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A Handbook for Measuring the Progress and Outcomes of Integrated Coastal and Ocean Management

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In collaboration with

A Handbook for Measuring the Progress and Outcomes of Integrated Coastal and Ocean Management

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This is a preliminary draft of the publication *A Handbook for Measuring the Progress and Outcomes of Integrated Coastal and Ocean Management*. The document aims to provide a tool for developing, selecting, and applying indicators to measure, evaluate, and report on the progress and outcomes of integrated coastal and ocean management (ICOM) initiatives. The handbook is intended as a method and a series of guidelines that could assist different types of customers: coastal managers and decision makers at the national and sub-national levels in the design, implementation, and assessment of ICOM initiatives, practitioners and experts engaged in evaluation research and evaluations, and donor agencies supporting coastal and marine management projects and programs. The publication contains suggestions on how to prioritize ICOM issues, define measurable objectives for ICOM programs and projects, and identify meaningful indicators to monitor the implementation and results of such programs and projects. The handbook is currently being tested in existing ICOM programmes and projects in different regions of the world. As a result of the testing exercise, a revised draft of the handbook will be released jointly with a companion collection of case studies, providing examples of development and application of indicators through validation and testing of the approach.

A HANDBOOK FOR MEASURING THE PROGRESS AND OUTCOMES OF INTEGRATED COASTAL AND OCEAN MANAGEMENT

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1 Overview

This section introduces the handbook on indicators for integrated coastal and ocean management (ICOM). It describes the rationale and background to the formulation of the handbook, explains the purpose, audience and use of the handbook, its organization and the main chapters, clarifies its intended contribution to improving indicator theory and practice, gives information on how to apply the approach, and describes the anticipated update to the document.

1.1 Rationale and background

- Why was the handbook developed?
- Which problems does it help resolve?

The objective of this handbook is to develop a common set of indicators — governance, ecological, and socio-economic — to be used to assess and report on the progress and results of integrated coastal and ocean management programs (ICOM). The handbook aims to contribute to promoting sustainable development of coastal regions by promoting results-based, accountable, and adaptive approaches to management.

A recent report estimates that almost 700 efforts in integrated coastal and ocean management (ICOM) have been initiated in more than 140 countries since the mid-1960s (Sorensen, 2000). Yet, probably only half of these efforts have reached the implementation phase, and there is a need to improve monitoring and evaluation practice. The use of adequate indicators could help improve the monitoring and evaluation by providing tools to follow-up on the initiatives.

The application of indicators for ICOM is still in the start-up phase. While environmental indicators have long been used to monitor the state of the coastal and marine environment, there has been very limited use of socioeconomic indicators to date, and the use of governance indicators has often been limited solely to the reporting of process indicators. The handbook intends to promote a more outcome-oriented approach to the selection and application of indicators to measure the progress and effectiveness of ICOM interventions.

The handbook has been conceived in response to the need to improve approaches to and methods in monitoring, evaluating and reporting on ICOM progress and results, in particular in relation to: (a) the institutionalization of monitoring and evaluation systems in ICOM initiatives; (b) the integrated consideration of environmental, socioeconomic, and governance dimensions; (c) the ability to isolate outcomes of purposeful ICOM initiatives from those of other initiatives and from changes due to natural variability; (d) the linkages between reporting on ICOM and state of the coast reporting; and (d) consistency of approaches and comparability of progress and results of ICOM initiatives within the same country or among countries.

The handbook is part of an effort led by the Intergovernmental Oceanographic Commission (IOC), the Department of Fisheries and Oceans (DFO) of Canada, and the U.S. National Oceanic and Atmospheric Administration (NOAA) to promote the development and use of ICOM indicators (See expert workshop in Ottawa in 2002 and IOC *Reference Guide on the Use of Indicators for Integrated Coastal Management* in 2003).

1.2 Purpose, audience and use of the handbook

- What are the main purposes of the handbook?
- Who should use the handbook?
- How should the handbook be used?

The handbook aims to provide a tool for developing, selecting, and applying indicators to measure, evaluate, and report on the progress and outcomes of integrated coastal and ocean management initiatives. The target audience for the handbook is wide and includes coastal and ocean managers, practitioners, and evaluators. The handbook is expected to provide additional skills to be applied in the process of monitoring and evaluating ICOM initiatives; as a result, the handbook could also be used for training purposes.

The handbook is intended as a method and a series of guidelines that could assist different types of target groups: coastal managers and decision makers at the national and subnational levels in the design, implementation, and assessment of ICOM initiatives, practitioners and experts engaged in evaluation research and evaluations, and donor agencies supporting coastal and marine management projects and programs.

The handbook provides an update on recently developed and tested approaches and methods in developing, selecting, and applying indicators for coastal and ocean management, thus contributing to both the theoretical debate and the practice of coastal management indicators. In this regard, the handbook can be seen as a reference document for researchers and other persons who are engaged in indicator-related research and applications.

The handbook is a generic tool with no prescriptive character and should be seen as a basis for the customized design of sets of indicators to measure progress and results of coastal management initiatives at different scales and in different contexts. The handbook could be used as a starting point to develop a monitoring and evaluation system attached to ICOM programs and projects.

The handbook should be used in conjunction with the companion collection of case studies, providing examples of development and application of indicators through validation and testing of the approach.

Box 2-1 Main users of the handbook

The handbook is intended to assist different users that deal with ICOM from different perspectives (e.g., managers and donors) and geographic scales:

Managers
Officials who administer ICOM programs or projects and need to improve their skills in the design, implementation, evaluation and revisions of these programs.

Decision makers
High-level officials who might not have specific knowledge of ICOM and who should know the objectives and expected outcomes of ICOM initiatives and their related responsibilities.

Practitioners
Experts who are engaged in implementing in-the-field tasks in ICOM initiatives and need to improve their technical skills to better carry out their contributions.

Researchers
Investigators who are active in research on marine policy about coastal and marine sectors and who want to improve their knowledge of the policy cycle of ICOM and the contribution of research to management.

Donors
Program managers and evaluators from multilateral and bilateral donor agencies who want to enhance approaches and methods for monitoring and evaluating ICOM initiatives, and to enhance the benefits of investments in ICOM.

1.3 Organization of the handbook

- What can one find in the handbook?
- How is the handbook organized?

The handbook contains suggestions on how to identify ICOM issues, define measurable objectives for ICOM programs and projects, and identify meaningful indicators to monitor the implementation and results of such programs and projects. The structure of the handbook is built around three main types of indicators of performance — governance, ecological, and socioeconomic— and includes an introduction to ICOM, suggestions on how to improve relationships among these indicators, and ideas for further research on indicators.

The handbook follows a simple structure that reflects the main dimensions involved in ICOM indicators — governance, ecological, and socioeconomic— and discusses, as well, the general context in which ICOM operates, the goals and objectives it can specify, and the outcomes or results it can produce. The handbook is organized into seven chapters following this introduction:

- *Chapter 2* – provides fundamental concepts, definitions, and applications of indicators in the context of management, including uses within "state of the environment" or "state of the coast" reporting, as well as global, regional, and national observation and monitoring systems.

- *Chapter 3* – provides an introduction to the ICOM process, focusing of the steps of the process and on ways to establish outcome-oriented targets for ICOM programs.
- *Chapter 4* – focuses on governance indicators, focusing on the quality of management processes and the establishment and sustainability of ICOM programs and projects.
- *Chapter 5* – describes indicators useful to measure the state of the coastal and ocean ecosystems and the effects of ICOM initiatives on these.
- *Chapter 6* – describes indicators to measure socioeconomic conditions in coastal and ocean areas, including impacts of ICOM programs.
- *Chapter 7* – addresses the issue of integration of environmental, socioeconomic, and governance dimensions in ICOM and provides an overview of their linkages, and discusses future steps in the development and application of ICOM indicators.

1.4 Contribution to improving indicators and management practices

- How can the handbook be used to improve the practice of application of indicators to assess ICOM initiatives?
- What is the relationship between the handbook and other indicator efforts?

The handbook takes stock of the most recent contributions to the assessment of ICOM and related indicators, but relies on practical applications of these indicators to longstanding and ongoing programs and projects at different spatial scales found in different areas of the world. The handbook intends to be a starting point for stimulating further research and more focused applications. As part of a larger set of tools, the handbook provides opportunities for connecting to global and regional initiatives on the development and use of coastal- and marine-related indicators, by providing information on organizations and programs engaged in indicator work and sources and repositories of data.

The handbook aims to contribute to current efforts to further develop indicators for ICOM in practical terms:

- The handbook is based on the latest ideas about sustainable development indicators, favoring a new generation of indicators and moving away from purely environmental and process-oriented indicators to integrate governance, ecological and socioeconomic dimensions into outcome-based frameworks; and

- The handbook also relies on practical applications and experience in the application of indicators to established ICOM initiatives and on additional testing of more recent initiatives for refinement and customization.

The handbook aims to contribute to the improvement of the design of new ICOM programs and projects.

The handbook promotes linkages with global and regional efforts to implement sustainable coastal development, such as the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA), national and regional initiatives to implement networks of marine and coastal protected areas, implementation of activities to coordinate fisheries management with ICOM, as well as linkages with monitoring and observation programs such as the Global Ocean Observing System (GOOS) and the Global Marine Assessment (GMA).

The handbook takes stock of current trends in ICOM indicator development and application and aims to explore the potential of indicators for measuring and reporting on progress and outcomes of ICOM for better results, accountability, and adaptive management.

1.5 Applying the Approach

- What are the key concepts underlying the handbook?
- How can the handbook be most useful to users?

The handbook can be applied following two basic principles. First, after having reviewed the basic principles of ICOM, the users can tentatively apply the indicators proposed by the handbook for governance, ecological, or socioeconomic performance to the programs and projects in which they are involved. Second, starting from the approach proposed by the handbook, the users can further develop, test, and refine the indicators proposed and incorporate them into the monitoring and evaluation system of existing or new initiatives.

The handbook has been conceived based on two major concepts that should be considered together:

1. The indicator framework proposed here integrates governance, ecological, and

socioeconomic dimensions, with a focus on outcomes or results rather than on processes, for some priority areas;

2. The handbook proposes a series of menus of indicators useful for ICOM based on previous experiences, literature review, and the testing exercise. However, the development and application of the indicators requires adaptation to specific needs of the users.

The handbook, and the analytical frameworks and indicators it proposes, can only be seen as a starting point – the implementation of the tools suggested by the handbook will differ according to the context, the scope, and scale of the ICOM initiative, and the issues addressed.

To help users in selecting, developing, applying, measuring, and refining their own indicators, the handbook will provide elements of good practice, in the form of a step-by-step guide. The handbook will also highlight the difficulties normally experienced in establishing monitoring and evaluation systems for ICOM.

The handbook should be used in conjunction with the companion collection of case studies. This volume provides examples of development and application of indicators in real situations that can be used as a reference for the adaptation of the approaches suggested by the handbook.

1.6 Anticipated revision of the handbook

- How will the handbook be updated?
- What other tools will be used in conjunction with the handbook?

The handbook incorporates results from a testing through several pilot cases that have applied the indicators and led to subsequent revision. The users can substantially contribute to the development of the handbook through practical use in their own context and experience. The handbook is available online together with other materials at: [website]. Users and other interested people are encouraged to provide comments and inputs.

The handbook should be useful to different kinds of users and is conceived as part of an IOC toolkit on indicators that include:

- The *Reference Guide on the Use of Indicators for Integrated Coastal Management* published in 2003;
- The 2003 special issue of Ocean *& Coastal Management* on "The Role of Indicators for Integrated Coastal Management";
- The companion volume of case studies in development and application of indicators for ICM (prepared as the testing and refinement component of this exercise);
- A regularly updated web site with results from the project, publications, a clearinghouse of projects, and links;
- A possible pilot decision-support tool in the form of the "dashboard of sustainability," an indicator-based software developed by the Joint Research Centre of the European Commission to explore the correlations among social, economic, environmental, and institutional indicators; and
- A training module to be delivered on site (e.g., through IOC regional offices) and online.

The current edition of the handbook can be considered open for revision, as new experiences, particularly from users, emerge. The handbook and related materials are available online, thus providing an opportunity for discussion and dissemination of further information and a venue for the update of, and follow-up to, the handbook.

This project on ICOM indicators can be conceived as an open-ended partnership, open to broad participation by managers, evaluators, donors, and others, including through cooperation with global and regional observation and monitoring programs and with initiatives of regional or more sectoral scope (e.g., marine protected areas, coastal tourism, or integrated coastal area and river basin management). In this regard, the opportunity to ensure wider dissemination of the products through different languages will also be considered.

2 Coastal and ocean indicators

2.1 The role of indicators in the management process

This section explains what indicators are and the types of indicators most relevant to ICOM; it then details the usefulness of indicators as measures of management objectives, for evaluation, and for reporting on the state of the environment. The section describes the characteristics of good indicators, highlights the importance of establishing baseline conditions, underlines the caution needed when using indicators, and provides elements for future work on indicators.

What are "indicators"?

An indicator is a measured or observed parameter that provides information about a system. The word indicator derives from the Latin verb *indicare,* whose meanings include: to point out, to indicate, to announce, to give notice of, to determine and to estimate. The verb does not actually specify what is being indicated or announced. It merely refers to the action itself.

The term indicator needs to be defined or interpreted in the clearest way possible. An "indicator" is supposed to make certain phenomena perceptible that are not—at least not immediately—detectable. This means that an indicator has a significance extending beyond what is directly obtained from observations. Indicators have three main functions: simplification, quantification, and communication.

Indicators generally simplify in order to make complex phenomena quantifiable in such a manner that communications is either enabled or enhanced. Indicators do not solve problems, but they are an important component in a process to understand, maintain, and improve a system. Different types of indicators are explained below.

Types of indicators

Inputs — What do we need?
Adequacy of resources in relation to management objectives, based primarily on measures of staff, funds, equipment, and facilities

Process — How do we go about it?
Adequacy of management processes and systems in relation to management objectives, related to issues such as day-to-day maintenance or adequacy of approaches to public participation

Outputs — What did we do and what products and services were produced?
Measures of the volume of work output (e.g., number of meetings held, number of permits issued, number of surveys completed, construction projects completed); actual work programs vs. planned work programs; actual vs. planned expenditures

Outcomes — What did we achieve?
Measures of populations of key species and populations; habitat change; improvements in environmental quality; reduced use conflicts; improvements in community well-being (increases in income, decreases in unemployment)

2.2 The role of indicators as measures of management objectives

Specifying objectives is essential to enable analysis of alternative management strategies for ICOM and for measuring progress toward meeting objectives.

Five problems are common in this regard:

1. Multiple objectives will exist, some of which will be conflicting, reflecting interests of different groups, e.g., increase fisheries yields for commercial or recreational fishers, increase the use of coastal areas for recreation and tourism, increase offshore and coastal production of oil and gas, decrease the discharges of land-based sources of pollution to coastal waters, and protect critical coastal and marine habitats;

2. Objectives are often expressed in terms of general goals, e.g., improve water quality, maintain biodiversity, or increase regional economic development. The general goals must be translated into quantitative objectives before meaningful analysis of management alternatives or measurement of progress is possible. For example, improving water quality could be defined in terms of achieving specific concentrations of particular substances in the water column over a particular period of time. For example, the "Chesapeake Bay 2000 Agreement" contains many measurable objectives such as restoring 25,000 acres of tidal

and non-tidal wetlands by 2010, reducing the rate of sprawl by 30 percent by 2012, and preserving 20 percent of the watershed as permanently protected open space by 2010;

3. Perceptions of problems often differ among stakeholders. An important role of planning is to identify and clarify these perceptions and to present operational definitions of objectives for consideration by the stakeholders;

4. Not only are there likely to be different perceptions of what problems exist, or don't exist, but often there are different views among the stakeholders about the relative importance of the problems. Again, an important role of planning is to suggest a basis for estimating the relative importance;

5. The perception by a stakeholder group or decision maker about the importance of a particular problem/objective may change as the analysis proceeds and more information is obtained. For example, an individual beginning with the principal objective of achieving a very high level of water quality may modify that objective when the estimated costs of achieving the originally-desired level are determined, or it is determined that very few individuals would benefit from improving water quality to that level.

Clear exposition of trade-offs among objectives is essential.

Although progress toward achieving many public sector objectives is difficult to measure, few meaningful objectives are beyond effective measurement

An objective is simply a statement of results to be achieved

An objective statement should contain four major elements:

- An action or accomplishment verb
- A single measurable key result
- A date or time period within which the result is to be accomplished
- The maximum investment, in terms of money, work-hours, or both, that decision makers are willing to make toward its accomplishment

2.3 The role of indicators in evaluation

Hockings et al. (2000) define "evaluation" as "…the judgment or assessment of achievement against some predetermined criteria" (usually a set of standards or objectives). Information on which such assessments can be based could come from many sources, but *monitoring (observation) has a particularly important contribution to make in providing the basic data that should underpin the evaluation.*

This is the element of management in which the greatest learning should occur, but unfortunately is typically neglected or carried out in a superficial manner in most coastal and ocean areas.

Ideally, evaluation should be a continuous process through which measures of performance are defined and systematically compared with program goals and objectives. Evaluation may also be undertaken periodically during the lifetime of a program.

Programs often have goals and objectives that are very vague or general and thus are not easily measured. In such cases it is difficult, if not impossible, to determine the extent to which goals and objectives are being achieved. In these instances, evaluations tend to fall back on indicators that measure effort (input) rather than results (outputs or outcomes). For example, the number of permits granted or denied might be used as an indicator of the performance of a coastal wetlands program rather than the number of acres of wetlands protected or restored.

Meaningful evaluations can only be conducted if management objectives have been stated in unambiguous (preferably quantifiable) terms and if indicators for assessing progress are identified in the planning phase and monitored. Most evaluations yield ambiguous results because these preconditions do not exist.

The handbook is intended to promote the use of evaluation, including self-evaluation, to improve the accountability and adaptive management of ICOM initiatives. To this end, indicators can provide a useful tool to identify, prioritize, and quantify objectives, monitor their achievement, evaluate the program, and ultimately adjust it. Indicators are also a powerful means to communicate information to policy makers and other interested parties, including the general public.

Evaluation should be a routine element of an integrated and adaptive management process. Integrated and adaptive management is based on a circular or iterative—rather than a linear — process that allows information about the experience of the past to feed back into and improve the way management is conducted in the future. Evaluation helps management to adapt and improve by "learning."

Evaluation consists of reviewing the results of actions taken and assessing whether these actions have produced the desired results. It is something that most good managers already do where the link between actions and consequences can be simply observed.

But the link between action and outcome is often not obvious. Faced with the daily demands of their jobs, many managers are not able to monitor systematically and review the results of their efforts. In the absence of such reviews, however, money and other resources can be wasted on programs that do not achieve their objectives. In a climate of ever-greater attention to performance and value for attained through ICOM investments, managers must expect to come under greater pressure to introduce systems of monitoring and performance that will:

- Promote and enable an adaptive approach to management where managers strive to learn from their own successes and failures and those of others; and

- Keep track of the resulting changes in management objectives and practices so that people can understand how and why management is being undertaken in a certain way.

Two common uses of evaluation are:

- Promoting adaptive management; and
- Promoting accountability

In practice, evaluation results are usually used in more than one way. Information used by managers to improve their own performance (adaptive management) can also be used for reporting (accountability) or lessons learned by others to improve future planning.

Whatever purposes it may serve, evaluation should be seen primarily as a tool to assist managers in their work, not as a system for watching and punishing managers for inadequate performance.

2.4 The role of indicators in "state of the environment" reporting

In the Pressure-State-Response (PSR) (OECD, 1993b), Driver-State-Response (DSR) (UN & World Bank, 2001) or the Driver-Pressure-State-Impact-Response (DPSIR) framework (EEA, 1998), governance performance indicators correspond to *response* indicators and are intended to measure the effectiveness of management actions in response or anticipation to environmental issues and to foster economic development in a sustainable way.

