National Land & Water Resources Audit
An Initiative of the Natural Heritage Trust

Trialing NRM Resource Condition Indicators in the Coastal Zone

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Mount, R.

Natural Heritage Trust
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An Australian Government Initiative

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Postal address: GPO Box 2182
Canberra ACT 2601

Office Location: 86 Northbourne Ave
Braddon ACT 2612

Telephone: 02 6263 6035
Facsimile: 02 6257 9518
Email: info@nlwra.gov.au
Internet: http://www.nlwra.gov.au

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 This project was managed by Rob Thorman, Monitoring and Evaluation Coordinator, National Land & Water Resources Audit, under funding from the Natural Heritage Trust. Further information go to: info@nlwra.gov.au

Table of Contents

Executive Summary

1. NRM Regions are engaging in monitoring and evaluating the natural environment to assist with prioritising investment decisions and providing a basis for reporting on Resource Condition Targets (RCTs). The Estuarine, Coastal and Marine (ECM) Matter for Target (MfT) within the Monitoring and Evaluation Framework listed 31 draft indictors, which were developed by the Coastal CRC for regional reporting purposes (Scheltinga et al., 2004).
2. In Tasmania, the ECM Indicators Working Group was formed with the intent of assessing whether the indicators proposed by the Coastal CRC were suitable for use in a Tasmanian context for both regional and state level reporting. Through an extended meeting process, the group produced a reduced set of indicators and began the process of documenting them.
3. The first part of this project was designed to carry out the documentation process. The result is a set of resource documents, known as the **Tasmanian Indicator Compendium**, which incorporates a **Tasmanian Extension** document for each Indicator. The Compendium helps with ensuring maximum information yields from monitoring investments. The documents largely do this by setting standards in data collection and data management and by identifying relevant data sources for each indicator.
4. The systematic compilation of data sources and metadata relevant to each indicator showed that there are significant opportunities for rapidly implementing arrangements with appropriate data custodians for some indicators (e.g. water quality and pests), while others need further development (e.g. animal species abundance).
5. The second part of this project was a trial that evaluated the pathway to implementing consistent statewide collection and management of Estuarine, Coastal and Marine (ECM) **monitoring data** for reporting environmental condition at the regional, statewide and national level. The participants in the trial were NRM Regional Managers (Directors, Coordinators and Program Managers) and NRM project Service Providers (Proponents or Principal Investigators).
6. The **results** showed that all key participants were keen to make further use of the Tasmanian Indicator Compendium. They were able to express advantages for all involved in the management of the ECM environment, both now and in the future, including:
    - The multiple use of data;
    - the value of data collected with consistent standards;
    - The benefit of data stored in a well managed secure environment; and
    - The value of data documented with quality control “flags” (i.e. metadata).

    The study also found that the Service Providers were already collecting data that is largely consistent with the standards documented in the Compendium.
7. Barriers to implementation included:
    - A lack of policy and capacity at the regional level and among Service Providers regarding data management, including engagement with data custodians, knowledge about data management and development of data management protocols and policies based on best practise principles, and
    - Complications regarding intellectual property (IP), though solutions are canvassed including ways to make the data immediately available for environmental management while protecting researchers’ IP through a “conditional release” strategy.
8. Future directions – please see the Recommendations in the next section.
9. Communications:
    - The interim results of the project were presented at the National ECM indicators workshop in Hobart February 2006.
    - All the Tasmanian NRM Regional Coordinators were briefed on the Compendium.

Recommendations

NRM ECM Indicator Compendium

1. That the Tasmanian NRM Estuarine, Coastal and Marine Indicator Compendium be recognised and used by the NRM Regions to assist the monitoring and evaluation of the condition of natural resources in the coastal zone.
2. That the Tasmanian ECM Indicator Working Group maintains a current version of the Tasmanian NRM Estuarine, Coastal and Marine Indicator Compendium and makes it accessible for general use by coastal zone managers.
3. That the Tasmanian ECM Indicator Working Group continues to identify and/or develop new Indicators, especially higher level or "headline" indicators.

Data management

4. That a set of data management policies be adopted that are based on best practice data management principles including maximising the use of data and minimising duplication of data collection. The policies should address the issues of custodianship, intellectual property, licensing, data formats, metadata, quality control, data maintenance and access arrangements, especially security, sensitive data, and conditional release issues.
5. That suitable data custodians are identified for each Indicator and a simple, practical process for delivering data be established that is consistent with best practise policies. Attention should be given to establishing arrangements for water quality and pest species data first.
6. That in the absence of a suitable data custodian, an interim data storage system is established where NRM monitoring data can be securely stored, managed and accessed.

Capacity Building

7. That capacity building training in information management is made available to assist the process of implementing the Tasmanian NRM Estuarine, Coastal and Marine Indicator Compendium, including the key concepts associated with standardised data management and delivery. The content should make use of the "Natural Resources Information Management Toolkit" (NLWRA & ANZLIC, 2003). Key participants to target include NRM Regional staff, such as program managers and facilitators, and the researchers and consultants providing services to NRM Regions.
8. That the Tasmanian ECM Indicator Working Group oversees the development of interpretive material based on the Tasmanian NRM Estuarine, Coastal and Marine Indicator Compendium that enables their use by a broader range of coastal managers, including community groups.

Reporting and Evaluation

9. That the regions further develop their reporting and evaluation capacity through developing pilot projects via partnerships with the State of the Environment Reporting unit and local, state and national governments. These projects should draw on the knowledge brokering models developed by Land and Water Australia (LWA, 2006) and those presented in the "Natural Resources Information Management Toolkit" (NLWRA & ANZLIC, 2003). Such projects should also be consistent with the "National Cooperative Approach to Integrated Coastal Zone Management Framework and Implementation Plan" (NRM Ministerial Council, 2006).

1. Part A: Indicator Compendium Report

1.1 Summary

NRM Regions are engaging in monitoring and evaluating the natural environment to assist with prioritising investment decisions and providing a basis for reporting on Resource Condition Targets (RCTs). The Estuarine, Coastal and Marine (ECM) Matter for Target (MfT) within the Monitoring and Evaluation Framework listed 31 draft indictors, which were developed by the Coastal CRC for regional reporting purposes (Scheltinga et al., 2004). In Tasmania, an ECM Indicators Working Group was formed with the intent of assessing whether the indicators proposed by the Coastal CRC were suitable for use in a Tasmanian context for both regional and state level reporting. Through an extended meeting process, the group produced a reduced set of indicators and began the process of documenting them. It was notable that a large amount of information and knowledge was required to make judgements about the value of each indicator and an effort was also made to document this knowledge to enable others to access it more easily. This project was designed to carry out the documentation process. The result is a set of resource documents, known as the Tasmanian Indicator Compendium, which are designed to assist those engaged with environmental management in Tasmania, whether at a regional or state level, with ensuring maximum information yields from monitoring investments. The documents largely do this by setting standards in data collection and data management and by identifying relevant data sources for each indicator.

1.2 Background

1.2.1 Description of the Tasmanian context

Tasmania is the smallest state in Australia with only about 500,000 people and about 68,000 km^2 of land, 23,000 km^2 of state coastal waters and 5,000 km of coastline. This project focuses on the coastal MfT and, when compared to other states, Tasmania has about the same length of coast as South Australia and more than Victoria and New South Wales combined. This means that often, there are few people and resources to manage a large resource, and, therefore, an astute application of resources is a necessity.

1.2.2 NRM M&E Framework

The NRM Monitoring and Evaluation (M&E) Framework is structured to enable ready access to monitoring and evaluation information about the health of the natural environment by "all partners in natural resource management – Commonwealth, States and Territories, and regions, communities and industries."

The framework clearly places the regions in a central position with regard to collecting environmental monitoring information. Reporting on the condition of the environment is designed to support future investment decisions, particularly by regions. However, regional reporting in Tasmania is in an early stage of development. There is a demand for reporting at the regional level and the RCT mechanism, which requires annual reports, is in place, though is yet to produce the first round of reports. There is also demand for broader environmental reporting at the regional level in a style more akin to State of the Environment (SoE) reporting, with a reporting period of closer to 5 years (pers. comm. NRM Program Managers). Both of these reporting methods require careful interpretations of monitoring data collected at spatial and temporal scales relevant to the environmental issues with which the regions are engaging.

At the state level in Tasmania there are two environmental reporting processes that make use of indicators, the Tasmania Together system and the 5 yearly State of the Environment (SoE) Reporting cycle. Tasmania Together sets broad goals then assesses the goals via Indicators that are measured against Targets (Benchmarks). Two of the 24 goals (23 and 24) relate to environmental matters

(Tasmania Together, 2001). The SoE unit within the Resource Planning and Development Commission (RPDC) currently reports on a series of Issues and Indicators, many of them similar to the NRM Indicators including ECM Indicators. The unit mostly draws on statewide data sets, typically maintained by data custodians within state agencies and has a 5 yearly reporting cycle.

The M&E Framework also sets an expectation for reporting on environmental condition at the national level. NRM ECM reporting is not currently supported at the national level though efforts are taking place to begin doing so, including through the OzEstuaries web site. Other environmental condition reporting takes place at the national level including comprehensive 5 yearly SoE reports and via biannual headline indicators delivered by the Australian Bureau of Statistics "Measures of Australia's Progress" series (ABS, 2005). The challenge is to make use of the data and information flows taking place at the local, regional and state levels to support meaningful national reporting.

The Tasmanian ECM Indicators Working Group sought to find a set of indicators that would meet these needs.

1.3 The Tasmanian Indicators Working Group

The Tasmanian ECM Indicator Working Group has a membership of key generalist managers and experts engaged in all aspects of coastal and marine management (See Appendix 1 for a participant list). The group considered that the indicators needed to be viable at a state level as that is where much of the environmental management expertise resides and where the information systems used to support environmental management are maintained. Further, much of the collection of new coastal environmental data and information is conducted by organisations that operate across the state, such as the Tasmanian Aquaculture and Fisheries Institute (TAFI) and Aquenal. The group also considered it important to set standards in relation to data collection as the large number of individual projects/investments being conducted could see data sets collected with inconsistent methods, which may mean they could not be used for comparison purposes with either existing or future data sets. This negates the possibility of monitoring through time and also reduces the opportunities for using the data multiple times.

