Secretariat
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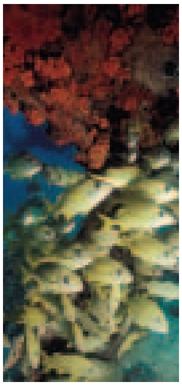
CBD Technical Series No. 22 / Ramsar Technical Report No. 1



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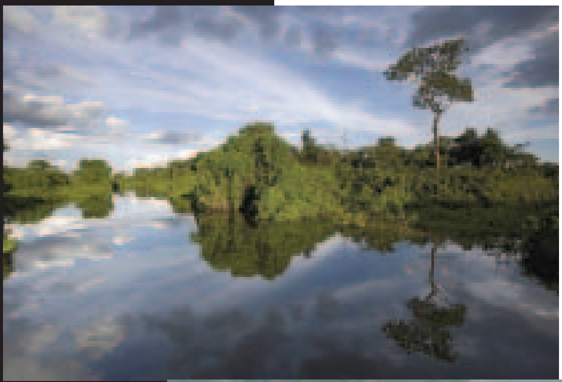
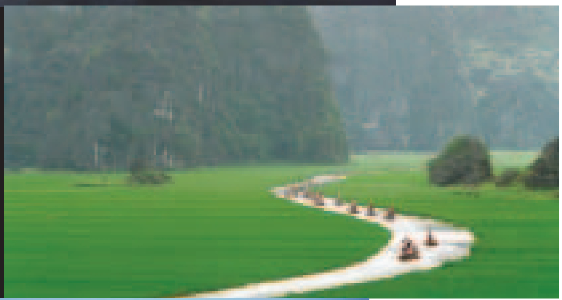
GUIDELINES FOR THE RAPID ECOLOGICAL ASSESSMENT OF BIODIVERSITY IN INLAND WATER, COASTAL AND MARINE AREAS





GUIDELINES FOR THE RAPID ECOLOGICAL ASSESSMENT OF BIODIVERSITY IN INLAND WATER, COASTAL AND MARINE AREAS

CBD Technical Series No. 22 / Ramsar Technical Report No. 1

Published jointly by the Secretariat of the Convention on Biological Diversity and the Secretariat of the Convention on Wetlands (Ramsar, Iran, 1971) ISBN:

Ramsar Technical Reports are designed to publish, chiefly through electronic media, technical notes, reviews and reports on wetland ecology, conservation, wise use and management, as an enhanced information support service to Contracting Parties and the wider wetland community in support of implementation of the Ramsar Convention. In particular, the series includes the detailed technical background reviews and reports prepared by the Convention's Scientific and Technical Review Panel (STRP), at the request of Contracting Parties, and which would previously have been made available in most instances only as "Information Papers" for a Conference of the Parties (COP). This is designed to ensure increased and longer-term accessibility of such documents. Other reports not originating from COP requests to the STRP, but which are considered by the STRP to provide information relevant to supporting implementation of the Convention, may be proposed for inclusion in the series. All Ramsar Technical Reports are peer-reviewed by the members and observers appointed to the STRP.

Ramsar Technical Reports and the CBD Technical Series are published in English in electronic (.pdf) format. When resources permit, the reports will be published also in the other official languages of both Conventions and in printed form. A version of the technical section of this document was adopted at the ninth meeting of the Contracting Parties to the Ramsar Convention and is available in both French and Spanish as resolution IX.1.annex.Ei at http://www.ramsar.org/res/key_res_ix_index_e.htm

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Citation:

Guidelines for the rapid ecological assessment of biodiversity in inland water, coastal and marine areas. Secretariat of the Convention on Biological Diversity, Montreal, Canada, CBD Technical Series no. 22 and the Secretariat of the Ramsar Convention, Gland, Switzerland, Ramsar Technical Report no. 1.

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TABLE OF CONTENTS

Foreword ... iii
Acknowledgements ... v

EXECUTIVE SUMMARY ... 6
1. INTRODUCTION ... 10
2. SCOPE AND APPROACH OF THESE RAPID ASSESSMENT GUIDELINES ... 11
3. WHAT IS "RAPID ASSESSMENT"? ... 12
4. ISSUES TO CONSIDER WHEN DESIGNING A WETLAND RAPID ASSESSMENT ... 12
5. WHEN IS RAPID ASSESSMENT APPROPRIATE? ... 14
5.1 Addressing socio-economic and cultural features of biodiversity ... 15
5.2 Assessing threats to wetland biodiversity ... 16
5.3 Rapid assessment in relation to monitoring ... 16
5.4 Rapid assessment and trends in biological diversity ... 16
5.5 Seasonality ... 16
5.6 Special considerations relating to small island states ... 17
6. A CONCEPTUAL FRAMEWORK FOR RAPID ASSESSMENT ... 17
6.1 Choosing rapid assessment types and outputs for different purposes ... 21
Purpose ... 21
Assessment types ... 23
7. DESIGN CONSIDERATIONS ... 28
7.1 Resources ... 28
Time ... 29
Money ... 29
Expertise ... 29
7.2 Scope ... 30
Taxonomic scope ... 30
Geographic scope ... 30
Site selection ... 31
7.3 Sampling and data analysis ... 31
8. REFERENCES ... 33

Appendix 1 Assessment analysis methods and indices ... 36

Appendix 2 Sampling methods for wetland habitats, features
and different wetland-dependent taxa ... 42

FOREWORD

According to the Millennium Ecosystem Assessment reports, inland water, coastal and near-shore marine ecosystems include the most threatened of the world's main habitat types. Demands placed by people on natural resources in and around these wetlands, particularly the unsustainable use of water resources, are consequently resulting in rapid changes, especially declines, in biodiversity. This in turn results in significantly reduced capacity of the ecosystems to provide the important services that are necessary for people, in particular to the poor and vulnerable communities in less developed countries, as well as the planet. Sustaining and rehabilitating, where necessary, these ecosystem services is a key requirement for the achievement of human development goals and targets.

Despite the tremendous importance of these ecosystems to human welfare, our knowledge of the biodiversity within them is fragmentary at best. There are many reasons for these knowledge gaps. The significant contribution of these ecosystems to human wellbeing has not always been matched by investment in research and management. They also support a very large diversity of life. Some habitats remain difficult to access and sample. The comprehensive assessment of these biological resources requires significant and long-term effort. We should not forget that, for some habitats in some regions, scientists have already improved our understanding, despite wide-ranging constraints. Neither should we ignore the role of local communities, who are already armed with considerable understanding of these environments.

We need more information to be able to manage these systems better. The urgency of biodiversity decline means that such information needs to be obtained quickly, using credible methods applied efficiently and effectively. Achieving a significant reduction in the rate of loss of biodiversity by 2010 requires substantial efforts and must be accompanied by scientifically valid approaches to the evaluation of our progress. For given locations or ecosystems we need to know better what biodiversity is there, its status, function and value and whether our efforts are contributing to improving things.

It is primarily for this reason that these guidelines have been produced. They present a suite of options for rapidly undertaking assessments in different habitat types and under differing technical capacity constraints. They include approaches for obtaining data for inventories, assessment and monitoring. They focus on biological assessments, mainly at the species level but also at the ecosystem level. The assessment of the social, economic and cultural values of the biodiversity of these ecosystems is equally, if not more, important. Therefore a complementary set of guidelines is being produced to assist with those aspects.

These guidelines have been produced through a lengthy and detailed consultative process. But no guidance can be totally comprehensive. We present them as a tool to assist those that need help to try to obtain better information effectively. The guidelines should be considered in the context of available local capacity and the availability of other sources of assistance with obtaining information. In particular, we stress that they should be used, if necessary, as a means to supplement information available through traditional and local knowledge.

We are particularly proud to present this document as a joint effort between the Convention on Biological Diversity and the Convention on Wetlands (Ramsar Convention). The Ramsar Convention is the lead implementation partner for wetlands for the CBD. The background to the collaboration between our two conventions in preparing these guidelines is explained in the text. Here we acknowledge the fruits of this collaboration in the best way we can – through a joint publication.

Ahmed Djoghlaf
Executive Secretary
Convention on Biological Diversity

Peter Bridgewater
Secretary General
Convention on Wetlands (Ramsar, Iran, 1971)

ACKNOWLEDGEMENTS

Draft guidelines for inland waters were originally developed by Conservation International and further refined at a workshop attended by Fatouma Ali Abdallah (Comoros), Leroy Mc.Gregor Ambroise (Saint Lucia), Geoffrey Cowan (South Africa), Joseph M. Culp (Canada),Hederick R. Dankwa (Ghana), Maria Hilda Cuadros Dulanto (Peru), Teresita Borges Hernández (Cuba), Ilja Krno (Slovak Republic),Ryszard Kornijów (Poland), Antanas Kontautas (Lithuania), Lionel Michael (Antigua and Barbuda), Rudy Vannevel (Belgium), Andrew Fraser (UNEP GEMS/Water), Matthias Halwart (FAO), Wafa A. Hosn (UQAM), Mary Lammert Khoury (The Nature Conservancy), Jean-Christophe Vié (IUCN), Leeanne E. Alonso (Conservation International), Nick Davidson (Ramsar Convention) and Robert Höft, Jo Mulongoy and Marjo Vierros (CBD Secretariat).

Draft guidelines for marine and coastal areas, based upon the format for inland waters, were originally developed through an electronic discussion forum with inputs from representatives of the following organisations or assessments: The Global International Waters Assessment (GIWA); Marine Rapid Assessment Programme of Conservation International; Atlantic and Gulf Rapid Reef Assessment (AGRRA); Ramsar Convention; UNEP-WCMC; Northwest Hawaiian Islands Rapid Reef Assessment (NOW-RAMP); The Intergovernmental Oceanographic Commission (IOC) of UNESCO; The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA); Land-Ocean Interactions in the Coastal Zone (LOICZ); Reef Check; Reefs at Risk of the World Resources Institute; Coral Reef Degradation in the Indian Ocean (CORDIO); Arctic Assessment and Monitoring Programme; FAO Fisheries Division; the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention); WWF; IUCN; Global Marine Assessment (GMA); Caribbean Environment Programme; South Pacific Environment Programme; the SPA protocol of the Mediterranean Action Plan; Eastern African Regional Seas Programme; Regional Coordinating Unit for East Asian Seas; and Regional Organization for the Protection of the Marine Environment (ROPME).

The draft guidelines were subsequently reviewed and improved by the Scientific and Technical Review Panel of the Ramsar Convention.

David Coates, Jo Mulongoy and Marjo Vierros (CBD Secretariat) and Max Finlayson, Nick Davidson and Dwight Peck (Ramsar STRP and Secretariat) edited this document.

Funding for the publication of the printed version of this document was provided by the Netherlands Government.

We are grateful to all for making this publication possible.

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EXECUTIVE SUMMARY

These guidelines have been produced through an extensive consultation process involving inputs from a large number of specialists. They are prepared in response to requests of the Conference of the Parties to both the Convention on Biological Diversity (CBD) and Ramsar Convention. They are designed as a suite of optional tools to assist those with urgent need and/or limited capacity and resources to undertake, where necessary, rapid inventories, assessment and monitoring of the biological diversity of inland water, coastal and near-shore marine ecosystems. They focus largely at species level considerations (i.e., assessments of taxa) but also include some tools relevant for assessment at the habitat/ecosystem level. Guidelines to assess the socioeconomic and cultural aspects of the value of biodiversity in these ecosystems are being developed to complement the current methods and will be published separately. The guidelines should be seen as additional means of obtaining information to that already held through existing and local knowledge which should be assessed, and used, as the first step in any survey.

Rapid assessment is defined here as a synoptic assessment, which is often undertaken as a matter of urgency, in the shortest timeframe possible to produce reliable and applicable results for its designed purpose. Given the importance of often limited inland wetlands in small island States, the importance of their coastal and marine systems and limited capacity, rapid assessment methods are particularly valuable in these States.

Issues to take into account when designing any rapid assessment include: the type of rapid assessment (they range from desk-top studies to full blown field surveys); the rapidity of stages (design/preparation, implementation and reporting); inventory, assessment or monitoring (which require different approaches); speed versus expense; spatial scale; compilation of existing data; creating audit trails to data; reliability; and, dissemination of results.

Rapid assessment is one of a suite of tools and approaches that Parties can use for assessing wetlands. They are not suitable for collecting all necessary types of information and often help identify where knowledge gaps are that require more detailed approaches. As far as possible, assessments should include identifying and quantify threat categories to biodiversity. Therefore, a checklist to cover this aspect is included.

Rapid assessment designed to assess trends in biological diversity implies that more than one repeat survey will be required. Seasonality aspects of wetlands are particularly difficult to capture using short-term approaches. The timing of a rapid assessment in relation to seasonality is a critically important issue to take into account.

