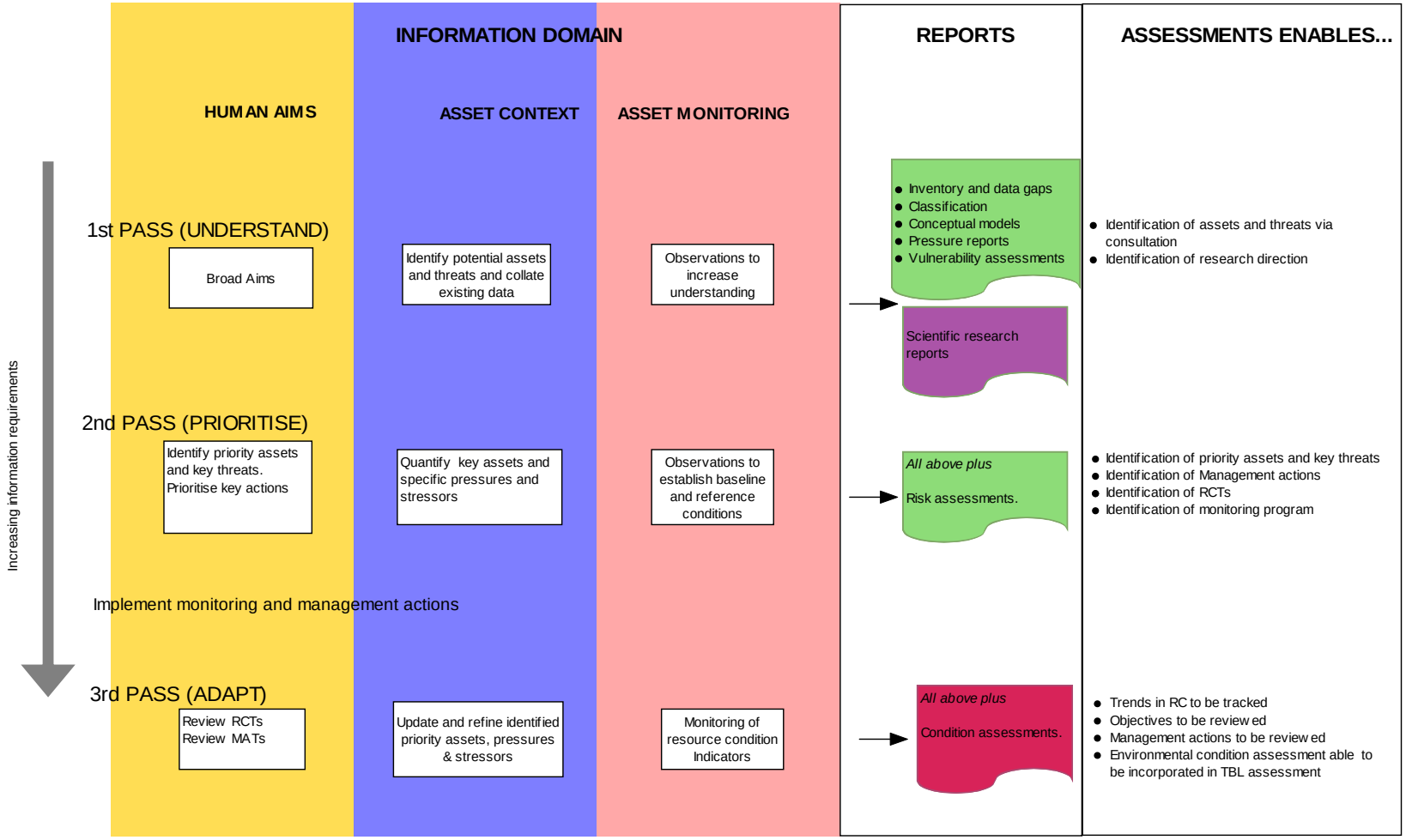


Figure 6 The National Estuarine Environmental Condition Assessment Framework. Colours relate to the information domains and assessment types in Figure 5 and Table 1

1.6 Definitions

Asset: The attributes of a system that hold value for the community and about which the community would be concerned if they were lost or degraded (DNRE 2002)

Condition (State): The state or health of individual animals or plants, communities or ecosystems (Scheltinga 2004).

Framework Component: A major element of the assessment framework, such as Audience, Purpose, Scope, Mapping Protocol, Classification Systems (Typology and Trajectory), Vulnerability Assessment, Risk Assessment, Indices (Themes) and Indicators, Reporting (Report Carding)

Framework Structure: The organising principles and overall approach underpinning the framework. For the NEECAF, it consists of the flexible, layered First, Second and Third Passes.

Indicators: Processes, species or community characteristics of a particular habitat that are indicative of a particular set of environmental conditions (Barton 2003).

National: An adjective describing something that is produced or agreed by jurisdictions at all levels including the Australian Government, State/NT Governments, NRM Regions and Local Governments.

NEECAF: National Estuarine Environmental Condition Assessment (ECA) Framework. A framework developed and adopted by regions states/territories and the Australian Government

Pressure/ Driver: Factors that impact on aquatic ecosystems and includes pollutants, changes to habitat, changes to flows, pest species and direct human impacts such as fishing (Moss et al. 2006).