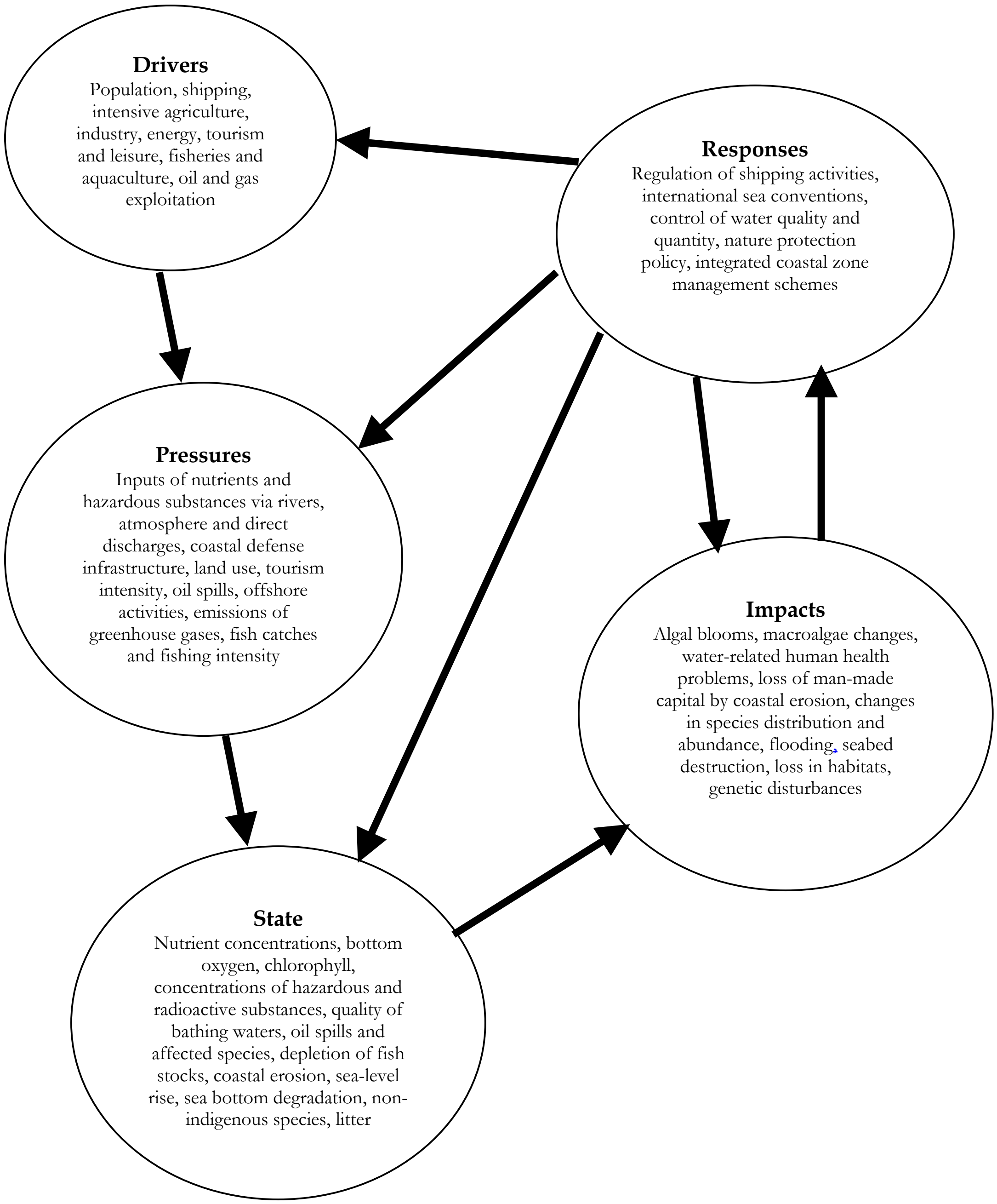

Figure 2-1 The DPSIR framework applied to the marine environment (EEA 2000)

The DPSIR framework provides a convenient framework to analyze linkages among socio-economic trends, ecological phenomena, and institutional responses. The framework follows a causal path that goes from *driving forces* of environmental change (e.g., population growth and density), which leads to *pressures* on the environment (e.g., change in biological oxygen demand), which results in changes in the *state* of the environment (e.g., amounts of organic pollution in coastal waters), which in turn results in environmental and socioeconomic *impacts* (e.g., changes in recreational value of bathing waters) and finally produces institutional *responses* (improvements in wastewater treatment).

The DPSIR framework represents a variation on the PSR framework originally proposed by OECD (1993b) and the DSR framework proposed by the United Nations (1996). It has been extensively used by the European Environment Agency (EEA) to address sectoral environmental issues (e.g., water quality), while it appears less robust to analyze the influence and effectiveness of institutional responses. In relation to the preparation of reports on the state of the environment, the UNEP (Rump 1996) suggests that the DPSIR framework be used to address the following fundamental questions:

- *What is happening?* (changes in the state of the environment and related impacts)
- *Why is it happening?* (causes of changes, be they natural or human, direct or indirect)
- *Are the changes significant?* (significance of the impacts caused by environmental changes)
- *What is or could be the response?* (institutional responses to environmental changes)

The EEA (2000) suggests focusing the last two questions on the effectiveness of the responses in changing driving forces and pressures. The evaluation of the effectiveness of policy responses is a difficult undertaking in relation to ICOM, due to its multidisciplinary and multisectoral nature and the difference in time scales at which the effects of a certain policy may be manifested.

In the original DSR framework developed by the UN CSD (1996, p. 20), indicators for driving forces, state and response were identified for the four main dimensions of sustainable development (social, economic, environmental, and institutional). The following matrix shows examples of indicators for the various components (adapted from CBD 2004, referred to the DPSIR framework).

Table 2-1 DSR indicators for the dimensions of sustainable development

Dimensions of SD / Indicators	*Driving forces*	*State*	*Responses*
Social	Population growth rate in urban coastal areas	Income levels, level of poverty	Budget given to environmental education; number of awareness raising campaigns
Economic	The dependence of communities on fishing	Employment in the fishing industry	The use of more efficient fishing techniques
Environmental	Changes in stream patterns	Chemical composition of the water	Changes in fish population dynamics
Institutional	The level of enforcement of laws and regulations related to coastal region management	Fish consumption indices	The number of co-management arrangements to improve management efficiency

Source: CBD 2004.

In the DSR framework, the linkages between pressures, state and responses rely less on causal connections than in the PSR framework, given the role of the broad phenomena represented by driving forces. In the revised approach to indicators, the United Nations (2001) reorganized the framework for indicators for sustainable development through a thematic approach, where sustainable development issues are organized into themes and sub-themes, as in the example below on oceans, seas and coasts.

Table 2-2 Indicators of sustainable development

Theme	*Sub-theme*	*Indicators*
Oceans, seas and coasts	Coastal zone	Algae concentration in coastal waters
		Percent of total population living in coastal areas
	Fisheries	Annual catch my major species

To be able to better analyze the progress and effectiveness of ICOM interventions, the DPSIR, DSR, or PSR frameworks need to be complemented by other, more specific frameworks to track the progress of ICOM across its typical stages and its achievement of intermediate outcomes (e.g., inter-institutional cooperative efforts, behavioral changes in coastal users, development of coastal infrastructure). In the context of development projects, the *outcome mapping* approach (Earl, Carden, & Smutylo 2001) can provide a useful framework to explore relationships between stakeholders and their “boundary partners”; the creation of a shared vision statement based on what the stakeholders “expect to see,” “would like to see,” and “would love to see”; and the identification of outcome challenges and the monitoring of outcome markers to track the progress of the intervention.

2.5 Characteristics of good indicators

From a scientific perspective, effective indicators should have the following characteristics:

1. *Be readily measurable* – Effective indicators should be measurable in practice and in theory. They should be measurable using existing instruments, monitoring programs and analytical tools available in the area, and on the time-scales needed to support management. They should have a well-established confidence limit, and signal should be distinguishable from background noise.

2. *Be cost effective* – Indicators should be cost-effective because monitoring resources are limited. Monitoring should be allocated in ways that provide the greatest benefits to society and the fastest progress towards sustainable development.

3. *Be concrete* – Indicators which are directly observable and measurable rather than reflecting abstract properties which can only be estimated indirectly are desirable because concrete indicators are more readily interpretable by diverse stakeholder groups that contribute to management decision-making.

4. *Be interpretable* – Indicators should reflect properties of concern to stakeholders and their meaning should be understood by as wide a range of stakeholders as possible. Public understanding of the indicator should be consistent with its technical meaning.

5. *Be grounded in theory* - Indicators should be based on well-accepted scientific theory, rather than based on theoretical links that are poorly defined or validated.

6. *Be sensitive* – the indicator should be able to detect trends in the ecosystem properties or impacts which the indicator is targeting

7. *Be responsive* – Indicators should be able to measure the effects of management actions so as to provide rapid and reliable feedback on the consequences of management actions.

8. *Be specific* – Indicators should respond to the properties they are intended to measure rather than to other factors and/or it should be possible to disentangle the effects of other factors from the observed responses.

From a management perspective, indicators should:

- Be relevant to management objectives

- Be clearly linked to the outcome being monitored that is important to society

- Be developed with all those involved in management (unlikely to work if imposed from above)

- Be part of the management process and not an end to themselves

2.6 Importance of establishing baseline conditions

Performance of ICOM programs against specified objectives and deadlines can only be assessed if baseline information on environmental and socioeconomic conditions of coastal zones is available. To this end, environmental and socioeconomic profiles of coastal zones have to be developed as well as an assessment of the main actors, laws and institutions influencing ICOM.

A diagnostics of coastal conditions (UNEP 1995) is aimed to (a) identify the current state of the coastal environment through appropriate indicators, (b) identify coastal resources under stress and their degree of vulnerability, and (c) forecasting the possible impacts of alternative development options. Information may regard:

1. A quantitative and qualitative inventory of *coastal resources*: land area, built-up area, agricultural land, land set aside for conservation, land set aside for special purposes, forests, water resources, surface waters, groundwater, coastal waters, marine resources, and wildlife resources.

2. An economic inventory of main *coastal and marine uses*: industry, agriculture, tourism, fishery and aquaculture, forestry, transport, and energy.

3. An inventory of *infrastructure*: roads, railways, air, water supply, and sewage treatment.

4. An inventory of *pollution discharges*: air, water, and wastes.

Such baseline information may be used to establish benchmarks and performance targets for ICOM programs. The measurement of coastal conditions and trends can then be correlated to information concerning governance and management actions to understand the effectiveness of ICOM programs and identify gaps and issues to be addressed, review program assumptions, and adjust to changing conditions.

2.7 Cautions about the use of indicators

Problems and shortfalls in the use of indicators also exist. These problems are related to the "misuse" of indicators, a poorly managed process of development, and using indicators for the wrong reasons. The opposite is true when indicators are a part of an established "toolbox" with an adequate process and information. Effective use of indicators should address these concerns (IOC, 2003).

- Reporting at higher scales can conceal locally relevant information integral to the issue at hand.
- Indicators can drive the process (as opposed to remaining a tool within the process).
- Can be held responsible for processes or outcomes that one has no control over.
- Can result in unrealistic expectations for results.
- Results can be assessed without consideration of spatial / temporal context.
- An inadequate ordering framework can lead to confusion over how to express the indicators for a particular issue.
- Indicators can fall into the trap of trying to measure what is measurable as opposed to measuring what is important.
- Dependence on a false model or false relationships amongst the indicators.

2.8 Future directions

- As understanding of coastal systems improve, we will be able to select better, more cost-effective indicators
- Improved instrumentation will allow more sensitive detection and observations
- Real-time measures and more powerful modeling will capture and analyze data more quickly
- Visualization techniques will allow more ready use by managers
- Indicator use will feed to better reporting and communication
- Accountability and adaptive management will be a reality

3 Integrated coastal and ocean management (ICOM)

3.1 Introduction

Collapsing fish stocks, degradation of ocean and coastal habitat and issues arising from conflicts among users of coastal and ocean spaces have prompted the international community to call for an integrated approach to managing coastal and ocean areas. These calls have been formally recognized in a number of International Agreements over the last decade. This chapter provides an introduction to integrated management of coastal and ocean management areas, and recommends an approach to the establishment of outcome-oriented targets for integrated coastal and ocean management (ICOM) programs.

Integrated coastal and ocean management is a continuous and dynamic process which takes into account ecological, economic and social considerations and employs a comprehensive method of planning and managing human activities in ocean and coastal areas. For integrated management to be effective, clear and unambiguous objectives are required. The objectives specified for any given management area, be it small or large, will help determine the actions within a management plan. Without these objectives, management will lack direction. Objectives should be quantified and measured through the use of indicators. The monitoring of these indicators then provides a method by which to evaluate the success of the management program and provides the ability to adapt to changing needs or conditions over time.

The geographic scope of a coastal or ocean management area can be either small or large, covering whole ecosystems or portions of an ecosystem. Small management areas may consist of an embayment or estuary, while larger coastal areas may include both the land and nearshore waters of a coastal province. Larger ocean management areas could include whole territorial seas up to the 200-mile limit of the Economic Exclusive Zone (EEZ), or even large ocean areas as in the Large Marine Ecosystem (LME) as defined by Sherman et al. (1992). Watershed or catchment basins which influence or impact on coastal or ocean areas also need to be considered in ICOM. Determining the size and location of a management area is generally influenced by existing marine use issues, conflicts among users, or degradation of the environment, and must consider, as well ecosystem structure and function within a given area. It is generally most useful to establish a hierarchical management system ("nesting of areas") for large and small-ocean and coastal areas to allow for considerations of linkages among areas and systems, as all areas are influenced, to one degree or another, by adjacent areas.

3.2 Functions of ICOM

In general, the major functions of ICOM include activities that range from area-based planning to the promotion of environmentally compatible economic development, to the protection of coastal and marine habitats and biodiversity (Table 3 -1).

Table 3 -1 Typical functions of ICOM

Area	*Functions*
Area planning	– Plan for present and future uses of ocean and coastal areas – Provide a long-term vision
Promotion of economic development	– Promote appropriate uses of ocean and coastal areas (e.g., marine aquaculture, ecotourism)
Stewardship of resources	– Protect the ecological base of ocean and coastal areas – Preserve biological diversity – Ensure sustainability of uses
Conflict resolution	– Harmonize and balance existing/potential uses – Address conflicts among ocean and coastal uses
Protection of public safety	– Protect public safety in ocean and coastal areas typically prone to significant natural, as well as human-made, hazards
Proprietorship of public submerged lands and waters	– As governments are often outright owners of specific ocean and coastal areas, manage government-held areas and resources wisely and with good economic returns to the public

In addition to providing the overall framework for the management of coastal and ocean activities within a defined area, ICOM also typically addresses specific issues in coastal and ocean areas, for example:

- Beach stabilization
- Conservation of coastal and marine habitats and biodiversity
- Protecting the coastal and marine environment from land-based pollution
- Combating marine pollution
- Fisheries
- Tourism
- Water management
- Impacts from climate change and sea level rise

While ICOM, by definition, addresses interconnections among multiple resources and issues and the environment, given limited resources and capacities, it is sometimes the case that developing countries will start out work on integrated coastal and ocean management by focusing on the types of specific issues listed above. This may well be a good way to begin ICOM in a country, by addressing a specific priority and urgent issue, and laying the groundwork for a more complex and multi-purpose oriented ICOM program in the future.

3.3 International guidelines on ICOM

All of the major agreements emanating from the 1992 UN Conference on Environment and Development have endorsed the application of the integrated coastal management approach, including: Agenda 21 (1992), Convention on Biological Diversity (1992), Barbados Programme of Action for the Sustainable Development of Small Island Developing States (1994), Global Programme of Action for the Protection of the Marine Environment from Land Based Activities (GPA) (1995), Code of Conduct for Responsible Fishing (1995) and Plan of Implementation for the World Summit on Sustainable Development (2002), the Framework Convention on Climate Change, and the International Coral Reef Initiative. In addition, a number of efforts have been made by international entities to further define, interpret, and operationalize the ICOM concept. The main international guidelines developed for ICOM, listed below in Table 3.2 are important for they set standards of an international model or norm for countries to follow. In some cases, a country's adherence to such international standards, or lack thereof, can be used by international funding agencies as a basis for approving of disapproving program funds.

While the guidelines in Table 3-2 emphasize different aspects of ICOM (such as its role in preserving biodiversity, addressing climate change, etc.) examination of the various guidelines reveals consensus among them as to the scope and purposes of ICOM, and on major approaches and principles.

Table 3-2 Main guidelines on ICOM

Year	*Organization*	*Guidelines*
1992	UN	Agenda 21, Chapter 17
1993	OECD	Coastal Zone Management: Integrated Policies
	World Bank	Guidelines for Integrated Coastal Zone Management
	IUCN	Cross-Sectoral, Integrated Coastal Area Planning (CICAP): Guidelines and Principles for Coastal Area Development
1995	UNEP	Guidelines for Integrated Management of Coastal and Marine Areas: With Special Reference to the Mediterranean Basin
1996	UNEP	Guidelines for Integrated Planning and Management of Coastal and Marine Areas in the Wider Caribbean Region
1998	FAO	Integrated Coastal Management and Agriculture, Forestry and Fisheries
1999	UNEP	Conceptual Framework and Planning Guidelines for Integrated Coastal Area and River Basin Management
	EC	Towards a European Integrated Coastal Zone Management (ICZM) Strategy: General Principles and Policy Options
	Council of Europe	European Code of Conduct for Coastal Zones
2000	CBD	Review of Existing Instruments Relevant to Integrated Marine and Coastal Area Management and Their Implementation for the Implementation of the Convention on Biological Diversity
2004	CBD	Integrated Marine and Coastal Area Management (IMCAM) Approaches for Implementing the Convention on Biological Diversity

Guidance documents developed in the context of international meetings should be added to the guidelines developed by international organizations. For example, the statements of the World Coast Conference (Beukenkamp, 1993), the guidelines for Enhancing the Success of ICM (IWICM 1996) or the Guidelines for Integrating Coastal Management Programs and National Climate Change Action Plans (Cicin-Sain et al. 1997) are also relevant to the application of ICOM.

3.4 ICOM in practice

There has been a significant increase in the number of countries adopting integrated coastal management programs in recent years, especially since the 1992 Earth Summit (United Nations Conference on Environment and Development). While in 1993 there about 57 countries working on some form of ICOM, at national and/or local levels (Sorensen 1993), in 2000, the number of countries working on ICOM had reached 98 (Cicin-Sain et al. 2001), and in 2004, is estimated at 120 countries. There are different patterns on ICOM dissemination, however, in different regions of the world, with major differences found in:

- *The scope of the efforts*—some efforts involve the whole coastal zone, while others involve only pilot projects confined to small local areas
- *The role of national and subnational authorities in coastal management*—e.g., in some cases, only the national governments are involved in providing ICOM policy direction and guidelines; in other cases, subnational authorities are heavily involved in ICOM, especially in the implementation of ICOM programs; in yet other cases (generally thought to be the most successful), both national and subnational authorities are involved in ICOM, playing mutually complementary and supportive roles.

- *The extent and importance of international funding*. Especially in developing countries, the role of external donors has been very important in catalyzing and starting ICOM. Difficulties encountered, however, have included: the presence of many smaller donor-driven projects which are often not aggregated into a larger program institutionalized into the country's public administration system, and the tendency for efforts to die down when foreign investment is withdrawn.

Another important ICOM trend concerns the extent of ocean areas included in these programs. Up until recently, most countries have emphasized management efforts in coastal lands and nearshore waters (generally 3 to 12 miles offshore). In recent years, there has been a growing movement to begin to develop management regimes for 200-mile Exclusive Economic Zones (EEZs) under national jurisdiction. A recent study, for example, identifies 20 countries and 3 regions of the world which are in the process of creating comprehensive national and regional ocean policies to govern the 200-mile EEZs.

3.5 Principles for ICOM

Integrated coastal and ocean management involves the application of a set of principles: *overarching principles, principles related to environment and development, and principles related to the special character of oceans and coasts*.

Overarching principles guiding ICOM are: 1) sustainable development, and 2) integration (by integration we mean to unify, or to put parts together into a whole). Several dimensions of integration are of special importance in ICOM, i.e.:

- *Intersectoral integration* (bringing together agencies and groups from different sectors such as fisheries, tourism, oil and gas development, etc.)

- *Intergovernmental integration* (bringing together the several levels of government: national, provincial, local) which typically have authority in the coastal zone and ocean)

- *Spatial integration* (bringing together management issues concerning the land side of the coastal zone (including up-river issues related to watersheds and river basins) and issues related to the ocean side)

- *Science-management integration* (applying practical knowledge from the natural and social sciences to managerial decisions about the oceans and coasts)

- *International integration* (especially in cases where there are important transboundary issues that cross national boundaries) (Cicin-Sain and Knecht 1998).

ICOM is also guided by the principles on *environment and development* which were endorsed by the international community at the 1992 United Nations Conference on Environment and Development and in subsequent international agreements: i.e.: the right to develop; inter-generational equity; environmental assessment; precautionary principle; polluter-pays principle; and openness and transparency in decision-making.

Finally, ICOM is also guided by principles related to the *special character of oceans and coasts and to the public nature of the oceans and to the use of coastal ocean resources* (Cicin-Sain and Knecht 1998):

Principles related to the special character of oceans and coasts

- Coastal and ocean systems require special planning and management approaches due to their high productivity, great mobility and interdependence

- The significant interactions across the land-water boundary require recognizing and managing the whole system. Activities well inland can significantly affect coastal and ocean resources

- Land forms fronting the water's edge (e.g., beaches, dunes) that help as buffers against erosion and sea level rise should be conserved, and interruptions of the natural longshore drift system should be minimized

- The biodiversity of rare and fragile ecosystems and endangered/threatened species should be protected.

- Efforts to stabilize the coast should be "designed with nature" using, e.g., special vegetation instead of physical structures.