An overall conceptual framework for rapid assessment is presented starting from the definition of purpose to the dissemination of results. Intermediate steps include: the review of existing knowledge (including traditional and local knowledge); identification of information gaps; study design; implementation and review of the approach; establishment of databases and creating metadata files; and, analysis and report production. Different purposes or objectives for information require different approaches. Assessment types include baseline inventory, species-specific assessment, change assessment, indicator assessment and resource assessment.

Design should consider: resources available, including time, money and expertise; scope, including taxonomic and geographic scope and site selection; sampling data and analysis, including identification of what data are required, how to collect it, how much to collect, how to enter it into a database, analyse it and integrate it into a report.

The guidelines include an extensive list of reference sources and details of where additional information might be obtained. Appendix I includes a non-exhaustive list in tabular form, including references, of the various general approaches available, and indices in current use, relevant to different aspects of wetland rapid assessment. These are sub-divided by assessment methods for habitats, physical-chemical parameters, basic biological data, diversity indices, biotic indices, similarity indices/comparative indices and integrated or combined approaches. Most are also further sub-divided by taxonomic group (e.g., bacteria and protozoa, algae, plants, invertebrates, macroinvertebrates, fish and birds). Indications are also given of the suitability of application of the approaches to various wetland categories (e.g., inland waters, marine and coastal, general aquatic, terrestrial, estuarine, rivers, or lakes etc.) or specific fauna or flora. Appendix II lists specific sampling methods and equipment required for wetland habitats or features and different wetland dependent taxa and includes provisional estimates of costs of equipment etc. where appropriate, including information on potential suppliers. These are sub-divided into sampling methods for water quality, wetland habitat types, macrophytes (plants), epiphytic macroinvertebrates, fish, reptiles and amphibians, birds and mammals. Both appendices include further lists of references and sources of additional information.

1. INTRODUCTION

The Conference of the Parties (COP) to the Convention on Biological Diversity (CBD), in decision IV/4, referring to its programme of work on the biological diversity of inland water ecosystems (for which the Ramsar Convention acts as the lead implementation partner), requested the development and dissemination of regional guidelines for rapid assessment of inland water biological diversity for different types of inland water ecosystems. Similarly, recommendation VI/5 of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the CBD requested "development of methodologies . . . for scientific assessments, including those relating to marine and coastal biological diversity." In parallel, the Ramsar Convention's Strategic Plan 2003-2008 (Action 1.2.3) requests its Scientific and Technical Review Panel (STRP), Ramsar Secretariat and Secretariat of the CBD to "develop guidelines for rapid assessment of wetland biodiversity and functions and for monitoring change in ecological character, including the use of indicators, for both inland and coastal and marine ecosystems, for consideration by COP9".

The CBD guidance for inland waters was originally drafted by Conservation International and further developed by an expert meeting convened jointly by the CBD and Ramsar Secretariats and involving both CBD and Ramsar experts nominated by national focal points. The guidance is specifically intended to meet the needs of both CBD and Ramsar Convention, in line with the CBD/Ramsar 3rd Joint Work Plan. Marine and coastal guidance, developed through an electronic working group, was modelled on that for inland waters, and its approach and general structure is consistent with the inland waters guidance.

The original CBD guidelines were made available to the eighth meeting of the CBD's SBSTTA and are available for download from the CBD Web site [http://www.biodiv.org/convention/ sbstta.asp] as UNEP/CBD/SBSTTA/8/INF/5 (inland waters) and UNEP/CBD/SBSTTA/8/INF/13 (marine and coastal), plus a short supplementary marine and coastal paper (UNEP/CBD/SBSTTA/9/INF/25).

Concerning the inland waters guidelines, CBD COP-7 in 2004 (decision VII/4) welcomed the guidelines, recognized their usefulness for creating baseline or reference data sets for inland water ecosystems of different types and for addressing the serious gaps that exist in knowledge of taxonomy, distribution, and conservation status of freshwater species, and invited its Parties, other Governments and relevant organizations to use and promote the application of the guidelines, in particular in the circumstances of small island developing states and in the territories of states in which inland water ecosystems suffer from ecological disaster.

In 2004, the Scientific and Technical Review Panel (STRP) of the Ramsar Convention considered how best to incorporate the various components of the CBD rapid assessment guidelines into the suite of Ramsar guidance on inventory, assessment and monitoring. The Panel determined that, given that the Ramsar definition of "wetlands" covers both inland waters and marine and coastal systems, it is most appropriate for its application by Ramsar Contracting Parties to make the guidance available as a single consolidated guidance document, with the relevant material from all three of the aforementioned CBD information papers merged. These present guidelines are thus a compiled and edited version of the CBD materials, taking into account the needs of both Conventions, prepared jointly by the Ramsar Secretariat, the Ramsar STRP and the CBD Secretariat.

The two Conventions use different terminology. Ramsar refers to "wetlands" whereas the CBD refers to inland water, coastal and marine ecosystems. For the purposes of this document these terms are interchangeable, as appropriate.

2. SCOPE AND APPROACH OF THESE RAPID ASSESSMENT GUIDELINES

The guidance provided here refers to "biological" assessments of biodiversity largely at the species and community level. However, some reference is also made to tools which will assist in the assessment of wetland ecosystems. Decision VII/4 (paragraph 21) of the CBD notes this focus and the need for additional guidance for the further assessment of ecosystem level aspects and economic, social and cultural aspects of such biodiversity. In terms of promoting increased emphasis on the need for the conservation and sustainable use of these ecosystems (wetlands) the latter guidance is arguably even more important. Work to develop guidance on the valuation of economic, social and cultural aspects of wetlands has already been partially completed and this guidance will be published by the Ramsar Secretariat jointly with the CBD Secretariat during 2006 in the Ramsar Technical Report series in order to achieve its wide dissemination (see also document UNEP/CBD/COP/8/INF/XX).

Information is also included in these guidelines on rapid assessment methodologies for assessing change in coastal ecosystems in the aftermath of natural disasters. These methodologies have been developed to assist in the assessment of the impacts to coastal ecosystems of the Indian Ocean tsunami of December 2004.

The present rapid assessment guidelines draw heavily on, and are consistent with, the general guidelines for selecting appropriate wetland inventory methods in Ramsar's "A Framework for Wetland Inventory" (COP8 Resolution VIII.6). As is set out in the rapid assessment guidelines, rapid assessment methods can be applied for a number of types and purposes of wetland inventory and assessment. Hence this guidance is relevant to the implementation of a number of aspects of the Ramsar "Integrated Framework for Wetland Inventory, Assessment and Monitoring" (COP9 Resolution IX.1 Annex E).

The guidelines are designed to serve the needs of Contracting Parties of both the Ramsar Convention and the Convention on Biological Diversity. Rapid assessment methods are placed in the context of more comprehensive inventory, assessment and monitoring programmes, and a conceptual framework for their design and implementation is included. They are intended to provide advice and technical guidance that is useful to wide range of Parties with different circumstances, including geographic size, wetland types, and institutional capacities.

The guidelines stress the importance of clearly establishing the purpose as the basis for design and implementation of the assessment in each case. They also emphasize that before deciding on whether a new field survey using rapid assessment methods is necessary, a review of existing knowledge and information, including information held by local communities, should be undertaken as the first priority. Proceeding with assessments that ignore the significant depth of knowledge that local communities have is not only a significant potential waste of resources but also undermines the principles of both Conventions and is therefore strongly discouraged.

Subsequent steps are then presented in the form of a "decision tree" to facilitate the selection of appropriate methods to meet the purpose of the assessment. An indication of the categories of information which can be acquired through each of the rapid assessment methods is provided. Summary information on a range of appropriate and available methods suitable for each rapid assessment purpose is included, as is information on a range of different data analysis tools.

3. WHAT IS "RAPID ASSESSMENT"?

Rapid assessment, for the purpose of this guidance, is defined as: "a synoptic assessment, which is often undertaken as a matter of urgency, in the shortest timeframe possible to produce reliable and applicable results for its defined purpose".

It is important to note that rapid assessment methods for wetlands are not generally designed to take into account temporal variance, such as seasonality, in ecosystems. However, some rapid assessment methods can be (and are) used in repeat surveys as elements of an integrated monitoring programme to address such temporal variance.

Rapid assessment techniques are particularly relevant to the species level of biological diversity, and the present guidance focuses on assessments at that level. Certain other rapid assessment methods, including remote sensing techniques, can be applicable to the ecosystem/wetland habitat level, particularly for rapid inventory assessments, and there is a need for further guidance on ecosystem-level rapid assessment methods. However, direct assessments at the genetic level of biological diversity do not generally lend themselves to "rapid" approaches. There are however alternative approaches to this problem, particularly for inland water ecosystems, in that the likely genetic diversity of many taxa can be estimated from a knowledge of ecosystem diversity, functioning and geological and zoogeographic history.

The complex nature and variability of wetland ecosystems means that there is no single rapid assessment method that can be applied to the wide range of wetland types and for the variety of different purposes for which assessments are undertaken. Furthermore, the extent of what is possible in a given case will depend on the resources and capacities available.

In the detailed guidance that follows, five specific purposes for undertaking rapid assessment are distinguished: baseline inventory (called inventory assessment in the original CBD version of the guidelines), specific-species assessment, change assessment, indicator assessment, and economic resource assessment.

4. ISSUES TO CONSIDER WHEN DESIGNING A WETLAND RAPID ASSESSMENT

The following nine issues should be taken into account when designing any rapid assessment:

i. Types of rapid assessments. Rapid assessments can range from desk studies, expert group meetings and workshops to field surveys. They can include compiling existing expert knowledge and information, including traditional knowledge and information, and field survey approaches.

ii. Assessments can be divided into three stages: design/preparation, implementation, and reporting. "Rapidity" should apply to each of these stages. Rapid assessments provide the necessary results in the shortest practicable time, even though preparatory and planning work prior to the survey may be time-consuming. In some circumstances (for example, when taking seasonality into account) there may be a delay between the decision to undertake the assessment and carrying it out. In other cases (for example, in cases of disturbances and disasters), the assessment will be undertaken as a matter of urgency, and preparation time should be kept to a minimum.

iii. Inventory, assessment and monitoring. It is important to distinguish between inventory, assessment, and monitoring (see Box 1) when designing data-gathering exercises, as they require different types of information. Baseline wetland inventory provides the basis for guiding the development of appropriate assessment and monitoring. Wetland inventories repeated at intervals do not automatically constitute "monitoring".

iv. Rapid assessment entails speed, but it can be expensive. Costs will increase particularly when assessing remote areas, large spatial scales, high topographic resolution, and/or a large number of types of features. Undertaking an assessment rapidly can mean a higher cost owing to the need, for example, to mobilize large field teams simultaneously and support them.

v. Spatial scale. Rapid assessments can be undertaken at a wide range of spatial scales. In general, a large-scale rapid assessment will consist of the application of a standard method to a larger number of localities or sampling stations.

vi. Compilation of existing data/access to data. Before determining whether further field-based assessment is required, it is an important first step to compile and assess as much relevant existing data and information as readily available. This part of the assessment should establish what data and information exists, and whether it is accessible. Data sources can include geographic information systems (GIS) and remote sensing information sources, published and unpublished data, and traditional knowledge and information accessed through the contribution, as appropriate, of local and indigenous people. Such compilation should be used as a "gap analysis" to determine whether the purpose of the assessment can be satisfied from existing information or whether a new field survey is required.

vii. For any new data and information collected during a subsequent rapid assessment field survey, it is essential to create an audit trail to the data, including any specimens of biota collected, through the establishment of a proper metadata record for the assessment.

viii. Reliability of rapid assessment data. In all instances of rapid assessment of biological diversity it is particularly important that all outputs and results include information on the confidence associated with the findings. Where practical, error propagation through the analysis of data and information should be evaluated to provide an overall estimate of confidence in the final results of the assessment.

ix. Dissemination of results. A vital component of any rapid assessment is the fast, clear and open dissemination of its results to a range of stakeholders, decision-makers and local communities. It is essential to provide this information to each group in an appropriate form of presentation and appropriate level of detail.

BOX 1. RAMSAR DEFINITIONS OF INVENTORY, ASSESSMENT AND MONITORING

Ramsar COP8 has adopted, in Resolution VIII.6, the following definitions of wetland inventory, assessment and monitoring:

Inventory: The collection and/or collation of core information for inland water management, including the provision of an information base for specific assessment and monitoring activities.

Assessment: The identification of the status of, and threats to, inland waters as a basis for the collection of more specific information through monitoring activities.
Monitoring: Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. (Note that the collection of time-series information that is not hypothesis-driven from wetland assessment should be termed surveillance rather than monitoring, as outlined in Ramsar Resolution VI.1.)

Note that "inventory" under this definition covers baseline inventory, but in many cases, depending on specific purpose, priorities and needs, can include not only core biophysical data but also data on management features which provide "assessment" information, although this may also require more extensive data collection and analyses.