Risk: Definition 1: Considers the likelihood and consequence of an event occurring (AS/NZS 1999) Definition 2: Considers the vulnerability of the system and the intensity of the pressure (stressor) on, a system – a highly vulnerable system exposed to a high level of pressure is considered at high risk (Moss *et al* 2006). Definition 3: Considers the importance of an asset and the intensity or strength of a threat (Heron and Sovitslis unpublished.)

Stressors: Major components of the environment when changed by human or other activities can result in degradation to natural resources. Stressors can be a component of the environment that is changed from its natural state or a component not usually present in natural (healthy) ecosystems (Scheltinga 2004).

TBL: Triple bottom line - decisions that consider economic, social and environmental factors

Threat: A source of impending danger or harm to the condition of natural resource assets or the services they provide. Can include both pressures and stressors

Trajectory / Phase: An aspect of the system that varies with time e.g. wet/dry season and open/closed estuary

Value: The worth we assign to an estuary or attributes of an estuary. These are reflected in the management objectives for the estuary

Vulnerability: The resilience or sensitivity of the system to a stressor (Moss *et al*. 2006).

1.7 References

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Appendix 1. National Outcomes and Minimum Set of Regional Targets

National Outcomes The national outcomes are aspirational statements about desired national natural resource outcomes	**Matters for which Regional Targets must be set**
	Resource Condition Matters for Targets
1. The impact of salinity on land and water resources is minimised, avoided or reduced. 2. Biodiversity and the extent, diversity and condition of native ecosystems are maintained or rehabilitated 3. Populations of significant species and ecological communities are maintained or rehabilitated. 4. Ecosystem services and functions are maintained or rehabilitated. 5. Surface and groundwater quality is maintained or enhanced. 6. The impact of threatening processes on locations and systems which are critical for conservation of biodiversity, agricultural production, towns, infrastructure and cultural and social values, is avoided or minimised. 7. Surface water and groundwater is securely allocated for sustainable production purposes and to support human uses and the environment, within the sustainable capacity of the water resource. 8. Sustainable production systems are developed and management practices are in place, which maintain or rehabilitate biodiversity and ecosystem services, maintain or enhance resource quality, maintain productive capacity and prevent and manage degradation.	1. Land salinity. 2. Soil condition. 3. Native vegetation communities' integrity. 4. Inland aquatic ecosystems integrity (rivers and other wetlands). 5. Estuarine, coastal and marine habitats integrity. 6. Nutrients in aquatic environments. 7. Turbidity / suspended particulate matter in aquatic environments. 8. Surface water salinity in freshwater aquatic environments. 9. Significant native species and ecological communities. 10. Ecologically significant invasive species.
	Management Action Matters for Targets
	1. Critical assets identified and protected. 2. Water allocation plans developed and implemented. 3. Improved land and water management practices adopted.

Please note: This table should be read in conjunction with the National NRM Monitoring and Evaluation Framework and the table describing "National Outcomes, Matters for Target and Performance Indicators"

Appendix 2. Current nationally agreed Estuarine, Coastal and Marine (ECM) Indicators

NM&EF indicator heading	Indicator
Estuarine, coastal and marine habitat extent and distribution	1 Extent and Distribution of key habitat types
Estuarine, coastal and marine habitat condition	**Biological condition** • Algal blooms • Animal or plant species abundance • Chlorophyll a • Coral bleaching • Mass mortality events • Pest species (number, density, distribution) • Targeted pathogen counts • Vertebrates impacted by human activities **Physical/chemical condition** • Dissolved oxygen • Nutrients • pH • Presence / extent of litter • Salinity (EC) • Sedimentation/erosion rates • Shoreline position • Temperature • Toxicants (in water / sediments / biota) • Turbidity / water clarity

Appendix 3. Principles of the National NRM&E Framework

The National Framework is based on principles which ensure that processes within the framework are useable, cost-effective, accurate, comprehensive and transparent. The Framework is structured so that it:

(a) is **useful for all partners in natural resource management** – Commonwealth, States and Territories, and regions, communities and industries.

(b) is **simple, cost-effective, affordable and practical**. To suit these ends the data infrastructure required to support the framework should:

- *avoid duplication of effort*, and maximise the benefits of earlier investment in data collection, by building on existing State, Territory and Commonwealth initiatives for developing and sharing of data such as the NLWRA and State of the Environment reporting;
- *use data for multiple purposes*, where ever possible. In particular, data are collected so that they can be used for both monitoring resource condition and assessing program outcomes. This requires data to be collected in such a way as to permit their use at a range of scales and levels (national, state, regional and local);
- *ensure that users can obtain the data*. Data are easily accessible to all sectors of the community in format, location, cost and under conditions that do not inhibit their use; and
- *ensure that users can easily find out whether suitable data already exist.* All data are documented in the Australian Spatial Data Directory with sufficient information for users to determine whether the data are suitable for their intended purpose.

(c) recognises that **NRM interventions encompass a range of time-scales**.

(d) supports **meaningful interpretation of data over time** by establishing standard national indicators, protocols for their sampling, measurement and interpretation, and data quality and management requirements

(e) **specifies assumptions** on which monitoring and evaluation activities are undertaken in a consistent manner which is open to all stakeholders

2.0 National Marine ECA Framework Round Table Structure and Content

2.1 Background

The round table is an opportunity to explore the potential for developing a national marine assessment framework

The National Marine Environmental Condition Assessment Framework round table is an opportunity to review the NEECAF, assess its suitability and make recommendations for undertaking marine assessments at a national level.