The group set a series of criteria for evaluating each of the indicators, as follows, where the indicator:

1. will allow reporting on change,
2. has an agreed or robust method,
3. is already being reported on for existing purposes,
4. is feasible (in terms of data availability, implementation/agreement of methods and costs of reporting),
5. is cost effective (can use existing information or very cost effective information to collect),
6. is a useful surrogate or keystone species for change in estuarine and coastal ecosystems, and
7. is the most relevant for reporting regionally, and possibly nationally.

These are similar in many ways with the SMART criteria for indicator selection (UNDP, 2006):

1. Simple
2. Measurable
3. Accessible
4. Relevant
5. Timely

A series of issues arose during the process including the definitions of "coastal", "estuarine" and "marine"; where there was overlap with other MfT; how any particular set of indicators operates as a whole; relationships between indicators, stressors and issues. The group resolved the definitional issue

by allocating segments of the coastal/marine continuum into: “estuarine and marine” meaning the subtidal marine environment; while the “coastal and terrestrial” means the intertidal areas and the onshore part of the coastal zone, including saltmarsh. Sub-groups were formed that divided the indicators up as follows:

A. WATER QUALITY/WATER CHEMISTRY

Including algal blooms, chlorophyll *a*, dissolved oxygen, pH, salinity, targeted pathogen counts, total nutrients in the water column with dissolved nutrients in the water column, toxicants, turbidity/water clarity and water temperature

B. HABITAT AND BIODIVERSITY (MARINE AND ESTUARINE)

Including animal or plant species abundance, extent/distribution of key habitat types, pest species (number, density, distribution)

C. HABITAT AND BIODIVERSITY (COASTAL TERRESTRIAL)

Including animal or plant species abundance, extent/distribution of key habitat types, pest species (number, density, distribution)

D. SHORELINE POSITION

Overlap with other MfT, particularly for the onshore component was complicated and further advice was sought from NRM.

1.4 Tasmania’s selected set of ECM Indicators

The finalised list of indicators selected by the Tasmanian Working Group is:

	Physical-chemical condition
1	Dissolved oxygen
2	pH
3	Salinity
4	Shoreline position
5	Dissolved nutrients in the water column
6	Toxicants: biota, sediments and water column
7	Turbidity / water clarity
8	Water temperature
	Biological condition
9	Animal or plant species abundance
10	Presence/extent of litter
11	Mass mortality events (ex Animal kills)
12	Algal Blooms
13	Chlorophyll *a*
14a	Pest species (number, density, distribution) (inter/subtidal)
14b	Pest species (number, density, distribution) (supratidal)
15	Targeted pathogen counts
	Habitat extent
16a	Extent/distribution of key habitat types (subtidal)
16b	Extent/distribution of key habitat types (inter/supratidal)

The full list is also given in Appendix 2 in a table that shows the linkages of each indicator with the various related stressors. After the initial set of indicators was identified, there was a further refinement made during, and after, the national Estuarine, Coastal and Marine Issues and Indicators Workshop held in Hobart on the 21-22 February 2006. The process and outcomes of that workshop are documented in the Workshop Report (Souter and McKenzie, 2006).

1.5 Documentation: Information structuring exercise

The process of documenting the selected set of indicators began with an information structuring exercise. This was considered necessary as the complexity of the subject matter and the ambiguity and multiple uses of some of the terms and concepts made documentation a challenging task. The application of a simple database entity-relationship approach enabled increased clarity about the components of task and their dependent relationships. The key components are Matters for Target; Indicators, Information Products; Data Sources; and Methods. Some further explanation follows.

- Matters for Target
  - An indicator could belong to a number of Matters for Target, for example turbidity or pests.
- Indicators
  - It is noteworthy that some indicators are very specific and deal with the measurement of a single parameter, for example salinity, while others were very broad, such as animal abundance.
  - Some indicators need to be interpreted in conjunction with others and could be considered to be more usefully thought of as essential foundational data rather than qualify as an indicator per se, such as pH, salinity and water temperature. Others are higher level indicators that rely on interpretations or analyses of a number of data sets including animal abundance or toxicant indicators.
  - Each indicator can have a number of data sources, methods and information products. They can also belong to more than one Matter for Target (e.g. Turbidity).
- Information Products
  - Consist of maps, tables, charts and interpreted comment.
  - Depends on level of reporting (national, state, regional, local)
  - Depends on type of reporting (resource condition, trigger level)
  - Note dependence on Triggers and Alert threshold levels.
  - Each Information Product can draw upon one or more Data Sources.
- Data Sources
  - Consists of data sets (typically digital databases including spatial data) and documents (reports/papers).
  - Metadata/citations are associated with each Data Source.
  - Each data source has a series of associated entities and issues clustered with it including:
    - Custodianship (e.g. Intellectual Property, licensing, data maintenance)
    - Data dictionaries, formats and standards (e.g. field definitions, units, coordinate systems)
    - Data storage and access (e.g. data warehousing, data mining, OLAP: Online Analytical Processing)

- Methods
  - The concept of methods is very broad and can be applied at almost any stage of the monitoring and evaluation process, including at the following stages: sampling design; data collection; laboratory analysis and data analysis and interpretation.
  - A number of methods can be used for each indicator and/or data source.

1.6 The Tasmanian Extension document: concept and format

The purpose of the documentation process is to produce a compendium of resource documents that carries a credible rationale and authoritative information to assist applying the indicator in Tasmania. The target audience are natural resource managers including in local and state government, the NRM Regions and project proponents. The documents should also provide assistance when interpreting and reporting on the monitoring data collected with the guidance of the documents.

Following the information structuring exercise and giving due consideration to the needs of each level of reporting (regional, state and national), it was decided to adopt an approach that extended the national indicator to the Tasmanian context rather than writing a new set of indicators for Tasmania. This approach reduces duplication and enables a greater likelihood of creating consistency between the various levels. As such, the national indicators, as presented on the national NRM web site, were adopted as the base documents and complemented with a Front Page and the Tasmanian Extension document.

1.6.1 Indicator Front Page

The front page clearly states the indicator name and provides background and contextual information essential to the use of the indicator including a direct reference to the Coastal CRC User's Guide for ECM Indicators for Regional Reporting (Scheltinga et al., 2004). That document provides a basis for the selection of indicators, including information about NRM Issues and their related Stressors. The front page also carries versioning information, which is a crucial component of a "living" document that is likely to be subject to regular revision as new methods, technical advances or data management changes are implemented. It may be thought of as a "wrapper" for the Tasmanian version of the Indicator.

1.6.2 National Indicator

The national indicator is included in its entirety without any changes. There is an issue concerning the draft (i.e. "For Advice") status of the indicators as any of them may be modified prior to becoming accepted. However, any indicator could be modified whatever its status and it was considered that the proposed format could readily cope with such changes.

1.6.3 Extension Document

Each of the entities defined by the information structuring exercise is included in the extension document plus **Summary** and **Contextual Information** at the beginning. The contextual information firstly, presents an explanation of the environmental and ecological context, if any, that requires a unique application of this indicator in Tasmania. Secondly, a description is given of the current drivers for monitoring this indicator at a statewide level and/or at the regional level, including legislative requirements and existing monitoring efforts. Then, if considered necessary, a critique is made of the national indicator. This is where differences with the national approach are documented.

Following the contextual information is a **Recommendations** section where standards are proposed with regard to Methods, Data Sets, Data Management and Information Products. As this is not a prescriptive document, the language used is to identify "preferred" standards, for example, a

"preferred" methodology for measuring turbidity. A brief description (adapted from the Extension document) is provided for each entity, as follows:

Preferred Methodology/s

This section identifies the method (or methods) that have "preferred" status. Ideally, these are the methods with which all new data are collected, analysed and interpreted OR which are implemented in addition to any other methods.

A brief explanation of the reasons for using each method is presented (e.g. "This is the internationally recognised methodology." OR "Even though this methodology is relatively simplistic and there is currently no central data repository, it will be possible in the future to combine data collected with the preferred method.").

Preferred Dataset/s

This section of the extension identifies the data set (or data sets) that have "preferred" status. Ideally, these are the data sets to which new data are appended.

A brief explanation of the reasons for contributing to each data set is presented (e.g. "Even though these data are collected with simple technology, this is a long term data set that would be useful to extend." OR "This is a well organised and resourced data set that is expected to be maintained by the custodian well into the foreseeable future and has excellent access arrangements in place." OR "This data set is likely to become the new standard in this field.").

Data management

For each "preferred" data set, the protocols required for managing the actual data set are identified. This includes:

- The identification of the "preferred" custodian.
- The identification of suitable access, licensing, intellectual property and quality standards and agreements.
- A description of the standards defined by the data custodian of the "preferred" dataset including the structuring and formatting required of the data itself (e.g. standard coordinate systems, projections, datum, scale, accuracy, file format).
- How to achieve completion of Australia New Zealand land Information Council (ANZLIC) compliant metadata, if required.

Information Product/s

Generally, Information Products need to be specific to the level of reporting (i.e. regional, statewide or national) and therefore need to be defined in the context of the question to be answered. It is at this stage that the quality, or "fitness-for-use", of the data sources is evaluated.

This section provides a description of each of the Information Product/s (IP/s) that is available, if any, to support the Indicator. These can include Indices generated from single or multiple data sets. They may consist of text, maps, tables or charts. Note that it may also include proto-Information Products, that is, potential or incipient Information Products that can be reasonably anticipated to be useful in the future.

The Extension document then presents a list of **References** to enable follow-through on any aspect of the document, which enhances the documents credibility. Finally, all **Data Sources** relevant to the Indicator in a Tasmanian context, including the "preferred" data source are presented in an Appendix. This constitutes a form of high-level **metadata** that is designed to enable rapid identification and location of the data source including direct hyperlinks from within the Extension to web resources.

1.6.4 Tasmanian Compendium of NRM ECM Indicators

The current set of indicators is available in draft form (i.e. Version 1) on the web from www.dpiw.tas.gov.au/coasts in the short term until a more permanent location is identified. A full set is attached to the end of the hardcopy version of this report.