5. WHEN IS RAPID ASSESSMENT APPROPRIATE?

Rapid assessment is one of a suite of tools and responses that Parties can use for assessing wetlands. Not all types of data and information needed for full wetland inventory and assessment can be collected through rapid assessment methods. However, it is generally possible to collect some initial information on all generally used inventory and assessment core data fields, although for some, rapid assessment can only yield preliminary results with a low level of confidence. Such types of data and information can, however, be used to identify where more detailed follow-up assessments may be needed if resources permit.

A summary of core data fields for inventory and assessment of biophysical and management features of wetlands, derived from that in Ramsar Resolution VIII.6, and the general quality of information for each which can be gathered through rapid assessment, is provided in Table 1.

Table 1. Adequacy of data and information quality which can at least partly be collected through "rapid assessment" field survey methods for wetland inventory and assessment core data fields for biophysical and management features of wetlands. (Derived from Ramsar Resolution VIII.6)

BIOPHYSICAL FEATURES	ADEQUACY OF DATA QUALITY COLLECTED THROUGH "RAPID ASSESSMENT"
Site name (official name of site and catchment)	✔
Area and boundary (size and variation, range and average values) *	✔
Location (projection system, map coordinates, map centroid, elevation) *	✔
Geomorphic setting (where it occurs within the landscape, linkage with other aquatic habitat, biogeographical region) *	✔
General description (shape, cross-section and plan view)	✔
Climate – zone and major features	(✔)
Soil (structure and colour)	✔
Water regime (e.g. periodicity, extent of flooding and depth, source of surface water and links with groundwater)	(✔)
Water chemistry (e.g. salinity, pH, colour, transparency, nutrients)	✔
Biota (vegetation zones and structure, animal populations and distribution, special features including rare/endangered species)	✔
Management features	✔
Land use — local, and in the river basin and/or coastal zone	(✔)
Pressures on the wetland - within the wetland and in the river basin and/or coastal zone	(✔)
Land tenure and administrative authority — for the wetland, and for critical parts of the river basin and/or coastal zone	(✔)
Conservation and management status of the wetland — including legal instruments and social or cultural traditions that influence the management of the wetland	(✔)
Ecosystem benefits/services derived from the wetland - including products, functions and attributes and, where possible, their benefits/services to human well-being	(✔)
Management plans and monitoring programmes — in place and planned within the inland water and in the river basin and/or coastal zone	(✔)

** These features can usually be derived from topographical maps or remotely sensed images, especially aerial photographs.*

5.1 ADDRESSING SOCIO-ECONOMIC AND CULTURAL FEATURES OF BIODIVERSITY

This guidance chiefly covers assessment of the biotic components of biological diversity. For many assessment purposes, it is also important to collect information on socio-economic and cultural features of biological diversity, although full economic valuation assessment is generally well outside the scope of rapid assessment. Nevertheless, as part of a rapid inventory assessment or risk assessment it may be useful to compile an initial indication of which socio-economic and cultural features are of relevance in the survey site. This can provide an indication of the likely changes to the natural resource base, and may be used to indicate which features should be the subject of more detailed follow-up assessment. The involvement of local communities in this process is particularly important.

For an indicative list of the socio-economic benefits/services of inland waters which are derived from biological diversity, see annex II of UNEP/CBD/SBSTTA/8/8/Add. 3. For further information on ecosystem benefits/services, see also the Millennium Ecosystem Assessment (2005).

Cultural functions and values of inland waters (derived from Ramsar COP8 DOC. 15, Cultural aspects of wetlands) that should be taken into account include:

- Palaeontological and archaeological records;
- Historic buildings and artefacts;
- Cultural landscapes;
- Traditional production and agro-ecosystems, e.g., ricefields, salinas, exploited estuaries;
- Collective water and land management practices;
- Self-management practices, including customary rights and tenure;
- Traditional techniques for exploiting wetland resources;
- Oral traditions;
- Traditional knowledge;
- Religious aspects, beliefs and mythology;
- “The arts” – music, song, dance, painting, literature and cinema.

5.2 ASSESSING THREATS TO WETLAND BIODIVERSITY

In many rapid assessments it will not be possible fully to assess the threats to, or pressures on, biological diversity. Nevertheless, as for socio-economic and cultural features, it may be useful, for identifying where the focus of any further assessment may be needed, to make a provisional assessment of threat categories. For this purpose, a checklist of threat categories such as that being developed by the IUCN Species Survival Commission (SSC) as part of their Species Information Service (SIS) may be helpful (see http://www.iucn.org/themes/ssc/sis/authority.htm.)

5.3 RAPID ASSESSMENT IN RELATION TO MONITORING

Hypothesis-based research for monitoring purposes needed for management of systems may require more comprehensive tools and methodologies than rapid assessment can provide. However, some rapid methods, although originally developed for monitoring, can equally be applied for the purposes of rapid assessment. Similarly, certain rapid assessment tools/methodologies can also be applied for longer term hypothesis-driven monitoring by repeated surveys. This can be a particularly valuable technique for addressing seasonality issues.

5.4 RAPID ASSESSMENT AND TRENDS IN BIOLOGICAL DIVERSITY

Rapid assessment designed to assess trends in biological diversity implies that more than one repeat survey will be required. For gathering such information, regular time-series data may be necessary, and in such circumstances this can be considered as rapid assessment if each survey is undertaken using a rapid assessment method, although the resulting overall assessment will generally take shape over a longer time period.

5.5 SEASONALITY

Most rapid assessments involve a single "snapshot" survey of a locality. However, the seasonality of many wetlands and of the biota dependent upon them (for example, migratory species) means that surveys of different taxa may need to be made at different times of year. The timing of a rapid assessment in relation to seasonality is a critically important issue to take into account if the assessment is to yield reliable results.

Other types of temporal variations in inland wetlands may also need to be taken into account, notably variations in flow regimes of different types of inland water ecosystems, which may include:

- perennial systems which experience surface flow throughout the year and do not cease to flow during droughts;
- seasonal systems which experience flow predictably during the annual wet season but may be dry for several months each year;
- episodic (periodic or intermittent) systems, which experience flow for an extended period but are not predictable or seasonal. These systems usually have flow contribution from rainfall as well as groundwater. At times, surface flow may occur in some segments only, with subsurface flow in other segments. The fauna can differ considerably depending on the duration of flow, colonization succession of different species, proximity of other water sources, and extent of time during which previous flow occurred; or
- ephemeral (short-lived) systems, which experience flow briefly and rarely and return to dry conditions in between. Their flow is usually sourced entirely from precipitation. Only aquatic biota able to complete their life cycles very rapidly (within a few days) are able to exploit such flow conditions.

5.6 SPECIAL CONSIDERATIONS RELATING TO SMALL ISLAND STATES

Given the importance of often limited inland wetlands in small island States, the importance of their coastal and marine systems, a general lack of information about their biodiversity, and limited institutional capacity, rapid assessment methods are particularly valuable in small island States. Priority purposes of assessment include:

- qualitative and quantitative aspects of water quality and quantity;

- causes of biodiversity loss and water pollution, including deforestation, pesticide flows, and other unsustainable exploitation; and
- pressures of unsustainable land uses (e.g., tourism, agriculture, fisheries, industry).

FAO has provided detailed information on the more important fisheries and aquaculture issues in small island developing states (see http://www.fao.org/figis/servlet/static? dom=root&xml=index.xml and also operates the Fisheries Global Information System (http://www.fao.org/fi/default.asp.). The Plan of Action on Agriculture in Small Island Developing States also recognizes the particular fisheries needs of small island developing States and provides guidance on the sustainable management of inland water and other natural resources.

6. A CONCEPTUAL FRAMEWORK FOR RAPID ASSESSMENT

The overall conceptual framework presented in this document is derived from, and consistent with, the Ramsar Framework for Wetland Inventory (Resolution VIII.6). Certain modifications concerning the sequence and titling of its steps have been made to take account of the specific element of minimizing time scales which is inherent in rapid assessment.

The process of applying the conceptual framework is summarized in Figure 1. Steps in the conceptual framework and guidance for the application of each step are listed in Table 2.

The framework is designed to provide guidance for planning and undertaking the initial wetland rapid assessment. Follow-up assessments, and those for new areas using a proven procedure and method, need not go through the entire process, although a review of methodology should be undertaken in relation to possible differences in local conditions such as different wetland ecosystem types.

In assessments undertaken in response to an emergency, e.g., a natural or human-induced disaster, the steps of the conceptual framework should be followed as far as possible. However, it is recognized that under such circumstances the need for a very rapid response can mean that shortcuts in applying the framework may be essential.

Figure 1. Summary of the key steps in applying the conceptual framework for rapid assessment (see Table 2 for further details).

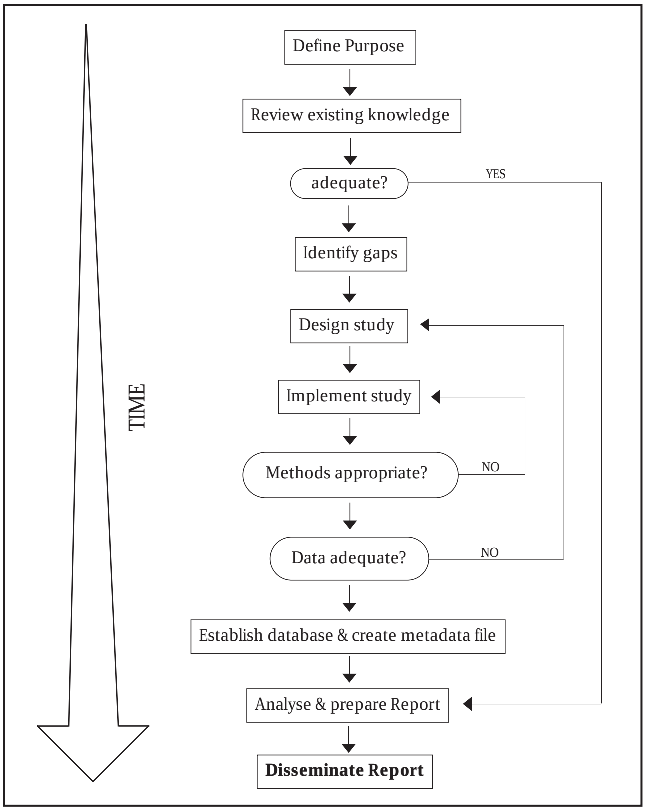

Table 2. Conceptual framework steps for designing and implementing a rapid assessment of wetland biodiversity

STEP	GUIDANCE
State the purpose and objective	State the reason(s) for undertaking the rapid assessment: why the information is required, and by whom it is required
Determine scale and resolution	Determine the geographical scale and resolution required to achieve the purpose and objective
Define a core or minimum data set	Identify the core, or minimum, data set sufficient to describe the location and size of the inland water(s) and any special features. This can be complemented by additional information on factors affecting the ecological character of the wetland and other management issues, if required.
Review existing knowledge and information – identify gaps (if done, write report, if not, design study)	Review available information sources and peoples' knowledge (including scientists, stakeholders, and local and indigenous communities), using desk-studies, workshops, etc., so as to determine the extent of knowledge and information available for inland water biodiversity in the region being considered. Include all available data sources1; and prioritize sites[2].
Study design	
Review existing assessment methods, and choose appropriate method	Review available methods and seek expert technical advice as needed, to choose the methods that can supply the required information. Apply Table 3 (rapid assessment types for different purposes), and then choose appropriate field survey methods.
Establish a habitat classification system where needed	Choose a habitat classification that suits the purpose of the assessment, since there is no single classification that has been globally accepted.
Establish a time schedule	Establish a time schedule for: a) planning the assessment; b) collecting, processing and interpreting the data collected; and c) reporting the results.
Establish the level of resources required, assess the feasibility & cost-effectiveness that are required	Establish the extent and reliability of the resources available for the assessment. If necessary make contingency plans to ensure that data are not lost due to insufficiency of resources. Assess whether or not the programme, including reporting of the results, can be undertaken within under the current institutional, financial and staff situation. Determine if the costs of data acquisition and analysis are within budget and that a budget is available for the programme to be completed. [Where appropriate, plan a regular review of the programme.]

STEP (CONT'D)	GUIDANCE (CONT'D)
Establish a data management system and a specimen curating system	Establish clear protocols for collecting, recording and storing data, including archiving in electronic or hard-copy formats. Ensure adequate specimen curating. This should enable future users to determine the source of the data, and its accuracy and reliability, and to access reference collections. At this stage it is also necessary to identify suitable data analysis methods. All data analysis should be done by rigorous and tested methods and all information documented. The data management system should support, rather than constrain, the data analysis. A meta-database should be used to: a) record information about the inventory datasets; and b) outline details of data custodianship and access by other users. Use existing international standards (refer to the Ramsar Wetland Inventory Framework – Resolution VIII.6)
Establish a reporting procedure	Establish a procedure for interpreting and reporting all results in a timely and cost effective manner. The reporting should be concise, indicate whether or not the objective has been achieved, and contain recommendations for management action, including whether further data or information is required.
Establish a review and evaluation process	Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust the assessment process.
Perform study and include continuous assessment of methodology (go back and revise design if needed)	Undertake study method. Test and adjust the method and specialist equipment being used, assess the training needs for staff involved, and confirm the means of collating, collecting, entering, analysing and interpreting the data. In particular, ensure that any remote sensing can be supported by appropriate "ground-truth" survey.
Data assessment and reporting (was purpose of the study achieved? If not, go back to step 3)	Undertake a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust or even terminate the program. Results should be provided in appropriate styles and level of detail to, inter alia, local authorities, local communities and other stakeholders, local and national decision-makers, donors and the scientific community.