At the NEECAF round table held in Melbourne in October 2007, participants, from all states and territories, supported the concept of the framework to guide estuarine assessments. In addition, participants agreed that state and regional estuarine assessment and management tools currently employed are compatible with the NEECAF; identified the key components of the framework; and made recommendations for improving the NEECAF (Arundel and Mount 2007).

The results of this roundtable will:

- Provide input to a scoping report which will recommend to the Audit a suitable assessment framework and mechanisms for conducting the national estuarine, coast and marine assessment (Scoping report due April 2008), and
- Provide the foundation for a national workshop on NRM ECM report carding (March 2008)

2.2. Objectives of the Round Table

Specifically the objectives of the National Marine ECA Framework workshop are to:

- **Identify the structure and potential core components for a viable marine Framework**
- **Identify what needs to be done to produce and implement a marine Framework**

To achieve these objectives, the round table is designed to provide a structured opportunity to:

- Clarify the need, purpose, scope and audience for a Framework
- Clarify and seek agreement on definitions and terms used in the framework
- Assess and modify a proposed outline for a NEECAF that has been synthesised from the existing frameworks. By doing so,
    - Identify core components required for a Marine ECA Framework.
    - Identify content and methods of core components
- Discuss the necessary next steps for developing and implementing a Marine ECA Framework

2.3. Methodology

The national round table is convened to facilitate discussion with key marine researchers and managers (Appendix 5) and provide a range of opportunities for participants to assess and provide feedback on the feasibility of developing a practical Framework.

Discussions and activities at the roundtable are designed to provide further information about the Framework and address the following questions

- What value is the Framework to you?
- Does what you are doing in your state or territory fit with the Framework?
- What are the main requirements of a national Marine ECA Framework?
- What are we aiming for?
- What aspects of the Framework need to be resolved to improve its value?

2.3.1. NEECAF Core Components

Drawing on the Framework proposed in Figure 6, the following are potential core components of an assessment framework: The Round Table will explore the value of these components to a Marine ECA Framework. The following questions are to be viewed simply as discussion starters.

Audience

Condition assessments are a valuable resource for a range of stakeholders including industry, tourism, fisheries and environmental managers.

Will the audience for a marine assessment report determine what is reported?

Scope

What criteria should be used to delineate the marine environment when undertaking condition assessments?

Vulnerability Assessment

Identifying the vulnerability of systems is considered a valuable 'First Pass' report for estuaries. Although the vulnerability of a system will vary depending on the stressor, flushing time and length of entrance closure are often used to assess the vulnerability of estuaries to a range of stressors.

Is vulnerability a useful component of marine assessments? If so how could it be measured?

Risk Assessment

Risk is incorporated into several estuarine, marine and freshwater assessment programs, however, the definition of risk varies with programs. Rissik *et al* (2005)) determine risk by comparing the level of pressure with the vulnerability of an estuary to that pressure. The risk to Victorian Rivers is calculated from a matrix of the value of an asset compared with the level of threat to that asset (Heron and Sovitslis unpublished.)

Is risk a useful component of marine assessments? If so how could it be measured?

Assets/Threats/Stressors

What are some key assets and threats in the marine environment? What criteria could be used to group them in a way to assist assessment and/or reporting?

Classification Systems (Typology and Trajectory)

Estuarine classifications such as wet/dry season and open/closed estuary entrance denote different phases in estuaries and are potentially useful for inclusion in assessments.

Are there any similar classifications in the marine systems that would assist with condition assessments or interpreting reports?

Reporting and Report Carding- Any ideas or interesting existing examples of reporting on marine condition are very welcome. However, reporting will be the focus of a separate workshop in Brisbane in March, 2008

2.4. References

Arundel, H. and R. Mount (2007). National Estuarine Environmental Condition Assessment Framework Round Table, National Land and Water Resources Audit.