The first versions of the Tasmanian Extension documents were written in collaboration with the specific members of the Tasmanian ECM Indicators Working Group that had pertinent expertise. The documents are currently going though a review process by the whole group to ensure the documents are as accurate as possible prior to releasing the documents into the public domain (i.e. Version 2).

1.7 Future work

Identification of a responsible custodian for the Indicator Compendium

The Tasmanian Indicator Compendium would obtain a higher level of authority and credibility if it is managed by an appropriate body. Perhaps the Tasmanian Indicator Working Group could be placed on a more official basis, or perhaps an agency could provide leadership and/or secretariat services to the group. The indicator documents, including any newer versions, need to be maintained and accessible, ideally, through the Internet. The custodian could host these or ensure that the latest versions are available from an appropriate Internet site, such as Geoscience Australia's OzEstuaries site.

Maintaining document currency

The documents will need to be maintained and upgraded to retain currency and relevance. Some sections of the documents will need developing as management of data progresses. For example, as preferred data sets are identified, and their associated data custodian, then data management protocols (e.g. formats, Intellectual Property, licensing, data access arrangements etc.) can be added to the extension. Similarly, as reporting requirements are confirmed, suitable Information Products can be identified and added.

Addition of new indicators including higher order indicators

Complete new indicators may be developed in response to progress with understanding the environment. For example, there are efforts directed towards developing indicator species, and assemblages (groupings) of species, that are capable of indicating changes in the quality of the estuarine and marine environments (see Appendix 6 for an issues paper). Another avenue for indicator development is the development of higher order indicators, often expressed as indices, which combine lower order indicators into an index of condition. An example of this kind of index is the Disturbance Index presented by Edgar et al. (1999) in their Tasmanian estuaries report.

A process needs to be established that enables new indicators to be added including documentation and conveying of authority e.g. "sign off" by the Working Group. Note that a Sedimentation Indicator is currently under development.

Hierarchical structuring of indicators

There could be consideration given to explicitly configuring each of the indicators into a hierarchical structure with regard to their application. For example, the first simple base level of data collection and analysis should be efficient, low cost and rapid and then, if an alert threshold was triggered, a second more complex, more resource intensive investigative level of monitoring could be instigated. This could then be followed up by further investigations as warranted. The Algal blooms Indicator provides a useful example where this approach could add clarity. For example, Chlorophyll *a* could be monitored on a regular basis and, if set trigger levels are exceeded, more detailed analyses could take place such as cells counts, toxicology and species identification.

Currently, the Tasmanian Extension documents suggest that the Toxicants Indicator should be treated this way, and in a less direct manner, the Algal Blooms Indicator (see the last paragraph of the Discussion). A more explicit approach could be adopted and the first level of methods would probably

provide a useful basis for a simplified community-based guide to monitoring. In addition, there probably needs to be separate recognition of the methods required to establish baselines and trigger levels for each indicator, as this is often requires a higher level of monitoring (e.g. see the Algal Blooms Tasmanian Extension).

Core Indicators

It could be useful to identify a minimum set of indicators for each type of monitoring program. For example, if water quality monitoring is planned, then the document should identify the minimum list of indicators required. This minimum, or "core", set of indicators could be identified by the Working Group for each foreseeable type of monitoring program. This concept could also be applied at the implementation stage by the regions where, conceivably, contracts could contain a listing of a minimum set of monitoring data that each contractor (proponent) needs to collect and deliver during the project.

Community group data collection

Another area that could be usefully developed is a set of preferred methods and datasets for community group participation. By necessity, the first round of documentation has focussed on the primary data collection agents; however significant amounts of good quality data are being, or are expected to be, collected by voluntary community-based participants. It is important that methods are presented in a way that enables high quality data to be delivered into stable, accessible data sets. An excellent example of what is possible is provided by the Northern Water Quality Monitoring Project (NTWQMP, 2005), which is contributing data into the Hydstra water quality database. These data collection protocols could be added as an appendix to each indicator in the Compendium so that it can be provided to interested parties as a simple stand-alone document that provides practical advice for data collection.

Development of the data management infrastructure

The flow of data from NRM projects could be enhanced if suitable custodians could be identified and then protocols developed that facilitate delivery of data including documentation of the data set (metadata) and quality assurance procedures. The second part of the project will explore these themes more deeply.

1.8 Key Learnings

The following key learnings were gleaned during the process of documenting the Tasmanian set of indicators. They are a collection of comments and thoughts that may be useful to others…

- Indicators are only a part of what is needed to obtain information about environmental resource condition – it is also necessary to carefully identify what question you are seeking to answer and then match the indicators to that question.
- Interpretation and reporting transforms monitoring data into information and knowledge that has meaning for resource managers.
- There is considerable infrastructure in place to provide a knowledge brokering service, including the Tasmanian State of the Environment reporting infrastructure.
- There is no "final" set of indicators as knowledge, and the need to monitor, is constantly evolving.
- Incipient indicators are in need of further development, such as shoreline position, sedimentation, shoreline habitat condition and animal abundance.
- There is a need for reference sites to enable comparisons with relatively "healthy" or "near-pristine" sites e.g. one of each type of estuary.
- Warning about how all this talk of indicators is "pie in the sky" unless there is a commitment to long term data collection and storage.

- There are a considerable number of the components in place in Tasmania to create a data infrastructure, especially for Water Quality data and Marine Pests.
- At the very least, implement documentation of the data collection including metadata.
- Attempt to ensure consistency of the data sets through consistent collection methods
- There needs to be some infrastructure for setting data standards, data storage and retrieval.
- Could consider gathering up existing data – a role for a "data archaeologist".
- There needs to be development of higher order indicators i.e. into scorecards. These need to be based on the collected data and enable comparisons of unlike systems e.g. "health" of different types of estuaries.

1.9 Communications

The Indicator Compendium is available in draft form (i.e. Version 1) on the web from www.dpiw.tas.gov.au/coasts

Interim results of the project were presented to the national Estuarine, Coastal and Marine Issues and Indicators Workshop in Hobart 21-22 February 2006. The presentation contributed positively to the dialog taking place at the workshop and the concepts and approaches developed in the project were well received. For example, two similar projects have been funded in South Australia and Queensland explicitly based on the Tasmanian pilot project.

On the 2nd May 2006, the draft (Version 1) Tasmanian Indicator Compendium was presented to all the Tasmanian NRM Regional Coordinators at a meeting in Prospect, Launceston. Again the project and its outputs were very well received, including requests to apply the same approach to all the other Matters for Target. The Coordinators immediately perceived value in the Compendium and expressed a keenness to participate in trialing their implementation, including seeking to incorporate them into the investment contracts.

2. Part B: Trialing Indicators with the regions

2.1 Summary

This trial evaluated the barriers and opportunities to implementing consistent statewide collection and management of Estuarine, Coastal and Marine (ECM) monitoring data for reporting environmental condition at the regional, statewide and national level. The method used to make the barriers and opportunities more explicit was semi-structured interviewing, which is a technique that enables insights and learning from key participants in the NRM program at the regional level. Both NRM Regional Managers (Directors, Coordinators and Program Managers) and NRM project Service Providers (Proponents or Principal Investigators) were engaged as participants. They were all asked about their responses to both the Tasmanian ECM Indicator Compendium and to data management and delivery issues, such as intellectual property (IP), data custodianship and data quality. Questions that were more specific to the type of participant were also asked. The Regional Managers (RM) were asked about the use of the Indicator documents as a resource for supporting both the implementing of contracts as well as receiving monitoring data. The Service Providers (SP) were asked more about data collection and data delivery. A further small study was made into the responses of key participants to plausible NRM project contractual clauses that directly refer to the Indicators.

The results showed that all key participants were keen to engage further with the Tasmanian Indicator Compendium, particularly as a reference document that can support many of the aspects of collecting and managing monitoring data. They were able to express advantages for all involved in the management of the ECM environment, both now and in the future, including: the multiple use of data; the value of data collected with consistent standards; the benefit of data stored in a well managed secure environment; and the value of data documented with quality control "flags" (i.e. metadata). However, more varied responses emerged about IP, especially with regard to the difference between data collection conducted to support a long-term research agenda compared to that collected on the basis of services provided by a consultancy. While the respondents were clearly aware of information management issues, they also exhibited a lack of information management policies, knowledge and capacity beyond, for example, the day-to-day personal data management that SP conducted for specific projects. Apart from some notable exceptions (e.g. SEAMAP Tasmania and Aquenal), there appeared to be little activity in organisational or interagency data exchange.

2.2 Background

Tasmania has three NRM Regions, namely North, South and Cradle Coast (in the North West). These Regions are in their second round of investments and are riding a wave of extremely rapid development in almost every aspect of the administration of the Strategies, Monitoring and Evaluation (M&E) Framework and the Investment Contracts. The establishment of Resource Condition Targets (RCTs) in each of the strategies, and their approaching reporting cycle, has focussed the Regions' attention on the need to monitor the condition of the environment, though there is also an expressed interest in broader environmental reporting (pers. comm. NRM Program Managers). While not every investment is designed to produce information about the condition of the environment, many are, and it is these types of projects that are the particular subject of this study. The relatively new focus (historically speaking) on obtaining monitoring information about the condition of the environment means that much of the data that is currently being collected is also being used to set baselines that will enable future comparisons and the determination of trends in environmental condition (e.g. marine habitat mapping).

The flow of data useful for monitoring is currently limited with much of the data remaining with individual project proponents (see Figure 2). The data are collected to provide the basis for the analysis and interpretations developed within any specific project and to develop the findings delivered in, typically, a Final Project Report (see Figure 1). With the relatively large number of

individual projects conducted by the NRM Regions, there are opportunities for capturing and pooling data and thus enabling its reuse. This has many potential benefits for all levels of management (see Figure 3), as noted in the Data Management Principles listed in the "Natural Resources Information Management Toolkit" (NLWRA & ANZLIC, 2003).