[1] It is important to include identification not just of local data and information but also other relevant national and international sources, which can provide supplementary data and information to underpin the rapid assessment (for example, the UNEP-GEMS/Water programme for water quality and quantity).

[2] IUCN has developed a methodology for prioritizing important sites for conservation of biodiversity of inland waters. See http://www.iucn.org/themes/ssc/programs/freshwater.htm for further information.

6.1 CHOOSING RAPID ASSESSMENT TYPES AND OUTPUTS FOR DIFFERENT PURPOSES

The primary purpose of this guidance is to be a practical reference for deciding on appropriate methods for the rapid assessment of wetland ecosystems. Table 3 provides a schematic guide to a number of available methods used for rapid assessment of wetland ecosystems. It is meant to enable the selection of appropriate assessment methods, based on a structured framework of selection criteria. These are organized in a progression of the most important factors of assessment of wetlands. Further information on rapid assessment data collection and analysis methods are provided in Appendices 1 and 2, and further consolidated information for wetlands on choices of rapid assessment methods in relation to different resource limitations (particularly of time, money and/or expertise) and the scope of the assessment will be provided in a forthcoming Ramsar Technical Report (separate detailed guidance for inland waters and for coastal and marine systems is also available in the CBD materials (UNEP/CBD/SBSTTA/8/INF/5 and UNEP/CBD/SBSTTA/8/INF/13 respectively)).

Choosing an appropriate method for the rapid assessment purpose should begin with the most basic and broad elements of an assessment, and then advance through progressively more selective criteria. Eventually a general framework of the necessary assessment should emerge, taking the amalgamated form defined by its purpose, output information, available resources, and scope. The idea is to meld informational parameters, like output and purpose, with logistical parameters such as time frame, available funding, and geographical scope, in order to present a realistic assessment model and determine what methods are available for its implementation.

Defining the purpose is the first step of an assessment. Table 3 provides three general purposes corresponding to five specific purposes, which will determine the assessment type. The five specific assessment types used in the decision tree are: baseline inventory, specific-species assessment, change assessment, indicator assessment, resource assessment. The assessment types are explained in detail below.

Once the purpose and assessment type have been determined, a step-wise approach should be taken through the more specific components of the assessment. These include the resource limitations and scope of the various elements of the assessment. This section begins with an appraisal of the resources available for the assessment. Time, money, and expertise are the critical resource components considered in the tree; availability of or limitations on these resources will determine the scope and capacity of any rapid assessment. There are then six more specific parameters (taxa, geography, site selection, methods, data collection, analysis) to consider in determining the scope of each of those relative to the resource limitations of the assessment. Variable combinations of resource limitations and scope criteria give shape to the assessment project.

Purpose

The approach starts with the supposition that any rapid wetland assessment ought to be performed with the overriding goals of conservation and wise use in mind. The methods used should augment knowledge and understanding in order to establish a baseline of wetland biological diversity, assess changes in, or the health of, wetland ecosystems, and support the sustainable use of the wetland resource. There are five specific reasons within this context to undertake a rapid assessment of wetlands. These cover the breadth of possible reasons for rapid assessment:

a) Collect general biodiversity data in order to inventory and prioritize wetland species, communities and ecosystems. Obtain baseline biodiversity information for a given area.
b) Gather information on the status of a focus or target species (such as threatened species). Collect data pertaining to the conservation of a specific species.
c) Gain information on the effects of human or natural disturbance (changes) on a given area or species.
d) Gather information that is indicative of the general ecosystem health or condition of a specific wetland ecosystem.
e) Determine the potential for sustainable use of biological resources in a particular wetland ecosystem.

The five categories of specific purposes each relate to a different numbered assessment type. The columns in Table 3 are related to the three objectives of the Convention on Biological Diversity. Columns I and II (baseline inventory and species assessment) are related to the conservation of biodiversity. Columns III, IV and V (Change, indicator, and resource assessments) address sustainable use while column V (Resource assessment) also refers to the equitable sharing of the benefits arising out of the utilization of genetic resources.

Table 3. Rapid Assessment types and possible outputs for different purposes

GENERAL PURPOSE	BIODIVERSITY BASELINE		DISTURBANCE AND ECOSYSTEM HEALTH		RESOURCE SUSTAINABILITY AND ECONOMICS
Specific purposes	Baseline inventory; prioritization; conservation; identification	Conservation of specific species; status of alien species	Change detection	Overall ecosystem health or condition	Sustainable use of biological resources
Assessment type	I. Baseline inventory	II. Species-specific assessment	III. Change Assessment	IV. Indicator assessment	V. Resource assessment
Types of data and analyses possible	**1.** Species lists/inventories. **2.** Habitat type lists/inventories. **3.** Limited data on population size/ structure, community structure and function, and species interactions **4.** Abundances, distribution patterns, and ranges. **5.** Genetic information. **6.** Important species: threatened, endangered, endemics, migratory, invasive alien species, other significance: cultural, scientific, economic, nutritional, social. **7.** Diversity indices. **8.** Water quality data. **9.** Hydrological information.	**1.** Status of a focal species: distribution, abundance, population size/ structure, genetic, health, size, species interactions, nesting, breeding and feeding information. **2.** Ecological data on focal species; habitat, symbionts, predators, prey etc. **3.** Threats to focal species and habitats. **4.** Life history table. 5. Water quality data. **6.** Hydrological information.	**1.** Monitoring data. **2.** Effects of an activity or disturbance on habitat/species/ communities: diversity loss, genetic issues, habitat changes or loss. **3.** Monitor impacts. 4. Determine changes in ecological character. **5.** Impact reduction options. **6.** Biotic indices. **7.** Habitat indices. **8.** Water quality data. **9.** Hydrological information. **10.** Early warning indicators.	**1.** Data on health or condition of inland water systems. **2.** Water quality data. **3.** Hydrological information. **4.** Biological parameters. **5.** Biotic indices.	**1.** Presence, status and condition of economically, culturally, nutritionally, and socially important species. **2.** Information on sustainability of use of a species. **3.** Limited monitoring data: stock assessment data, habitat status. **4.** Limited information relevant to resource management. **5.** Water quality data. **6.** Hydrological information.
May also depend on:		Inventory assessment	Inventory assessment (recommended)		Species-specific assessment

Assessment types

In order to choose an adequate method for the assessment of wetland biodiversity, five types of rapid assessment are recognized that apply to wetlands. These assessment types vary according to the purpose and desired output of a particular assessment project. Each assessment type has specific outputs and applies to specific purposes. It is therefore important to determine the goals and overall purpose of any assessment relating to diversity, conservation, and management. Any particular project, defined by its purpose and output goals, should fall within the range of one or more of these five assessment types. The assessment types are briefly described below.

I. Baseline Inventory

Baseline inventories focus on overall biological diversity rather than extensive or detailed information about specific taxa or habitats. The goal is to gather as much information as possible about the wetland ecosystem through extensive and, as much as possible, comprehensive sampling of its biological constituents and related features (see also Ramsar Wise Use Handbook 10, Wetland Inventory). Species and habitat type lists are likely to be the most important form of data, but other relevant baseline data could include: species richness, abundances, relative population sizes, distribution and ranges, cultural significance in addition to biodiversity significance, and other relevant biological information pertaining to water quality (see e.g. DePauw & Vanhooren 1983 and USGS National water quality assessment program on http://water.usgs.gov), hydrology and ecosystem health. Data on geography, geology, climate, and habitat are also important. Local communities can be a valuable source of information concerning species richness of a habitat. For example, through community and consumption surveys information can be gathered in a short time span.

A full species baseline inventory involves an intense sampling effort to take inventory of the species present in an area. This inventory can then be used to determine the conservation value of an area in terms of its biodiversity. The goal is to sample as many sites and list as many species as possible in the short amount of time allotted for the assessment. Ideally, the species lists would correspond to specific sampling sites within the survey area. Separate lists of species for each taxonomic group observed/collected at each sampling site are useful in order to distinguish among different habitats and localities in the survey area. Taxonomic data would likely include sampling of fish, plankton, epiphytic and benthic invertebrates, aquatic and terrestrial plants, and algae.

Wetland habitat types can be inventoried through field survey or analysis of Geographic Information Systems (GIS) and remote-sensing data (see also Appendices II and III of the Ramsar "Framework for Wetland Inventory" (Resolution VIII.6); and the planned Ramsar Technical Report "Guidance for GIS applications for wetland inventory, assessment and monitoring"). To inventory habitat types in the field, several sites need to be sampled in order to get a range of habitat types of the area and the ecological gradations within it. If GIS is available, classification of wetland habitat types is possible using spatial data such as elevation, physiography, and vegetative cover. Ideally, information gathered during the assessment on wetland species and ecosystems should be geo-referenced.

A baseline inventory provides initial information about a defined area of interest. The output information could be useful in prioritizing species or areas of particular concern for conservation, identifying new species, and developing a broad view of the overall biodiversity of an area. For conservation and management, this information is especially pertinent in the prioritization of species and areas. Prioritized species should then be assessed according to species-specific assessment methods. If localities or habitats are prioritized for particular human stresses on them, then they should be considered for assessment according to the change assessment methods.

Possible outputs from an inventory assessment include:

Data:
Baseline wetland biodiversity data: species lists/inventories, habitat type lists/inventories, limited data on population size/structure, abundances, distributional patterns and ranges
Ecological data pertaining to the area: important wetland habitats, communities and their relationships
Background information on geology, geography, water quality, hydrology, climate, and habitat zones for greater ecological context

Applications:
Species prioritization: identify and prioritize any species of special concern or interest
Area/habitat prioritization: identify and describe important habitats or areas
Conservation recommendations
Basic data and diversity indices (see also Appendix 1)

II. Species-specific assessment

A species-specific assessment provides a rapid appraisal of the status of a particular wetland species or taxonomic group in a given area. The assessment provides more detailed biological information about the focus species within the context of its protection, use, or eradication (e.g., in the case of invasive species Thus, this assessment type generally pertains to ecologically or economically important species and can provide rapid information about an important species in an area where its status is unknown or of particular interest. Likewise, the assessment can be used to confirm the status of species as threatened, endangered, or stable in a certain area (if the assessment is repeated more than once).

Possible outputs from a species-specific assessment include:

Data:
Data pertaining to the status of focal species: distribution, abundance, population size/structure, genetics, health, size, nesting, breeding and feeding information
Ecology and behaviour, information pertaining to focal species: habitat, range, symbionts, predators, prey, reproductive and breeding information

Applications:
Conservation recommendations
Identification of economic possibilities/interests
Identification of threats and stresses to focal species and habitat
Assessment of status of alien species
Habitat classifications and similarity/comparative indices (see Appendix 1)

III. Change assessment

Often an assessment is needed in order to determine the effects of human activities (pollution, physical alterations, etc.) or natural disturbances (storms, exceptional drought, etc.) on the ecological integrity of a wetland area. The information collected in this type of assessment can be either retrospective or predictive in nature. Such predictive assessments are often undertaken in Environmental Impact Assessment of projects (see also Ramsar Wise Use Handbook 11, Impact assessment).

A retrospective approach aims to assess actual disturbances or alterations of various projects or management practices as they apply to biodiversity and biological integrity. In terms of biodiversity, this approach can be difficult without pre-disturbance (baseline) data for comparison, and it may therefore require trend analyses or the use of reference sites or environmental quality standards (EQS). Reference sites are areas of the same region that parallel the pre-disturbance condition of the impacted area in order to provide data for comparative analysis.

Four approaches to rapid assessment of change can be distinguished:

a) Comparing two or more different sites at the same time;
b) Comparing the same site at different times (trends);
c) Comparing the impacted site to a reference site;
d) Comparing the observed status to environmental quality standards. Most existing rapid assessment methods are designed for this purpose; some of these (either biological, physical-chemical or eco-toxicological) may also be used as "early warning indicators" (see also Ramsar's risk assessment guidance - Annex to Resolution VII.10 & Ramsar Wise Use Handbook 8: Section E; and guidance on vulnerability assessment [Ramsar Technical Report in prep.).