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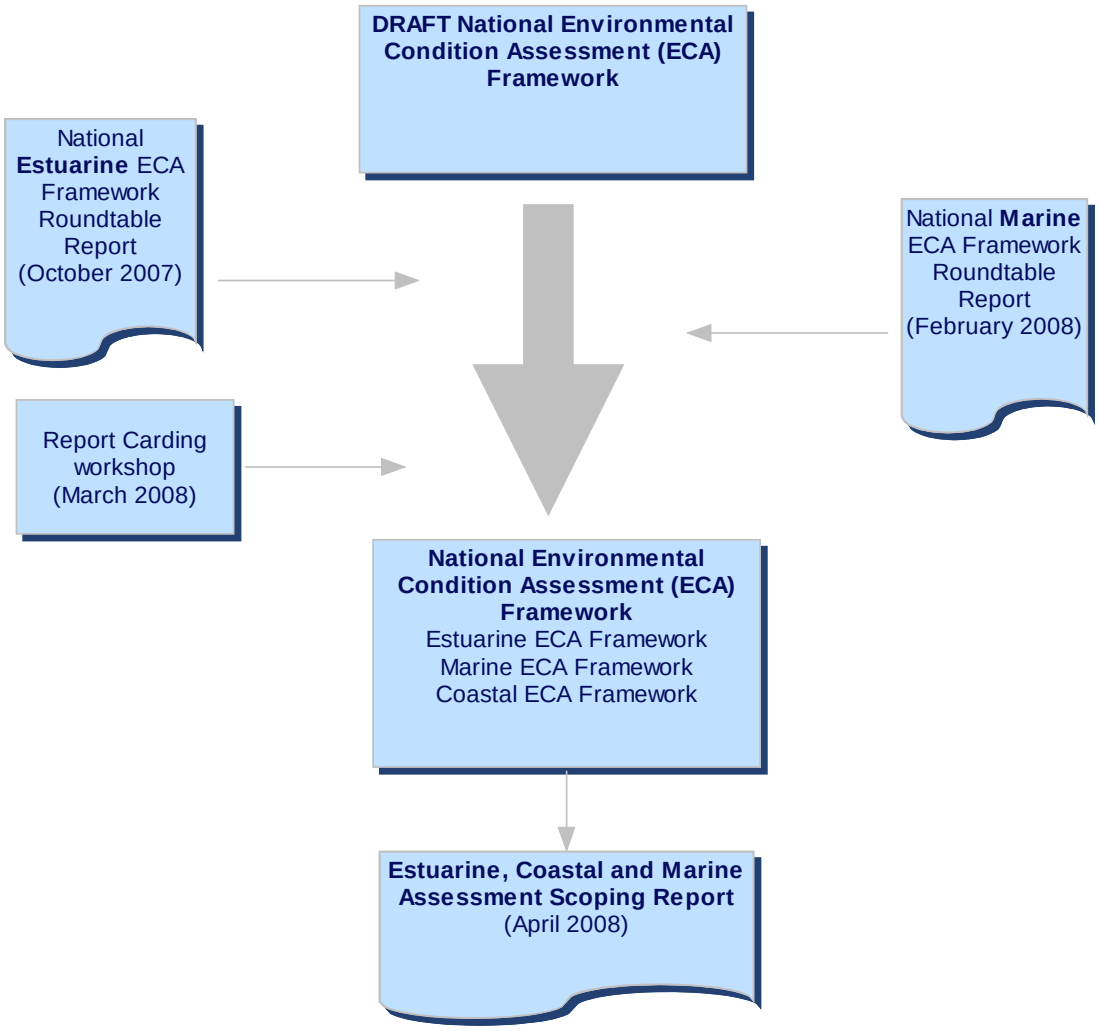
Appendix 4. Development of the National ECA Framework. Relationship with other reports and workshops



Appendix 5. Participants in the National Marine ECA Framework Round

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Mark Butz		Facilitator	

3.0 National Marine ECA Framework Round Table Review of Existing Programs

The review includes a brief summary of relevant frameworks used in the assessment of marine and where relevant, estuarine systems, both interstate and overseas. It is presented as a quick reference to facilitate discussion at the roundtable. We have attempted to identify the key components of the frameworks and denoted where possible assessment types and indicators used.

State of the Environment Reporting

State of the Environment reporting is regularly undertaken (approximately every 3 to 5 years depending on jurisdiction) at a national level, within each state and in some states at a regional level. Reports divide the environment into broad categories called themes (or chapters); for example, the atmosphere, biodiversity, the land, inland waters, estuaries and the sea (or coast and marine), human settlements and natural and cultural heritage. Each theme is divided into Issues (see examples in Table 2 & Table 3) and indicators selected to measure the condition of the environment with respect to each issue.

The Organization for Economic Co-operation and Development's **'pressure-state-response**' model (OECD 1993) provides a framework for selection of indicators for SoE reporting in Australia. The PSR model includes:

- Pressures (or threats) i.e. human activities that potentially impact on the environment;
- State (or condition) i.e. the structure and function of the environment; and
- Response (or actions) undertaken to address pressures on the environment in order to improve or maintain its condition.

The OECD PSR framework does not attempt to specify the causal link between human activities and the state of the environment.

The framework evolved to include **Driving forces** (such as transport e.g. shipping and catchment activities) i.e. a DPSR model. This was further refined to include the **impact** of the pressure on the condition of the environment and create a DPSIR (Figure 7). This variation of the PSR model is used in South Australian and national SoE reporting.

In addition to pressure, state and response, the Western Australian SoE report includes **'Implication'** which identifies the social, environmental and economic consequences of the issue.

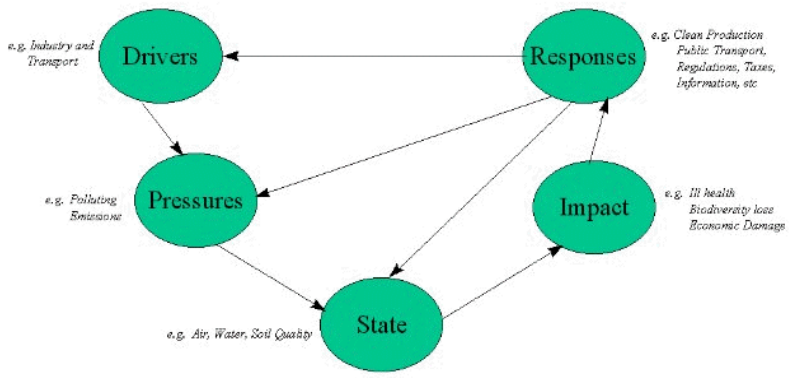

Figure 7. THE DPSIR Framework for reporting on Environmental issues. Source National Strategies for Sustainable Development http://www.nssd.net/graphics/page_title/nssdnet.gif

In order to standardise reporting across Australia, a core set of environmental indicators (ANZECC 2000) was endorsed in 1999 (Table 4). As was anticipated, the core set has evolved, and further indicators have been added in the different states as their suitability and applicability has been tested.