Principles related to the public nature of the oceans and to the use of coastal ocean resources

- Since ocean resources are part of the public domain, management must be guided by stewardship ethic, fairness and equity
- Historically-based claims of indigenous peoples should be recognized
- While ICOM is intended to foster the coexistence of multiple uses in an area, in case of irreconcilable conflicts, protecting renewable living resources and their habitats should have priority over exploitation of non-living, non-renewable resources
- New coastal developments that are marine dependent should have priority over those that are not.

3.6 Sustainable development as the overarching goal of ICOM

The major purpose of ICOM is to achieve sustainable development of ocean and coastal areas and their resources. Sustainable development should maximize the economic and social/cultural benefits that can be derived from the ocean or coastal area without compromising the health of these same ocean and coastal ecosystems.

To achieve sustainable development in ocean and coastal areas, it is generally accepted that the following elements must be present:

- Ecosystem-based management
- Integration
- Knowledge-based decision-making

Ecosystem-based management

Ecosystem-based management (EBM) recognizes that sustainability and a healthy marine environment are of primary importance in achieving sustainable development. The main focus of EBM is on maintaining the functional and structural integrity of the ecosystem. This focus, however, must recognize the role humans play within the ecosystem with respect to direct and indirect impacts of their activities. Management of human behaviour and activities is needed to achieve ecosystem health. Development of ecosystem-based management objectives, focused on ecosystem characteristics provides the guidance needed to achieve sustainable development. As ecosystem characteristics may change over time, it is important to consider both current state and long term changes in determining ecosystem-based objectives.

Integration

Coastal and ocean area management typically involves multiple users, multiple government agencies, different levels of government (e.g., national, provincial, local), and interactions with other nations in the case of shared seas. ICOM also typically involves both land and water aspects, and relies on the application of knowledge from various disciplines. Integration (meaning to unify, or to put parts together in a whole), is thus a central element of ICOM. The following dimensions of integration are usually thought to be of central importance in ICOM: 1) intersectoral integration, 2) intergovernmental integration, 3) spatial integration, 4) science-management integration, and 5) international integration.

Knowledge-based decision making

Knowledge-based decision-making refers to using the best available physical, natural and socio-economic science information in planning and decision making for coastal and ocean management areas. Science should be used in conjunction with traditional and local knowledge to ensure that all forms of knowledge are available to planners and managers. It is important to recognize that over time new knowledge will become available and should be added to the base of information accessible to managers for application in their decision-making. This is what is commonly referred to as the practice of adaptive management.

3.7 Management by objectives

The development and implementation of an integrated management plan requires having clear and unambiguous objectives that can lead to specific and achievable outcomes. As integrated management takes into consideration ecological and social/economic factors as well as governance for a given management area, it is therefore important that these considerations are reflected in the management objectives. Objectives can therefore be grouped into three general categories;

- Ecological,
- Socioeconomic and
- Governance objectives.

It is important to the process of integrated management that consideration is given to the interactions between the ecological, socioeconomic and governance objectives. This suite of objectives and their respective indicators provides managers with the ability to observe linkages such as the effect from human pressures (fishing, sewage disposal) on an ecosystem characteristic (diversity, habitat type). When developing management objectives it is valuable to keep the following questions in mind:

- What do you want to achieve as your objective?
- Can you measure whether you have met your objective or the processes to meeting your objective? That is, can you relate the objective to an indicator?
- How long will it take to reach your objective? One, five, ten years?
- What are the steps to reach your objectives? For example a more efficient regulatory process, increased research, development of guidelines?
- Can you link an objective from one aspect of ICOM (environment, socioeconomic, governance) with those of one or more objectives from another group(s)?

3.8 Process of ICOM

There are a number of general steps to follow in conducting ICOM for coastal or ocean areas. The overall elements of the ICOM process are illustrated below in Figure 3.1. The individual steps and their sequencing may vary depending on the characteristics of the area requiring management. In some cases not all steps are necessarily required to be completed, nor to be completed in the linear progression as outlined here.

1. Organization or body that has responsibility for the integrated management process. This responsibility often comes through a legislative or other legal mandate.

2. Define management area
   a) Often triggered by specific events, needs, problems, local interest
   b) Examples include where there are multiple use conflicts, ecological degradation
   c) Takes into consideration ecological, and jurisdictional and legal parameters.

3. Engage affected interests (this may often be occurring while conducting step two)
   a) The engagement process helps define the ecological, economic and social issues.
   b) This stage is ongoing throughout the process. The level of engagement is often dependent on the scope of the issue(s), size and population of the area.

4. Development of ecological and socio-economic assessments
   a) Documentation of current ecological, social and economic conditions in the area serve to establish a baseline
   b) Assessment of the condition of the ecosystem and the drivers and pressures which may impact on it.

5. Establishment of integrated management objectives and indicators.
   a) Objectives would include ecological, economic and governance objectives and indicators.
   b) Objectives and indicators are most effective and efficient when the three types (ecological, economic, and governance) can be linked with each other.

6. Develop and implement ICOM Plans
   a) New management body if required
   b) Endorsement of plan
   c) Goals, objectives, roles and responsibilities
   d) Enhanced sectoral management
   e) Incorporating or linking to existing plans such as for mariculture, fisheries management etc.
   f) Implementation is not a one time only activity but actually a continuous process loop.

7. Monitoring, evaluation and reporting

a) Monitoring of indicators enables managers to more effectively adapt and revise the management plan over time and as new information becomes available.

b) Routine monitoring of coastal and ocean indicators will improve the capacity to track progress in the management and use of management areas and can result in an improved ability to share information among ICOM partners and stakeholders for planning and compliance purposes.

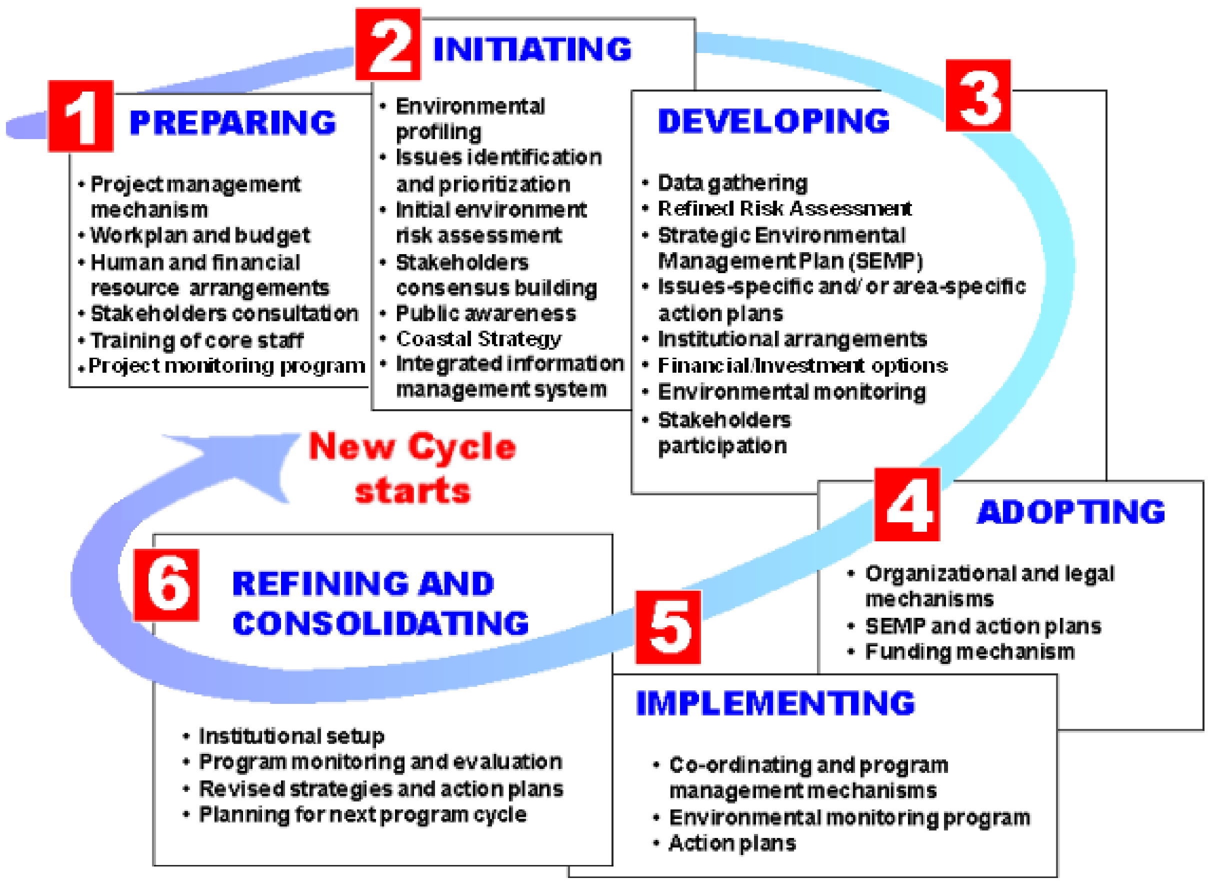

Figure 3-1 Elements of the Integrated Coastal and Ocean Management Process (Chua et al. 2003)

3.9 Common ICOM characteristics

There are a number of common characteristics or features to ICOM. These characteristics generally apply regardless of the size of the management area and apply to such variables as the purpose of the ICOM area, principles, functions, to the use of science in decision making, as summarized in Table 3.3

Table 3-3 Characteristics of Integrated Management for coastal and ocean management areas (*Adapted from CBD/COP 2000*).

Main variable	*Characteristics*
Purpose	To guide coastal and ocean area development in an ecologically sustainable manner
Principles	Precautionary, inclusive and collaborative, flexibility, stewardship, conservation
Functions	ICOM is intended to strengthen and harmonize sectoral management in coastal and ocean management areas. It preserves and protects the productivity and biodiversity of coastal and ocean ecosystems and maintains overall health and intrinsic value of these systems. ICOM promotes the rational economic development and sustainable utilization of coastal and ocean resources and facilitates conflict resolution in coastal and ocean areas. Stewardship of resources is promoted through ICOM as well as the facilitation of actions required for providing greater public safety from natural and anthropogenic hazards.
Spatial coverage	ICOM programs embrace all the coastal and upland areas, the uses of which can affect the coastal waters and the resources therein, and extend seaward to include that part of the coastal ocean that can affect the land of the coastal zone. ICOM programmes can also include the entire ocean area over which national governments have stewardship responsibilities.
Horizontal and vertical integration	Harmonizing and coordinating between different sectors and different levels of government. The mechanisms used for coordinating and harmonization must be tailored to fit the unique aspects of each particular national government setting.
Use of science	Given the complexities and uncertainties that exist regarding ocean and coastal areas, ICOM must be built upon the best natural and socio-economic science information available in conjunction with traditional and local knowledge of the area. Techniques such as risk assessment, economic valuation, vulnerability assessments, resource accounting, benefit-cost analysis, and outcome-based monitoring should be built into the ICOM process as appropriate.

3.10 Indicators for ICOM

As ICOM progresses in specific geographic areas, the need and responsibility to track progress also increases. Indicators, i.e. parameters or values derived to provide succinct information about a phenomenon, are powerful tools as a feedback loop to an action plan, an early warning signal about an issue or evolving condition of a system, and a concise message for engagement, education, and awareness.

Indicators should reflect the specific management issues that triggered the initiation of an ICOM planning process, such as multiple user conflicts, ecological degradation, community interest, or a commitment to improve the management of a local marine area. A structured approach to ICOM calls for indicators that relate clearly to the management objectives set through planning for the management area.

Uses of indicators in ICOM

- Monitor key compositional, structural and functional characteristics of marine ecosystems against desired conditions as established through ecosystem-based management

- Track progress and effectiveness of measures and actions, e.g. marine environmental quality objectives or the creation of marine protected areas.

- Provide a focal point to summarize consistent information for sub-national, national and international reporting, and across reporting scales and jurisdictions.

- Monitor the long-term cumulative impacts of human actions on the marine environment, ecosystem status and health, and trends on the major drivers and pressures of the system.

- Guide adaptive management towards necessary course corrections as events unfold.

- Track progress in the process of implementation of an ICOM plan, including its efficiency, effectiveness and adaptability.

Ecological, socio-economic, and governance indicators

Indicators can be divided in three categories in relation to their specific contribution to ICOM decision-making:

- *Ecological indicators* reflect trends in the state of the environment. They are descriptive in nature if they describe the state of the environment in relation to a series of environmental issues such as eutrophication, loss of biodiversity or over-fishing. They become performance indicators if they compare actual conditions to desired conditions expressed in terms of ecological targets.

- *Socioeconomic indicators* represent the state of the human component of coastal ecosystems (e.g. economic activity) and are an essential element in the development of ICOM plans. They can help measure the extent to which ICOM is successful in managing human pressures in a way that results not only in an improved environment, but also in improved quality of life in coastal areas, and in sustainable socioeconomic benefits.

- *Governance indicators* measure the performance of program components (e.g. state of ICOM planning and implementation). They also measure the progress and quality of interventions and of the ICOM governance process itself.

The list of potential indicators is very long and judicious choices must be made based on relevance, technical adequacy and feasibility. As for ICOM planning, the specific reporting requirements will vary from one geographic area to another, hence affecting the selection of indicators, the required partnering arrangements, and the cost of reporting. Selection criteria generally recommended in the literature and by indicator practitioners, essentially address relevance, technical adequacy and feasibility.

The full set of indicators proposed for a given area will also need to be examined to consider complementarities among indicators and adequate coverage of key issues. For example where different indicators deal with a similar coastal issue, one indicator or a smaller subset could be selected for development. It may also be best to group various variables into one indicator or merge some of the proposed indicators to create indices.

The following chapters provide further guidance on suites of governance performance, ecological, and socioeconomic (quality of life) indicators that may be useful in support of ICOM (Table 3-4). The indicators are also seen in relation to the main ICOM goals and objectives (Figures 3-2 – 4).

Table 3-4 Proposed list of ecological, socioeconomic (quality of life), and governance performance

Goal	No.	Indicator	Measurements
Ensuring the coordination and coherence of administrative actors and policies	—	Functions of administrative actors related to the coast	- ICOM functions of administrative actors clearly defined by legislation or administrative acts - New agencies for ICOM established and responsibility assigned
	G.1	Coordinating mechanism	- Existence and functioning of a coordinating mechanism for ICOM - Outcomes of the coordination process
	G.2	Legislation	- Existence of legislation on coastal and marine resources - Adequacy of the ICOM legislation
	G.3	Environmental assessment	- Use of EIA and SEA procedures and modifications to coastal projects - Use of CCA procedures in coastal tourism development
	G.4	Conflict resolution mechanism	- Agreed procedures and mechanisms for conflict resolution - Changes in the proportion of conflicts successfully mitigated, resolved, or prevented - Overall change in the number of conflicts
Ensuring the quality and effectiveness of management	G.5	Integrated management plans	- Existence, characteristics, and status of ICOM plans - Extent (percentage) of coastline covered by ICOM plans
	G.6	Active management	- Level of implementation of ICOM plans, actions and projects, including infrastructure building - Procedures, legal tools, and monitoring and sanctioning applied for enforcement of ICOM plans/actions - Level of enforcement of, or compliance with, ICOM plans
	G.7	Monitoring and evaluation	- Existence of an operational monitoring and evaluation system with related indicators - Consideration of results into ICOM initiatives - Adjustments made to ICOM initiatives

Goal	No.	Indicator	Measurements
	G.8	Human, technical, and financial resources	- Staff - Budget - Facilities
Improving knowledge and awareness of the coastal zone	G.9	Inputs from scientific research	- Existence of research studies and scientific publications - Completion of a diagnostic assessment that identifies root causes of coastal degradation and establishes priority for interventions - Existence and dissemination of a state of the coast report - Media events related to coastal issues - Existence and functioning of a science advisory body - Existence and operation of routine monitoring of the marine environment - Inputs from scientific research and diagnostic assessment into ICOM
	G.10	Stakeholder participation	- Level of stakeholder participation - Level of stakeholder satisfaction with participation and with ICOM outcomes
	G.11	NGO and CBO activity	- Existence and characteristics of NGOs and community organizations active in ICOM - Level of activity of NGOs and community organizations active in ICOM
	G.12	Education and training	- Educational and training programs incorporating ICOM - People having completed educational and training programs in ICOM - Employment of people with education and training in ICOM
Mainstreaming ICOM into sustainable development	G.13	Technology	- Availability of ICOM-enabling and supporting technology at an acceptable cost - Level of use of ICOM-enabling and supporting technology in substitution of counter-ICZM technology - Level of coordination of ICZM-enabling and supporting technology

Goal	No.	Indicator	Measurements
	G.14	Economic instruments	- Availability of economic instruments, including environmental quality certifications, in conjunction with regulatory instruments - Level of implementation and enforcement of economic instruments
	G.15	Sustainable development strategy	- Existence of sustainable development strategy or Agenda 21 incorporating ICOM chapter - Level of implementation of ICOM chapter of sustainable development strategy or Agenda 21
	—	International recommendations and guidelines on ICOM influencing the ICOM process	- Awareness of international recommendations and guidelines on ICOM - ICOM decisions influenced by international recommendations and guidelines
	—	Participation in international efforts related to ICOM and influence on the ICOM process	- Active participation in international agreements and cooperative efforts in ICOM such as transboundary or multinational projects - Influence of such involvement on the national / local ICOM process
	—	Ratification and implementing legislation for international agreements relevant to ICOM	- Ratio between agreements ratified and legislated for - Degree of implementation of international agreements
Maintaining ecosystem structure	E.1	Diversity	- Diversity of communities - Diversity of populations - Diversity of species - Genetic diversity - Invasive species/pests
	E.2	Distribution	- Horizontal distribution (patchiness, aggregation) - Vertical distribution (food web/trophic structure)
	E.3	Abundance	- Biomass (key populations) - Number of individuals (marine mammals) - Density (plants, benthic org.)
Maintaining ecosystem function	E.4	Production and reproduction	- Complexity of food web - Key predator/prey interactions - Keystone species - Size spectra

Goal	No.	Indicator	Measurements
	E.5	Trophic interactions	- Complexity of food web - Key predator/prey interactions - Keystone species - Size spectra
	E.6	Mortality	- Fishing mortality - Incidental mortalities (by-catch) - Natural mortality (predation)
Conserving oceanographic properties	E.7	Species health	- Species at-risk of extinction - (Bio)accumulation of toxic compounds - Diseases and abnormalities - Seafood quality
	E.8	Water quality	- Water column properties - Oceanographic processes & variability (& regime shifts) - Sedimentation (e.g. transport of suspended sediments) - Pollutants and contaminants - Eutrophication parameters
	E.9	Habitat quality	- Habitat types - Habitat alteration - Sea level change - Landscape and bottomscape integrity - Sediment quality (nature/properties of sediments)
Maximizing sustainable wealth generation and the reduction of poverty	S(QL).1	Total economic value	- Exploitation of living resources (commercial fisheries; artisanal fisheries; recreational fisheries) - Exploitation of non-living resources (oil and gas; minerals and metals) - Non-consumptive uses (shipping; tourism and eco-tourism) - Economic value-added - Value of exports - Management and administration costs
	S(QL).2	Total employment	- Number employed - Employment payroll value - Same sub-categories as total economic value
Minimize environmental degradation from human activity	S(QL).3	Sustainably managed exploitation	- Environmental assessments conducted - Fisheries with management plans

Goal	No.	Indicator	Measurements
	S(QL).4	Pollutants and introduction	- Population served by wastewater treatment - Volume, number, and type of point-source discharges - Non-point-source nutrient loading (e.g., fertilizer use) - Discharged sediments and nutrients - Volume of ballast and bilge discharge - Litter and debris
	S(QL).5	Habitat alteration	- Land use/land cover patterns and composition - Population density - Extent of hard-surface areas - High-impact fishing gear/practices - Dumped and dredged material (e.g., shipping channel maintenance)
Protecting human life, public and private property, and maintaining an equitable population dynamics	S(QL).6	Disease and illness	- Fecal choliform counts - Days of beach closure - Extent of contaminated species - Extent of contaminated water - Seafood-vectored illnesses
	S(QL).7	Weather and disasters	- Economic value of loss from marine weather-related events - Lives lost from weather and marine disasters
	S(QL).8	Population dynamics	- Degree of public access - Resident and total (seasonal) population - Marine attachment

Goal	Objective	G1 Coordination mechanism for ICOM	G2 Legislation enabling ICOM	G3 EIA, SEA, and CCA procedures	G4 Conflict resolution mechanism	G5 Integrated management plans	G6 Implementation of integrated management plans	G7 Routine monitoring and evaluation	G8 Sustained availability of resources	G9 Dissemination of scientific information	G10 Stakeholder participation	G11 NGO and CBO activity	G12 Educational and training curricula	G13 Enabling and supporting technology	G14 Use of economic instruments	G15 ICOM incorporate into sustainable development strategy
Ensuring the coordination and coherence of administrative actors and policies	Ensuring the coordination of administrative functions	■	■	■	■	■	■									■
	Enabling ICOM through a regulatory framework		■	■												
	Resolving conflicts among actors and stakeholders	■	■		■											
Ensuring the quality and effectiveness of management	Managing coastal uses in an integrated way					■	■									■
	Adapting management to changing conditions							■		■						
	Sustaining the ICOM process over time								■				■			
Improving knowledge, awareness, and support	Making optimal use of scientific information							■		■			■			
	Ensuring support to the ICOM process									■	■	■				
Mainstreaming ICOM into sustainable development	Supporting ICOM through appropriate technology												■	■		
	Supporting ICOM through economic instruments														■	
	Mainstreaming ICOM into sustainable development strategies															■