Rapid change assessment methods can be particularly helpful for assessing the impacts of natural (and other) disasters such as floods, storm surges, and tsunamis. Several methods for the rapid assessment of coastal wetland systems for the aftermath of disasters have been developed specifically as response tools for the Indian Ocean tsunami of December 2004. These include:

i) A "Field protocol for the rapid assessment of coastal ecosystems following natural disasters", using a coastal transect approach to assess if certain types of wetlands, (including mangroves and coral reefs, tidal flats, and saltmarshes) measurably reduced the damaging effects of the tsunami on people and infrastructure and to determine how wetland benefits/services and ecological restoration can help to recover lost livelihoods (available on: http://www.wetlands.org/Tsunami/data/Assessment%20v3.doc. Further information on assessment methods is available at http://www.wetlands.org/Tsunami/Tsunamidata.htm); and

ii) "Guidelines for Rapid Assessment and Monitoring of Tsunami Damage to Coral Reefs", prepared by the International Coral Reef Initiative (ICRI) and the International Society for Reef Studies (ICRS) (available on: http://www.unep-wcmc.org/latenews/emergency/ tsunami_2004/coral_ass.htm; http://www.icriforum.org/ and http://www.ReefBase.org/

A predictive approach would assess the potential consequences of a particular project, such as a dam or development, and also establish a baseline of biodiversity data for long-term monitoring of the changes.

This approach allows for "before and after" assessment data, as well as for identification of species and habitat areas likely to be affected by the impending changes. Comparative analysis of areas where changes have already occurred can be used to predict potential impacts. This is the field of environmental impact assessment (EIA) (see also Ramsar Resolution VIII.9 and Ramsar Wise Use Handbook 11), trend- and scenario-analysis, and modelling (in terms of predictions). It relies to a large extent on the results of a retrospective approach, specifically early warning indictors. There is a direct link between the predictive approach and policy responses. However, most of these methods are not generally very "rapid".

Special attention must be paid to changes at a biological community level, which may occur even when habitat conditions remain the same. This is the case with fast-spreading pioneer species adapted to the post-disturbance ecological conditions, which replace naturally occurring species. This presents a difficult question concerning the condition of the system, which may become more species-rich compared to its ecological history. The situation is especially complex when new species are considered more desirable than those that made up the original ecological system. Change assessment outputs are grouped below depending on whether they pertain to existing or potential changes.

Possible outputs from a change assessment include:

Data:
Baseline biodiversity data for long-term monitoring of changes. Species lists, abundances, distribution, densities
Geology, geography, water quality, hydrology, climate, and habitat information pertinent to the particular impact on the greater ecological context of the area
Basic information for wetland risk assessment and EIA, and
Data on specific taxa, changes in water quality, hydrological alterations and habitat structure (requires baseline or reference site data)

Applications:

Identify and prioritize species and communities within the impact range
Identify and prioritize important habitats within the impact range
Predict potential impacts through comparison of existing impacts in similar sites
Determine effects of human pressures and natural stresses on biodiversity and habitat structure
Identify specific pressures and stresses related to impact
Identify possible management practices to mitigate pressures and stresses
Make conservation recommendations
Determine biotic indices, scores and multimetrics (see Appendix 1; and Fausch et al. 1984; Goldstein et al. 2002; and Karr 1981)

IV. Indicator Assessment

An indicator assessment assumes that biological diversity, in terms of species and community diversity, can tell us a great deal about the water quality, hydrology and overall health of particular ecosystems. Biomonitoring is often associated with this type of assessment – this traditionally refers to the use of biological indicators to monitor levels of toxicity and chemical content, but recently this type of approach has been more broadly applied to monitoring the overall health of a system rather than its physical and chemical parameters alone (see Nixon et al. 1996). The presence or absence of certain chemical or biological indicators can reflect environmental conditions. Taxonomic groups, individual species, groups of species, or entire communities can be used as indicators. Typically, benthic macro-invertebrates, fish, and algae are used as organismic indicators (see Rosenberg & Resh 1993; Troychak 1997). It is therefore possible to use species presence/absence, and in some instances abundances and habitat characteristics, to assess the condition of wetland ecosystems.

Possible outputs from an indicator assessment include:

Data:

Presence/absence/abundance of species or taxa
Taxonomic diversity
Physical/chemical data (e.g., pH/conductivity/turbidity/O2/salinity)

Applications:

Assess the overall health or condition of a given inland water ecosystem
Assess water quality and hydrological status
Make conservation recommendations
Indices of diversity and ecosystem health, habitat classification, physical-chemical assessment methods and basic data on biological assessment (see Appendix 1 for further details on biomonitoring indices)

V. Resource assessment

A resource assessment aims to determine the potential for sustainable use of biological resources in a given area or water system. Data pertain to the presence, status and condition of economically important species, species on which livelihoods depend, or those with a potential market value. Ideally a resource assessment can facilitate the development of ecologically sustainable development as an alternative to destructive or unsustainable activities.

Thus, a major objective of the resource assessment is to develop or determine sustainable use practices as viable economic options in areas with rich biological resources. For this reason, an important factor of resource assessment is the full involvement of local communities and governments, for example through community biodiversity surveys (see NSW National Parks and Wildlife Service 2002). This is especially important in relation to the needs, capacity and expectations of all involved parties. This integrative approach is important to the successful implementation of any sustainable harvesting system. Another extension of a resource assessment may be to provide baseline information used to monitor the health of fisheries and other resources.

The use of methods for the economic valuation of wetlands are highly relevant to resource assessment, and a number of such methods can be considered as "rapid". (Further information on available wetland economic valuation methods is available in a forthcoming Ramsar Technical Report and in the Ramsar publication Economic Valuation of Wetlands: a Guide for Policy Makers and Planners (1997).

Possible outputs from a resource assessment include:

Data:
Determine the presence, status and condition of socio-economically important species
Identify important parties
Identify interests, capacity, and expectations of all involved parties
Collect baseline monitoring data such as stock assessments, and
Assess the socio-economic consequences of different resource management options.

Applications:
Fishery and other aquatic resources sustainability, habitat status, stock assessments, information for fishermen/resource users
Options for sustainable development and recommendations for management.

7. DESIGN CONSIDERATIONS

7.1 Resources

The methods available for rapid wetland biodiversity assessment are contingent on the purpose and output of specific projects. Equally important is a consideration of available resources and limitations, especially as they apply to the scope of the assessment. Time, money and expertise are resource limitations that determine the methodologies available to a particular assessment project. Furthermore, they define the project in terms of its scope in the following areas: taxa, geography, site selection, analysis, data, and sampling methods. These are important components of a wetland biodiversity assessment, and the scope or capacity of each vary depending on the project needs and its resource limitations.

Time, money and expertise are the key factors to consider in a rapid wetland biodiversity assessment. In abundance, these resources allow for a great deal of flexibility, while insufficiency limits nearly all aspects of a potential assessment project. However, in some cases abundance in one area can compensate for limitations in another. The availability of these resources will, to a large extent, determine the scope and capabilities of the assessment.

Time

Time is a fundamental consideration for any rapid assessment.

Scientifically, long-term monitoring and research offer statistical advantages over rapid assessment. With these, more detailed and thorough sampling is possible, which can measure change over time and produce more statistically rigorous results. However, the short time frame implicit in a rapid assessment is what makes this type of survey appealing; it allows for a snapshot or overview allowing fast judgment about the condition of an area. Thus, rapid assessment can provide information when informed decisions need to be taken urgently. Rapid assessment can also be a good way to establish baseline data that can then be used for further study if warranted. The amount of time available for the assessment is an important resource, and adequate planning should determine how it will be spent. Rapid assessment can never replace long-term monitoring and research.

There is flexibility in the definition of "rapid" but the term implies that time is of the essence. The time frames for rapid assessment are broadly based on typical lengths of rapid assessments and are separated as follows: short (1-7 days), medium (8-30 days), and long (30+ days). This refers to the amount of time to complete the entire project from start to finish, including transport, data collection, and preliminary analysis. Final analysis and results may take more time, but preliminary conclusions are important and need to be available quickly – otherwise the purpose of a rapid assessment is lost.

Money

The amount of funding available for an assessment will, along with time, determine the capabilities and scope of a rapid wetland assessment. Because monetary amounts are relative, and broad categories cannot account for the fluid nature of currency values, a simple categorization is used. This is not based on values or actual monetary amounts, but rather on the relative amount of funding available to carry out the assessment. Therefore, the available capital for a given assessment is either limited, meaning that it can be considered limiting, or less than the amount desired to carry out the objectives of the project, or ample, meaning that there is enough money to carry out all elements of the assessment in a scientifically sound and usable way.

Expertise

An expert is someone who, for example, can identify specimens of a taxonomic group to the species level, is familiar with current sampling and collection methods, can analyse data, and is familiar with the taxonomic group within a larger biological and ecological context. It does not refer to people with a general understanding or basic knowledge in the field. It is important to determine the availability of experts on a local, regional and international level. Local expertise is a great resource when it is available. Often local experts will have a good understanding of local geography, ecology, and community issues. However, if there is no local expert, an expert from outside the locality or region may need to be brought in. In highly specialized cases there may only be a small number of people, or even just one person, who can be considered an expert in the area of study.

Institutional support refers to the use of technical facilities for analysis, storage of data, and other forms of support. Determination of the available expertise should include a consideration of the institutional support that is available, as this may present a limitation to the capacity and scope of any project. In deciding on what form of rapid assessment is feasible, it is important to determine whether individuals who are experts in the field of study (including local experts) are or are not available for the assessment project.

7.2 Scope

The scope requires a consideration of the scale of various elements of an assessment. How much area does the assessment cover? How many species will be sampled? How much data will be collected? How many sites will be sampled?

In general the scope of a rapid assessment is contingent upon the purpose and resources of the assessment. Ample resources allow for proportional increases in the scope of various parts of an assessment. It is difficult to have an extensive geographic scope for a two-day assessment on a tight budget. In this respect some aspects of the scope are related to one another as well. For example, it could be possible to survey a broad geographic area in two days if the scope of the site selection and data collection were both highly reduced. In general, if the resources for an assessment are ample, the scope becomes entirely dependent on the purpose and objectives of the project.

The scope of an assessment can vary internally in the following areas: taxa, geography, site selection, sampling, and data analysis. Each of these should be considered separately. For example, a given assessment project may have a broad geographical scope, covering an expansive area, while the taxonomic scope could be quite focused, concentrating on a limited number of taxonomic groups.

Taxonomic scope

The taxonomic scope depends upon how many and which taxonomic groups will be involved in the study.

Some surveys may focus solely on aquatic invertebrates, while others may include several taxonomic groups. Typically the purpose of the assessment will determine which groups are pertinent to the study, as certain taxonomic groups will be more or less useful in certain assessment types. For example, benthic macro-invertebrates are often used in impact assessments of rivers and streams because they are sensitive to water conditions and are relatively easy to sample. Some types of aquatic mammals or bird species are also affected by changes in water conditions, but they are more difficult to sample and are not good indicators of these changes since the response is more subtle and takes place over a longer time frame.

It is important to consider that in any given assessment, certain species or taxonomic groups will be more easily sampled than others. The cost (in terms of time and money) of including a taxonomic group that is particularly difficult to survey must be weighed against the benefits of including that group. In some cases it may be better to forego certain groups if time and money would be better spent on other groups. Related to this is the relative size of the taxonomic group involved. In a given area, the taxonomic scope of a survey of, for example, caddisflies (Trichoptera) may be greater than a survey focusing on aquatic mammals, birds and fish species.

Geographic scope

The geographic scope of an assessment depends upon the taxonomic groups involved and/or the size of the area relevant to the project. The geographic scope can vary depending upon the range of a particular species, the extent of a particular ecosystem or habitat, or the area affected by an impact. This could range from small microhabitats such as a specific sediment type or it may extend across relatively large geographical areas, such as entire watersheds, lake systems, basins or coastal zones.

The geographic scope will also vary depending on how large an area must be studied in order to obtain statistically sound data. Therefore, it is important to determine the geographic scope in terms of the range or size of the surveyed area, and also the number of habitats to be studied. The ability to assess these different levels of geographic scope is dependent on the resources available to the project.

Site selection

Site selection refers to the number and type of wetland sites needed for the assessment. As for geographic scope, site selection is highly dependent on other aspects of the assessment. A baseline inventory requires a relatively broad assessment of the biodiversity at several sites with variable habitats. A species-specific assessment would concentrate on habitats used by the target species and may forego several sampling sites in order to provide greater depth of study in fewer sites. Site selection for an impact assessment would concentrate on sites associated with the impact in question. Resource-assessment sites focus on areas that could be used for exploitation. An indicator assessment would include as many sites as are needed to produce the necessary data.

In considering the type of sites to be selected, one possible question is whether sites should be chosen by virtue of being characteristic or distinct. Characteristic sites are representative of the typical habitat of a given area. However, in most areas, habitat is not continuous, and localized gradations in habitat create a mosaic of related but distinct communities that grade into one another. Selecting distinct sites allows for surveys of these unique and specialized habitats.