The national SoE report is divided into 9 themes. The Coast and Marine theme is divided into issues under the broad headings of marine biodiversity, pressures on the Australian coast and responses to pressures. Seventy indicators were selected to measure trends or changes in each issue. The contribution of indirect pressures from overlapping themes of: land, inland waters and atmosphere and the ecosystem services provided by the coast and marine are explicitly recognized (Table 2). An example of issues and indicators identified under the Marine theme for a state SoE report are presented in Table 3.

Most Coast and Marine indicators are not supported by state-wide on-going monitoring programs. Therefore, reporting on trends in the indicators over time often relies on use of qualitative data, 'snapshots' in time or programs with limited spatial coverage. Indicators provide a quantitative or often qualitative description of the environment and of potential pressures on the coast and marine, that is, they are **A1 type assessment**. Because a clear causal link between the indicator (e.g. changes in species distribution and extent of habitats) and pressures is not established, differentiating natural variation from variation as a result of human pressure is often not possible. For most issues **broad objectives** are established.

Table 2 Issu**es** identified in The National State of the Environment Report (SoE 2006)

• Condition of the ocean and coastal waters
• Condition of species, habitats and ecosystems
• Condition of marine vegetation
• Condition of fisheries
• Condition of marine genetic diversity
• Climatic and carbon dioxide factors

• Water quality

• Contributions of the coasts and oceans to human life
  o Ecological services (air, water, climate)
  o Food
  o Medicines and other potentially useful biological compounds
  o Non-living material (materials and energy fuels)
  o Non-material values benefits (heritage, recreation, aesthetic and spiritual)
  o Medium for transportation

• Direct pressure of human activities on coasts and oceans
  o Pressure of fishing
  o Direct pressures of harvesting non-living materials
  o Direct pressure of shipping
  o Direct pressure of coastal activities (other than shipping and fishing)

• Contributions and pressures between the coasts and oceans and the atmosphere
  o Climate and carbon dioxide
  o Ozone depletion
  o Airborne substances

• Contributions and pressures between the coasts and oceans and inland water
  o Effect of changes in inland waters on the coasts and oceans
  o Effect of changes in coasts and oceans on inland waters
  o Condition of species at the inland waters-oceans interface

• Contributions and pressures between the coasts and oceans and land
  o Effects of changes in the ocean on the land
  o Effects of changes in the land on the oceans
  o Condition of species at the land-ocean interface

• Societal responses to direct pressures of human activities on coasts and oceans
  o Protection of coasts, oceans and marine and coastal biodiversity
  o Responses to pressures of fishing
  o Responses to pressures of coastal activities
  o Responses to shipping pressures
  o Responses to pressures of harvesting non-living materials

Table 3 Marine Issues and Indicators Source: (EPA 2007) State of the Environment Report WA. Indicator types: P- pressure C-condition

Marine Indicators	**Indicator type**
Headline Indicators	
Indicator M1 Proportion of the marine Environment having defined values	
Indicator M2 Proportion of the marine environment actively monitored for compliance with environmental values	
Degradation of the marine environment	
Indicator M3 Areas and locations of marine habitat which have been lost or seriously degraded by human activities	C
Indicator M4: Areas impacted by trawler activity	P
Indicator M5 Trend over time in environmental impacts of trawling	P
Indicator M6 Areas impacted by overfishing	P
Marine Contamination	
Indicator M7 Levels of nutrients toxicants pathogens compared to guidelines and standards	C
Indicator M8 number of marine algal blooms	C
Indicator M9 Mollusc and sediment levels of heavy metals and tributylin	C
Indicator M10 Number of aquaculture and beach water closures due to detection of pathogens	C
Indicator M11Nutrients entering the marine environments	P
Indicator M12 Toxic compounds entering the marine environment	P
Indicator M13 Pathogens entering the marine environment	
Indicator M14 other physical and Chemical Stressors as pollution in the marine environment	

Introduced Marine Species	
Indicator M15 number of introduced marine species	C
Indicator M16 potential invasive marine species for WA	P
Indicator M17 Compliance of shipping with ballast water requirements	P
Emerging Issue- Marine Debris	

Table 4 Core indicators for Estuaries and Marine.Source ANZECC 2000

Marine Habitat and Biological Resources
Changes in coastal use
Disturbance of marine habitat
Total seafood catch
Estimated wild fish stocks
Estuarine and Marine Water Quality
Coastal discharges
Maritime pollution incidents
Exceedences of marine and estuarine water quality guidelines
Bio-accumulated pollutants
Algal blooms in estuarine and marine environments
Waste water treatment (coastal waters)
Disturbance of potential acid sulfate soils
Global Processes
Sea level
Sea surface temperature

Environmental indicators for National State of the Environment Reporting: estuaries and the sea

A **pressure-state-response** model was used to select a key set of 61 indicators for Australian state of the environment reporting at the national scale (Ward *et al.* 1998). The indicators are classified into eight groups, these are: protected and cited species or taxa, habitat extent, habitat quality, renewable products, non-renewable resources, water or sediment quality, integrated management and ecosystem-level processes. Monitoring strategies and approaches to interpreting and analysing each of the indicators are discussed, and possible sources of data are noted. Recommendations are also made for further development of environmental indicators for estuaries and the sea.