Figure 3-2 Matrix of relevance of ICOM governance indicators to goals and objectives

		Diversity of communities	Diversity of populations	Diversity of species	Genetic diversity	Invasive species/pests	Horizontal distribution (patchiness, aggregation)	Vertical distribution (food web/trophic structure)	Biomass (key populations)	Number of individuals (marine mammals)	Density (plants, benthic org.)	Primary productivity: quantity and quality	Secondary productivity	Life-stage history	Reproductive parameters	Spawning survival rates (survivorship)	Mean generation time (longevity)	Complexity of food web	Key predator/prey interactions	Keystone species	Size spectra	Fishing mortality	Incidental mortalities (by-catch	Natural mortality (predation)	Species at-risk of extinction	(Bio)accumulation of toxic compounds	Diseases and abnormalities	Seafood quality	Water column properties	Oceanographic processes & variability (and regime	Sedimentation	Pollutants and contaminants	Eutrophication parameters	Habitat types	Habitat alteration	Sea level change	Landscape and bottomscape integrity	Sediment quality (nature/properties of sediments)
Goal	**Objective**	**E1**					**E2**		**E3**			**E4**						**E5**				**E6**			**E7**				**E8**					**E9**				
Conserving the components of biological organization	Maintaining genetic diversity				■	■																																
	Maintaining species diversity			■		■														■																		
	Maintaining ecosystem diversity	■				■	■	■	■	■	■																											
Conserving the functions of the ecosystem	Maintaining the primary production											■	■	■								■	■	■														
	Maintaining the trophic structure																	■	■	■	■			■														
	Maintaining the mean generation time													■	■	■	■					■	■	■														
Conserving the geological, physical and chemical properties of the ecosystem	Maintaining the geological, physical and chemical properties of the ecosystem within bounds of natural variability'																								■	■	■	■	■	■	■	■	■					
	Monitoring and assessing the variability of oceanographic parameters and properties																												■	■	■	■	■			■	■	■
	Minimizing the levels of contaminants, forces and energy introduced into the marine environment																																	■	■			

Figure 3-3 Matrix of relevance of ICOM ecological indicators to goals and objectives

Goal	Objectives	Exploitation of living resources	Exploitation of non-living resources	Non-consumptive uses	Economic value-added	Value of exports	Management and administration costs	Number employed	Employment payroll value	Same sub-categories as total economic value	Environmental assessments conducted	Fisheries with management plans	Population served by wastewater treatment	Volume, no., and type of point-source discharges	Non-point-source nutrient loading	Discharged sediments and nutrients	Volume of ballast and bilge discharge	Litter and debris	Land use/land cover patterns and composition	Population density	Extent of hard-surface areas	High-impact fishing gear/practices	Dumped and dredged material	Fecal chloroform counts	Days of beach closure	Extent of contaminated species	Extent of contaminated water	Seafood-vectored illnesses	Economic value of loss from marine weather-	Lives lost from weather and marine disasters	Degree of public access	Resident and total (seasonal) population	Marine attachment
		E1						E2			E3		E4						E5					E6					E7		E8		
Maximizing sustainable wealth generation and the reduction of poverty	Exploiting sustainably living resources	X			X	X	X	X	X	X	X	X										X				X		X					
	Exploiting sustainably non-living resources		X		X	X	X	X	X	X	X																						
	Ensuring sustainable non-consumptive uses			X	X	X	X	X	X	X	X														X						X		
Minimizing environmental degradation from human activity	Managing sustainably exploitation and extraction	X	X	X							X	X										X	X										
	Minimizing pollution and litter	X	X	X									X	X	X	X	X	X	X					X	X	X	X	X					
	Minimizing introduced alien species	X		X													X																
	Minimizing habitat alteration and destruction										X	X	X	X	X	X		X	X		X	X	X										
Protecting human life, public and private property, and establishing or maintaining equitable population dynamics	Minimizing damage from coastal hazards																												X	X			
	Ensuring public health																	X						X	X	X	X	X					
	Ensuring public safety																												X	X			
	Ensuring adequate population dynamics																			X												X	

Figure 3-4 Matrix of relevance of ICOM socioeconomic indicators to goals and objectives

Goal	No.	Indicator	Measurements
Maximizing sustainable wealth generation and the reduction of poverty	S(QL).1	Total economic value	- Exploitation of living resources (commercial fisheries; artisanal fisheries; recreational fisheries) - Exploitation of non-living resources (oil and gas; minerals and metals) - Non-consumptive uses (shipping; tourism and eco-tourism) - Economic value-added - Value of exports - Management and administration costs
	S(QL).2	Total employment	- Number employed - Employment payroll value - Same sub-categories as total economic value
Minimize environmental degradation from human activity	S(QL).3	Sustainably managed exploitation	- Environmental assessments conducted - Fisheries with management plans
	S(QL).4	Pollutants and introduction	- Population served by wastewater treatment - Volume, number, and type of point-source discharges - Non-point-source nutrient loading (e.g., fertilizer use) - Discharged sediments and nutrients - Volume of ballast and bilge discharge - Litter and debris
	S(QL).5	Habitat alteration	- Land use/land cover patterns and composition - Population density - Extent of hard-surface areas - High-impact fishing gear/practices - Dumped and dredged material (e.g., shipping channel maintenance)
Protecting human life, public and private property, and maintaining an equitable population dynamics	S(QL).6	Disease and illness	- Fecal choliform counts - Days of beach closure - Extent of contaminated species - Extent of contaminated water - Seafood-vectored illnesses
	S(QL).7	Weather and disasters	- Economic value of loss from marine weather-related events - Lives lost from weather and marine disasters

Goal	No.	Indicator	Measurements
	S(QL).8	Population dynamics	- Degree of public access - Resident and total (seasonal) population - Marine attachment

		Coordination mechanism for ICOM	Legislation enabling ICOM	EIA, SEA, and CCA procedures	Conflict resolution mechanism	Integrated management plans	Implementation of integrated management plans	Routine monitoring and evaluation	Sustained availability of resources	Dissemination of scientific information	Stakeholder participation	NGO and CBO activity	Educational and training curricula	Enabling and supporting technology	Use of economic instruments	ICOM incorporate into sustainable development strategy
Goal	**Objective**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**G8**	**G9**	**G10**	**G11**	**G12**	**G13**	**G14**	**G15**
Ensuring the coordination and coherence of administrative actors and policies	Ensuring the coordination of administrative functions	■	■	■	■	■	■									■
	Enabling ICOM through a regulatory framework		■	■												
	Resolving conflicts among actors and stakeholders	■	■		■											
Ensuring the quality and effectiveness of management	Managing coastal uses in an integrated way					■	■									■
	Adapting management to changing conditions							■		■						
	Sustaining the ICOM process over time								■				■			
Improving knowledge, awareness, and support	Making optimal use of scientific information							■		■			■			
	Ensuring support to the ICOM process									■	■	■				
Mainstreaming ICOM into sustainable development	Supporting ICOM through appropriate technology												■	■		
	Supporting ICOM through economic instruments														■	
	Mainstreaming ICOM into sustainable development strategies															■

Figure 3-2 Matrix of relevance of ICOM governance indicators to goals and objectives

Goal	Objective	Diversity of communities	Diversity of populations	Diversity of species	Genetic diversity	Invasive species/pests	Horizontal distribution (patchiness, aggregation)	Vertical distribution (food web/trophic structure)	Biomass (key populations)	Number of individuals (marine mammals)	Density (plants, benthic org.)	Primary productivity: quantity and quality	Secondary productivity	Life-stage history	Reproductive parameters	Spawning survival rates (survivorship)	Mean generation time (longevity)	Complexity of food web	Key predator/prey interactions	Keystone species	Size spectra	Fishing mortality	Incidental mortalities (by-catch	Natural mortality (predation)	Species at-risk of extinction	(Bio)accumulation of toxic compounds	Diseases and abnormalities	Seafood quality	Water column properties	Oceanographic processes & variability (and regime	Sedimentation	Pollutants and contaminants	Eutrophication parameters	Habitat types	Habitat alteration	Sea level change	Landscape and bottomscape integrity	Sediment quality (nature/properties of sediments)
Goal	**Objective**	**E1**					**E2**		**E3**			**E4**						**E5**				**E6**			**E7**				**E8**					**E9**				
Conserving the components of biological organization	Maintaining genetic diversity				X	X																																
	Maintaining species diversity			X		X														X																		
	Maintaining ecosystem diversity	X				X	X	X	X	X	X																											
Conserving the functions of the ecosystem	Maintaining the primary production											X	X	X								X	X	X														
	Maintaining the trophic structure																	X	X	X	X			X														
	Maintaining the mean generation time													X	X	X	X					X	X	X														
Conserving the geological, physical and chemical properties of the ecosystem	Maintaining the geological, physical and chemical properties of the ecosystem within bounds of natural variability'																								X	X	X	X	X	X	X	X	X					
	Monitoring and assessing the variability of oceanographic parameters and properties																												X	X	X	X	X			X	X	X
	Minimizing the levels of contaminants, forces and energy introduced into the marine environment																																	X	X			

Figure 3-3 Matrix of relevance of ICOM ecological indicators to goals and objectives

Goal	Objectives	Exploitation of living resources	Exploitation of non-living resources	Non-consumptive uses	Economic value-added	Value of exports	Management and administration costs	Number employed	Employment payroll value	Same sub-categories as total economic value	Environmental assessments conducted	Fisheries with management plans	Population served by wastewater treatment	Volume, no., and type of point-source discharges	Non-point-source nutrient loading	Discharged sediments and nutrients	Volume of ballast and bilge discharge	Litter and debris	Land use/land cover patterns and composition	Population density	Extent of hard-surface areas	High-impact fishing gear/practices	Dumped and dredged material	Fecal chloroform counts	Days of beach closure	Extent of contaminated species	Extent of contaminated water	Seafood-vectored illnesses	Economic value of loss from marine weather events	Lives lost from weather and marine disasters	Degree of public access	Resident and total (seasonal) population	Marine attachment
Goal	**Objectives**	**E1**						**E2**			**E3**		**E4**						**E5**					**E6**					**E7**		**E8**		
Maximizing sustainable wealth generation and the reduction of poverty	Exploiting sustainably living resources	■			■	■	■	■	■	■	■	■										■				■		■					
	Exploiting sustainably non-living resources		■		■	■	■	■	■	■	■																						
	Ensuring sustainable non-consumptive uses			■	■	■	■	■	■	■	■														■						■		
Minimizing environmental degradation from human activity	Managing sustainably exploitation and extraction	■	■	■							■	■										■	■										
	Minimizing pollution and litter	■	■	■									■	■	■	■	■	■	■					■	■	■	■	■					
	Minimizing introduced alien species	■		■													■																
	Minimizing habitat alteration and destruction										■	■	■	■	■	■		■	■		■	■	■										
Protecting human life, public and private property, and establishing or maintaining equitable population dynamics	Minimizing damage from coastal hazards																												■	■			
	Ensuring public health																	■						■	■	■	■	■					
	Ensuring public safety																												■	■			
	Ensuring adequate population dynamics																			■												■	

Figure 3-4 Matrix of relevance of ICOM socioeconomic indicators to goals and objectives

4 Governance performance indicators

Table 4-1 Summary of governance performance indicators

Goal	Code	Indicator	Page
Ensuring the coordination and coherence of administrative actors and policies	**G.1**	Existence and functionality of a coordinating mechanism for ICOM	46
	G.2	Existence and adequacy of legislation enabling ICOM	48
	G.3	EIA, SEA, and CCA procedures for plans, programs, and projects affecting coastal zones	50
	G.4	Existence and functioning of conflict resolution mechanisms	52
Ensuring the quality and effectiveness of management processes	**G.5**	Existence, status and coverage of ICOM plans	54
	G.6	Level of implementation, compliance with, and enforcement of ICOM plans and related activities	56
	G.7	Routine monitoring, evaluation and adjustment of ICOM initiatives	58
	G.8	Sustained availability and allocation of human, technical, and financial resources for ICOM, including the leverage of additional resources	60
Improving information, knowledge, and awareness	**G.9**	Existence, dissemination, and application of ICOM-related scientific research and information	62
	G.10	Level of stakeholder participation in, and satisfaction with, ICOM decision-making processes	64
	G.11	Existence and activity level of NGO and community organizations supportive of ICOM	66
	G.12	Incorporation of ICOM into educational and training curricula and formation of ICOM cadres	68
Ensuring the sustainability of management efforts	**G.13**	Use of technology, including environmentally friendly technology, to enable and support ICOM	70
	G.14	Use of economic instruments in support to ICOM	72
	G.15	Incorporation of ICOM into sustainable development strategy	74

4.1 Coastal and ocean governance

Definition and purposes

"Coastal and ocean governance" may be defined as the processes and institutions by which coastal and ocean areas are managed by governments (in association with communities, industries, non-governmental organizations and other stakeholders) through national, subnational, and international laws, policies, and programs, as well as through customs, tradition and culture. The fundamental goal of a system of coastal and ocean governance is to maximize the short- and long-term benefits to the public from the conservation and use of the natural resources of ocean and coastal areas.

The main purposes of coastal and ocean governance are to:

- Achieve sustainable development of the multiple uses of ocean and coastal areas;
- Maintain essential ecological processes, life support systems, and biological diversity in ocean and coastal areas;
- Reduce vulnerability of coastal and ocean areas and their inhabitants to natural and human hazards;
- Analyze and address implications of development, conflicting uses, and interrelationships among physical processes

and human activities in ocean and coastal areas; and

- Promote linkages and harmonization among coastal and ocean sectors and activities (Cicin-Sain and Knecht, 1998).

Ideally, an ICOM program should operate within a closely integrated, coherent management framework within a defined geographical limit (Chua, 1993: 91).

Since ocean areas, in most nations, are in the public domain, governance of these areas demands: (1) a high level of stewardship; (2) the assumption of responsibility for the long-term well-being of ocean resources and associated coastal resources and areas; (3) the promotion of sustainable development of multiple uses of ocean and coastal areas to achieve economic and social benefits for stakeholders and the public; and (5) public accountability and transparency in the conduct of ocean and coastal governance.

The importance of institutional factors in ICOM

There is generally a recognition in ICOM projects of the need to work from two directions - "bottom up" (involving the local community, as well as provincial authorities) and "top down" (involving the national government) since, in most cases, national, provincial, and local governments share jurisdiction over the coastal zone and ocean.

A key aspect of ICOM is the design of institutional processes of integration/harmonization to overcome the fragmentation inherent in the sectoral management approach (which manages each major activity separately (e.g., tourism, fisheries, oil and gas), and in the splits in jurisdiction between levels of government at the land-water interface.

Generally, governance factors thought to be important in enabling successful ICOM interventions include (Belfiore 2005):

- Having appropriate legal authority, e.g., the establishment of a coastal/ocean law or decree
- Appropriate institutional arrangements, such as a lead agency and an ICOM coordinating body
- Clear geographical boundaries of the plan or program
- Having regulatory powers and instruments for controlling development within the application area
- Having the human, technical, and financial resources to carry out the plan or program
- Putting procedures in place for the monitoring, evaluation, and adjustments to the plan and/or program

The creation of an ICOM *coordination mechanism* that brings together coastal and ocean sectors, different levels of government, users, and the public into the ICOM process is thought to be a useful vehicle for achieving policy integration. Attributes of a successful institutional coordination mechanism for ICOM include:

- Based on appropriate legal authority
- Able to affect the activities of all the agencies and levels of government involved
- Perceived as a legitimate and appropriate part of the process
- Capable of making informed decisions (with the assistance of a technical secretariat and scientific advisors)
- Whenever possible, the coastal management entity should be at a higher bureaucratic level than the sectoral agencies to give it the necessary authority to harmonize sectoral actions
- The effort should be adequately financed and staffed
- The planning aspects of integrated coastal management should be integrated into national development planning.

4.2 Governance indicators for ICOM

As noted by IOC (2003, 79), "the use of performance indicators for ICM is still in its infancy." While there have been efforts to monitor progress of ICOM at the global level (OECD), regional level (EU), and at the program level (most notably Coastal Resources Center and

PEMSEA), difficulties are apparent especially with respect to tying ICOM efforts to on-the-ground changes, and to attributing on-the-ground changes to the effects of ICOM programs.

While this is still a very underdeveloped area, it has become increasingly important because decisionmakers and the public in many countries, as well as international donors and others, are demanding to see the tangible results of ICOM investments. Hence, development of a set of parsimonious governance indicators which can be easily applied in different socio-political contexts looms as a major challenge for analysts and decisionmakers alike.

When examining governance indicators, it is important to recall that ICOM is geared at achieving social and environmental benefits through an integrated management process. Hence, discussion of governance indicators must also ultimately encompass a discussion of the relationship between governance indicators and socio-economic and environmental indicators--the results of governance in terms of specific improvements in social and environmental conditions

ICOM efforts around the world, too, are at different stages of development or maturity, i.e., some may be in the initiation stage, the implementation stage, the operation stage, or the evaluation stage. A different combination or set of governance variables may be used to measure progress according to the stage of development of an ICOM program (see, for example, Chua et al. 2003 for indicators related to the stages of program formulation, program implementation, program sustainability, and monitoring and evaluation).

Also, the practice of ICOM exhibits different modes in different countries. In some countries, there might be only a national-level ICOM program. In other countries, there might be a program combining national, regional, and local components. In other countries, especially some developing countries, ICOM efforts may be confined primarily to local efforts in small areas. Governance indicators need to be adapted to these varying modalities found in different national contexts.

It should be noted, too, that much of the experience to date in the application of governance indicators has taken place vis-à-vis coastal management—involving coastal lands and nearshore coastal waters. Increasingly, however, as nations develop coordinated management approaches to the management of 200-mile Exclusive Economic Zones (EEZ), there is a demand for and pressure to apply governance indicators to measure progress of management of these ocean areas. While many of the governance indicators developed for coastal management may well be applied to ocean management in areas further offshore, other variables might also need to be emphasized given, for example, the dominance of public (versus private) interests in EEZ ocean areas versus in coastal lands where, because of the presence of private property rights, public and private interests must be balanced.

Finally, one of the major challenges in the development and application of governance indicators lies in the fact that they should be very practical and useful for guiding governance improvements. This is the essence of adaptive management—development and application of indicators to test how one's program is doing and adapting accordingly to achieve better results.

Definition

Governance indicators measure the quality of aspects and dimensions of the governance and management processes aimed at ensuring that sustainable development of coastal and marine areas is pursued in an open, participatory, accountable, effective, and coherent way. These indicators measure the performance of program components that address coastal environmental and socioeconomic issues.

Governance performance indicators focus on *inputs, processes, outputs, outcomes and impacts* of strategies, programs and projects. The use of governance performance indicators is particularly useful in setting quantifiable objectives and related performance targets and assessing progress towards achieving them. As discussed earlier, this is particularly important in generating continuing political and public support for ICOM programs—decisionmakers and the public wants to know:

- What difference do investments in ICOM make in terms of protecting coastal and ocean resources, biodiversity and the environment, and exercising stewardship on behalf of current and future generations?

- What difference do investments in ICOM make in terms of enhancing economic opportunities, public health, and quality of life in coastal communities?

- What difference do investments in ICOM make in terms of resolving conflicts among current and potential uses of the coast and ocean, and in attaining balanced and orderly development of these areas?

- Are management decisions about ocean and coastal areas made in an open and transparent fashion involving multiple stakeholders, and are accountable to the public interest in these areas?

- Are the management processes set up to manage the coast and ocean effective and efficient, particularly in terms of:
  - Integrated institutional and legal arrangements
  - Mobilization of human and financial resources
  - Deployment of facilities and equipment
  - Generation and application of scientific knowledge
  - The implementation of strategies, plans, and programs
  - Public education and awareness
  - Stakeholder participation
  - Monitoring and evaluation

A simplified model of how these variables relate to one another may be found in Figure

Table 4-2 ICOM classes of indicators

Governance process variables (inputs and outputs)	*Governance outcome and impact variables*
Institutional development (or capacity) variables	*Accountability*
– Integrated institutional and legal arrangements	– Public accountability of ICOM programs
– Mobilization of human and financial resources	
– Deployment of facilities and equipment	*Conflict resolution*
– Generation and application of scientific knowledge	– Resolution and mitigation of multiple use conflicts and attainment of appropriate and orderly development
– Implementation of strategies, plans, and programs	
– Public education and awareness	
– Stakeholder participation	*Stewardship*
– Monitoring and evaluation	– Improvements in the protection of coastal and marine resources, biodiversity and the environment
	Socioeconomic benefits
	– Improvements in economic opportunities, public health and safety, and quality of life in coastal communities

The assumption is that an appropriately structured and carried out management process (involving the exercise of decisionmaking over uses and activities in the entire coastal and ocean area) will yield the types of benefits noted in the column on the right. However, it has to be noted that often there is limited political will to influence the variables; in addition, variables related to governance should include also a consideration of the articulation of roles and responsibilities in ICOM, in particular those of subnational entities.