While state and national environmental managers have an interest in obtaining access to the data and information flowing from the investments, the majority of data collection and interpretation is taking place at the regional and subregional level (see Figure 1, Figure 2 and Figure 3). The purpose of this study is to trial the newly developed Tasmanian Indicator Compendium with the key participants at the regional level, that is, the NRM Regional Managers (RM) and the project Service Providers (SP). Some specific NRM projects were identified as representative of work contributing to monitoring in the Estuarine, Coastal and Marine areas. These projects are listed in Table 1.

Table 1. Projects involved in trialing the Tasmanian ECM Indicators Compendium.

Project	NRM Region
Condition Of Rocky Reef Communities, A Key Marine Habitat Around Tasmania	Statewide (Cradle Coast)
Biodiversity And Degradation In North-Western Tasmanian Estuaries	Cradle Coast
Mapping Estuarine And Marine Habitats In The Southern NRM	South
Environmental Flow Regimes For Estuarine Health And Productivity (Little Swanport)	South
Foreshore Condition Assessment	South
Develop And Implement A Framework To Measure Change In Marine, Coastal And Estuarine Water Quality	South
Establishing A Water Quality Monitoring Framework For Georges Bay	North
Bringing Back The Bay: Water Quality And Marine Habitats In Georges Bay	North
Integrated Catchment Management: Georges Bay, Tamar And Cameron Inlet	North

2.3 Methods

The methods applied consisted of a series of semi-structured interviews with key informants. This approach seeks to gain insights into complex situations where structured interview schedules would fail to anticipate the full range of potential circumstances and understandings of the participants. The methodology is capable of gleaning key learnings from the individuals involved and is able to probe for the underlying reasons for initial responses (Patton, 1990). The method also explicitly acknowledges the interviewer's knowledge and subjectivity and recognises that they are a participant observer.

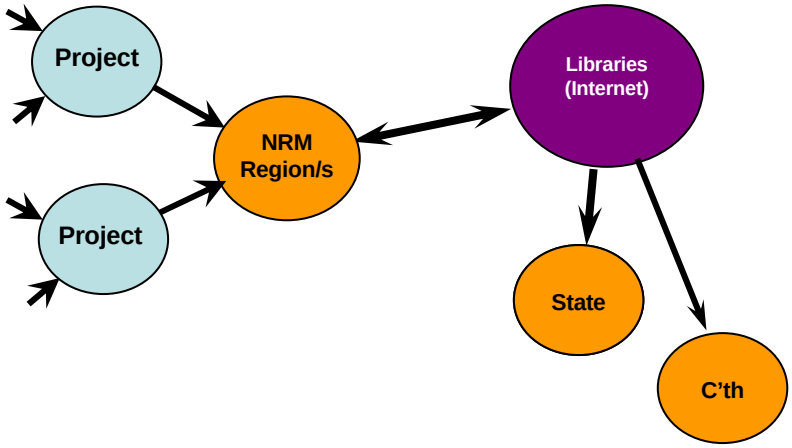

Figure 1. The current flow of information in the form of reports is from the projects to the regions and to the common pool of information stored in libraries and on the Internet.

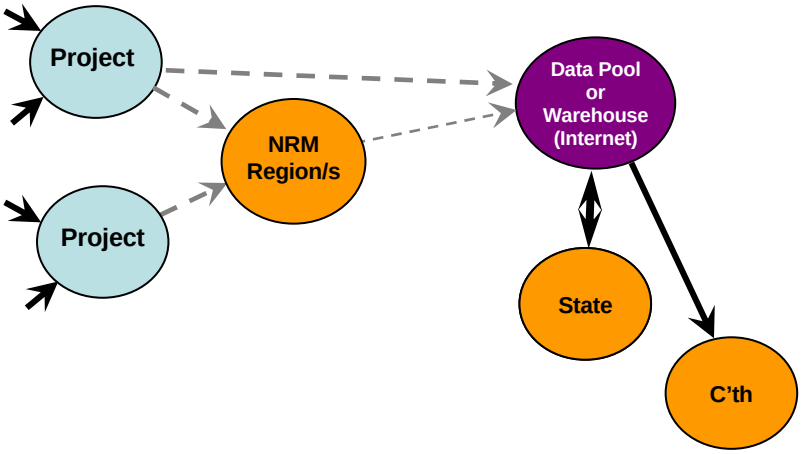

Figure 2. The current flow of monitoring data is poor between the projects and the regions and the regions and the data custodians, which are mostly situated at the state government level.

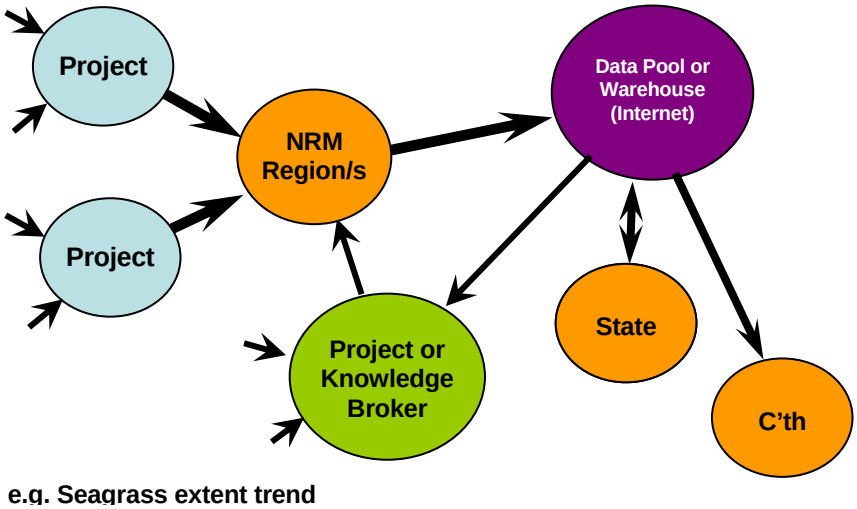

Figure 3. The potential flow of information could be greatly enhanced with the implementation of integrated management best practice guidelines and the principles of good data management (NLWRA & ANZLIC, 2003). The greater availability of data would enable improved interpretation and reporting of environmental indicators to all levels of government including the regions.

Two semi-structured interview schedules were prepared, one for the Regional Managers (RM) (see Appendix 3) and one for the Service Providers (SP) (see Appendix 4). Clearly, assumptions are made about the core subject matter, though the method allows for additional inputs as well. The core subject matter included each participant's responses to the documented Indicators and the issues associated with the collection and management of data suitable for monitoring. For details see the relevant appendices. The interview proceeded as follows:

- Introduction and confidentiality issues,
- Briefing on the ECM Indicator Compendium (in an effort to ensure all participants have consistent information about the Compendium),
- Responses to the Compendium, including an assessment of
    - The indicators themselves and
    - The indicator documents (i.e. base NRM Indicator plus the Tasmanian Extension) as a resource,
- Responses to questions about data management including
    - Data collection (e.g. technical standards) and
    - Data delivery (e.g. custodianship, IP, metadata, data formats, access).

The SP participants were asked to imagine, and discuss, a hypothetical situation where they were required to collect and deliver data to the standards specified in the Indicator Compendium. Similarly, the RM participants were asked to imagine, and discuss, administering a project where the SP was required to deliver monitoring data and the Compendium was used to set the standards. Ten key participants were interviewed and a round table discussion conducted with all the NRM Regional Coordinators at a statewide Coordinators' meeting.

A small number of RM and SP were presented with some hypothetical contractual clauses relating to the NRM ECM Indicator Compendium (see Appendix 5) and asked for a response. It was intended to present the clauses to all participants; however various impediments prevented that eventuating.

2.4 Results: Regional Managers (RM)

Generally, the Regional Managers (RM) responded positively to the Tasmanian NRM ECM Indicators Compendium. They considered that the documents would provide a very useful resource for supporting the implementation of monitoring and evaluation projects. There were strongly affirmative remarks made and requests that this sort of approach be applied to all the other Matters for Target. The documents were anticipated to provide particular value during the contractual negotiations by setting consistent standards. Requests were made for the finalised (non-draft) versions to be made available as soon as possible. They noted that many of the projects relevant to monitoring were conducted by organisations with scientific expertise (e.g. TAFI) and that the documents were pitched to this readership. One request for a simplified version of the indicators was made to enable a wider range of SP to participate with data collection (i.e. "monitoring for dummies"). Another was keen to see the development of higher order indicators so that only one or two indicators would be needed to make an assessment of environmental condition, that is, "going well", "going the same" and "going down".

There was a particularly clear statement by one region that they were definitely not interested in becoming a **custodian** for environmental data. They anticipated that the SP would deliver data directly to the relevant data custodian, which was generally assumed would be part of a State Government agency. They were not quite clear how **quality control** would be implemented and assumed that the obvious person to write **metadata** was the SP, as they knew the most about the data. This is where there are differences among the regions as another region is regularly using spatial data and has a working relationship with a state government agency to support their spatial data usage. A view was expressed that some "in-house" storage and use of data is desirable, though systems are not

yet in place that would enable that to happen. This RM also envisaged that, where appropriate, some data sets would be forwarded to the data custodian.

Intellectual Property (IP) is an issue that is challenging the Regions. There was an apparent desire expressed by the RM to assert a claim over data collected with public monies. The rationale was to ensure broad community benefit was maximised from investments in data collection. The current climate, where IP is becoming more actively protected, was considered to be making agreements about the use of data more complicated to achieve.

The interpretation and **reporting** on indicators, whether for RCTs or more broadly, was of interest to most RM and there was considerable interest in seeking efficiencies through utilising the existing reporting infrastructure, including the State of the Environment Reporting unit. However, one RM expressed that it was currently a higher priority to ensure that the data collection component of the M&E framework was functioning well rather than develop the reporting component. That RM suggested that while the Indicator Compendium provided an authoritative standard setting function, it was also critical to consider the **capacity building** requirements for implementation, including training (e.g. as per the Natural Resources Information Management Toolkit) and support documentation (e.g. check lists and step by step instructions) for both NRM facilitators and SP. The use of the Indicator Compendium in the **contractual** stage of a project was considered likely to be a workable and the draft clauses (Appendix 5) provide a strong basis for further development.