Coastal CRC Integrated Estuary Assessment Framework

The recent Coastal CRC Integrated Estuary Assessment Framework (IEAF) (Moss *et al.* 2006) builds on the Users' Guide to Estuarine, Coastal and Marine Indicators for regional NRM Monitoring(Scheltinga *et al.* 2004), which is also the source document for most of the current national set of indicators. The proposed IEA framework clearly draws on all the information domains including identifying pressures, vulnerability, human use values,

conservation values, desired condition objectives and monitoring of condition. The following section briefly outlines the approach of the framework.

A key goal of the IEA framework is to improve the linkages between the condition indicators and management objectives through the identification, and then monitoring, of environmental stressors. The **stressors** are defined as a component of the environment that can impact on other parts of the environment and can be thought of as carefully defined pressures. These stressors are identified through a process of, firstly, identifying "issues" of concern to the people with an interest in managing the asset (e.g. NRM Regional managers) and then, secondly, identifying the stressor that is most strongly related to the issue. The first stage of identifying the issues can be regarded as an expression of knowledge based in the Human Aims domain, while the linking of the issue to the stressor depends on knowledge drawn from the Asset Context domain, especially including system (asset) typology, trajectory, form and functioning (e.g. ecological, chemical, physical).

Vulnerability is defined as the vulnerability or sensitivity of the system to a stressor and thus its measurement is, in information terms, dependent on knowledge of both the stressor and its interaction with the system. For example, estuaries may be assessed as having relatively low vulnerability to eutrophication if they have high flushing rates. Risk to a system is then assessed based on the vulnerability of, and pressure (stressor intensity) on, a system. Boundaries between categories of vulnerability, pressure and risk are determined with knowledge drawn from the Asset Context and Human Aims information domains. The whole risk assessment process clearly depends on information from both domains.

The measured condition of a system via an indicator is designed to provide both an up-to-date assessment of the condition of a system and, through repeated measures, allow for the discernment of trends in condition through time. The IEA framework specifies that condition indicators should provide information relevant to a specific stressor and the selection of the indicators should be based on knowledge of the stressor impacts (Asset Context domain) as well as the values of interest within the system (Human Aims domain) that are likely to be impacted. The categorisation of indicator measurements into, for example, "good" or "poor" ratings can be done using reference values, i.e. guidelines, alert or trigger values (e.g. ANZECC), or other sources of knowledge. Note that condition ratings relate to human values associated with the system (i.e. management objectives or natural values). Condition measurements and ratings, therefore, draw on all three information domains including the Asset monitoring domain for measurements and a combination of all three domains for guidelines.

The IEA framework then suggests conducting a comparison of **Risk,** as a measure of predicted condition, and Condition, as a measure of the current state of the system. This comparison provides a guide and crosscheck to the diagnosis of the system. The condition rating also may be compared directly with values held by the community to assist prioritising action.

Overall, the proposed IEA framework both implicitly and explicitly draws on all the information domains to be able to deliver a resource condition assessment that is both linked to identified issues and stressors and will assist with directing management actions. Whether this can be achieved is currently being trialled in Queensland.

VPSIRR (Vulnerability – Pressure – State – Impact –Risk and Response):

VPSIRR is a software package based on the Vulnerability-Pressure-State-Impact-Risk and Response model outlined in Moss *et al.* (2006) (Rissik *et al.* 2005). The package enables the user to develop a conceptual model of the system and ultimately determine the risk to an estuary or coastal lake from the pressures and associated stressors acting on the system. The package also provides information regarding quality of data available for the assessment

This framework does not explicitly deal with asset classifications (typologies) or mapping protocols. Trajectories (phases) are dealt with for wet/dry seasonal differences

The South-west Marine Bioregional Plan: Bioregional profile

The Bioregional Profile is the first step in the development of a Marine Bioregional Plan for Australia's South-west Marine Region.

The objectives of the South-west Bioregional Profile (DEWR 2007) are to describe:

- the conservation values of the Region – including marine species, communities and places already specifically protected under legislation, and those identified through the planning process as key ecological features;
- the considerations and information, which will be used to guide the identification of MPAs; and
- ecosystems and human activities.

The Plan identifies 17 key ecological features (or **Assets**) of the south-west region. The rationale for inclusion takes into account; unique sea floor features areas of high biodiversity, feeding, breeding and nursery aggregations; enhanced productivity; and species and species groups with an important ecological role.

Ecological indicators of Commonwealth waters of Australia's exclusive economic zone

A current CSIRO pilot project (lead by Dr Keith Hayes, Division of Mathematical and Information Sciences) is using a qualitative modeling tool and 'loop analysis' to improve both indicator selection and interpretation of indicator trends (C. Marshall pers comm.). The project will be piloted on a selection of key ecological features (**assets**) identified in the South-west Marine Bioregional Plan Bioregional Profile.

In contrast to the PSR model and its variants (which assume relationships between variables to be uni-directional causal chains), the model used in the project requires a network of relationships of the assets to other features and threats(pressures) within the system. A causal network of interactions among the variables will be explicitly described using qualitative models (depicted as signed diagraphs). Uncertainty where the links are not clear and/or where alternative structures are possible will be described with alternative models. Having explicit descriptions of causal networks allows: the model structures to be tested against empirical observations; research to be better targeted to address uncertainty; and the models to be easily updated if required.