In this chapter we focus especially in describing the governance process variables (inputs and outputs) and governance outcome and impact variables. Regarding the central governance outcome and impact variables of benefits to the environment and benefits to coastal communities, we discuss these briefly in this chapter but treat them in more depth in the final chapter of this report, where we bring together discussions of environment and socio-economic indicators found in later chapters with the discussion of governance indicators.

The governance performance indicators presented in this handbook measure progress towards the achievement of ICOM governance goals and objectives in four main areas (Figure 4-1):

a) *Institutional coordination and coherence* addresses the need to ensure that (i) the functions of administrative actors are properly defined, including through the establishment of a coordinating mechanism; (ii) a legal framework exists to support ICOM and the pursuance of coherent objectives; (iii) the impacts of sectoral plans, programs and projects potentially affecting coastal zones are taken into account through procedures for environmental impact assessment (EIA), strategic environmental assessment (SEA), and carrying capacity assessment (CCA); and (iv) conflict resolution mechanisms are available to anticipate, resolve, or mitigate conflicts over the use of coastal space and resources.

b) *Quality and effectiveness of management* may be measured through (i) the formal adoption of integrated management plans; (ii) active management and implementation in the coastal zones falling under integrated management plans; (iii) routine monitoring and evaluation of management and its outputs, outcomes, and impacts and the consideration of results into management; and (iv) the sustained availability of human, financial, and technical resources to enable effective management.

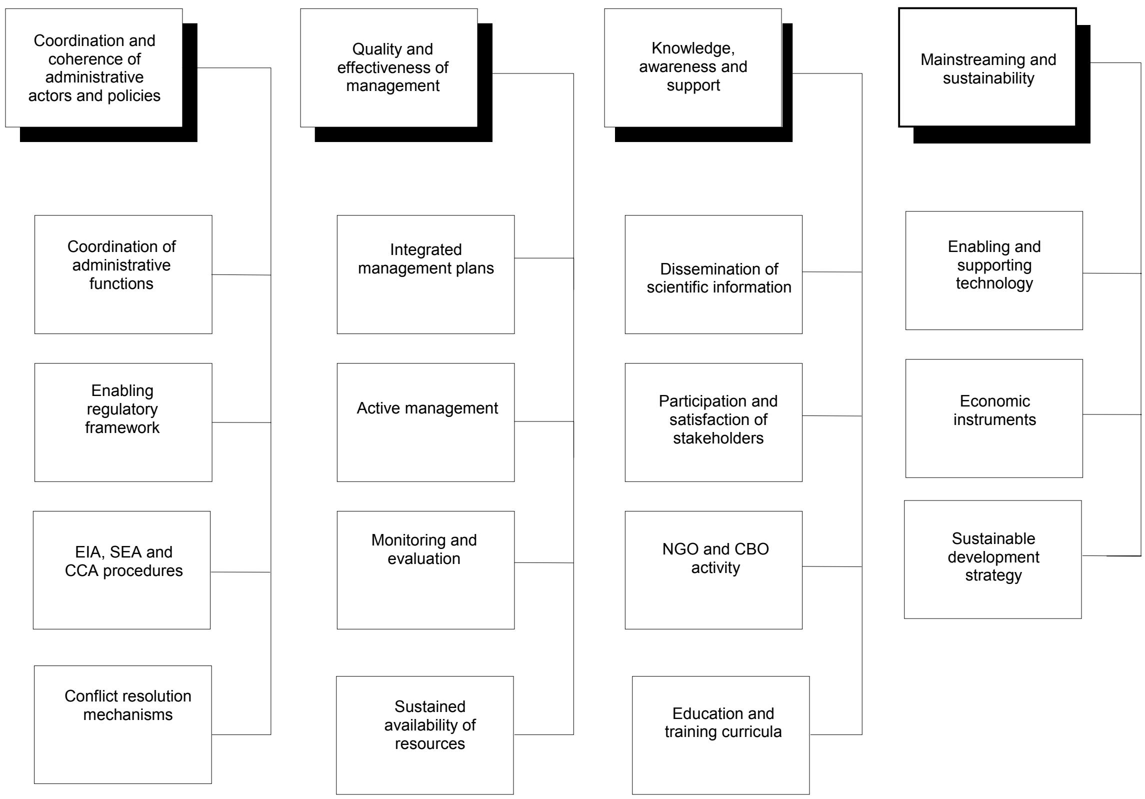

Figure 4-1 Hierarchy of governance objectives

c) *Improved knowledge, awareness and support* is ensured by (i) the production of results from scientific research, its use for management, and its dissemination to a wider audience; (ii) the participation of stakeholders into decision-making processes; (iii) the activities of nongovernmental organizations (NGOs) and community-based organizations (CBOs); and (iv) the introduction of ICOM-related subjects into educational and training curricula for the formation of ICOM cadres.

d) *Mainstreaming ICOM into sustainable development* will entail (i) the development and application of technologies that can enable and support ICOM; (ii) the use of economic instruments to promote ICOM objectives through the private sector; and (iii) the strategic incorporation of ICOM objectives into broader sustainable development strategies.

Other governance performance indicators may be developed for specific priority areas, such as:

- Beach stabilization
- Marine and coastal protected areas
- Marine and coastal biodiversity
- Land-based pollution
- Marine pollution
- Fisheries
- Tourism
- Water management
- Climate change and sea level rise
- Management of small islands

For each of the high-level goals and objectives presented in Figure 4-1 indicators and related measures can be identified to measure progress toward achieving them. In some cases, certain indicators are related to more than one objective, thus providing additional means of verification of the progress.

The following section provides a menu of 34 indicators, 15 of which are considered key indicators and are fully developed (Table 4-3). Other indicators are considered potential indicators for which additional efforts are required to be included in the key list (see IOC 2003). In general, those indicators may not be significant in any context, overlap with other indicators or imply significant technical and financial resources to be measured.

Table 4-3 Detailed list of governance performance indicators

Goal	*Objective*	*Indicator and parameters*
Ensuring adequate institutional, policy and legal arrangements	*Ensuring the coordination and coherence of administrative actors and policies*	Definition of functions of administrative actors – ICOM functions of administrative actors clearly defined by legislation or administrative acts – New agencies for ICOM established – Primary responsibility for ICOM mandated to a single agency
		Policy goals and objectives and strategies for ICOM – Policy goals and quantifiable objectives for ICOM formally adopted – Strategies and procedures for the implementation of the ICOM objectives developed and formally adopted, including incorporation of ICOM principles into sectoral instruments
		G.1 Existence and functioning of a representative coordinating mechanism for ICOM – Existence of a coordinating mechanism – Functioning of the coordinating mechanism – Outcomes and influence of the coordinating mechanism

Goal	Objective	Indicator and parameters
	Supporting integrated management through adequate legislation and regulations	**G.2 Existence and adequacy of legislation enabling ICOM** – Existence of legislation on coastal and marine resources – Adequacy of the ICOM legislation
	Assessing the environmental impacts of policies, plans, programs, and projects	**G.3 EIA, SEA and CCA procedures** – Use of EIA and SEA procedures and modifications to coastal projects – Use of CCA procedures in coastal tourism development
	Resolving conflicts over coastal space and resources	**G.4 Existence and functionality of a conflict resolution mechanism** – Stakeholders and issues at stake – Agreed procedures and mechanisms for conflicts resolution – Changes in the proportion of conflicts that are mitigated, resolved, or prevented – Overall changes in the number of conflicts
Ensuring adequate management processes and implementation	*Managing the coastline through integrated plans*	**G.5 Existence, status, and coverage of ICOM plans** – Existence and status of ICOM plans – Characteristics of ICOM plans – Extent (percentage) of coastline covered by ICOM plans
	Managing coastal watersheds through integrated plans	Existence, status, and coverage of watershed plans – Existence and status of watershed plans – Characteristics of watershed plans – Extent (percentage) of watershed area covered by ICOM plans
	Conserving coastal and marine biodiversity through management plans	Existence, status, and coverage of management plans for coastal and marine ecosystems – Existence and status of coastal/marine ecosystem-based management plans – Characteristics of ecosystem-based management plans – Extent (percentage) of coastal/marine ecosystems covered by management plans
	Implementing and enforcing ICOM plans and actions	**G.6 Clearly defined, understood, and respected enforcement procedures for ICOM** – Level of implementation of ICOM plans, actions and projects, including infrastructure building – Procedures, legal tools, and monitoring and sanctioning applied for enforcement of ICOM plans/actions – Level of enforcement of, or compliance with, ICOM plans

Goal	Objective	Indicator and parameters
	Routinely monitoring, evaluating and adjusting ICOM efforts	**G.7 Routine monitoring, evaluation and adjustment of ICOM initiatives** – Existence of an operational monitoring and evaluation system with related indicators – Consideration of results into ICOM initiatives – Adjustments made to ICOM initiatives
	Supporting ICOM through sustained administrative resources	**G.8 Sustained availability and allocation of human, technical, and financial resources for ICOM, including the leverage of additional resources** – Staff – Budget – Facilities
Enhancing information, knowledge, awareness, and participation	*Ensuring that management decisions are better informed from science*	**G.9 Existence, dissemination, and application of ICOM-related scientific research and information** – Existence of research studies and scientific publications – Completion of a diagnostic assessment that identifies root causes of coastal degradation and establishes priority for interventions – Existence and dissemination of a state of the coast report – Existence and functioning of a science advisory body – Existence and operation of routine monitoring of the marine environment – Inputs from scientific research and diagnostic assessment into ICOM
	Improving awareness on coastal issues	Dissemination of information on coastal issues to the public – Section on the coastal and marine environment in a regularly published state of the environment report or separate state of the coast report – Media events covering coastal issues held
	Ensuring sustained support from engaged stakeholders	**G.10 Level of stakeholder participation in, and satisfaction with, ICOM decision-making processes** – Level of stakeholder participation – Level of stakeholder satisfaction with participation and with ICOM outcomes
	Supporting ICOM through partnerships	Establishment of partnerships and steering groups – Number of functional public-private partnerships created – Number of ICOM-related projects initiated as a result of partnerships
	Ensuring NGO and community involvement	**G.11 Existence and activity level of NGO and community organizations supportive of ICOM** – Existence and characteristics of NGOs and community organizations active in ICOM – Level of activity of NGOs and community organizations active in ICOM

Goal	Objective	Indicator and parameters
	Ensuring adequate levels of higher education and professional preparation for ICOM	**G.12 Incorporation of ICOM into educational and training curricula** – Educational and training programs incorporating ICOM – People having completed educational and training programs in ICOM – Employment of people with education and training in ICOM
Mainstreaming ICOM into sustainable development Economic instruments Mainstreaming	*Enabling and supporting ICOM through technology, including environmentally friendly technology*	**G.13 Use of technology, including environmentally friendly technology, to enable and support ICOM** – Availability of ICOM-enabling and supporting technology at an acceptable cost – Level of use of ICOM-enabling and supporting technology in substitution of counter-ICZM technology – Level of coordination of ICZM-enabling and supporting technology
	Incorporating economic instruments into coastal management policies	**G.14 Use of economic instruments in support to ICOM** – Availability of economic instruments, including environmental quality certifications, in conjunction with regulatory instruments – Level of implementation and enforcement of economic instruments
	Mainstreaming coastal and ocean management into sustainable development	**G.15 Incorporation of ICOM into sustainable development strategy** – Existence of sustainable development strategy or Agenda 21 incorporating ICOM chapter – Level of implementation of ICOM chapter of sustainable development strategy or Agenda 21
Enhancing the international dimension of ICOM	*Enhancing ICOM by implementing international recommendations and guidance*	International recommendations and guidelines on ICOM influencing the ICOM process – Awareness of international recommendations and guidelines on ICOM – ICOM decisions influenced by international recommendations and guidelines
	Enhancing ICOM through involvement in international cooperative initiatives	Participation in international efforts related to ICOM and influence on the ICOM process – Active participation in international agreements and cooperative efforts in ICOM such as transboundary or multinational projects – Influence of such involvement on the ICOM process
	Enabling ICOM through implementation of international agreements	Ratification and implementing legislation for international agreements relevant to ICOM – Ratio between agreements ratified and legislated for

As for other types of indicators, the identification and selection of governance performance indicators should be undertaken in collaboration with key stakeholders, thus facilitating the definition of a shared vision for the coastal area, the main goals and objectives, and the steps to achieve it. In this perspective, governance performance indicators are linked to environmental and socioeconomic indicators to the extent they measure activities, outputs, and immediate or short-term outcomes directly connected to the achievement of environmental and socioeconomic benefits.

The problem of attribution of changes in the environmental and socioeconomic conditions of coastal areas is similar to other sectors of public policy interventions but complicated by the multisectoral nature of ICOM and the contribution of multiple policies to single issues (e.g., water quality). Therefore, it is often difficult to isolate the specific contribution of ICOM efforts to environmental and socioeconomic goals. Performance measurements taken at regular intervals for specific issues or dimensions may help clarify the outcomes and impacts of government interventions. The analysis of the *contribution* (Mayne 1999) of ICOM programs to environmental and socioeconomic outcomes may help in this sense. The contribution analysis relies primarily on:

- Exploring the ICOM program logic
- Identifying and documenting behavioral changes as a direct result of the program
- Using "discriminating" indicators, that is indicators that focus on the specific outcomes of the program
- Tracking performance over time
- Exploring alternative explanations for the achieved or non-achieved outcomes
- Collecting additional evidence

The selection of governance performance indicators should be based on a number of criteria:

a) Relevance to the policy and management needs
b) Analytical soundness
c) Easiness to understand and communicate
d) Responsiveness to institutional development and changes
e) Monitoring cost-effectiveness
f) Suitable to be aggregated at the national level
g) Contribution to monitoring of progress towards implementing international and regional commitments
h) Contribution to reporting obligations under international and regional agreements

The selected indicators should satisfy as many criteria as possible: poorly defined indicators may hinder a proper assessment of progress in ICOM. Excessively long lists of indicators for which no data sources are readily available would make their measurement costly or impractical. Yet, indicators chosen solely based on available data without considering optimal indicators may not be completely useful for a thorough assessment of progress in ICOM. The selection of indicators should be

The cost of governance performance indicators may range from low to high depending on the number of indicators, the frequency of measurement and the quality of the monitoring and evaluation system. The identification, selection, development, application, and monitoring of governance performance indicators may be done in an incremental way: starting with available data, identifying information needs, and progressively expanding the indicator system-thematically, temporally, and geographically. To this end, different levels of analysis and detail may be used, distinguishing between core indicators, complementary indicators, and detail indicators (see below, *Levels of analysis*).

Spatial and temporal scales

With few exceptions, the governance performance indicators are generally significant at all spatial scales—national, subnational, local—depending on the initiative under examination. In the best case, the measurement of governance performance indicators should be done at the same scale of the phenomena of interest for the environmental and socioeconomic dimensions. In practice, governance performance indicators should be measured at the scale at which ecosystems are managed and, where possible, coherently with the natural boundaries of the ecosystem.

The choice of the temporal scale at which to measure each indicator may depend on individual monitoring and evaluation systems. In this regard, it may be important to organize the monitoring of the indicators according to the phases of the ICOM policy cycle (see below, *Levels of analysis*). In general, an attempt should be made to measure more frequently those variables subject to more rapid changes and less frequently those variables that change less rapidly. In order to explore the interrelationships between changes in governance performance measures and changes in the environmental and socioeconomic variables, the use of conceptual frameworks may be useful, exploring causal theories that link program or project assumptions with key management activities, and resulting intermediate and end outcomes.

Levels of analysis

Governance performance indicators can be measured with different levels of detail (Figure 4-2). A *first level* can provide a *summary* of the main issues involved with governance performance. At this first level, often suitable for reporting at the national level, the indicators may largely consist in "checklists" to be answered in a binary or semi-quantitative way, for example:

	2005	2010
A mechanism for inter-institutional coordination is in operation	Yes/No	Yes/No

Or also:

	Current status	Target 2010	Target 2015
Coastline covered by integrated management plans (km or percentage)			
Under development			
In place			

A *second level* may focus on the *analysis* of the measures provided by the indicator, providing a qualitative assessment, for example:

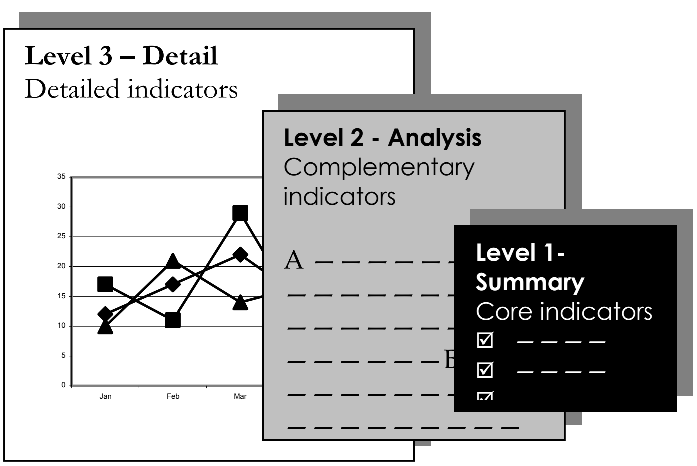

Figure 4-2 Levels of Analysis

a) Level of representativity, functionality, effectiveness and sustainability of the coordinating body on coastal affairs (*Are all the relevant agencies and stakeholders involved? Does the coordinating body meet and deliver recommendations? Are the recommendations of the coordinating body influential on coastal-related policies? Are relevant institutions supportive of the activities of the coordinating body?*)

b) Quality and implementation of integrated management plans (*What is the completeness and quality of the integrated management plan? Is the plan being implemented? Are the provisions of the plan enforced? Are stakeholders compliant with the plan?*)

A *third level* may be concerned with the provision of additional *details*, the measurement of *medium- and long-term changes* in the institutional setting and the measurement of *outcomes and impacts* on the environmental and socioeconomic dimensions, for example:

a) Institutional development and coherence (*Has the coordinating body influenced other sectoral policies affecting the coastal area? How has the coordinating body contributed to ensuring coherence of those policies? How has the coordinating body contributed to advancements in the ICOM policy cycle?*)

b) Effectiveness of integrated management plans (*are integrated management plan s for the coast achieving their objectives? Are there visible and scientifically demonstrated signs of improvement in environmental quality?*)

4.3 Detailed description of governance performance indicators

G.1 Institutional coordination

Nature of indicator

Definition
The existence and functioning of a representative coordinating or management body that involves key government agencies involved in ICOM.

Unit of measurement
Qualitative assessment of five dimensions:
(a) Is there a coordinating body for ICOM and with which mandate?
(b) Is the coordinating body representative and to what extent?
(c) Is the coordinating body functional and to what extent?
(d) Is the coordinating body effective and to what extent?
(e) Is the coordinating body sustainable and to what extent?

Relevance

Purpose
The existence and functioning of a coordinating body for ICOM reflects the interest, at all levels, of ensuring the coordination of different actors having an influence on coastal and marine resources as well as the representation of the interests of relevant stakeholders. A representative and fully functional coordinating body is an essential feature of ICOM. A high-level policy planning body may be charged with the preparation of ICOM management policies, plans, and programs.

International conventions, agreements, and targets
Agenda 21 (paragraph 17.6) recommended the establishment of coordinating mechanisms (such as a high-level policy planning body) for integrated management and sustainable development of coastal and marine areas and their resources, at both the local and national levels. The Plan of Implementation of the World Summit on Sustainable Development (paragraph 30[e]) further recommended coastal States to develop mechanisms on integrated coastal management. There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
A coordinating body for ICOM may be characterized by the following features:
- Involves a high political level
- Is representative of different interests, both governmental and sectoral
- Has a defined mandate and authority
- Addresses in a comprehensive way the integrated management and sustainable development of coastal and marine areas and their resources
- Involves consultation with different administrative levels and the most relevant segments of stakeholders
- Operates in a transparent way and its accountable for its decisions
- Ensures regular and transparent communication and information exchange
- Is influential on policies and programs affecting coastal and marine resources
- Results in operational decisions concerning the sustainable development of coastal and marine resources

Measurement approaches
There are two levels of measurement: One level refers to the existence of a coordinating body for ICOM, the other level refers to the degree of representation, functionality, effectiveness, and sustainability of such a body.