2.5 Results: Service Providers (SP)

The Service Providers (SP) were generally very positive about the Tasmanian NRM ECM Indicator Compendium. One SP was not convinced that community groups and consultants would find them useful as the documents were not simple enough and provided too much background information. Another SP was concerned that inadequate attention had been given to the overall design of monitoring programs and thought that it was critical that each set of specific monitoring questions needed to be carefully matched with a tailored set of indicators. The SP were also clear that, currently, there is often a **severe lack of monitoring data**, and, in particular, biological data. This lack of pooled, accessible data was considered a barrier to developing effective measures of ecological functioning, which requires reference data from relatively undisturbed systems (e.g. estuaries) to establish indicators of "health". For further information, you are referred to the issues paper in Appendix 6 written by Alastair Hirst and the Marine Ecology Group, TAFI (2006) that highlights the current state of estuarine biological indicators based on macroinvertebrates.

All the SP anticipated that benefits would flow from **standard setting** (e.g. via the preferred methods in the Indicators), including the ability to make comparisons through time and across geographic regions. In all cases, the standards set in the Indicators were consistent with the current practices of the SP. Partly for this reason; most of the SP did not anticipate increases in **costs** associated with the delivery of data to a custodian. This view was also supported by the observation that as they need to thoroughly prepare the data for analysis, the extra step of preparing the data for a data custodian would not be particularly onerous. However, one SP did anticipate that there would be extra effort in quality control and writing metadata. They stated that any metadata system needed to be very easy to use including via the use of proformas and drop-down lists. There were some misconceptions and a lack of knowledge about metadata standards.

The concept of **pooling data** to enable multiple uses of the data had general support and is a long held vision by all the SP. One SP noted that obtaining data from varied sources in differing formats and in differing measurement units created significant problems while preparing it for analysis. The issue of **data quality** and was of also clear interest to the SP and they thought it was important to flag the actual range of the errors associated with the data values rather than allocate an arbitrary quality flag, such as "good" or "poor". Historical monitoring data was considered very valuable and likely to increase in value through time.

The attitudes towards **delivering data** were somewhat varied, though all participants expressed a keen willingness to contribute to pooled data sets. One SP thought it would be sensible for NRM to develop

and maintain purpose-built resource condition databases. There appeared to be a lack of awareness about relevant data custodians within the state or nation and a lack of active data management policies within the SP' organisations. One SP considered that it was valuable to have a listing of **relevant data sources** for each indicator, as that would enable a simplified and faster search for other pertinent data.

The issue of **IP** and the need to publish was uppermost for the research-based SP. They all asserted that their livelihood was dependent on publishing and suggested that a conditional release of the data would best suit their needs. This **conditional release** would, ideally, be designed to ensure that the data is not used in publications without some sort of consent, acknowledgement or authorship for the originator of the data. This view was partly based on the notion that they have generated significant IP over periods of time much longer than any single project. In other words, they argued that they had a longer-term approach than any one funding cycle and clearly felt ownership of the overall direction of their research, and, importantly, the data generated by their research. The conditional release of data would enable its immediate use for environmental management purposes and, for some SP, could lapse after a set period of time, such as 2 years. It was envisaged that some data, such as salinity measurements, could be immediately placed in the public domain.

The following are some answers (in blue and in quotes) collected to a subset of the interview questions:

1. **Opening Question**: What is your reaction to the Tasmanian ECM Indicators? Have you any comments you would like to make about any aspect of the Indicators, whether general or specific in nature? You comments could be about the Indicators, the process that was used to identify or document them, or details about how successfully they could be used...
   - "Historical data is very valuable and gives insight into trends – for example, salinity data is often very useful in estuaries."
   - "It is essential to recognise that the indicators, by themselves, are not necessarily very useful as they really need to be used to answer questions about the ecological functioning of a particular system. People need to know what the specific questions are that they need answering before choosing a suitable set of indicators."
   - "Sampling protocols need to be carefully designed so the data can be used to answer the specific question."
   - "Another major need is for reference data or reference sites for each indicator so that comparisons can be made against places that are in good condition. This is hard to do, but if benchmarks aren't set, particularly for biological indicators, it is hard to make a judgement about how things are going."
   - Probe - What indicators need be added or removed, if any?
   - "It is really important for there to be better indicators developed, including ones that operate at a higher level – composite indicators that are based on a series of data sets. This is particularly the case for biological indicators."

2. **Data collection**: Could you please identify any issues you perceive with the use of the documents as a resource when conducting projects, in particular
   - Assistance with identifying standard methods
   - "Data is only relevant if standardised and documented"
   - "It is helpful to state the errors in the collected data including measurement, spatial, temporal and precisions errors."
   - "It is more difficult to state the errors for biological data."
   - Assistance with delivering data in a form suitable for the preferred data sets.
   - "Ideally, NRM should hold the data and start from scratch to develop purpose built NRM databases."
   - "It is annoying obtaining data from a variety of sources and there are always difficulties with merging data – mostly because of differing data formats." Obs: Clearly, the proponent is thinking in terms of retrieving the data in the future.

- Probe – Do your current practices align with the preferred methods, and if not, where are there differences?
- "Yes, they do."

3. **Data Delivery**: Ask them to identify issues with delivering data to NRM regions including Quality Assurance/Quality Control issues, Intellectual Property issues, data management and storage issues.
   - "I have no problems with delivering the data at all – I strongly support the pooling of data as it enables everyone to benefit. Data is expensive to collect and it is great if it gets used more than once."
   - "There may be a need to set a time period before release into the public domain as, after all, the researchers are dependent on publishing papers for a living."
   - "O.K. to deliver data when submitting the final report, but perhaps set a conditional release."
   - "The data must be easy to upload when delivering it."
   - "Entering data manually would be basically unrealistic." Obs: i.e. transcribing data from paper records.
   - "Mostly, the data should be at a good standard as it has been prepared and checked before being analysed." Obs: i.e. re Quality Control - data grooming conducted prior to analysis to remove erroneous data.
   - "There are lots of data sets here – almost all of them are on researchers' hard drives and when a researcher goes, the data often goes missing."
   - Probe – Will this change the way you cost projects?
   - "It is reasonable to consider how much it will cost, though I suspect it won't cost that much more as the data should be in pretty good shape anyway."
   - Probe – What needs to be in place for this to work for you?
   - "Currently, the Regions are very vague about the specifics of data collection, but the onus is on them to obtain the data they need for their Resource Condition Targets. It would be good to tighten up the requirements at the time of negotiating the contract. I suppose at the regions become more aware of what they need they will ask for it."

2.6 Discussion

The recent "National Cooperative Approach to Integrated Coastal Zone Management Framework and Implementation Plan" (NRM Ministerial Council, 2006) highlights the increased focus on enhancing information management in the coastal zone. The following priority areas are especially relevant to this project.

Priority Area 1 (Integration across the Catchment-Coast-Ocean Continuum) identifies a series of objectives and actions that prioritise the development of information management systems including the sharing of knowledge and information and State of the Environment Reporting. One of the objectives relevant to this project is:

- The availability of useful data and, in particular, the usefulness of State of Environment reporting, is increased for coastal managers through improved availability of reliable coastal zone information.

This objective is supported by actions including, "1.5.1 Improve national and state/territory SoE reporting by:

- Identifying key indicators which will allow future trends to be effectively and quantitatively measured,
- Ensuring baseline data against coastal condition, pressure and response indicators is collected in such a manner that it can be effectively coordinated with research about coastal zone pressures and incorporated into strategic planning and decision making, and

- More effectively coordinating the collection by universities and other research organisations of baseline coastal condition, pressure and response information.

Priority Areas 6 (Capacity Building) and 7 (Monitoring and Evaluation) also have information management as a central component including the objective that "Coastal information needs are identified and processes that support information sharing arrangements are supported."

The Natural Resources Information Management Toolkit (NLWRA & ANZLIC, 2003) provides a framework for assessing the current trial. The key recommendation of the Toolkit is to "facilitate the development and implementation of data policies at a local level, which are based on best practise principles, such as those outlined in the *ANZLIC Policy Statement on Spatial Data Management*" (ANZLIC, 1999). These principles include:

- Not reinventing the information management wheel
- Ensuring efficiencies in data collection
- Sharing data wherever possible
- Presenting a sound business case
- Reducing duplication of data acquisition
- Look whether the data already exists before collecting
- Assess whether the data is fit-for-purpose
- Use existing classification systems and standards where possible
- Think beyond the immediate use and prioritise data that can be reused
- Select the most robust organisation as the data custodian
- Ensure metadata is competed for every data set.

At a higher level, the Toolkit specifies a series of components for an integrated information management solution including:

- Management framework
- Supportive information policy and data standards
- Structured data and metadata
- Skilled people and capacity building
- Applications for publishing and access, and
- Clearinghouse and network technology

The recent report on managing NRM spatial data in Tasmania (Lynch, 2005) also highlights the importance of setting data standards and addressing information management issues. The current trial addresses many of these components, though clearly focuses on data standards and data management in relation to monitoring environmental condition.

2.6.1 Tasmanian NRM ECM Indicator Compendium

- The Compendium clearly obtained a positive reception, especially for its perceived value in setting consistent methodological standards for data collection.
- The credibility and authority of the documents were largely unquestioned and the methods presented are highly consistent with current best practise in Tasmanian research organisations and consultants, including those currently conducting the majority of the NRM ECM work. This means there should be few difficulties in requiring SP to adopt the standards.

- There are differences of opinion about how the indicators should be applied and warnings expressed that reference levels for evaluating the indicators need more development, especially for biological indicators such as algal blooms and animal species abundance.

2.6.2 The Indicators as resource documents

- The documents are considered likely to form a suitable basis for setting authoritative standards from within project contracts and provide the current SP with a detailed resource document, including for setting methods, data management and identifying existing relevant data sets.
- There is concern that the documents are overly technical and not directive enough. A proposed solution is to interpret the indicators in the form of a "User Field Manual", or similar, with simplified methods and a step-by-step guide to application, such as would be suitable for a community group. This level of documentation would also identify a "core list" of indicators that every project of a particular type (e.g. a water quality monitoring project) should collect and deliver to a data custodian. Existing resources with a potentially similar style include:
    - The draft WaterWatch "Estuarine Monitoring Users Guide" will be available shortly.