Once a qualitative model is produced, loop analysis will be used to make probabilistic predictions of the likely qualitative change to variables (increase, decrease or stay the same) given a particular pressure scenario. The analysis will identify the relationship of pressures (including combinations) on a particular asset. The output from the modeling analysis provides a transparent context for selection of variables as indicators of the asset-pressure interaction. Indicators will be the set of variables that collectively provide an unambiguous signal of response to a specified scenario. In this way, the interaction among variables that are indicators of asset-pressure interactions will be explicitly described.

A 'reality check' will be applied to firstly provide advice on where and when asset-pressure interactions are most likely and secondly to avoid recommending variables that are impractical to monitor. Algorithms will be developed to objectively rank/filter indicators based on the level of threat to the asset, their scientific merit (from analyses outline above) and a number of practical considerations (e.g. cost and feasibility of data collection).

The output from the project will include an evaluation of using qualitative modelling and loop analysis for indicator selection, recommendations for indicators of ecosystem health for the south-west marine region and recommendations for a process for selection of indicators for Commonwealth waters of other regions.

A Strategic Framework for Marine Research and Monitoring in the Shark Bay World Heritage Property

A framework has been developed to identify marine research and management priorities for the Shark Bay World Heritage Property, Western Australia. However the general approach could be applied to any marine system. The recommended first step in the framework is creation of comprehensive databases (**inventories**) to ensure there is an adequate understanding of the physical environment, marine resources and human usage patterns. The importance of this step (i.e. an A1 assessment) is stressed in the report.

Fundamental **research priorities** are determined by scoring the value of the attribute (**asset**) and the adequacy of existing information. The Asset value includes Ecological significance (including trophic status, **vulnerability**, recovery potential and areal extent/biomass), Biodiversity significance (from locally to globally significant) and Social significance.

The level of knowledge is determined according to a matrix that scores the amount of information available in each four categories; inventory, baseline data, monitoring parameters and management targets.

Priorities for Applied Research (i.e. increasing understanding of how the system responds to human pressures), are determined by considering the scores assigned to assets, pressures and level of existing knowledge. Pressures are ranked according to biological intensity, spatial scale, temporal scale, consequences and probability. The output from this step can be regarded as an A2 assessment type

The framework also stresses the need to establish minimum and maximum levels of information required to support a management program. This information should include inventories, baselines, identification of key monitoring parameters and adequate predictive capacity to establish management **triggers** and **targets**

Monitoring priorities are determined by considering the relative significance of the value (asset) and the level of pressure on these values. Priority is given to high value assets that are subject to a high level of pressure.

The Best Practice Framework for the Monitoring and Evaluation of Water Dependent Ecosystems

The Framework (Wilkinson 2007) provides a detailed structure for designing and undertaking a monitoring program in water dependant ecosystems (WDE) of South Australia. Four sequential groups of tasks are identified (Figure 8)

Group 1 – Rationale and priorities. Steps within this section require key questions to be addressed. These include why and if monitoring is required and have alternatives been considered. The next task requires review of monitoring objectives to clearly establish the purpose for monitoring; some options include to better understand the system, to determine effectiveness of management, to monitor change in condition or to provide a snap shot of current condition. Each option requires a different level of monitoring activity. The WDE summary table provides a systematic method for compiling physical and biological information about the system (e.g. **assets**) as does a table to identify and rank **risk** and **threats**.

Group 2 – Conceptual understanding. Tasks in this section include: developing a **conceptual model** to identify influences on the WDE condition; development of Stommel diagrams, which assist with determining the appropriate spatial and temporal scale for monitoring; identifying any events (e.g. seasonal runoff) which are likely to impact on the WDE; and developing a stressor model which indicates drivers, **stressors**, ecosystem responses and indicators

Group 3 – Monitoring program. The tasks in this section are designed to determine: what you need to measure; establish the frequency at which data is collected; and the resources required to undertake the monitoring.

Group 4 – Implement and Assess. This section provides: details of steps required to implement the monitoring program; guidelines for data collection and storage; and information on evaluating and assessing data.

A review assesses the monitoring results against the program objectives and also the effectiveness of the selected indicators. The final step is to incorporate any new system understanding into the WDE conceptual models- consistent with an adaptive management approach.