Choosing between distinct versus representative habitats often depends on the resources and purpose of the assessment. If time is short, it may be best to quickly survey representative areas in order to get a good general picture of the situation before trying to assess more unique sites. If more time is available, and the purpose is to survey as many species as possible, or to describe habitat types, then distinctive habitats may deserve more attention.

Consideration should also be given to site accessibility, taking into account factors such as remoteness, restrictions due to land use (e.g. military zones), land tenure, susceptibility to flood/fire events, and seasonal/weather conditions.

7.3 Sampling and data analysis

The type of sampling method used is determined according to the objective of the assessment and should be more or less the same for all nations, including small island states. The sampling methods used will vary according to the need to be standardized, whether they can or cannot be technical, the time limitations, and the type of equipment available. Most importantly, the methods should strive to provide insightful, statistically sound data that can be applied to the purpose of the assessment.

For most studies, a variety of water quality variables should be measured. These can include temperature, electrical conductivity (EC, a measure of the total dissolved salts), pH (an measure of the water's acidity or alkalinity), chlorophyll A, total phosphorous, total nitrogen, dissolved oxygen, and water transparency (Secchi depth). These variables can be measured with individual instruments or with one combination instrument that includes several types of probes.

Macrophytes can be searched visually from above or under the water surface (scuba) or by means of special samplers. Fishes can be sampled using a wide variety of methods (see Appendix 2), keeping in mind the applicable legislation. Asking local fishermen and examining their catches can be a helpful method as well. Aquatic invertebrates can be sampled from the water column (plankton), from emergent, floating-leaved, and submerged vegetation (epiphytic fauna), and from the bottom sediments (benthic invertebrates) by appropriate sampling technique. Reptiles and amphibians are generally sampled using nets, traps or by visual search during day and night.

Appendix 2 lists a wide range of sampling methods for different wetland features and taxa which can be used in rapid assessments. Some other useful general reference sources for sampling methods include: Merritt et al (1996); James & Edison (1979); Platts et al (1983); Nielsen & Johnston (1996); and Sutherland (2000). Useful websites for reference include: the United States Environmental Protection Agency (www.epa.gov/owow/monitoring), the World Conservation Monitoring Centre (www.unep-wcmc.org), the World Biodiversity Database provided by the Expert Center for Taxonomic Identification (ETI) (www.eti.uva.nl), and the Ecological Monitoring and Assessment Network (Canada; http://www.eman-rese.ca/eman/intro.html).

In the context of rapid assessment, data used should be of the appropriate type and quality for their intended use. If more resources are available in time, money and expertise, the possibilities of obtaining reliable data and sound statistical results are higher. In addition, it is important to gather pre-existing information on the site, the species, the habitats to gain better insight on the types of data, sampling designs and analyses needed in the assessment.

The following seven questions should be addressed in collecting data

a) What are the types of data? The variables of concern are determined by the purpose of the assessment. They can be qualitative such as lists, classes or categories used for example in inventories and ecological description or they can be quantitative, numerically based, such as counts and measurements used for example in population densities, abundances, etc. The variables needed to be collected to calculate specific metrics are well documented (see e.g. Barbour et al 1999);

b) How to collect data? There are two types of sampling designs: probability sampling based on randomness and targeted design that focuses on site-specific problems. Probability sampling design allows making inference about an entire region based on estimates on the sample sites. Simple random sampling defines the population and then randomly selects from the entire population. When there is variability associated with groups or habitats, stratified random sampling can lower the error associated with population estimates. Cluster sampling is designed for very large populations, first grouping sampling units into clusters which are often based on geographic proximity, then clusters are randomly selected and data are only collected from sampling units within these clusters. The use of GIS reduces the effort and time in randomly selecting the assessment sites. Finally, sampling should follow protocols such as those established for sampling fish, macroinvertebrates and periphyton. The Ecological Monitoring and Assessment Network hosted by Environment Canada provides detailed information on monitoring protocols for various taxa (http://eqb-dqe.cciw.ca/eman/ecotools/protocols/freshwater).

c) How much data to collect? The sample size depends on factors such as the resources available, the geographic and temporal scope of the assessment, and the confidence levels. The number and type of sites should provide an adequate sampling for quantitative or qualitative analysis. In general, the greater the number of sites sampled, the greater coverage of the area. Choosing fewer sites allows for more in-depth survey at each site. For some assessments, an increased number of sampling sites may be beneficial, where as others may warrant more time spent at each site for more intense sampling. The choice is not “either/or”, and consideration should be given to reach the best compromise between coverage and intensity. Replicates are needed to account for variance associated with measurement error in an assessment;

d) How to enter data? Using bioinformatics (software, database applications, etc.) to manage data is very reliable and useful. The application can be developed to serve the specific needs of the assessment. Field data sheets or forms can be printed out and filled on site. Biodiversity informatics allows for more efficient analysis, dissemination and integration of the results with other databases. Examples of field data sheets for inland wetlands are provided by the EPA program on Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers (http://www.epa.gov/OWOW/monitoring/techmon.html);

e) How to analyse data? Depending on the data collected and the purpose of the assessment, methods used for analyses could be simple descriptive, univariate, EDA (exploratory data analysis), or multivariate (clustering, similarity analysis, ordination, MANOVA). Two approaches have been used: multimetrics used by most water resource agencies in the United States or multivariate used by several water resource agencies in Europe and Australia (for further details on measurements of ecological diversity see Magurran 1988); and

f) How to integrate data and report on it? It is important to integrate data from one assemblage to those of other assemblages to complement the assessment at a larger spatial and temporal scale and to provide more complete assessment of biological diversity. Assessment reports should contain the scientific information, results and recommendations for further action to guide authorities, scientists, but also to reach a broader, non-scientific audience by adding graphical displays, and presentation on multimedia tools. Finally, depending on the ownership of the information, the database collection and the results should be disseminated through the internet and relevant networks of biological information to serve the needs of diverse user groups.

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APPENDIX 1

ASSESSMENT ANALYSIS METHODS AND INDICES

This appendix provides a non-exhaustive and indicative list of analysis methods and indices relevant to different aspects of wetland rapid assessment, as well as reference sources to reviews or key papers for further information. For 'Application': IW = inland wetlands; MC = coastal/marine wetlands.

ASSESSMENT METHOD	APPLICATION	REFERENCES
HABITAT ASSESSMENT METHODS		
Habitat classifications		
River Habitat Survey (RHS)	IW	Raven et al. (1998)
CORINE Biotopes classification	terrestrial, aquatic	Nixon et al. (1996)
Ecological Systems Classification	aquatic, terrestrial	Groves et al. (2002)
Huet's Fish zones	IW	Nixon et al. (1996)
Davidson's aquatic communities	estuaries	Nixon et al. (1996)
EUNIS habitat classification	MC	http://mrw.wallonie.be/dgrne/sibw/EUNIS/home.html
US NOAA habitat classification	MC: Pacific and Caribbean	http://biogeo.nos.noaa.gov/benthicmap/
Predictive systems		
RIVPACS	rivers, benthic macroinvertebrates	Nixon et al. (1996)
AUSRIVAS	IW: macroinvertebrates	http://www.deh.gov.au/water/rivers/monitoring.html http://ausrivas.canberra.edu.au/main.html Schofield & Davis (1996)
HABSCORE	rivers, salmonids	Nixon et al. (1996)
Ecopath with Ecosim	Ecosystem effects of fishing, management applications	http://www.ecopath.org/
Physical-chemical assessment methods		
AUSRIVAS geoassessment	IW	http://www.deh.gov.au/water/rivers/monitoring.html Parsons et al. (2002)
Prati Index	IW/MC	Prati et al. (1971)
BIOLOGICAL ASSESSMENT METHODS		
Basic data		

ASSESSMENT METHOD	APPLICATION	REFERENCES
Abundance of individuals of given taxa	IW/MC	Hellawell (1986)
Total numbers of individuals (without identification)	IW/MC	Hellawell (1986)
Species richness	IW/MC	Hellawell (1986)
Diversity Indices		
Simpson's index	IW/MC	Washington (1984), Hellawell (1986)
Kothé's Species Deficit	IW/MC	Washington (1984)
Odum's 'species per thousend	IW/MC	Washington (1984)
Gleason's Index	IW/MC	Washington (1984)
Margalef's Index	IW/MC	Washington (1984), Hellawell (1986)
Menhinick's Index	IW/MC	Washington (1984), Hellawell (1986)
Motomura's geometric series	IW/MC	Washington (1984)
Fisher's 'alpha' (= William's alpha)	IW/MC	Washington (1984), Hellawell (1986)
Yules 'characteristic'	IW/MC	Washington (1984)
Preston's log-normal	IW/MC	Washington (1984)
Brillouins H	IW/MC	Washington (1984)
Shannon-Wiener H'	IW/MC	Washington (1984), Hellawell (1986)
Pielou Eveness	IW/MC	Washington (1984)
Redundancy R	IW/MC	Washington (1984)
Hurlbert's PIE encounter index	IW/MC	Washington (1984)
McIntosh's M	IW/MC	Washington (1984), Hellawell (1986)
Cairns Sequential Comparison Index (SCI)	IW/MC	Washington (1984), Persoone & De Pauw (1979), Hellawell (1986)
Keefe's TU	IW/MC	Washington (1984)
BIOTIC INDICES, SCORES AND MULTIMETRICS		
Saprobic systems		
Kolkwitz & Marsson's Saprobic System	IW/MC: bacteria, protozoa	Washington (1984)
Liebmann	IW/MC	Persoone & De Pauw (1979)
Fjerdingstad	IW/MC	Persoone & De Pauw (1979)
Sladecek	IW/MC	Persoone & De Pauw (1979)
Caspers & Karbe	IW/MC	Persoone & De Pauw (1979)
Pantle & Buck	IW/MC	Persoone & De Pauw (1979)
Zelinka & Marvan	IW/MC	Persoone & De Pauw (1979)
Knöpp	IW/MC	Persoone & De Pauw (1979)
Algae		
Palmer's Index	IW/MC: algae	Washington (1984)

ASSESSMENT METHOD	APPLICATION	REFERENCES
Plants		
Haslam & Wolsley's Stream Damage Rating and Pollution Index	IW	Nixon et al. (1996)
Plant Score	IW	Nixon et al. (1996)
Newbold & Holmes' Trophic Index	IW	Nixon et al. (1996)
Fabienne et al.'s Macrophyte Trophic Index	IW	Nixon et al. (1996)
Macroinvertebrate systems		
Wright and Tidd's 'oligochaete indicator'	Oligochaeta	Washington (1984)
Beck's index	macroinvertebrates	Washington (1984)
Beak et al.'s 'lake' index	IW: lakes	Washington (1984)
Beak's 'river' index	IW: macroinvertebrates	Washington (1984)
Woodiwiss' Trent Biotic Index (TBI)	macroinvertebrates	Washington (1984)
Chandler's Biotic Score	macroinvertebrates	Washington (1984)
Biological Monitoring Working Party Score (BMWP)	macroinvertebrates	Metcalfe (1989)
Average Score Per Taxon (ASPT)	macroinvertebrates	Metcalfe (1989)
Tuffery & Verneaux's Indice Biotique de Qualité Générale	macroinvertebrates	Persoone & De Pauw (1979) Metcalfe (1989)
Indice Biologique Global (IBG)	macroinvertebrates	Metcalfe (1989), AFNOR T90-350 (http://www.afnor.fr/portail.asp?Lang=English). Standard available for purchase from: http://www.boutique.afnor.fr/Boutique.asp?lang=English&aff=1533&url=NRM%5Fn%5Fhome%2Easp
Belgian Biotic Index (BBI)	macroinvertebrates	De Pauw & Vanhooren (1984)
Goodnights and Whitleys 'oligochaetes'	Oligochaeta	Washington (1984)
Kings and Balls' Index	tubificids, aquatic insects	Washington (1984)
Graham's Index	macroinvertebrates	Washington (1984)
Brinkhurst's index	Tubificids, Limnodrilus	Washington (1984)
Raffaeli and Mason's index	Nematodes, copepods	Washington (1984)
Sander Rarefaction method	Polychaetes & bivalves (marine)	Washington (1984)
Heister's modification to Beck's index	macroinvertebrates	Washington (1984)
Hilsenhoff's index	macroinvertebrates	Washington (1984)
EPT-index	Ephemeroptera, Plecoptera, Trichoptera	
Rafaelli and Mason's index		Washington (1984)
K135 Quality Index (Netherlands)	macroinvertebrates	Nixon et al. (1996)
Danish Fauna Index	macroinvertebrates	Nixon et al. (1996)