The existence of a coordinating body for ICOM can be monitored by examining the official documents (legislation and/or management plan) establishing the ICOM program or project and the related organizational chart. The legal and formal mandate and authority can be understood from statutes, plans, or other documents. The same document would allow identifying the parties represented within the body. The frequency of meetings, their attendance, and the resulting decisions can be monitored by examining official meeting records. The influence of the formal acts of the coordinating body – recommendations or decisions – on sectoral policies and their coordination could be measured indirectly through other indicators (institutional, environmental, or socioeconomic indicators), provided that adequate time series of data on outcomes are available. The sustainability of the coordinating body can be assessed by examining its activities over time. In most cases, the measurement will involve the examination of documents and interviews with key informants.

Limitations of the indicator
There are no agreed international definitions or standards regarding what constitutes a coordinating body for ICOM except in general terms as set out in *Agenda 21* and follow-up agreements. The indicator has a largely qualitative character and further work is required to develop criteria to assess its representativeness, functionality, effectiveness, accountability, and sustainability.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

Alternative definitions
Agenda 21 and the *Plan of Implementation of the World Summit on Sustainable Development* refer to coordination mechanisms rather than coordinating bodies. Such coordinating mechanisms can take the form of high-level policy planning bodies, councils for strategic planning and management, or interagency commissions with advisory role, and can be permanent or temporary. They can also be a combination of forms. There is ample variety in the forms and functions of coordinating bodies and mechanisms that reflects the specificities of political and administrative systems and types of interventions.

Assessment of data

Data needed to compile the indicator
ICOM plan, document of incorporation of a coordinating mechanism for ICOM, composition of the coordinating body, dates and locations of meetings of the coordinating body, records of meetings.

Data sources and collection methods
The data will be available in government records. To document review, interviews and surveys may be added to gain further insights.

Analysis and interpretation of data
Description and qualitative assessment of the mandate and composition of the coordinating body, its operation, influence on sectoral policies, accountability, and sustainability.

Reporting scale and output
The indicator may be monitored at all scales. The outputs may consist in a list and a narrative description of the coordinating body as above. When measured on a subnational level, a map may be added showing the subnational administrative units where institutional coordination is occurring.

Additional information

Organizations and programs involved in the development of the indicator
The United Nations Department of Social and Economic Affairs, Division for Sustainable Development is the UN agency most involved in the coordination of ocean and coastal issues.

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G.2 Enabling legislation

Nature of indicator

Definition
The existence and adequacy of legislation for ICOM.

Unit of measurement
The existence and adequacy of legislation enabling the implementation of ICOM goals, objectives, activities, and interventions. There are several dimensions to measure:

Generic provisions:
- Existence of specific law(s) dealing with coastal and ocean areas
- Legal endorsement of sustainable development and ICOM-related principles
- Definition of coastal zone
- Demarcation of coastal zone
- Definition of the functions of the administrative actors dealing with coastal zones, including the role of a lead agency
- Institutional cooperation and coordination
- Information on coastal zones

More detailed provisions:
- Land ownership
- Beach access
- Coastal land use planning
- Control of industrial and commercial activities on the coast
- Control of recreational activities
- Protection of areas of ecological and natural value
- Pollution
- Coastal erosion and soil protection
- Coastal hazards
- Public information and participation
- Monitoring and sanctions
- Awareness and understanding of legislative controls
- Effectiveness of regulatory system

The indicator may be measured at the national, regional, and local scale, taking into account the authority and functions of the different administrative levels.

Relevance

Purpose
The existence and adequacy of legislation is significant to describe the extent to which the goals and objectives of ICOM are supported by a clear and enforceable legal basis and the extent to which this enables the implementation of ICOM activities and interventions. ICOM legislation defines what is required, permitted and forbidden by stakeholders and administrative actors in the coastal zone. Awareness and understanding of ICOM legislation by stakeholders increases the chance of compliance with it and therefore the achievement of ICOM goals and objectives.

International conventions, agreements, and targets
While not specifically recommended by international agreements, the existence and adequacy of legal frameworks for ICOM underlies the implementation of all international conventions and agreements dealing with the subject. There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
Legislation for ICOM may be characterized by the following features:
- Incorporates sustainable development principles and principles specific to oceans and coasts
- Supports ICOM goals and objectives
- Sets our processes for institutional cooperation and coordination
- Lays out ICOM management activities and interventions

Measurement approaches
Determine the existence of legislation on coastal and marine areas; this can be a law specific to coastal and marine areas or general texts whose provisions are applicable to coastal and marine areas. Determine whether the legislation — specific or not — incorporates sustainable development principles, provides a legal definition of coastal and marine areas and elements for the demarcation of coastal and marine areas at the local level and whether this definition is adequate to pursue ICOM. Determine whether the legislation clarifies the authority and functions of administrative actors in coastal and marine areas, includes provisions on land ownership, permitted and prohibited activities in the coastal zone, and protection of natural heritage. Determine whether the legislation provides for public

information and participation, monitoring of the conditions of the coastal zones, including through the use of indicators, and monitoring of its applications and sanctioning for incompliance. Determine whether the provisions of the legislation are understood and followed by the stakeholders.

Limitations of the indicator
The content of legislation for ICOM can significantly vary among countries and also within countries when subnational authorities have authority over the coastal zone. Provisions of the legislation can be of a general or more detailed character, thus adding to the variety of instruments. Even in the absence of specific legislation for ICOM, general or sectoral legislation can support ICOM goals and objectives. However, the existence of legislation for ICOM does not necessarily imply effective implementation and compliance. The indicator might not be suitable to express meaningful trends and is open to subjective interpretation.

Status of the methodology
There is no internationally agreed methodology for measuring the indicator.

Alternative definitions/indicators
While certain countries have adopted a statutory approach to ICOM, others rely on a non-statutory approach. Few countries have developed framework or organic legislation for ICOM or coastal codes. Often legislation applicable to the coastal zones is embodied in general texts dealing with the environment, protected areas and nature conservation, water, or town and country planning. In addition, texts specific to the coastal zones actually address its marine component, as in the case of legislation on the public maritime domain, fishing, coastal defenses, ports and navigation, offshore oil and gas, and maritime jurisdictions.

Assessment of data

Data needed to compile the indicator
Legal documents or pertinent laws at different levels.

Data sources and collection methods
The data will be available in government records. To document review, interviews and surveys may be added to gain further insights.

Analysis and interpretation of results
A narrative report focusing on the coverage of ICOM goals and objectives by legislation, the degree of consistency of general and sectoral legislation, the clarification of the functions of administrative actors, the degree of support to ICOM activities and interventions, the degree of compliance. The output may consist in a report on the existing legislation on ICOM and its adequacy.

Reporting scale and output
The indicator may be monitored at all scales. The output may consist in a report on the existing legislation on ICOM and its adequacy. When measured on a subnational level, a map may be added showing the subnational administrative units legislation is enabling or hindering ICOM.

Additional information

Organizations and programs involved in the development of the indicator
- OECD
- PAP/RAC (Mediterranean)

References

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G.3 Environmental assessment

Nature of indicator

Definition
The mandatory assessment of the potential effects on coastal and marine environment of sectoral policies, plans, programs and projects occurring in the coastal area and adjacent watersheds and offshore areas.

Unit of measurement
Qualitative and quantitative assessment of the following dimensions:
(a) Existence of statutory procedures for environmental impact assessment (EIA) for projects relevant to coastal and marine areas
(b) Existence of statutory procedures for strategic environmental assessment (SEA) for policies, plans and programs relevant to coastal and marine areas
(c) Existence and procedures for carrying capacity assessment (CCA)
(d) Application of EIA procedures
(e) Application of SEA procedures
(f) Application of CCA procedures
(g) The level to which EIA, SEA, and CCA procedures enable and support ICOM efforts

Relevance

Purpose
The objective of the indicators is to measure to whether the ICOM process is enabled and supported by a process of environmental assessment carried out both at the strategic level of sectoral plans and programs and at the level of individual projects, including for cumulative impacts, and its effectiveness in supporting sustainable development goals. This process is also particularly relevant to ICOM in that is based on public consultations and promotes participation and transparency of decision making.

International conventions, agreements, and targets
Prior assessment and systematic observation of major projects is recommended by *Agenda 21* as an application of preventive and precautionary approaches (paragraph 17.5[d]). The identification and assessment of problems (paragraph 21) as well as the establishment of priorities, including the application of EIA procedures (paragraph 22) are an important component for the implementation of the *GPA*. The use of EIA procedures is also recommended by the *Barbados Programme of Action* to improve management of land resources (paragraph 34.A[vii]). In the context of building capacity in marine science, information and management, the WSSD Plan of Implementation promotes the use of environmental impact assessments and environmental evaluation and reporting techniques (paragraph 36[c]). The *Aarhus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters* also recommends the use of EIA procedures and public consultations for them.

Methodological description

Underlying definitions and concepts
EIA can be defined as the prior assessment of public and private projects likely to have significant effects on the environment—encompassing human beings, fauna, flora, soil, water, air, climate, landscape, material heritage, cultural heritage, and the interactions among them. EIA may be applied to a variety of projects having a potential influence on the coastal and marine environment, including, for example:, thermal power stations, oil refineries, trading ports, harbors, wastewater treatment plants, extraction of oil and natural gas, dams, oil and gas pipelines, fish farming, reclamation of land from the sea, shipyards, coastal defenses, and marinas. EIA procedures provide for environmental consequences of projects are identified and assessed before authorization is given, the public can give its opinion and this is taken into account in the decision making, and final decisions are made public.

In the case of SEA, environmental assessment applies to plans and programs, and even policies. These may be in the sectors of agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use. SEA enables a more strategic and long-term planning than EIA and promotes further the involvement of the public in the decision-making process and the incorporation of environmental consideration into development actions. SEA can provide a framework for the coordination of sectoral policies, thus enabling ICOM integrated approach.

Carrying capacity assessment or analysis is a tool that is typically been used in relation to the planning process for tourism development in coastal or island areas as well as protected areas to set capacity limits for sustaining tourism in a place through the measurement of tourism density, the use of beaches and tourist infrastructure, congestion of facilities and transportation infrastructure, demand and impact on water and energy resources, sea pollution, etc.

Measurement approaches
The measurement of this indicator may be based on the following dimensions, which are similar for EIA and SEA:
(a) The existence of legally established procedures for EIA or SEA and the types of interventions subject to environmental impact review
(b) The interventions relevant to the coastal and marine environment actually subjected to review, the level of public consultation involved, and the final decision made
(c) The interventions required to undertake modifications and the monitoring of the follow-up
(d) The estimated environmental and socioeconomic benefits achieved through the modifications or canceling of the interventions following the environmental review
(e) The impact on the coordination of sectoral policies

In the case of CCA, a similar approach may be adopted, focusing on the modifications induced in the tourism development initiative following the application of the CCA and the on the estimate of the environmental and socioeconomic benefits.

Limitations of the indicator
The indicator is of a broad nature and involves a number of dimensions that need to be assessed in a qualitative and quantitative way. While in the presence of adequate documentation it is relatively easy to ascertain which interventions have been subjected to environmental review, the quantification of the environmental and socioeconomic benefits accrued to the coastal and marine areas under examination might require a significant effort.

Status of the methodology
Methodologies for EIA, SEA and CCA are well developed and might be adapted to the specific contexts of coastal and marine areas.

Alternative definitions
N/A

Assessment of data

Data needed to compile the indicator
Legislation and regulations, environmental impact assessment studies opinions of competent authorities

Data sources and collection methods
The data will be available primarily at government competent authorities for EIA and SEA. They can be collected through document review, databases, interviews and surveys.

Analysis and interpretation of results
The analysis of the data should focus on the environmental, socioeconomic, and governance outcomes of the EIA, SEA, and CCA processes.

Reporting scale and output
The indicator may be best monitored at the subnational scale and data showed in tables and a map showing the location of the interventions.

Additional information

Organizations and programs involved in the development of the indicator
Both the EC and the World Bank are currently involved in the development of methodologies for SEA.

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G.4 Conflict resolution

Nature of indicator

Definition
The existence and functioning of a mechanism for the resolution of conflicts in the coastal zone.

Unit of measurement
Qualitative and quantitative assessment of the following dimensions:
(a) Stakeholders and issues at stake involved in conflicts, nature and intensity of conflicts
(b) Existence of agreed procedures and mechanisms for the resolution of conflicts over coastal resources
(c) Changes in the proportion of conflicts that are successful mitigated, resolved, or prevented
(d) Overall changes in the number of conflicts over coastal resources

Relevance

Purpose
The existence and functioning of procedures and mechanisms for the resolution of conflicts over coastal resources and the actual reduction of conflicts — be they prevented, mitigated, or resolved — reflects the ability of ICOM or an ICOM initiative to strike a satisfactory balance between competing interests in the coastal zone at all levels: coordination of different administrative actors, social conflicts, economic conflicts. By its nature, the coastal area is an area of conflicts due to limited availability of resources and competing interests over such scarce space and resources. One of the roles of ICOM is to provide a framework to reconcile such competing interests and conflicts at all levels — institutional, social, economic — and all spatial scales — local, regional, national. Therefore, the indicator is highly relevant to ICOM and coastal sustainable development.

International conventions, agreements, and targets
Attention to user conflicts has been called for by *Agenda 21*, in relation to coordinating mechanisms for integrated management and sustainable development of coastal and marine areas and their resources (paragraph 17.6[c]) and the *Code of Conduct for Responsible Fishing* (article 10.1.4). There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
A mechanism for conflict resolution may be characterized by the following features:
(a) Provides for dispute resolution procedures alternative to litigation
(b) Ensures representation of all interests
(c) Ensures the enforceability of the agreement reached
(d) Limits power imbalances between parties
(e) Provides for funding mechanisms for conflict resolution as part of an ICOM initiative
(f) Gives consideration to the involvement of third parties

Conflict resolution may be ensured also through procedures for negotiated rule making, incentive, and compensation. The perception of a successful resolution of a conflict may vary depending on the party, however, as in general terms a criterion to consider is that the parties accept that the solution has been achieved according to agreed rules.

Measurement approaches
There are three levels of measurement: the first level refers to the stakeholders involved in conflicts and the issues at stake; the second level refers to the existence and characteristics of a coordinating mechanism for ICOM; the third level refers to the number and types of conflicts over coastal resources and their changes.

First, it is necessary to identify which conflicts exist over the use of coastal resources, which stakeholders are involved in conflicts, and what are the issues at stake. Then it is necessary to understand the characteristics of the conflicts: their geographical and temporal scale, the intensity, whether the conflicts have been resolved and by whom and with which outcome and degree of agreement. Second, it is necessary to determine which procedure or mechanism for the resolution of conflicts over coastal resources exists and its characteristics.

Third, it is necessary to assess the proportion of conflicts which are successfully resolved, or mitigated or prevented, through the use of such mechanism and the changes in the overall number of conflicts over coastal resources.

Limitations of the indicator
The change in the number of conflicts that are successfully resolved and the reduction in the number of conflicts over coastal and marine resources reflect in general terms the ability of an ICOM initiative although the perception of a successful resolution may vary according to the parties' views.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

Alternative definitions
N/A

Assessment of data

Data needed to compile the indicator
Project and government agency records, community management records, records from conflict resolution meetings, results from interviews, results from participatory rural assessments.

Data sources and collection methods
Government agencies, stakeholders. Review of records and documents, interviews, participatory rural assessments.

Analysis and interpretation of results
Assessment of individual conflicts can be done through the use of matrices of conflicts showing issues at stake, stakeholders involved, time period, scale, intensity, whether conflicts are ongoing/managed/resolved, and how they are managed/resolved. The functioning of the mechanism for conflict resolution can be assessed based on the criteria presented above. Changes in the level of conflicts can be analyzed by stakeholder and issue at stake, assessing whether certain types of conflicts are less tractable than other.

Reporting scale and output
The indicator needs to be monitored at the level of individual coastal areas and ICOM initiatives. The output may consist in a narrative report with analysis matrices and maps.

Additional information

Organizations and programs involved in the development of the indicator
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References

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Internet links
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G.5 Management plans

Nature of indicator

Definition
The existence and adoption of plan for ICOM that details goals and objectives to be achieved, the institutional arrangements entailed, the management measures to be undertaken, and the legislative and financial support for implementation.

Unit of measurement
Qualitative assessment of the following dimensions:
(a) Existence of the plan
(b) Status of the plan
(c) Completeness of the plan
(d) Enforceability of the plan

The indicator may be measured at all scales.

Relevance

Purpose
The existence and adoption [and implementation?] of an ICOM plan reflects the commitment of the relevant agency or agencies to manage coastal and marine areas in an integrated, cross-sectoral, and multidisciplinary way. The ICOM plan sets out the strategic directions, goals, and objectives for the coastal zone covered by the plan, details the institutional structure, the measures and activities, and the legislative and financial means for the achievement of such goals and objectives.

International conventions, agreements, and standards
Agenda 21 calls for coordinating mechanisms and high-level policy planning bodies for the implementation of integrated coastal and marine management and sustainable development plans and programmes at appropriate levels as well as a number of other measures (paragraph 17.6). The *Plan of Implementation of the WSSD* has further called for the promotion of integrated, multidisciplinary and multisectoral coastal and ocean management at the national level (paragraph 30[e]) as well as for the assistance to developing countries for the implementation of integrated coastal area management plans as a tool for the conservation and sustainable management of fishery resources (paragraph 30[g]). The development of national strategies and actions plans for coastal zone management or related sectors has also been called for by the *Barbados Programme of Action for the Sustainable Development of Small Island States* (paragraph 26[a][1]), the *Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities* (paragraph 19), and the *Code of Conduct for Responsible Fishing* (articles 7.3.3 and 9.1.3). There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
An ICOM plan may be characterized by the following features:
- Outlines a vision and the strategic directions for the coastal zone subject to the plan
- Incorporates sustainable development principles and principles related to the special nature of oceans and coasts
- Defines goals and objectives
- Defines specific activities to achieve the goals and objectives
- Details a management strategy and administration
- Includes provisions for surveillance and enforcement
- Includes provisions on monitoring, evaluation and adjustment
- …

Measurement approaches
Qualitative assessment of two main aspects: (a) the existence and status of the plan and (b) the completeness and enforceability of the plan. First, the existence of the plan in a printed form should be ascertained and its status — formulation, approval, adoption and signatories, level of implementation, and review and update — assessed. Second, the plan should be examined in relation to its content (underlying principles, scope, area of application, goals and objectives, management strategy, administrative structure, surveillance and enforcement, monitoring and evaluation, etc.). Third, the enforceability of

the plan should be assessed by examining the legal and administrative basis of the management measures.

Limitations of the indicator
There are no internationally agreed definitions or standards for ICOM plans and for the measures that an ICOM plan may entail. The indicator is of a qualitative nature and interpretation of its adequacy may be open to subjective interpretation. Criteria need also to be developed concerning the effectiveness of an ICOM plan.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

Alternative definitions
In some cases, goals and objectives may have been expressed informally, and yet agreed upon, by interested parties or be embodied in environmental or sectoral development plans. Integrated coastal and ocean management may be part of strategies and plans encompassing a larger geographical area, such as a watershed or including the entire national or regional/provincial territory.

Assessment of data

Data needed to compile the indicator
ICOM management plan.

Data sources and collection methods
Document review of the official gazette and government records, accompanied by interviews with key informants.

Analysis and interpretation of results
Description and qualitative assessment of the existence, status, contents, and enforceability of the ICOM plan.

Reporting scale and output
The indicator may be reported at all scales through a narrative report and maps.

Additional information

Organizations and programs involved in the development of the indicator
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References
Bower, B., Ehler, CV, & Basta, D. *A Framework for Planning for Integrated Coastal Zone Management*. Silver Spring, Maryland: NOAA, 1994.
Clark, J.R. *Coastal Zone Management Handbook.* Boca Raton, Florida: Lewis Publishers, 1995.
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G.6 Implementation of plans

Nature of indicator

Definition
The level of implementation, compliance with, and enforcement of ICOM plans and related activities.

Unit of measurement
Qualitative and quantitative measures of:
- Level of implementation of ICOM plans and related activities
- Use of procedures and legal tools for the implementation and enforcement of ICOM plans and activities
- Level of enforcement of ICOM plans and activities
- Level of compliance with ICOM-related provisions

Relevance

Purpose
The level of implementation, compliance with, and enforcement of ICOM plans and activities reflects the reality of the execution and performance of ICOM initiatives, as well as the degree of acceptance on the part of the users subject to the plan. The implementation, compliance with, and enforcement of ICOM strategies and plans for the integrated development and use of land and sea space and their mandatory character for national and / or local authorities, as well as private individuals, concerning conditions for land use and other activities and projects is the direct and practical translation of the ICOM vision, principles, goals, and objectives and represent an essential contribution to the sustainable development of coastal and marine areas.