      A series of community monitoring programs on seagrass and intertidal and subtidal reef are documented on the Parks Victoria web site (Parks Victoria, 2006), including, for example, the following on seagrass monitoring: "Sea Search: Community–Based Monitoring of Victoria's Marine National Parks and Marine Sanctuaries - Seagrass Monitoring" (Koss et al., 2005).
- While the Compendium is perceived as providing a technical level of documentation, other aspects of implementing information management policies also need addressing including capacity building through training and support documentation for NRM facilitators and Service Providers. Existing support resources include:
    - The OzEstuaries web site, which has an extensive series of indicator support information (http://www.ozestuaries.org/indicators/indicators.jsp). To quote the web site, "The Coastal Indicator Knowledge and Information System is an information source and education tool for managers, students, researchers and policy makers interested in estuaries and coastal waterways. It comprises information on biophysical indicators, as well as coastal issues and the underlying human activities that give rise to them."
    - The Natural Resources Information Management Toolkit (NLWRA & ANZLIC, 2003) has a series of highly relevant training modules that could be offered.

2.6.3 Data collection issues

- There was agreement that the standards set in most of the Indicators documents were consistent with those in current use and, therefore, no problems were anticipated in meeting the stated standards. However, some indicators contained standards that were less clear. For example, the algal blooms indicator met with some strong debate about how to implement a monitoring program (please see the indicator for a description of the various views). Without going into detail, some indicators were less resolved with regard to their methods and interpretation. This reflects the reality of the situation, as many of the indicators evolve through time in response to changing technology and knowledge. The Animal and plant species abundance Indicator and the Toxicants Indicator are two other cases in point.
- There was concern expressed that the regions, or any other organisations endeavouring to monitor the natural environment, need to carefully frame the questions they are attempting to answer and then design a suite of indicators that will support answering those questions rather than simply use a set list of regularly used indicators. The Coastal CRC "Users' Guide to ECM Indicators for Regional Monitoring" (Scheltinga at al., 2004) provides a useful basis for identifying NRM environmental issues and how to select a suitable suite of indicators.

2.6.4 Data delivery issues

Clearly, both the RM and the SP were entering uncharted waters with regard to the delivery of data. A series of issues were presented that will require attention and resources to address including the identification of data custodians for each data set (and all the associated issues of metadata, licensing, data formatting and access) and the resolving of intellectual property (IP) rights. Lynch's (2005) recommendations are highly relevant here and should be considered.

- The overriding philosophy of **data custodianship** is defined in the ANZLIC "Guidelines for Custodianship" (1998) as "is that custodians manage the spatial information as trustees for the community to enable the integration of spatial information." There is a need to identify suitable custodians for each indicator and to put in place arrangements for the straightforward transfer of data into the care of the custodians. Care should be taken to ensure adequate protection of IP (see the next section) and that timely access is assured for environmental management purposes. Training, or at least, straightforward support documentation or data templates need to be available for SP to minimise any additional workloads and ensure maximum efficiency.
- Whether for RM or SP, the **IP issue** is often challenging, and most participants appeared to be unaware of the consequences of their decisions about IP. However, all participants were aware that IP is definitely on the agenda for their respective organisations. There appeared to be other issues clustered around IP including frustrations with the degree or speed of access to publicly funded environmental condition information, and, on the other hand, concerns about the possible delivery of painstakingly created IP into the public domain where other can take advantage of the windfall without due recognition to the originators. A clear distinction was presented about the difference between researchers and consultants, where consultants were providing a service for a fee while researchers had a longer term research agenda, which they supported with piecemeal and short term funding for various components. The concept of **conditional release** of data is of interest and well managed data bases can easily implement security policies that would protect IP yet enable the data to be used for environmental management purposes.

2.6.5 Environmental reporting

The general response to the issue of reporting and interpretation of monitoring data was a clear call to make use of existing infrastructure wherever possible. Much interest was expressed in exploring the possibility of a collaborative engagement with the State of the Environment Reporting (SoER) unit to address local and region reporting needs. The identity of organisations or agents who could play a knowledge brokering role was not clearly articulated by the RM; however they acknowledged that SP or organisations such as the SoER unit would be capable of delivering that service.

2.7 Conclusions and Recommendations

The project has initiated the trialing of the NRM ECM Indicator Compendium in the Regions and with Service Providers and has successfully drawn out some of the problems and successes of the Compendium. The successes include the ready acceptance of the Compendium and the consistency of the Compendium standards with the current Service Providers data collection methods. The Compendium trials now need to be ramped up to an actual implementation; however a number of additional components need to be in place, such as:

- The finalisation of the indicators by the TasIndicators Working Group,
- Adoption of best practice data management policies and principles,
- Appropriate data custodians identified and arrangements instituted that address critical issues including IP, formats, access, security and quality.
- The insertion of appropriate data delivery clauses in to the NRM contracts, and

- Capacity building through the training of NRM program managers and facilitators in data and information management (and, where necessary, the Service Providers), and the development of support materials (step by step guides),

Please see the Executive Summary for a listing of the conclusions drawn from the second part of the project and also see the Recommendations section at the head of the document (following the Executive Summary).

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Appendix 1: Tasmanian ECM Indicators Working Group Participants

Chris Rees, Eloise Carr, Greg Dowson, Ian Houshold, Stewart Blackhall, Stephen Harris, Tania Raymond, Rosemary Gales, Alastair Wells, Mike Pemberton, Stephen Gallagher, Alice Morris, Sonia Lloyd and Colin Shepherd, DPIWE;

Nicole Middleton, Tasmanian Coastcare Facilitator;

Christine Crawford and Alastair Hirst, TAFI;

Stephen Waight and Fiona Wells, SoE Unit, RPDC;

Ray Murphy, RPDC;

John Harkin and Chris Cleary, Monitoring and Evaluation, NRM Tasmania;

Fleur O'Neill, NRM South;

Ed Butler and Peter A. Thompson, CSIRO;

Derek Shields, Aquenal;

John Hunter and Richard Mount, UTAS;

Brian Leahy, Tasmanian Shellfish Executive Council;

Brian Smith, Queen Victoria Museum;

Christian Bell, MCCN;

Christine Coughanowr and Ruth Eriksen, Derwent Estuary Program.

Appendix 2: Current Tasmanian Indicator set

		Aquatic Sediments	Bacteria/pathogens	Biota removal/disturbance	Excess freshwater	Excess salt (hypersaline)	Freshwater flow regime	Habitat removal/disturbance	Hydrodynamics	Litter	Nutrients	Organic matter	Pest (plant, animal) species	pH	Toxicants	Water Temperature
	Physical-chemical condition															
1	Dissolved oxygen											X				
2	pH													X		
3	Salinity				X	X	X		X							
4	Shoreline position	X					X		X							
5	Dissolved nutrients in the water column										X					
6	*Toxicants: biota, sediments and water column														X	
7	Turbidity / water clarity	X														
8	Water temperature															X
	Biological condition															
9	Animal or plant species abundance	X		X				X								
10	Presence/extent of litter									X						
11	Mass mortality events (ex Animal kills)											X		X	X	
12	Algal Blooms								X		X					
13	Chlorophyll a								X		X					
14a	Pest species (number, density, distribution) inter/subtidal												X			
14b	Pest species (number, density, distribution) supratidal												X			
15	Targeted pathogen counts		X													
	Habitat extent															
16a	Extent/distribution of key habitat types (subtidal)	X						X								
16b	Extent/distribution of key habitat types (inter/supratidal)	X						X								

Appendix 3: Interview Schedule: Regional Managers

Interview Schedule – NRM Managers (current and imminent NRM projects)

4. **Intro and briefing**: Explain the purpose of the interview and subsequent report – to identify the issues surrounding the implementation of ECM Indicators in Tasmania. Provide a briefing of the TasIndicator Compendium and the focus on **monitoring** (i.e. collection and storage of data).

5. **Confidentiality**: Confidentiality is assured, non-disclosure of personal details, will use the information for the purposes of the report only. Given the size of Tasmania, it **may** be possible to identify someone form their comments. Are you prepared to continue?

6. **Opening Question**: What is your reaction to the Tasmanian ECM Indicators? Have you any comments you would like to make about any aspect of the Indicators, whether general or specific in nature? You comments could be about the Indicators, the process that was used to identify or document them, or details about how successfully they could be used...
   - Probe – Which indicators can you see yourself using?
   - Probe - What indicators need be added or removed, if any?

7. **Documents as a Resource**: Could you please identify any issues you perceive with the use of the documents as a resource when entering into a project agreement, in particular with
   - Identifying standard data collection methods (i.e. preferred methods)?
   - Identifying standard data sets (i.e. preferred data sets) and standard data management protocols?
   - Probe – is there enough detail or too much detail or anything missing in the Indicator documents?
   - Probe – Is the document adequately credible and authoritative?

8. **Data Delivery**: Ask them to identify issues with delivering data to NRM regions including Quality Assurance/Quality Control issues, Intellectual Property issues, data management and storage issues.
   - Probe – where would the data be stored and maintained?
   - Probe – Who would be the Data Custodian?
   - Probe – How do you envisage QA/QC issues to be managed?
   - Probe – who would document the data (metadata)?
   - Probe – where would the metadata be stored and maintained?
   - Probe – who would have access to the data and when?
   - Probe – Do you foresee any IP issues here?

9. **Trial participation**: Would you be prepared to participate in a trial of the indicators with one of your projects?

10. **Further participants**: Can you identify anyone else who would be good to talk to about these things?

11. **Closing Question**: Any other comments or closing remarks?

General Probes: Tell me more about that. Amplify or expand on that. Clarify that.

Appendix 4: Interview Schedule: Service Providers

Interview Schedule – Proponents (current and imminent NRM projects)

1. **Intro and briefing**: Explain the purpose of the interview and subsequent report – to identify the issues surrounding the implementation of ECM Indicators in Tasmania. Provide a briefing of the TasIndicator Compendium and the focus on **monitoring**.

2. **Confidentiality**: Confidentiality is assured, non-disclosure of personal details, will use the information for the purposes of the report only. Given the size of Tasmania, it **may** be possible to identify someone form their comments. Are you prepared to continue?