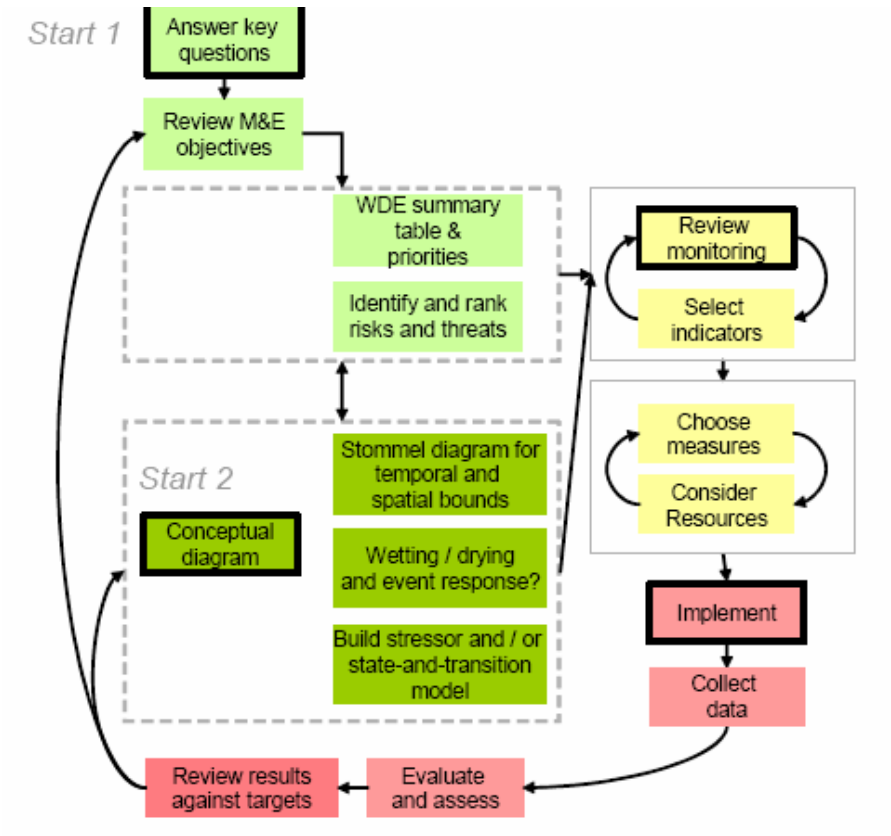

Figure 8. Structure, flow and arrangement of the Best Practice Framework for Monitoring and Evaluation of Water Dependent Ecosystems. Source: Wilkinson *et al* 2007

U.S.A.

The Coastal Research and Monitoring Strategy (CRMSW 2000) integrates monitoring, research and assessment. The strategy allows cross jurisdictional reporting and state-specific issues to be considered in a national context. The strategy is based on the three-tiered approach developed by the United States Environmental Protection Agency (USEPA): Characterisation of the problem (Tier 1); Diagnosis of causes (Tier 2); and Diagnosis of interaction and forecasting (Tier 3) (Figure 9).

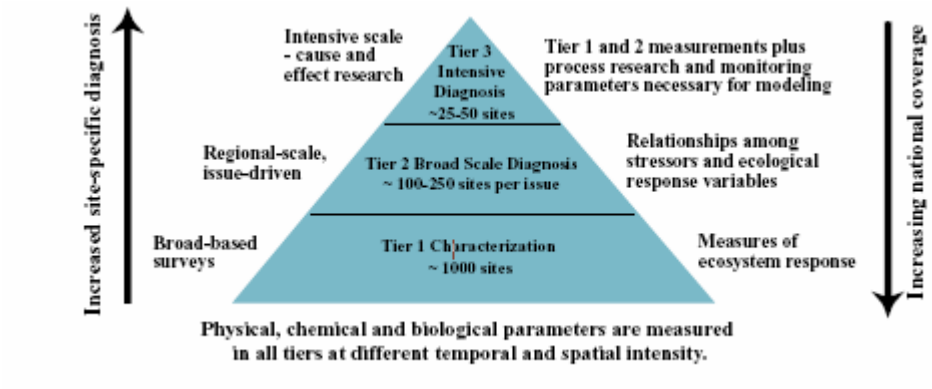

Figure 9. Conceptual framework of a national coastal monitoring strategy. Source CRMSW (2000)

The Strategy anticipates four types of assessments be produced National Summary Assessments; National Habitat Assessments, focused around specific habitats; National Issue-Specific Assessments; and Regional Assessments.

In addition to chemical and physical criteria, the USEPA is encouraging the development of biological criteria for assessment of coastal water and estuarine integrity. A comprehensive technical guide (Gibson et al. 2000), provides advice on sampling design and methods appropriate for different levels of sampling or investigative effort. Methods are divided into 4 Tiers: Tier 0 a review of existing data; Tier 1 a one-site visit to refine information and establish candidate biocriteria; Tier 2 builds on Tier 1 and establishes reference condition data and use biocriteria for management decision making; Tier 3 requires more extensive sampling to establish management objectives for waters that don't meet the biocriteria.

The EMAP (Environmental Monitoring and Assessment Program) was initiated by the EPA and involves a range of state and national agencies. The EMAP estimates current status and trends in the condition of ecological resources (USEPA 2006) and examines associations between indicators and natural and human caused stressors (Table 5).

Two features of EMAP are: the probability-based selection of sample sites and the use of ecological indicators. The data collected during surveys is used to examine the relationships between environmental stressors and the condition of ecological resources. This information is used to develop programs that evaluate, restore and maintain the chemical, physical and biological integrity of coastal and estuarine waters.

The USEPA also investigated classification of estuaries based on the sensitivity of the estuary to particular stressors (U.S. Environmental Protection Agency. 2004). Classification is based on factors such as retention time, ecosystem processing capacity and modifying factors (these alter the relationship between exposure and effect (e.g. pH affects aluminium toxicity and turbidity which alters the amount of carbon fixation from a given concentration of nitrogen and/or phosphorus).

Table 5. Example of indicators measured in the Environmental monitoring and assessment program (EMAP) (U.S. Environmental Protection Agency. 2006)

Coastal indicators
Water Column Indicators
Water Clarity
Dissolved oxygen
Dissolved nutrients (Nitrogen and Phosphorus)
Total Suspended Solids
Sediment Indicators
Silt-Clay Content
Sediment contaminants
Sediment toxicity testing
Biological Indicators
Benthic organisms
Fish-tissue contaminants

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