International conventions, agreements, and targets
For references to international conventions and agreements see indicator 3.3, ICOM Plan. There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
The implementation of ICOM strategies, plans, programs, and activities, as well as their enforcement and compliance with, may be characterized by the following features:
- Performance of the ICOM strategies, plans, programs, and activities in relation to the relevance to the stated objectives
- Implementation of policy measures (e.g., planning, institutional strengthening, regulatory and economic instruments, or environmental education)
- Monitoring of compliance with ICOM provisions
- Compliance with ICOM provisions
- Existence and use of enforcement procedures

Measurement approaches
Qualitative and quantitative assessment of several dimensions:
(a) The relevance of the ICOM initiative to the needs it addresses and objectives it pursues
(b) The level, quantity, and quality of implementation and related outputs and activities of the ICOM initiative and progress towards the realization of outcomes and activities
(c) The effectiveness of the implementation in terms of the timeliness and cost-effectiveness of the intervention
(d) The efficiency of implementation in terms of availability of funds and human resources, managerial and work efficiency, and implementation difficulties
(e) The degree of intergovernmental and intersectoral integration achieved by the initiative
(f) The degree of compliance of the users with the initiative
(g) The measures put in place to enforce the initiative
(h) The prospect for sustainability of the initiative

The methodologies available for measuring this indicator and its dimensions generally fall within the scope of performance evaluation.

Limitations of the indicators
To be fully useful the indicator has to be linked to the environmental and socioeconomic indicators for an assessment of outcomes and impacts. This entails the combination of

performance evaluation methodologies with a robust series of baseline data on the phenomena the ICOM initiative intends to address.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

Alternative definitions
Alternative definitions for this indicator can be found in relation to the performance evaluation of ICOM interventions and environmental compliance and enforcement.

Assessment of data

Data needed to compile the indicator
ICOM management plan, management records, evaluation reports.

Data sources and collection methods
Document reviews of the official gazette, records from government offices and multilateral and bilateral donors, and independent evaluations, to be complemented by interviews and surveys.

Analysis and interpretation of results
Description and quantitative and qualitative assessment of the implementation, compliance with, and enforcement of the ICOM initiative.

Reporting scale and output
The indicator can be measured at all scales. The output may consist in a narrative report on the implementation, compliance with, and enforcement of ICOM strategies, plans, programs, and activities. Maps may also be attached.

Additional information

Organizations and programs involved in the development of the indicator
- EUCC, Europe
- PAP/RAC, Mediterranean
- PEMSEA, Southeast Asia

References

Bower, B., Ehler, CV, & Basta, D. *A Framework for Planning for Integrated Coastal Zone Management*. Silver Spring, Maryland: NOAA, 1994.

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Internet links
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PAP/RAC. *Mediterranean ICAM Clearing House*. http://www.pap-medclearinghouse.org/ (06/05/2005).

G.7 Monitoring and evaluation

Nature of indicator

Definition
The routine monitoring and evaluation of ICOM initiatives and activities and, where needed, the subsequent adjustment of the program or project.

Unit of measurement
Quantitative and qualitative measurement of the following dimensions:

- The existence, coverage (issues, baseline data, spatial, temporal), nature (self-assessment vs. independent evaluation), and quality of an operational monitoring and evaluation system, including indicators, for the ICOM initiative
- The degree of involvement of stakeholders in the monitoring and evaluation process
- The delivery of results from the monitoring and evaluation systems and their consideration by the ICOM managers
- The adjustments made to the ICOM initiative as a result of the information provided by the indicators
- The transparency of the monitoring and evaluation process and the dissemination of the results to a wide audience, including through state of the coast reports

Relevance

Purpose
An operational monitoring and evaluation system is vital to the continuous assessment of the progress of ICOM initiatives and their effectiveness. While this handbook is in itself a contribution to the development of a monitoring and evaluation system, most ICOM initiatives incorporate such system but this indicator is included to measure some specific dimensions of the monitoring and evaluation system that reflect its quality and usefulness. The use of monitoring and evaluation systems and indicators is directly relevant to ICOM and sustainable development as an implementation means in that it can help determine whether ICOM initiatives are meeting their stated objectives and generating the intended impacts, as well adapt to changing conditions.

International conventions, agreements and targets
Monitoring and evaluation in a general sense and more specifically for ICOM has been recommended by a number of international agreements. The *United Nations Convention on the Law of the Sea* refers to the monitoring of the risks of pollution (art. 204), while *Agenda 21* recommends the development of environmental criteria (paragraph 16.6[n]), socioeconomic indicators and environmental assessment (paragraph 17.8[b]), and the building of capacity of developing countries in the area of data and information (paragraph 17.68). Agenda 21 also recommends the development of sustainable development indicators (chapter 40, passim). Monitoring of components of biological diversity is provided for by the *Convention on Biological Diversity* (art. 7), while the *Barbados Programme of Action* calls for comprehensive monitoring programs for coastal and marine resources (paragraph 26[a][ii]), support to SIDS for surveillance and monitoring of activities in the exclusive economic zones (paragraph 26[c][iv]), monitoring and assessment for decision making on water management (paragraph 29[a][ii]) and hazards (paragraph 29[a][iii]). The *Global Programme of Action* recommends the identification and evaluation of problems (paragraph 8[a]) and the development of criteria to determine whether programs are meeting their objectives (paragraph 29[a][iii]). The *Code of Conduct* suggests elements for the monitoring and control of fishing activities (artt. 6.10 and 7.7.3) and aquaculture (art. 9.1.5), as well as monitoring of the coastal area as part of coastal area management (art. 10.2.4) and multidisciplinary research on coastal area management (art. 10.2.5) and fish stock assessment and impacts from habitat alteration and ecosystem changes (art. 12.5). The *Johannesburg Plan of Implementation* also recommends further work on sustainable development indicators (paragraphs 130-131). There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
A monitoring and evaluation systems for ICOM may be characterized by the following features:

- Coverage of environmental, socioeconomic, and governance issues directly relevant to ICOM
- Availability of baseline data on such issues with adequate spatial and temporal coverage and use of indicators
- Adequate capacity and preparation (human resources, infrastructure, instrumentation) to operationalize the system
- Meaningful involvement of relevant stakeholder in the design, implementation, and use of the system
- Transparency of the system, also through the combined use of internal and external evaluation
- Routine use of the system and periodic delivery of results to decision makers
- Adaptation of the ICOM initiative based on the results provided by the monitoring and evaluation system
- Dissemination of results from the monitoring, evaluation, and adaptation process to a wide audience

Measurement methods
Qualitative and quantitative assessment of the following dimensions:

(a) The existence of a monitoring and evaluation system for the ICOM initiative
(b) The characteristics of the monitoring and evaluation system (relevance to the issues and objectives of the ICOM initiative, coverage, availability of baseline data, periodicity of measurements)
(c) The involvement of relevant stakeholders in the design and implementation of the system
(d) The monitoring capability of the organization in charge (human resources, infrastructure, instrumentation, funding)
(e) The routine use of the system for monitoring the conditions of the coastal zone and the progress of the ICOM initiative
(f) The delivery of policy oriented information

(g) The adjustments made to the ICOM initiative as a result of the information provided by the system
(h) The dissemination of the information from the system to a wide audience

Limitations of the indicators
Often monitoring and evaluation systems are designed and implemented at a late stage, thus not providing enough information to assess the progress of an ICOM initiative and adopt the necessary adjustments. Moreover, often such systems focus on sectoral monitoring loosing a more comprehensive picture encompassing environmental, socioeconomic, and governance issues. Concerning evaluation, this too often focuses on management processes with limited attention to outcomes and impacts.

Status of the methodology
There is currently no internationally agreed methodology for the indicator.

Alternative definitions
N/A

Assessment of data

Data needed to compile the indicator
Quantitative and qualitative results of review of plans, evaluations, state of the coast report, budget, staffing, management systems, work program, and patrol reports.

Data sources and collection methods
ICOM plan, state of the coast report, evaluation reports, budget, staffing, management systems, work program, and patrol reports. Review of documents, budget, staffing and management systems, annual work program, and patrol reports.

Analysis and interpretation of results
Description and qualitative and quantitative assessment of monitoring capacity, operativity of the monitoring and evaluation system, stakeholder involvement and transparency of the monitoring and evaluation process, consistency of results of the monitoring and evaluation process and the state of the coast, use of indicators, consideration of results in the decision making process, and adjustments to the ICOM initiative based on the results of the process.

Data collection methods
The indicator can be monitored at the level of the individual ICOM initiative, independently from its scale. The output may consist in a narrative report on the monitoring, evaluation, and adjustment of the ICOM initiative.

Additional information

Organizations and programs involved in the development of the indicator
- EU (Europe)
- PEMSEA (Southeast Asia)

References
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Pomeroy, R.S., Parks, J.E. & Watson, L.M. *How is Your MPA Doing?* Gland: IUCN, 2004.

Internet links
IOC, NOAA, DFO & CMP. *The Role of Indicators in Integrated Coastal Management*. http://www.udel.edu/CMS/csmp/indicators/index.html (09/05/2005).

G.8 Administrative resources

Nature of indicator

Definition
The availability and allocation of administrative resources for ICOM as an expression of the capacity of the management team to administer and implement ICOM activities through time, based on the degree of access to and enabling human, financial, and facilities and equipment resources.

Unit of measurement
There are three dimensions to measure in both quantitative and qualitative terms:
(a) The number, formation, experience, and performance of staff devoted to ICOM
(b) The budget allocated and available for ICOM activities and interventions
(c) The facilities and equipment available for ICOM activities and interventions

Relevance

Purpose
The operation of ICOM programs and projects entails the timely availability of adequate administrative resources — staff, budget, and equipment — to carry out the related activities and interventions. The indicator reflects the appropriateness of the resources available to the management team to adequately carry out such activities and interventions.

International conventions, agreements and targets
Agenda 21 (paragraphs 17.12-17) details a number of requirements for the means of implementation for ICOM: financing and cost evaluation, scientific and technological means, human resources development, capacity building. There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
The indicator may be characterized by the following qualities:
(a) An adequate number of formed/trained and performing staff is available to prepare, implement, and follow up management activities and interventions related to ICOM
(b) Adequate and sustained financial resources are allocated and made readily available to support management activities and interventions related to ICOM
(c) Adequate and regularly maintained facilities and equipment are available to carry out activities and interventions related to ICOM

Measurement approaches
First, ICOM activities and interventions need to be identified and related needs in terms of staff, financial resources, and facilities and equipment determined. Second, necessary staff levels, experience, education, and performance must be identified and compared against the current status to determine needs. Third, the budget allocated to ICOM and the availability and timeliness of release of funds must be calculated. Fourth, the quantity and quality of facilities and equipment (age, condition, and maintenance) must be examined. When possible, data might also be expressed as percentages of the staff, budget, equipment and facilities available at the relevant agency (e.g., ICOM within an Environment or Land Use Planning Department).

Limitations of the indicator
The dimensions and sub-dimensions of the indicator need to be carefully isolated and measured. Staff levels, for example, need to be combined with required preparation and experience, on-the-job training completed, performance rating, and turnover. Training completed, for example, is not a surrogate measure for preparation or performance. The budget allocated to ICOM needs to be calculated above all in relation to the highest priorities and a distinction must be made between normal budget allocations and project allocations. Availability of funding should be checked against their actual disbursement and sustainability over time. The indicator can show significant changes over time but it might be difficult to measure during project implementation because of the substitution of project funds for normal budget allocations. Also, some ICOM functions might be shared among several agencies, making it difficult to isolate them from activities of a broader scope.

Status of the methodology

There is no internationally agreed methodology for measuring the indicator.

Alternative definitions
N/A.

Assessment of data

Data needed to compile the indicator
Staff records, budget documents, management records and inventories.

Data sources and collection methods
Government records for document review, interviews and surveys.

Analysis and interpretation of results
Prepare a narrative report on the current availability and allocation of staff, budget, and facilities and equipment to ICOM activities and interventions in relation to determined need and provide recommendations.

Reporting scale and output
The indicator can be reported per administrative unit. The output may consist of a report on the current status of staffing, budget, and facilities and equipment for ICOM.

Additional information

Organizations and programs involved in the development of the indicator
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References
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Internet links
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G.9 Inputs from scientific research

Nature of indicator

Definition
The existence and application of scientific research and its input into the ICOM process.

Unit of measurement
Qualitative assessment of three dimensions:
(a) The carrying out of scientific research targeted or useful to ICOM
(b) The production of scientific outputs from this research
(c) The use of such outputs by ICOM managers
(d) The existence of a scientific advisory committee for ICOM

Relevance

Purpose
The existence and application of scientific research targeted or useful to ICOM reflects the relevance of scientific research to management purposes, its feedback into management, and, ultimately, the improvement of management actions as a result of scientific knowledge. The indicator is not specific to ICOM in that a similar indicator can be applied to many other sectors. However, the indicator is significant in measuring the extent to which scientific research, targeted or not, is undertaken, generates knowledge relevant to ICOM, and is actually incorporated into ICOM initiatives. Given the complexity of the coastal system, effective management cannot occur without a sound scientific basis.

International conventions, agreements and targets
The development of scientific research for ICOM and ICOM-related activities is crosscutting to many international conventions and agreements. Provisions related to scientific research for ICOM are contained, among others, in *Agenda 21* (paragraphs 17.6[c], [d], and [g]; 17.8), the *Law of the Sea* (articles 200-2001), the *GPA* (paragraph 26), and the *Barbados Plan of Action* (paragraph 45[a][5]). There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
The existence and application of scientific research and input may be characterized by the following features:
- There must be availability of scientific knowledge relevant to ICOM
- There must be mechanisms to enhance the communication between scientists and managers
- The scientific knowledge must be applicable and used by ICOM managers

Measurement approaches
There are different levels to measure. The first level measures the existence and coverage of scientific studies relevant to ICOM and detailed information may be collected on the content of such studies. In the case of completed studies, a second level is to measure the outputs generated by the studies. A third level concerns the use of the scientific outputs by ICOM managers, as well as the processes for the prioritization of scientific research targeted to ICOM and the mechanisms available for routine communication between scientists and managers.

Limitations of the indicator
A major limitation with this indicator lies in the difficulty to isolate specific inputs from scientific research into ICOM initiatives and the sheer volume of scientific studies that are relevant to ICOM. Another limitation is given by the great amount of scientific literature.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

Alternative definitions
While not exactly an alternative definition, the indicator could also be calculated in terms of the investments made in scientific research considered relevant to ICOM, assuming that results and scientific knowledge generated from such research are generally used by ICOM managers.

Assessment of data

Data needed to compile the indicator
Scientific studies and results, meeting records

Data sources and collection methods
Government records, university and research centers records and databases, national academy of science reports on coastal and marine research. Document review, interviews.

Analysis and interpretation of results
Description and qualitative assessment of the lines of research relevant to ICOM, individual studies, the use of results and outputs for management, and further research needs.

Reporting scale and output
The indicator may be monitored at different scales. The output may consist in a report on the contribution of scientific research to ICOM.

Additional information

Organizations and programs involved in the development of the indicator

- GESAMP
- IOC
- GOOS

References

GESAMP. *The Contributions of Science to Coastal Zone Management*. GESAMP Reports and Studies 61. Rome: FAO, 1996.

GESAMP. *A Sea of Troubles*. GESAMP Reports and Studies 70. London: UNEP, 2001(a).

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IOC. Marine Sciences and Observations for Integrated Coastal Area Management. *IOC.* http://ioc.unesco.org/icam/ (06/05/2005).

UN. Ocean Issues. *Atlas of the Oceans*. http://www.oceansatlas.org/html/workissues.jsp (06/05/2005).

G.10 Stakeholder participation

Nature of indicator

Definition
The level of participation of stakeholders in decision-making processes and activities related to ICOM and their level of satisfaction with ICOM mandates and outcomes.

Unit of measurement
Qualitative assessment of three main dimensions:
(a) Level of participation of stakeholders in decision-making processes and activities related to ICOM
(b) Level of satisfaction of stakeholders with such participation
(c) Level of satisfaction of stakeholders with ICOM outcomes (environmental quality, human health, economic opportunities)

Relevance

Purpose
The level of participation of stakeholders in decision-making processes and activities related to ICOM and their satisfaction reflect the amount of active involvement of users in ICOM and the consideration of their views and concerns by ICOM managers. The active participation and satisfaction of stakeholders in the decision-making processes and activities can improve the success of ICOM initiatives by increasing the level of ownership and sustained support. Stakeholder participation is also a measure of the transparency and accountability of the ICOM decision-making process.

International conventions, agreements, and targets
Agenda 21 (paragraph 17.6) recommended the establishment of coordinating mechanisms for integrated management and sustainable development of coastal and marine areas and their resources, at both the local and national levels. Such mechanisms should include consultation, as appropriate, with the academic and private sectors, non-governmental organizations, local communities, resource user groups, and indigenous people. The involvement of stakeholders is also recommended in relation to the development of capacity building efforts (paragraph 17.17). The involvement of stakeholders is also recommended by many other coastal- and ocean-related conventions and agreements: for example, the *Law of the Sea* for public participation in environmental impact assessment procedures (article 14[1][a]); the *Barbados Programme of Action for the Sustainable Development of Small Island States* for the participation of local communities in monitoring programmes for coastal and marine resources (paragraph 26[a][2]) and the involvement of non-governmental organizations, women, indigenous people and other major groups, as well as fishing communities and farmers, in the conservation and sustainable use of biodiversity and biotechnology (paragraph 45[a][8]); the *Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities* for the involvement of stakeholders in integrated coastal management approaches, in particular local authorities and communities and relevant social and economic sectors, including non-governmental organizations, women, indigenous people and other major groups (article 23); and the *Code of Conduct for Responsible Fishing* for the representation and consultation of the fisheries sector and fishing communities are consulted in the decision-making processes and other activities related to coastal area management planning and development (paragraph 10.1.2). On environmental issues in general, the UNECE *Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters* (Aarhus Convention) provides for the involvement of stakeholders in sustainable development processes, links government accountability and environmental protection through the interaction between public and public authorities, and promotes a new process for public participation in the negotiation and implementation of international agreements. There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
Stakeholders participation in and satisfaction with ICOM decision-making processes and activities may be characterized by the following features:

- Through appropriate mechanisms, stakeholders are informed of, consulted on, and participate in decision-making processes and activities related to ICOM
- Stakeholders are satisfied with their participation in ICOM decision-making processes and activities and perceive that their views and concerns are taken into account by ICOM decision makers and managers

Measurement methods
There are two levels of quantitative and qualitative measurement: the first level refers to the level

of participation of stakeholders in ICOM decision-making processes and activities; the second level refers to the level of satisfaction of stakeholders with such participation. Stakeholders are individuals, groups, or organizations interested, involved, or affected by ICOM interventions. Through a participatory stakeholder analysis it is possible to identify the key stakeholders and assess their characteristics, interests, respective relationships, and relative importance in and influence on an ICOM initiative. The stakeholders are identified by the activities directly or indirectly affecting an ICOM initiative and can be divided into primary and secondary stakeholders. Information on stakeholder characteristics, interests, and relationships can be organized through the use of tables and diagrams. The level of participation of stakeholders in decision-making processes and activities can be determined by observing their participation in meetings or conducting a survey. Through a survey, it is possible to investigate the level of satisfaction of stakeholders with their participation in ICOM decision-making processes and activities.

Limitations of the indicator
It might not be easy to identify all the stakeholders relevant to an ICOM initiative, particularly those who are poor, unorganized, and powerless. Similarly, it might not be easy to elucidate all the relationships among stakeholders. Often, only unsatisfied stakeholders participate in meetings and some have unrealistic expectations on their participation, resulting in a low level of satisfaction. Participation does not equate to satisfaction and this, in turn, does not necessarily guarantee the best decisions have been made.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

Alternative definitions
There might be other measures of stakeholder participation and satisfaction, for example, access to environmental information; public participation in decision on specific activities, such as in environmental impact assessment procedures; public participation concerning plans, programs, and policies; public participation during the preparation of executive regulations and/or legally binding normative instruments; and access to justice. The above definitions are from the UNECE *Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters* (Aarhus Convention).

Assessment of data

Data needed to compile the indicator
Results of interviews and surveys, meeting records.

Data sources and collection methods
Interviews and surveys with key informants and reviews of government records.

Analysis and interpretation of results
The results of the stakeholder analysis can be expressed through matrices and tables tabulating totals and breakdown by stakeholder groups. Scores of level of satisfaction resulting from the surveys can be calculated and measured over time to detect changes. Data can be expressed both in quantitative and qualitative terms.

Reporting scale and output
The indicator is best monitored at the level of individual ICOM initiatives. The output may take the form of a stakeholder analysis matrix, stakeholder participation matrix, scores of stakeholder satisfaction with participation, narrative report.

Additional information

Organizations and programs involved in the development of the indicator
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References
King, G. *Participation in the ICZM Process: Mechanisms and Procedures Needed*. Cardiff: Hyder Consulting, 1999.
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Internet links
…

G.11 NGO and community involvement

Nature of indicator

Definition
The existence of NGOs and community organizations (formal and/or informal) and the level of activities in support of ICOM objectives and initiatives.