3. **Opening Question**: What is your reaction to the Tasmanian ECM Indicators? Have you any comments you would like to make about any aspect of the Indicators, whether general or specific in nature? You comments could be about the Indicators, the process that was used to identify or document them, or details about how successfully they could be used...
   - Probe – Which indicators can you see yourself using?
   - Probe - What indicators need be added or removed, if any?

4. **Data Collection**: Could you please identify any issues you perceive with the use of the documents as a resource when conducting projects, in particular
   - Assistance with identifying standard methods
   - Assistance with delivering data in a form suitable for the preferred data sets.
   - Probe – Do your current practices align with the preferred methods, and if not, where are there differences?
   - Probe – Do you comments apply to both Core data, and Incidental/supplementary data?
   - Probe – In the Indicator documents, is there enough detail or too much detail or anything missing?

5. **Data Delivery**: Ask them to identify issues with delivering data to NRM regions including Quality Assurance/Quality Control issues, Intellectual Property issues, data management and storage issues.

   - Probe – Will this change the way you cost projects?
   - Probe – What needs to be in place for this to work for you?
   - Probe – Are you comfortable with documenting the data via metadata?

6. **Trial participation**: Would you be prepared to participate in a trial of the indicators with one of your projects?

7. **Further participants**: Can you identify anyone else who would be good to talk to about these things?

8. **Closing Question**: Any other comments or closing remarks?

General Probes: Tell me more about that. Amplify or expand on that. Clarify that.

Appendix 5: Model contractual clauses for ECM data management

The following clauses were drafted by Richard Mount and Alastair Kay (NRM South Program Manager) to initiate the development of the legal aspects of implementing data management for environmental condition indicators. The clauses are designed to fit into the model contract developed by NRM South and would need to be adapted for other contracts. Please note that they have NOT been reviewed by a lawyer.

The idea is to point at the specific NRM ECM Indicators from within the contract's Schedule but to have fairly generic data management definitions and clauses within the body of the contract. This could enable this sort of clause to work with other Indicators and other Matters for Target.

1.1 Definitions

"Data Custodian" means the Custodian responsible for a specific Data Set as specified in each Indicator Document listed in Item 5 of Schedule 1, or, in the absence of a specified Data Custodian, the NRM Environmental Data Storage System (NEDSS);

"Data Set" means a named collection of data as specified in an Indicator Document listed in Item 5 of Schedule 1, that contains individual data units, usually organised by the environmental condition or state of interest, for example, turbidity or habitat extent;

"Deliverable Data" means the Data Set or Data Sets specified in an Indicator Document listed in Item 5 of Schedule 1 that is required to be delivered to a Data Custodian;

"Indicator Document" means one of the documents listed at Item 5 Schedule 1.

Or maybe:

"Indicator Document" means one of the documents published by the Tasmanian NRM Estuarine, Coastal and Marine (ECM) Indicators Working Group that forms part of the Tasmanian ECM Indicator Compendium;

1.2 Collection and management of data

Data collection and management

If the preferred standards specified in the Recommendations section of the Indicator Documents listed in Item 5 of Schedule 1 are not suitable or are unavailable, data must be collected and managed according to Australian best practice and the NRM South Data Guidelines, otherwise the Service Provider must:

(a) collect and manage the Deliverable Data in accord with the preferred standards specified in the Indicator Documents listed in Item 5 of Schedule 1 including that the methods used for data collection must comply with the standards defined in the "Preferred Methods" section.

(b) provide evidence to the NRM South Delegate that the Deliverable Data has been accepted by the Data Custodian/s specified for each Data Set in the Indicator Documents listed in Item 5 of Schedule 1 including:

(i) that the Deliverable Data was delivered in a format and to a quality acceptable to the Data Custodian,

(ii) that metadata about the Data Set was delivered in a form acceptable to the Data Custodian, and

(iii) that licensing and access arrangements are in place that ensure the interests of all Parties are protected, including copyright, intellectual property, privacy and confidentiality and that clauses 12.3 and 12.4 are supported.

1.3 Tasmanian NRM ECM Indicators Schedule

Item 5: Data collection and management (Definitions clause 1.1) (clause 6.2)

The following table identifies the Indicator Documents and the Deliverable Data. Deliverable Data will be collected and managed to the standards specified in the associated Indicator Document. This is to ensure that the Data Sets can be used to support the specified Indicators, given appropriate interpretation and reporting.

The Indicator Documents are published by the Tasmanian NRM ECM Indicators Working Group and are available from www.dpiw.tas.gov.au/coasts and the base national Indicator documents are available from http://www.nrm.gov.au/monitoring/indicators/index.html

Indicator Number	Indicator Document Name	Indicator Version	Deliverable Data?
	Physical-chemical condition		
1	Dissolved oxygen	1.0	yes
2	pH	1.0	yes
3	Salinity	1.0	yes
4	Shoreline position	1.0	
5	Dissolved nutrients in the water column	1.0	yes
6	Toxicants: biota, sediments and water column	1.0	
7	Turbidity / water clarity	1.0	yes
8	Water temperature	1.0	yes
	Biological condition		
9	Animal or plant species abundance	1.0	
10	Presence/extent of litter	1.0	
11	Mass mortality events (ex Animal kills)	1.0	
12	Algal Blooms	1.0	
13	Chlorophyll *a*	1.0	yes
14a	Pest species (number, density, distribution) (inter/subtidal)	1.0	
14b	Pest species (number, density, distribution) (supratidal)	1.0	

15	Targeted pathogen counts	1.0
	Habitat extent	
16a	Extent/distribution of key habitat types (subtidal)	1.0
16b	Extent/distribution of key habitat types (inter/supratidal)	1.0

Appendix 6: Estuarine biological indicators issues paper

A rationale and recommendations for using benthic macroinvertebrates for monitoring human impacts in Tasmanian estuaries

Views of the Estuarine Ecology Group (as expressed by Alastair Hirst)
Tasmanian Aquaculture and Fisheries Institute (TAFI)
University of Tasmania
2006

Why use macroinvertebrates to monitor human impacts?

Benthic macroinvertebrates are widely utilised indicators of human impacts in marine and coastal environments, for which there is a large body of existing literature and knowledge. They provide a means by which biological responses to human impacts can be directly measured, rather than simply inferred (as is the case with physico-chemical measurements that have no biological reference). The benthos (sea floor) is an effective place to look for indicators of human-induced stress in coastal environments because the benthic fauna live in close association with bottom substrata, where organic pollutants and chemical contaminants tend to accumulate and where low-oxygen conditions are typically most severe. Benthic invertebrates are known to be sensitive to a range of human impacts, and responses to perturbations such as organic and chemical pollution, siltation, dredging and changes to salinity regimes are reasonably well-understood and documented. Changes to benthic invertebrate communities can also be readily linked to ecosystem functioning as these animals play a vital role in detrital decomposition, nutrient cycling and energy flow to higher trophic levels (e.g. as food for fish, birds).

Typically benthic macroinvertebrates are preferred over other biota (e.g. fish, zooplankton). This is because: a) they are relatively sedentary allowing in situ assessments of exposure to pollution and other adverse conditions in their immediate environment and, thus, greater certainty regarding impacts, b) they are ubiquitous, occurring in all soft-sediment environments, whereas other commonly utilised biological indicators such as seagrasses may not always be present, c) individuals live for months to years, hence benthos provides information not only on present conditions, but also integrated information that reflects conditions over a considerable time period, and d) they are easier and simpler to sample in the field requiring little specialised sampling equipment. The greatest drawback to using macroinvertebrates to monitor human impacts surrounds the cost associated with processing samples in the laboratory (sorting and identification), and for very diverse assemblages these costs may be prohibitive. However, a number of studies have demonstrated that such costs can be minimised by either reducing the taxonomic resolution used (e.g. family-level identifications) and/or increasing the mesh size used to sieve samples with little loss of information. The cost of this indicator must be weighed against other biological indicators of human impacts for a fair comparison to be made, rather than against other physico-chemical indicators that are generally cheaper to collect but clearly do not convey the same level of information and may be only rough proxies of biological change. Macroinvertebrate-based monitoring programs may also provide valuable information on biodiversity (identifying areas of high conservation value and potentially acting as proxies for other groups, see Edgar et al. 1999 in relation to fish) and the incidence of pest or introduced species (many of which are benthic or encrusting).

Biological indicators are also considered to be more robust measures of environmental condition. Estuaries, in particular, are dynamic environments, displaying high variation in physico-chemical variables over time (tidal and seasonal). Faunal responses to such changes are by comparison muted, in part because these communities are adapted to the natural fluctuations within these environments. As a consequence, benthic invertebrates potentially provide a more robust and less variable measure of environmental condition than physico-chemical variables that are inherently more variable and therefore less easily interpretable. A couple of samples a year may be sufficient to characterize the biology of an estuary, but it is unlikely that two samples will adequately characterize the physico-chemical status of an estuary to the same extent. Invariably this will require sampling at a greater frequency, increasing the cost of the exercise. Traditional approaches to water-quality monitoring, however, do complement biological monitoring by providing information upon which to interpret observed changes.

Recommended approach

The estuarine ecology group at TAFI recommends a community-level approach to monitoring benthic communities rather than one based upon the measurement of pre-selected “indicator” species or single indices of community structure (e.g. species richness or other biotic indices). In essence, this means all species are identified and counted and then utilised in assessments of condition. This approach has a number of advantages over a single measure because information about all species present is retained within the analysis, rather than discarded. This is a more powerful approach to analysing biological change within a system because it is able to integrate the responses of multiple species within a system increasing the sensitivity of the test. By comparison measurement of species richness (numbers of species) alone, may fail to detect an impact at a site because significant changes in species composition (from natural to stressed) may not necessarily be followed by concomitant changes in species richness.