ASSESSMENT METHOD	APPLICATION	REFERENCES
Wiederholm's Benthic Quality index (BQI)	IW: chironomids, oligochaetes (lakes)	Nixon et al. (1996)
Detrended Correspondence Analyses (DCA)	IW: lakes	Nixon et al. (1996)
Jeffrey's Biological Quality Index (BQI)	macrobenthos (estuaries, coastal waters)	Nixon et al. (1996)
Biotic Sediment Index (BSI)	macroinvertebrates (sediments)	De Pauw & Heylen (2001)
Fish		
Karr's Index of Biotic Integrity (IBI) (Fish index)	IW/MC: fish	Karr (1981)
BIRDS		
International Waterbird Census (IWC) for wintering waterbirds	IW/MC: birds	Nixon et al. (1996); http://www.wetlands .org/IWC/Manuals.htm
"all in"-systems		
Patrick's histograms	IW/MC: algae to fish; except bacteria	Washington (1984)
Chutter's index	IW/MC: all; except Cladocera & Copepoda	Washington (1984)
Similarity indices / Comparative indices		
Jaccard's index	IW/MC	Washington (1984), Hellawell (1986)
Percentage similarity (PSC)	IW/MC	Washington (1984)
Bray-Curtis dissimilarity	IW/MC	Washington (1984)
Pinkham and Pearson's Index	IW/MC	Washington (1984)
Euclidean or 'ecological' distance	IW/MC	Washington (1984)
Washington (1984)	IW/MC	Hellawell (1986)
Mountfort Index of similarity	IW/MC	Hellawell (1986)
Raabe's Comparative measure	IW/MC	Hellawell (1986)
Kulezynski's Coefficient of similarity	IW/MC	Hellawell (1986)
Czekanowski's Comparative measure	IW/MC	Hellawell (1986)
Sokal's Distance measure	IW/MC	Hellawell (1986)
Ecosystem health		
AMOEBA	IW/MC	Nixon et al. (1996), Ten Brink et al. (1991)
INTEGRATED OR COMBINED ASSESSMENT SYSTEMS		
TRIAD - Quality Assessment	IW/MC: BSI, ecotox., phys.-chem. (sediments)	http://www.nos.noaa.gov/nccos/ccma/publications.aspx?au=Chapman http://www.ingentaconnect.com/content/klu/ectx/2002/00000011/00000005/05096179
EPA 's Rapid Assessment Protocols (RBP)	IW/MC	Barbour et al. (1999)
SERCON	IW/MC: Physical diversity, naturalness, representativeness, rarity, species richness	Boon et al. (2002) (see also: Parsons et al. (2002)

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APPENDIX 2

SAMPLING METHODS FOR WETLAND HABITATS, FEATURES AND DIFFERENT WETLAND-DEPENDENT TAXA

Note that cost estimates are for equipment, etc., and do not include costs of fees or salaries. Listing of a source of equipment does not imply endorsement of the supplier or the equipment.

Water Quality:

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
physical probes	IW/MC	pH, O2, electric conductivity temperature, BOD, and flow rate	short- 10 -30 minutes	$100-3000 depending on number of probes and quality	lakes, rivers, wetlands, all water bodies	none	no	pH probe, temperature probe, DO (dissolved oxygen) probe, conductivity meter, flow meter, BOD collection equipment, titration equipment	http://www.geocities.com/RainForest/Vines/4301/tests.html http://www.hannainst.com/index.cfm	English, Wilkinson and Baker (1997)
Secchi Disc	IW/MC	water transparency	short, 5-10 minutes	$10	mostly standing water or slow flowing rivers; shallow coastal waters	none	no	secchi disc	http://www.nationalfishing-supply.com	Wetzel & Likens (1991); English, Wilkinson and Baker (1997)
Water sample collection and Lab analysis	IW/MC	total phosphorus, total nitrogen, chlorophyll-a	10 minutes in field, 3 hours in laboratory per sample	high – larboratory equipment	all water bodies	training in using laboratory equipment	water samples	spectrophotometer, filters, bottles, water samples, net for reactive phytoplankton	http://www.hannainst.com/index.cfm	Wetzel & Likens 1991; Downing & Rigler 1984; Strickland & Parsons 1972
visual assessment of water colour	IW	water colour and type (black, white, clear, etc.), turbidity	fast- 1-5 minutes	0	all water bodies	none	no	water samplers for deeper water (can be used in conjunction with zooplankton sampling)		
visual assessment of sediment	IW/MC	sediment colour and type (organic, sandy clayish, etc)	fast- 1-5 minutes	0	all water bodies	none	sediment sample	grab sampler (can be done in conjunction with benthic invertebrate sampling)	http://www.elcee-inst.com.my/aboutus.htm	English, Wilkinson and Baker, 1997

Wetland habitat types:

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
field habitat assess-ment	IW/MC	channel morphology, bank charac-teristics, discharge, velocity, sed-imentation, evidence of distubance, microhabitat structure (riffles etc), riparian attributes, water depth	1-3 hours	low	Any inland or coastal wetland habitats	training in field methods	no	flow meter, tape meas-ure, camera, substrate sampler		www.usgs. gov/nawqa
patial data analysis		land use, vegetation type and dis-tribution, riparian cor-ridor charac-teristics, val-ley morphol-ogy, size and shape of water bod-ies, channel gradient, water colour, hydrologic regime, slope	variable, depending on data res-olution and availability	variable-depending on data res-olution and availability	all wetland types	knowledge of reading data and GIS	no	satellite imagery, aer-ial photos, digital eleva-tion models, land cover, hydrogra-phy, geology		www.fresh-waters.org; www.usgs. gov
Manta board survey		Mapping of lakeshore lit-toral habitats to comple-ment simul-taneous mapping of coastal topography, land form and land use	15 km of shoreline per day by team of 4-5 people	Boat, fuel	Any clear waters gen-erally with with depth of 3-10 m depending on water vis-ibility	Can be acquired in 1-2 days	no	Manta board; snorkelling equipment; inflatable boat plus outboard; maps; underwater paper and pencils, GPS	The manta board can easily be constructed from marine ply	www.ltbp.or g/PDD1.HT M Allison et al. (2000); Darwall & Tierney (1998); English, Wilkinson & Baker (1997)

Macrophytes (plants):

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
visual search	IW/MC	note visible plants within certain areas ie. full river mark, high water mark; for qualitative analysis	variable depending on area searched	$0	rivers, lakes, ponds, wetlands; any coastal/ marine habitat	Species identification	yes	Basic	Everywhere	NSW National Parks and Wildlife Service (2002)
random sampling	IW/MC	qualitative, more unbiased than a visual search	1-5 hours	$0	rivers, lakes, ponds, wetlands; any coastal/marine habitat	Species identification & knowledge of making random samples	yes	Basic	Everywhere	Downing & Rigler (1984), Moss et al. 2003 in press; NSW National Parks and Wildlife Service (2002)
Plots	MC	All coastal vegetation (plot size variable depending on vegetation type	Variable: usually c. 1 hour/plot	Low	All coastal habitats, including mangroves	Species identification & survey design	Yes	Basic	Everywhere	NSW National Parks and Wildlife Service (2002)
grab	IW/MC	good, quantitative method	1-5 hours	$350-1100	rivers, lakes, ponds, wetlands; soft bottom coastal/ marine vegetation	Skill in grab use; knowledge on random of transect sampling	yes	Grab sampler, buoys, GPS, boat	http://www.elcee-inst.com.my/aboutus.htm	Downing & Rigler (1984)
Diving/ snorkeling	IW/MC	allows investigating plants in deep water	Usually c. 1 hour, depending on repetition	Low (snorkelling) to high (Scuba)	rivers, lakes, ponds, wetlands; clear coastal/marine waters	diving certification	yes	diving equipment, scissors to collect specimens; underwater sheets, slates & pencils	http://www.mares.com	English, Wilkinson & Baker (1997)

Zooplankton (small invertebrates in water):

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
box samplers	IW/MC	for plankton crustaceans and rotifers	1-3 hours	$100	rivers, lakes, ponds; all coastal/marine waters	skill in using samplers	yes	plankton (box) samplers	http://www.mclanelabs.com	Downing & Rigler (1984)

Epiphytic macroinvertebrates:

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
various samplers, depending on type of vegetation	IW/MC	Any inland wetland; littoral (near shore) zone	1-4 hours	$100-$200/ sampler	rivers, lakes, ponds, reservoirs, seagrass and macroalgal beds	skill in sampling	yes	tube or box samplers, sieves		Downing & Rigler (1984); Kornijów & Kairesalo (1994); Kornijów (1997)

Benthic macroinvertebrates:

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
visual search/ snorkel/ dive (quadrats, intercept and band transects)	IW/MC	good for locating big animals (e.g. crustaceans); suitable for suerveying clear waters and medium/large animals	Usually c. 1 hour, but variable depending on extent of repetition	Low (snorkelling) to high (scuba)	rivers, lakes, all clear coastal waters	diving certification	yes	snorkel/scuba gear, dip net, underwater sheets, slates and pencils, collecting material	http://www.nationalfishingsupply.com/seinenets1.html http://www.mares.com	English, Wilkinson & Baker (1997)
grabs, tube samplers	IW/MC	all invertbrates inhabiting soft or sandy sediments	Variable, generally about 1 hour/site	$350- $1100	good for sampling soft and sandy sediments	skill in using grab apparatus	yes	Grab samplers, wire mesh sieve, Rose Bengal stain, buoys, boat, sorting box, jars and preservatives	http://www.elcee-inst.com.my/limnology.htm http://www.elcee-inst.com.my/aboutus.htm	Downing & Rigler (1984); English, Wilkinson & Baker (1997)
kick net	IW/MC	all invertebrates inhabiting hard s ubstrates	1-5 hours	$55	good for wadable streams with gravel or stoney bottom	skill with kick nets	yes	kick net	http://www.acornnaturalists.com/p14008.htm http://www.greatoutdoorprovision.com	Downing & Rigler (1984) http://www.wavcc.org/wvc/cadre/WaterQWuality/kicknets.htm

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
dip net	IW/MC	suitable for sampling nectic (swimming) animals (e.g. beetles, water mites) in shallow waters	1-2 hours	$5-$20/ net	lakes, rivers, wetlands (incl Coastal)	skill in using dip nets	yes	dip net	http://www.stelingnets.com/dip_nets.html http://www.seamar.com	Downing & Rigler (1984)
seine	IW	suitable for sampling big invertabrates (crustaceans) in shallow water without strong current	1-4 hours	$10-$20/ net	small rivers, possible in lakes with a boat	skill in seining	yes	seine net	http://www.nationalfishingsupply.com/seinenets1.html	Downing & Rigler (1984)
sledge	MC	Semiquantitative epifauna sampling	About 1 hour/site	Not available	Soft-bottom habitats	Skill in sledging	Yes	Sledge, sieves, sorting box, buoys, GPS		English, Wilkinson & Baker (1997)
dredge	MC	Semiquantitative at best: useful for broad area surveys and inventories	About 1 hour/site	$500-600 per dredge	Soft-bottom: samples deeper into substrate	Skill in dredging	Yes	Dredge, sieves, boat, sorting box, rope, GPS	http://wild-co.com	English, Wilkinson & Baker (1997)
trawl	MC	Qualitative: larger epifauna and demersal nekton (complementary to other methods)	2-3 hours/site	$1000 for nets, boat rental and field assistance	Soft-bottom substrates	Skill in trawling	Yes	Trawl, sieves, boat, sorting box, rope, GPS	http://www.seamar.com	English, Wilkinson & Baker (1997)
Surber sampler	IW/MC	all invertebrates inhabiting stony or gravel subtrates	1-3 hours	$200	gravel or stony bottom rivers and streams, standing waters	knowledge of using Surber and requirements to quantify data	yes	Surber sampler, bucket	http://www.kc-denmark.dk/public_html/surber.htm http://www.kc-denmark.dk	Downing & Rigler (1984)
aerial nets		for catching adult invertebrates	1-5 hours	$35-$50	land	skill in using aerial nets	yes	insect net	http://www.rth.org/entomol/insect_collecting_supplies.html http://bio-quip.com	Downing & Rigler (1984)

Fish:

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
seine nets		mostly smaller fishes	1-4 hours	$10-250/ net, depending on size	shallow water without strong current, small rivers, possible in lakes with a boat, (for big nets a boat can be needed for deployment and pulling)	skill in seining	yes, net does not kill fishes	seine net boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.nationalfishingsupply.com/seinenets1.html http://www.seamar.com	Bagenal (1978); English, Wilkinson and Baker (1997)
gill net	IW	all fish sizes and types	24 hours- leave out overnight	$150-200/net	shallow to medium depth waters, standing waters or slow flowing rivers none		yes, net kills fishes	gill nets	http://www.nationalfishingsupply.com/seinenets1.html 1	Bagenal 1978
Kill nets	MC	all fish sizes and types, depending on mesh size	12-24 hours- leave out overnight	$50-$500/net	shallow to medium depth waters	Skill in setting the nets	yes	drift, trammel, block, encircling and/or gill nets, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.seamar.com	English, Wilkinson and Baker (1997)
fish traps (fykes)	IW/MC	all fish sizes and types, mostly bottom living fishes	24 hours- leave out overnight	$50-100/trap	mostly shallow waters (for deeper waters a motorised winch is needed)	Skill on setting traps in right places. Fishermen assistance advised	yes, trap does not kill fishes	fish traps, (may need motorized winch), boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.seamar.com	Bagenal (1978); English, Wilkinson and Baker (1997)
Trap nets	MC	Most fish sizes and types, primarily in shallow waters	12-24 hours, based on tides (barrier and bag) Corrals are set up for longer and collect every 24 hours or so	$50-$500/nets, corral depending on size	shallow waters	Skill in setting the nets. Corral requires expert people (fishermen)	yes	Barrier, bag nets and/or fish corral, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.seamar.com	English, Wilkinson and Baker (1997)