A range of taxa have been proposed as suitable indicators of human impacts (the indicator species concept). In practice this approach has limited application at a broad scale because indicators tend to be impact and location specific. For example, capitellid polychaete worms are commonly used as indicators of severe organic enrichment around fish farms and sewage outfalls but may not be naturally present at many locations. Similarly broad-scale impacts are unlikely to be singular, but multiplicative (a range of impacts and stresses operating simultaneously and interacting with one another) and therefore the choice of indicator taxa is likely to be difficult. With time we may be able to identify taxa that are indicative of a range of impacts, but we simply don’t have the data at this stage.

The greatest challenge confronting those wishing to monitor estuaries in Tasmania is that human impacts are often pre-existing and pervasive making the identification of suitable reference points to assess human impacts a difficult task (see also recommendations below). Although not often explicitly stated, most monitoring programs aim to detect departure within natural systems from what is considered be a ‘healthy’ state. Invariably, this had led to the invention of concepts such as ‘ecosystem health’. However, in reality these concepts are vague, operationally difficult to define in the field and generally unhelpful. Most of us would agree that estuarine ecosystems in Tasmania were healthy prior to the arrival of Europeans in the 1800s and the subsequent alterations to land use that followed. The difficulty is that we don’t know what estuaries were like back then, and hence it is difficult to ascertain to what extent many estuaries have been affected by human impacts. However, if we are to assess estuaries, and in the process detect either improvement or deterioration in condition, we will need to define what it is we consider healthy. This will inevitably require making some compromises about the choice of suitable reference points as few estuaries in Tasmania are completely free of human impacts. From our perspective this would involve collecting data from a range of estuaries deemed to be in minimally impacted catchments or largely unmodified by human activities and

using this information to make assessments about the level of impact within potentially degraded estuaries. In essence this is the reference condition approach adopted successfully by a range of other rapid assessment techniques (e.g. AusRivAS - Australian River Assessment Scheme program for monitoring river health using benthic macroinvertebrates).

A list of broad recommendations for sampling and monitoring macrobenthic communities is given below. This includes our specific recommendations about what to measure, where within the estuary and when. It does not include specific recommendations about what sample sizes to collect at this point.

What to measure:

Macroinvertebrates collected in the field using a corer or grab and retained on a 1.0 mm mesh sieve. As species identification requires a high-level of expertise and is often time consuming, specimens can be identified to family-level with only minimal training, greater accuracy and speed. We suggest that specimens are retained (i.e. stored and fixed with all relevant information) - in case species level identifications are considered necessary at a later date. A courser mesh size would reduce sorting and processing costs further, but would miss smaller, opportunistic species often indicative of stressed and impacted conditions. Therefore we would recommend sieving samples with a 1.0 mm sieve and identifying animals retained on this sieve at the family-level. In many cases families will comprise a single species, thus, conveying the same level of information.

TAFI scientists have previously sampled soft-sediment invertebrates in the field using a 15 cm diameter PVC plastic corer inserted to a depth of 10 cm. We find this gives reasonable estimates of diversity and abundance particularly when replicated. We recommend continuing with this method to allow comparisons with existing studies/data.

Where (within the estuary) to sample:

One of the greatest components of variability found, when sampling within and between estuaries, is associated with changes in tidal height (Edgar and Barrett 2002). It is debateable of how much interest this is when monitoring estuaries. It is more important to capture within estuary spatial variation so that comparisons between estuaries (e.g. between reference and impacted estuaries) are not confounded by insufficient replication at these levels (see Morrisey et al. 1992a, b). This also ensures that sampling is representative of the estuary. As a consequence we recommend sampling at a single tidal height. TAFI studies are usually conducted in the shallow sub-tidal (<1.0 m depth) or at the low tide mark. Species richness and faunal densities are typically higher here, but this also has the advantage of standardising the sampling methodology. Sampling should also be confined to similar habitats, i.e. comparisons between unvegetated sediments and sediments covered by seagrass are likely to be confounded by inherent structural differences between these sediments that have little to do with differences between sites and estuaries. TAFI recommends sampling unvegetated sediments free of aquatic macrophytes (seagrass, macroalgae) because these are the most commonly encountered benthic habitats within estuaries (and most coastal habitats).

Decisions about where to sample within estuaries must be made with particular reference to the likely putative impacts. If a point-source pollution is considered, such as a sewage outfall, then sites should be arranged in a way that allows rigorous assessment of the likely impact (i.e. adjacent to and away from the point of impact). For many estuaries in Tasmania impacts originate from within the catchment (e.g. elevated nutrient and sediment loadings) and therefore

are likely to affect the entire estuary. Work in the NW of Tasmania has indicated that catchment impacts are more likely to be manifested in the upper parts of an estuary, which are more heavily influenced by riverine processes (Hirst et al. 2005). Conversely sampling in and around the mouth of an estuary may tell us little about the condition of an estuary, unless it is heavily impacted, because these biological communities maybe more heavily influenced by marine processes (and this is reflected in the fact that many of the species here are marine in origin). Consequently, TAFI recommends sampling within the body of the estuary, away from the mouth, and, if possible, including the upper regions of an estuary where salinities are naturally lower. These regions generally support a specialised estuarine fauna that is often restricted to estuaries (Edgar et al. 1999). Changes to these 'estuarine' invertebrate communities are likely to tell us more about changes in the condition of the estuary (be they anthropogenic or natural) than invertebrates communities found at the mouth and in the lower part of the estuary. This is simply because changes to the latter are likely to reflect, or be confounded by, recruitment from adjacent coastal areas, independent of changes within the estuary – although this contention is largely untested at this point. For many of the same reasons these 'estuarine' communities are likely to detect change earlier. One obvious exception to this recommendation is when changes to the opening (and thus closing) regime of an estuary mouth is considered. In this context sampling of the invertebrate communities within the lower estuary would provide important data. Careful and thoughtful design is essential when planning all monitoring programs.

When to sample:

In the ideal world, sampling should provide information about pre-impact conditions. For example, if one wanted to assess the impacts associated with opening a (naturally closed) estuary, information about the estuary prior to, and after, the implementation of these changes would allow for a more rigorous assessment of the potential impacts. As many impacts in estuaries are pre-existing, or have a long-standing historical context, such information is not always available, increasing the uncertainty of the conclusions drawn from monitoring (i.e. changes must be inferred from other information, rather than directly addressed).

Temporal and seasonal variability in invertebrate community structure is typically considered to be negligible in estuaries, particularly when contrasted with spatial variation within and between estuaries (Edgar and Barrett 2002). However, this contention is generally poorly tested for estuaries in Tasmania. Nevertheless, we would recommend sampling estuaries at a similar time every year so that comparisons can be made between years and over time. For example, the AusRivAS program for monitoring river health samples rivers and streams in both spring and autumn and is capable of making assessments based on either seasonal sample. We would suggest following a similar protocol for estuaries. Samples collected in spring would provide information on estuarine communities following a period of typically higher river flows and freshwater inputs into estuaries and, thus, potentially higher inputs of contaminants originating from within the catchment. In contrast, samples collected in autumn provide information about the estuaries following a period of typically reduced freshwater input, higher water temperatures, increased water clarity and greater overall productivity. As marine influences are generally higher in autumn compared to spring, due to lower river flows and thus greater tidal incursion, autumn samples may be less informative than spring samples regarding catchment derived impacts. But again this remains to be tested more fully for a range of estuaries.

Summary

Benthic macroinvertebrates are one of the most widely used biological indicators of human impacts in coastal and marine environments. They are common and easy to sample and a range

of methods exist for analysing change in these communities. They are more expensive to collect and process than traditional physico-chemical water-quality indicators, but provide a direct assessment of biological and hence ecological change. The costs associated with monitoring macroinvertebrates are likely to be comparable to those of other biological indicators (plankton, fish or birds), however, the latter are considered less reliable indicators of human impacts in part because of their greater variability (both spatial and temporal). There may be circumstances where monitoring bird or fish populations is important, particularly as there is greater community interest in these groups, however, this is likely to stem from specific questions rather than a generic need. TAFI scientists recommend monitoring benthic macroinvertebrates at the community-level because this provides a more powerful, sensitive and informative approach to detecting change than biotic indices and, as yet unidentified, indicator species. Samples collected in the field should be sieved using a 1.0 mm mesh sieve and the animals retained, identified to family-level. This level of taxonomic identification can be achieved with only a moderate level of training –estuaries are typically less diverse then say, for example, rivers. Sampling should be conducted at a similar time of year so that seasonal effects are minimized. We suggest, tentatively, that spring may be the most informative period in which to sample. Lastly, sampling should be replicated (in terms of numbers of sites) to ensure that the data collected is sufficiently indicative of conditions

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Appendix 7: Project Objectives

1.1 Description of Services: **Trialing resource condition indicators for the coastal zone**

A. Background

The Coastal Estuarine and Marine Indicators Working Group in Tasmania has broad specialist membership across State and Commonwealth agencies, NRM regions, research and education institutions, Local government, industry, consultants and community.

The Group has identified a suite of 14 resource condition indicators to collect data and report on the *Estuarine, Coastal and Marine Habitat Integrity* Matter for Target within the natural resource management monitoring and evaluation framework. The Group is now well progressed with identifying within Tasmania existing data sets, monitoring programs, methodologies and standards that relate to these indicators.

B. Objectives

1. To confirm identification of appropriate resource condition indicators for estuarine, coastal and marine habitat integrity in Tasmania as a national case study.

2. To foster collaboration and cooperation between stakeholders and identify information and data sharing opportunities, agreements and protocols

3. To document existing monitoring and research programs across Tasmania relevant to the agreed indicators and collate metadata for each program consistent with Audit standards.

4. To create a GIS database of mapped sites for existing monitoring and research programs relevant to the resource condition indicators and their associated pressure indicators

5. To trial indicators against selected Tasmanian estuaries and adjacent inshore marine waters across the spectrum of estuary types and disturbances from *pristine* to *highly modified*, and identify appropriate indicator subsets, baseline monitoring gaps and data needs within the state

6. To assist NRM regional bodies to trial implementation of the indicators in selected estuarine and marine investments

C. Scope of Work

The identification and trialling of resource condition indicators for estuarine, coastal and marine habitat integrity as part of the national NRM monitoring and evaluation framework implementation.

Appendix 8: Tasmanian NRM ECM Indicator Compendium

Available from http://www.dpiw.tas.gov.au/coasts