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
Trawl (various types: e.g. beam, Otter)	IW/MC	use only for deep water pelagic, schooling and bottom-dwelling fish, can be very destructive to the environment	1-4 hours	$1000 for nets, boat rental and field assistance	only for deeper, large waters without obstacles on the bottom or surface debris	skill in trawling	yes, nets kill fishes	trawl net, boat, at least 2-3 people to help measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.fao.org/fiservlet/org.fao.fi.common.FiRefServlet?ds=geartype&fid=103 http://www.seamar.com	Bagenal 1978 English, Wilkinson and Baker (1997)
Scoop and tray nets	MC	suitable for small fish near surface, use only against banks	1-5 hours	$5-$20/ net	Used in inaccessible areas, such as mangroves	Skill in using the nets but easy to learn	yes	Scoop and tray net, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.seamar.com	English, Wilkinson and Baker (1997)
Push net	MC	Catches only small organism	1-2 hours	$5-$20/ net	Most shallow waters	Skill in using the nets — but easy to learn	yes	Push net, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.seamar.com	English, Wilkinson and Baker (1997)
Cast net	MC	Suitable for small fish and prawns	1-2 hours	$50-$200/ net	Good for confined areas and shallow waters	Skill on cast. Operators vary in efficiency.	yes	Cast net, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.nationalfishingsupply.com	English, Wilkinson and Baker (1997)
Drop net	MC	Small organisms	1-2 hours	$50-$100/ net	Good for small and shallow areas	Skills on construct and use. Labour intensive	yes	Drop net, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.seamar.com	English, Wilkinson and Baker (1997)

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
Lift net	MC	Small and rare species that must be concentrated	1-2 hours	$50-$100/ net	Good for small and shallow areas	Skills on use the net	yes	Lift net, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.seamar.com	English, Wilkinson and Baker (1997)
Spear fishing (various types)	MC	Suitable for all species but used primarily for big and selective species (difficult to catch by other means)	1-6 hours	$50-$200/ spear gun	Any clear waters; difficult areas	Skill is obtained by practicing	Yes	Spear gun and gear, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://divebooty.com	English, Wilkinson and Baker (1997)
Longline (drift or bottom)	MC	Selective fish, according to bait used	12-24 hours - leave out overnight	$100-$300/ per line, depending of number of hooks	Any water, except high-relief hard bottom	Skill in long-lining	Yes	hook, line, bait, buoys, weights, boat, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.seamar.com	English, Wilkinson and Baker (1997)
dip nets	IW/MC	suitable for small fish near surface	1-5 hours	$5-$20/ net	limited area within rivers, lakes, other wetlands	skill in using dip nets	yes	dip net	http://www.sterlingnets.com/dip_nets.html	Bagenal 1978
hook and line	IW/MC	suitable for any fish type and any water, depending on bait used	variable depending on repetition	variable depending on repetition	rivers, lakes, other wetlands	skill in line fishing	yes	hook, line, bait, (boat), measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://www.nationalfishingsupply.com	
Rotenone	MC	All fish of the encircle area. Kills all the fish. Permit could be required	Minutes per site	$350/20 litres	Encircle area with a net in shallow-open area. For deep waters, use it in caves and crevices	Skill on setting net	Yes	Rotenone, net, scoop net, measuring boards, scales, sheets, pencils, slates, plastic bags, plastic labels, preservative, GPS	http://southernaquaculturesupply.com/index.php	English, Wilkinson and Baker (1997)

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
sonars	IW/MC	suitable for schooling, pelagic fish, not very precise data	depending on the size of the water body	$100 - 1000	deep lakes and large rivers; all coastal waters, but mostly deep	skill in operating the sonars	skill in operating the sonars	Sonar, boat		
electro fishing	IW	optimal for sampling medium to big fish, better in colder water with some salinity	1-5 hours, variable depending on repetition and habitat type	$500-2000	mostly shal-low waters	training in electro-fishing and license	yes, stuns fishes but does not kill them	electro-shocker set; collecting equipment	http://www.fisheriesmanagement.co.uk/electrofishing.htm	Bagenal 1978
dive/ snork-elling (tran-sects, station-ary, roving)	IW/MC	suitable for surveying particular ecosystems that are difficult to locate or reach; clear waters	usually about 1 hr., but variable depending on repetition	low (snorkelling) to high (scuba), cost of equipment	lakes, rivers, all coastal clear waters	Snorkelling: none; diving needs certification. Identification of species and survey design	no	snorkel/ scuba gear, dip net, underwater sheets, pencils and slates	http://www.mares.com	English, Wilkinson and Baker (1997)
ques-tionnaire	IW/MC	ask local fishermen about the fishes they have observed and use	2-4 hours	low	all water bodies	Easy to apply but requires knowledge to prepare question-naire	no	paper, pens, maybe refresh-ments for locals		

1 The so-called "biological survey gill nets" can be ordered from: Fårup SpecialnetKaustrupvej 3Velling6950 Ringkøbing Denmark or from: Lundgren Fiskefabrik A/BStorkyrkobrinken 12S-11128 Stockholm, Sweden Tel +45 97 32 32 31

Reptiles and Amphibians

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
dip nets (amphibians)	IW/MC	suitable for catching tadpoles	usually about 1 hour, but variable depending on repetition	$5-$20/ net	rivers, lakes, other inland wetlands, any coastal waters where species occur	skill in using dip nets	yes	dip net	http://www.sterlingnets.com/dip_nets.html http://www.seamar.com	NSW National Parks and Wildlife Service (2002)
visual search (ambphibians/ reptiles)	IW/MC	good for locating relatively visible organisms	variable	$0	land and surface water	knowledge of micro-habitats	no	None		NSW National Parks and Wildlife Service (2002)
vocalizations	IW/MC	listen for and sometimes record frog calls and identify species from call	variable, several hours depending on search and record time	low- tape recorder	any water bodies, riparian habitats, land	knowledge of frog calls and identify species from calls, habitats	no	tape recorder, cassettes, playback, flashlights	Any good electronic shop	NSW National Parks and Wildlife Service (2002)
pitfall traps with drift fence (amphibians/ reptiles)	IW/MC	good for collecting animals that are difficult to sight; estimate relative abundance and richness	should be left out 24-48 hours	$0 if old buckets are used	land	skill in setting up pitfall traps with drift fences	yes	buckets, hand shovel, metal for fence	http://www.agric.nsw.gov.au/reader/2730	NSW National Parks and Wildlife Service (2002)
llitter search (amphibians/ reptiles)	IW/MC	usually used for finding frogs in conjunction with quadrants	variable depending on repetition	$0	land	minimal	yes		Everywhere	NSW National Parks and Wildlife Service (2002)
transects (amphibians/ reptiles)	IW/MC	used to control sample area to quantify and standardize data	dependant on length and number of transects	$0	Land	knowledge of establishing transects	yes	marking tape	http://www.npws.nsw.gov.au/wildlife/cbsm.html	NSW National Parks and Wildlife Service (2002)
Snorkelling/dive (reptiles)	IW/MC	used especially for looking for turtles	variable depending on repetition	low (snorkelling) to high (scuba)	rivers, lakes	any coastal waters	diving certification	snorkel/ scuba gear, dip net, underwater sheets, slates and pencils	http://www.mares.com	NSW National Parks and Wildlife Service (2002)
nooses (reptiles)	IW/MC	suitable for lizards	depends on number of lizards sought	$0 - can be made of grass	land	skill in making noose and spotting lizards	yes	long, flexible, but strong weed/ rope	http://www.macnstuff.com/mcfl/1/lizard.html	NSW National Parks and Wildlife Service (2002)

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
turtle traps (reptiles)	IW/MC	used to trap turtles on land and water	at least 1 day	$65-$150/ trap	lakes, rivers, land, other inland and coastal wetlands	knowledge of setting turtle traps	yes	turtle trap, bait		Limpus et al. (2002); NSW National Parks and Wildlife Service (2002)
ques- tionnaire	IW/MC	ask local people, incl. fishermen about the species they have observed and use	2-4 hours	low	all water bodies	Easy to apply, but requires experience in question- naire design	no	paper, pens, maybe refresh- ments for local people		NSW National Parks and Wildlife Service (2002)

Birds:

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
airplane surveys	IW/MC	can get crude esti- mates of population numbers and relative population abundance; biassed against cer- tain species	1-4 hours	high- cost of hiring an air- plane	any open areas; may also be only means for surveying densely vegetated wetlands	experience in quickly recognizing species	no	if possible, fly at height enabling naked eye identifica- tion; binoculars, tape recorder, maps, GPS gear	http:// www. telescope. com	NSW National Parks and Wildlife Service (2002)
point counts	IW/MC	Terrestrial species: used in conjunc- tion with transects to control sam- ple area to quantify and standardize data can be done on foot in dry season and canoe in wet season	1-5 hours	$100	land, rivers, wetlands; all coastal habitats	knowledge of parameters for carrying out and recording point counts	no	binoculars, measuring tape, flagging	NSW National Parks and Wildlife Service (2002)	http://www. npws.nsw. gov.au/ wildlife/cbsm .html; NSW National Parks and Wildlife Service (2002)
transects	IW/MC	Terrestrial & aquatic species: used to control sample area to quantify and stan- dardise data – can be done on foot or by boat	1-5 hours, but depends on sampling area	$100	Any open habitat	Knowledge of the species and of survey design		Binoculars, measuring tape	NSW National Parks and Wildlife Service (2002)	NSW National Parks and Wildlife Service (2002)

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
vocalizations	IW/MC	listen for and sometimes record bird calls and identify species from call	variable, several hours depending on search and record time	low- tape recorder (if needed)	any water bodies, riparian habitats, land; coastal habitats	knowledge of how to identify bird species from calls, habitats	no	tape recorder, cassettes, playback (if needed)	Any good electronics shop	NSW National Parks and Wildlife Service (2002)
locate nesting sites	IW/MC	bird species nesting on or near water	1-5 hours	$100	any water bodies	knowledge of nesting habitats and nesting ecology (to avoid disturbance)	no	binoculars, maps	http://www.telescope.com	NSW National Parks and Wildlife Service (2002)

Mammals:

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
sighting	IW/MC	look for mammals to surface	variable	$0	rivers, lakes, wetlands; all coastal/ marine habitats	minimal	no	binoculars if necessary	http://www.telescope.com	NSW National Parks and Wildlife Service (2002)
locate breeding sites	IW/MC	appropriate for aquatic mammals living also on land	1-5 hours	$0	land	knowledge of breeding habitats	yes	None		
Traps	IW/MC	small and medium sized mammals (e.g. otters, minks)	12 hours- leave out overnight	$20-50/trap	land, riparian, shallow water; all coastal habiatas	Trap-setting and locating skill	yes, trap does not kill animals	Tomahawk trap, Sherman traps	http://www.thecatnetwork.org/trapping.html	NSW National Parks and Wildlife Service (2002)
Tracks	IW/MC	detecting mammal presence on land, riparian	1-4 hours- depends on search time	$0	land and riparian areas	able to detect tracks and identify species from tracks	no	minimal- take photo or make plaster cast	Any camera supplier	NSW National Parks and Wildlife Service (2002)

METHOD	APPLIES TO INLAND WATERS (IW) AND/OR MARINE/ COASTAL (MC)	APPLICATION	FIELD TIME	COST	WETLAND TYPES	REQUIRED EXPERTISE	POSSIBILITY OF COLLECTING?	EQUIPMENT NEEDED	SOME SOURCES OF EQUIPMENT	REFERENCE SOURCES FOR METHODS
transects	IW/MC	quantifies data if there are many sightings	1-5 hours	$0	river, lakes, wetlands; open coastal habitats	knowledge of establishing transects	no	binoculars if necessary	http://www.telescope.com	http://www.npws.nsw.gov.au/wildlife/cbsm.html
Airplane surveys	MC	Crude estimates of population numbers and relative population abundance biased against certain species)	1-2 hours, but depends on size of survey area	High – airplane hire cost	All open areas	Experience in quickly identifying species	No	Binoculars	http://www.telescope.com	NSW National Parks and Wildlife Service (2002)

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