Unit of measurement
Quantitative and qualitative assessment of the following dimensions:
- The number and characteristics of NGOs and community organizations active in fields related to ICOM
- The level of activities carried out by the NGOs and community organizations in support to ICOM (participation in meetings, advocacy and awareness raising, field projects, etc.)
- The degree of influence of these activities on the advancement of ICOM

Relevance

Purpose
The indicator provides a measure of the support major groups such as NGOs and the civil society provide to government-driven activities such as ICOM. The indicator should be useful to detect (a) the relative importance ICOM issues have for the civil society and its organized institutions such as NGOs, (b) the degree of involvement of these organizations in official ICOM initiatives and (c) the actual contribution these activities have on the advancement of ICOM and ICOM initiatives. The existence and activity of supportive NGOs and community organizations is vital to the advancement of ICOM, both at the level of individual initiatives and in more general terms. NGOs and community organizations represent resource users and stakeholders and some of ICOM activities may also be implemented through NGOs and community-based organizations. In addition, the presence of NGOs and community organizations in an ICOM initiative is a signal of transparency, participation, and representation. This has a value beyond ICOM itself and pertains to the modalities through which to pursue sustainable development.

International conventions, agreements and targets
The role of NGOs and other major groups in sustainable development processes has been extensively recommended by *Agenda 21* in its section III. There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
NGO and community involvement in ICOM may be characterized by the following features:
- NGOs and community-based organizations exist that are relevant to ICOM
- NGOs and community-based organizations are organized to participate in the management of ICOM activities
- NGOs and community-based organizations carry out activities relevant to ICOM (co-management, advocacy, awareness raising, field projects, etc.)
- Activities carried out by NGOs and community-based organizations are actually contributing to advance ICOM and ICOM initiatives

Measurement approaches
Qualitative and quantitative assessment of the following dimensions:
(a) The existence of NGOs and community-based organizations relevant to ICOM
(b) The characteristics of such NGOs and community-based organizations (mission and objectives, functions and responsibilities, period of existence, budget and staff)
(c) The activities carried out by those NGOs and community organizations (participation in ICOM meetings and advocacy, awareness raising, education and training, field projects, etc.)
(d) The perceived contribution of such activities to the advancement of ICOM and ICOM initiatives

Limitations of the indicators
Not necessarily ICOM initiatives are carried out through the aid of community-based organizations. It might be difficult to assess the specific contributions made by NGOs and community organizations to ICOM and ICOM initiatives.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

Alternative definitions
Nongovernmental and community organizations may take many forms and different types of involvement into ICOM initiatives. Therefore, the indicator needs to be proportioned to the reality of each case it is applied to.

Assessment of data

Data needed to compile the indicator
Quantitative and qualitative Information on NGOs and community-based organizations and their activities in support to ICOM.

Data sources and collection methods
NGO directories, meeting minutes, annual reports. Document reviews.

Analysis and interpretation of results
Narrative report with the list of NGOs and community organizations active in ICOM-related activities, their characteristics (mission and objectives, functions and responsibilities, period of existence, budget and staff), their activities related to ICOM (participation in ICOM meetings and advocacy, awareness raising, education and training, field projects, etc.), and an appreciation of the actual contribution of these activities to the advancement of ICOM and ICOM initiatives.

Data collection methods
The indicator can be monitored at all scales. The output may consist in a narrative report, supported by enough data.

Additional information

Organizations and programs involved in the development of the indicator
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References

King, G. *Participation in the ICZM Process: Mechanisms and Procedures Needed*. Cardiff: Hyder Consulting, 1999.

Olsen, S. & Kerr, M. *Building Constituencies for Coastal Management: A Handbook for the Planning Phase*. Coastal Management Report 2214. Narragansett, Rhode Island: University of Rhode Island, Coastal Resources Center, 1998.

Wilcox, D. *The Guide to Effective Participation*. Brighton: Joseph Rowntree, 1994.

Internet links
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G.12 Education and training

Nature of indicator

Definition
The incorporation of ICOM into educational and training curricula, the number of persons graduating and/or trained with such curricula, and the number of persons with such preparation employed in ICOM-related agencies.

Unit of measurement
Quantitative and qualitative assessment of a number of dimensions:
- The number and characteristics (e.g., location, duration, attendance, etc.) of university programs incorporating ICOM in their curricula
- The number and characteristics of training courses incorporating ICOM held
- The number of people graduating having attended university programs incorporating ICOM in their curricula
- The number of people having completed training courses incorporating ICOM in their syllabus
- The number of graduates with an ICOM preparation employed in ICOM-related agencies
- The number of people having attended ICOM training courses employed in ICOM-related agencies
- Persons employed in ICOM-related agencies who underwent on-the-job training in ICOM
- Degree of satisfaction of people attending ICOM-related university and training courses
- Degree of satisfaction of offices having employed or already in the office persons graduated or trained in ICOM

Relevance

Purpose
ICOM requires new multidisciplinary and management skills. This indicator intends to reflect to which degree the educational and formative system provides the multidisciplinary and management skills required to implement ICOM and to which degree these new skills are requested by ICOM-related agencies. New multidisciplinary and management skills are a prerequisite for the implementation of ICOM. The degree to which education and training is providing such skills and the job market associated to ICOM is requesting them is a powerful indicator of the role of these new approaches. Therefore, the indicator, given its specificity, is directly related to ICOM and, more in general, to sustainable development.

International conventions, agreements and targets
Agenda 21 clearly recommended that coastal States should promote and facilitate the organization of education and training in integrated coastal and marine management and sustainable development for all types of users and the incorporation of management and development, as well as environmental protection concerns and local planning issues, in educational curricula and public awareness campaigns (paragraph 17.5). Education and training in ICOM should also be part of capacity-building efforts in developing countries (paragraph 17.6). The role of education and training for ICOM is recognized by all other international agreements addressing ICOM-related issues. There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
Education and training for ICOM may be characterized by the following features:
(a) University programs specifically targeting ICOM or incorporating ICOM in their curricula
(b) Training courses, be their for unemployed or employed people, incorporating ICOM in their syllabi

Measurement methods
There are three to four levels of measurement:
1. (a) The number of university programs incorporating ICOM in their curricula and (b) the number of training courses incorporating ICOM in their syllabi and the characteristics of such programs and courses (undergraduate/master/PhD, duration, requirements, etc.).

2. (a) The number of people having successfully completed a university degree (undergraduate/master/PhD) encompassing ICOM-related courses and (b) the number of people – distinguished between unemployed and employed in ICOM-related agencies – having successfully completed ICOM-related training courses. This dimension may include also (c) the dissertations completed on ICOM topics.
3. (a) The number of people having successfully completed a university degree encompassing ICOM-related courses employed in ICOM-related agencies and (b) the number of unemployed people having successfully completed ICOM-related training courses employed in ICOM-related agencies.
4. In addition, the level of satisfaction may be measured of (a) people having taken university programs or training courses in ICOM-related subjects and (b) the ICOM-related agencies employing people having taken university programs or training courses in ICOM-related subjects.

Limitations of the indicator
The calculation of the indicator is complicated by the difficulty of accessing the data and of delimiting the scope of "ICOM-related" subjects. Moreover, the completion of university programs or training courses is not by itself a synonymous of capacity in ICOM. On the other hand, the employment of people with an ICOM formation does not necessarily translate in better ICOM formulation and implementation.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

Alternative definitions/indicators
In alternative, employment in the private sector, the academia, and NGOs could also be considered. In addition, the existence of specific fellowships for ICOM studies could be assessed, as well as other mechanisms to promote multidisciplinary education as well as international exchanges, internships, etc. As a proxy for employment, the advertisement of ICOM-related jobs (short-term, permanent, project-based, including in development assistance activities) could be considered.

Assessment of data

Data needed to compile the indicator
University records, government agencies employment records, education statistics, results from surveys

Data sources and collection methods
Universities, vocational training institutions, government agencies, statistical services. Document review, surveys.

Analysis and interpretation of results
Description and quantitative and qualitative analysis of the adequacy and the contribution of education and training activities to form a new cadre of ICOM scientists and managers.

Data collection methods
The indicator can be monitored at the national level and aggregated at the national level. The output may consist in a narrative report corroborated by adequate statistics.

Additional information

Organizations and programs involved in the development of the indicator
- UN, TRAIN-SEA-COAST program

References
Crawford, B.R., Cobb, J. S., & Loke Ming, Ch. *Educating Coastal Managers, Proceedings of the Rhode Island Workshop*. Narragansett, RI: University of Rhode Island, Coastal Resources Center, 1995 (http://www.crc.uri.edu/comm/htmlpubs/ecm/index.html)

Internet links
UN. *TRAIN-SEA-COAST*. http://www.un.org/Depts/los/tsc_new/TSCindex.htm (06/05/2005).

G.13 Enabling technology

Nature of indicator

Definition
The use of technology, including environmentally friendly technology, to enable and support ICOM.

Unit of Measurement
Qualitative and quantitative assessment of different dimensions:

- Availability of technology that can enable and support ICOM at a feasible cost
- Use of technology to enable and support ICOM initiatives and removal of technology counterproductive for ICOM
- Coordination of the use of technology to enable and support ICOM

Relevance

Purpose
Technology can play an important role for ICOM at different levels: at the level of the phases of analysis and diagnosis of coastal issues, planning, implementation, and evaluation. The role of this indicator is to measure to which extent the ICOM process and activities are better enabled and supported by the use of technology, including environmentally friendly technology, how this technology substitutes technology counterproductive for ICOM, and how this process is well coordinated.

Relevance to international conventions, agreements and targets
Among other agreements, *Agenda 21* recommends that coordination mechanisms for ICOM promote environmentally sound technology and sustainable practices (paragraph 17.6[m]). Scientific and technological means also provide a fundamental base for the implementation of ICOM, including cooperation among states in the development of necessary coastal systematic observation, research and information management systems, and provision of access to and transfer of environmentally safe technologies and methodologies for sustainable development of coastal and marine areas to developing countries, and the development of technologies and endogenous scientific and technological capacities (paragraph 17.13). The use of clean technology is called for by the *GPA* (paragraphs 9[d] and 10), also in relation to the transfer of environmentally sound technologies to developing countries (paragraph 13). Among the strategies and measures to achieve the objectives of the GPA there are best available techniques (BAT) and practices (BAP), clean production practices, environmentally sound and efficient technologies, product substitution, waste recovery, recycling, and waste treatment (paragraph 26[a][i and ii]. While the *Barbados Programme of Action* address technology issues in a separate section (section XIII), but calls for the sharing of expertise on geographic information systems (GIS) techniques and facilities for the assessment of coastal and marine resources (paragraph 26[C][i]).

Methodological description

Underlying definitions and concepts
Technology for ICOM may be characterized in different ways:

(a) Technology supporting information acquisition and management (aerial photography and satellite remote sensing, global positioning system, geographical information systems, etc.)

(b) Technology for the exploitation of the coastal space and its resources (e.g., exploration and exploitation of energy and non-renewable resources, pollution reduction and prevention through best available practices [BAP], best available technology [BAT], and integrated pollution prevention and control [IPPC], fishery and aquaculture, water and sediment management, climate change and sea level rise adaptation)

(c) Technology to preserve coastal space and its resources (e.g., treatment and monitoring of sewage, cleaner production processes for persistent organic pollutants, heavy metals and radioactive pollutants, nutrients and nonpoint pollution, oil pollution emergency, aquifers and salt water intrusion, physical alteration and destruction of habitats, coastal defense and safety, dredging)

Measurement methods
The indicator and its dimensions may be measured in a qualitative and quantitative way on different levels. A first level refers to the need for better and new technologies based on the limitations posed to ICOM by existing technologies. The assessment then addresses: (a) which technologies could best enable and support ICOM and which ICOM phases, components, and tasks could be most improved through technology, and (b) which technology are actually available for introduction and which is their feasibility. A second level refers to the actual use of ICOM-enabling and supporting technologies in substitution of technologies that are counterproductive for ICOM. A third level refers to the measurement of the effectiveness of these

technologies and the quantification of the environmental, social, and economic benefits achieved. The indicator is also associated to the use of voluntary agreements with the private sector for the adoption of environmentally friendly technologies, economic instruments to stimulate this process, research and development policies and activities, demonstration projects to assess the feasibility and effectiveness of new technologies.

Limitations of the indicator
This indicator is of a general nature and it might not be easy to assess the contribution of technology to enable and support ICOM initiatives. A way to measure the indicator might be considering more closely issues related to the development, transfer and use of environmentally sound technologies for specific uses or environmental problems (use of coastal resources such as fish stocks, technologies to clean up oil spills, facilities for the treatment of waste oil and wastes at ports, treatment of urban wastewaters, etc.) in the attempt to measure how technologies can enable and support ICOM and their effectiveness in delivering more efficiently environmental, social, and economic benefits.

Status of the methodology
There is currently no internationally agreed methodology for this indicator.

***A*lternative definitions**

The concept of "ICOM-enabling and supporting technologies" is extremely broad and attention has to be paid to defining operationally the scope of the indicator.

Assessment of data

Data needed to compile the indicator
Government, statistical services, and enterprise records and statistics, results of interviews and surveys.

Data sources and collection methods
Document review of government records, statistical information, accompanied by interviews and surveys.

Analysis and interpretation of results
The analysis and interpretation of results should focus on one or more the following: (a) the need for technologies that could enable and support ICOM and their feasibility, (b) the determining factors for decisions concerning the use of technologies in ICOM, and (c) the environmental changes brought about by these technologies and their efficiency.

Reporting scale and output
The indicator can be measured at the level of individual ICOM initiatives but also aggregated at the national scale. The output may consist in a narrative report supported by substantial factual data.

Additional information

Organizations and programs involved in the development of the indicator
- OECD
- UNIDO
- UNEP, Division of Technology, Industry, and Economics
- Mediterranean, Regional Activity Centre for Cleaner Production (RAC/CP)

References
Capobianco, M. *Role and Use of Technologies in Relation to ICZM*. Venice: Tecnomare, 1999.

Internet links
OECD. Technology and Sustainable *Development. Sustainable Development.* http://www.oecd.org/topic/0,2686,en_2649_34499_1_1_1_1_37425,00.html (06/05/2005).
RAC/CP. *Regional Activity Centre for Cleaner Production*. http://www.cema-sa.org/car/cat/index.htm (06/05/2005).
UNEP/TIE. *Division of Technology, Industry, and Economics*. http://www.uneptie.org/ (06/05/2005).

G.14 Economic instruments

Nature of indicator

Definition
The use of economic instruments, in addition to regulatory instruments, to support ICOM.

Unit of measurement
Qualitative and quantitative assessment of different dimensions:
(a) The existence and availability of economic instruments for ICOM
(b) The actual use of economic instruments in combination with regulatory instruments
(c) The effectiveness and efficiency of economic instruments

Relevance

Purpose
Economic instruments can complement regulatory instruments and, at times, substitute them to improve efficiency, integrate environmental considerations into mainstream economic decision-making, reduce environmentally damaging subsidies, stimulate innovation and competitiveness, help internalize environmental costs, support the polluter and user pays principle, and, ultimately, promote environmentally sustainable development. ICOM cannot be based solely on a command and control approach and needs to make use of economic instruments to correct the market distortions that often are at the base of environmental problems and to help businesses and consumers to make long-term choices.

International conventions, agreements and targets
The *Rio Declaration* calls national authorities for promoting the internalization of environmental costs and the use of economic instruments (principle 16). *Agenda 21* recommends the use of economic incentives to apply clean technologies (paragraph 17.22[d]) and the same does the *GPA* (paragraph 9[d]). OECD as also recommended the use of economic instruments in environmental policies, including for the coastal zone (Recommendation C(92)114/Final and Recommendation C(90)177/Final).

Methodological description

Underlying definitions and concepts
Economic instruments for ICOM may be of different type, for example:
(a) Emission charges (e.g., on household wastewater)
(b) Water pricing (e.g., for household and industrial waters)
(c) Fines on discharges from ships
(d) License fees on fishing
(e) Boat registration fees
(f) Taxes on fertilizers
(g) Taxes on land development
(h) Reduction of subsidies on polluting activities
(i) Subsidies for land conservation
(j) Energy pricing for transport activities

Measurement approaches
The indicator may be measured on different levels. One level refers to the availability of economic instruments that could beneficially be utilized to support ICOM policy objectives or address specific environmental problems. At this level, the appropriate conditions for the introduction of economic instruments are also assessed. A second level refers to the actual use of these economic instruments to support ICOM policies and objectives. A third level refers to the benefits achieved through the use of economic instruments. This dimension may refer to specific sectors or environmental problems and has to be measured in relation to environmental and socioeconomic indicators.

Limitation of the indicator
The indicator is of a broad and long-term scope. It might be difficult to measure it in relation to specific ICOM initiatives rather than in relation to general environmental policies, including for water, land, and natural resource management.

Status of the methodology
There is currently to internationally agreed methodology for the indicator in its application to ICOM. However, there is substantial literature on the use of economic instruments developed by OECD also as part of the country environmental performance reviews.

Alternative definitions
Among economic instruments, voluntary agreements with the private sector may be included, as well as the use of environmental quality certifications (e.g., ISO 14000 on environmental management and

EMAS [Environmental Management and Audit Schemes]). These certifications could actually constitute a specific indicator to measure.

Assessment of data

Data needed to compile the indicator
Quantitative and qualitative information on the use of economic instruments for coastal and marine uses (water and land use, natural resource management) as well as on the type and number of voluntary agreements between governmental authorities and the private sector(s) and the environmental certifications.

Data sources and collection methods
Review of business, chamber of commerce, and government records and databases, monographs and databases by intergovernmental organizations (OECD, UNIDO) accompanied by interviews and surveys.

Analysis and interpretation of data
The analysis and the interpretation of data should focus, where possible, on the measurable changes brought about by the introduction of economic instruments and voluntary agreements for the use of clean technologies.

Reporting scale and output
The indicator can be monitored at the national scale. The output may consist in a narrative report including tabular data.

Additional information

Organizations and programs involved in the development of the indicator

- OECD (global)
- PAP/RAC (Mediterranean)

References

Grigalunas, T.A. & Congar, R. (eds). *Environmental Economics for Integrated Coastal Area Management: Valuation Methods and Policy Instruments*. UNEP Regional Seas Reports and Studies 164. Nairobi: UNEP, 1995.

METAP. *Participation and Financing as Mechanisms for Improving Sustainability of Integrated Coastal Zone Management*. Helsinki: Finnish Environmental Institute, 2002.

PAP/RAC. *Analysis of the Application of Economic Instruments for Combating the Land-Based Pollution in the Mediterranean Coastal Areas*. Split: PAP/RAC, 2002.

UNEP. *Use of Economic Instruments in Environmental Policy: Opportunities and Challenges*. Nairobi: UNEP, 2004.

Internet links

OECD/EEA. OECD/EEA database on economic instruments and voluntary approaches used in environmental policy and natural resources management. *Environment*. http://www1.oecd.org/scripts/env/ecoInst/index.htm (06/05/2005).

PAP/RAC. Database on economic instruments in the Mediterranean. *PAP/RAC*. http://www.pap-sapei.org/ (06/05/2005).

G.15 Mainstreaming ICOM into sustainable development

Nature of indicator

Definition
The integration of ICOM into the national (or also regional) strategy for sustainable development, fully recognizing the value of coastal and marine resources and the role they play for development.

Unit of measurement
Quantitative and qualitative assessment of a number of dimensions:
- Existence of a national sustainable development strategy
- Role of ICOM in the strategy
- Level of implementation and degree of effectiveness
- Existence of performance targets and indicators
- Availability of funds for ICOM implementation
- Cross-sectoral projects

Relevance

Purpose
The integration of ICOM into the national sustainable development strategy reflects the commitment to ensure the protection and development of coastal and marine areas in the broader context of a national sustainable development strategy through a more integrated economic, social, and environmental policy planning. The indicator is precisely the expression of the integration of ICOM into sustainable development: the national sustainable development strategy integrates priorities in the social, economic, and environmental sectors, and in this sense can enhance national prospects for economic growth and employment while protecting the environment. The role of ICOM in this process expresses the commitment to protecting and managing in a sustainable and strategic way coastal and marine resources.

International conventions, agreements and targets
Agenda 21 calls for the implementation of national sustainable development strategies and the integration of environment and development in decision making (chapter 8), as well as for the integrated management and sustainable development of coastal areas, including exclusive economic zones (chapter 17). More recently the *Plan of Implementation of the WSSD* recommended the development integrated, multidisciplinary and multisectoral coastal and ocean management at the national level (paragraph 30[e]). There are no internationally established targets and standards for this indicator.

Methodological description

Underlying definitions and concepts
The mainstreaming of ICOM into sustainable development strategy may be characterized by the following features:
(a) ICOM chapter included in the sustainable development strategy
(b) ICOM-related objectives integrated in the economic, social, and environmental sectors
(c) Coordination mechanism or body encompassing ICOM interests
(d) ICOM priorities and outcomes included in the strategy
(e) ICOM activities targeted with clear budgetary priorities
(f) Multi-stakeholder participation and effective partnerships in ICOM-related activities
(g) Engagement of a high political level (e.g., Ministry of Planning and Finance)
(h) Implementable and with short-term and tangible objectives, including a plan for internal and external resource mobilization
(i) Transparency and accountability through continuous monitoring and evaluation

Measurement approaches
There are two levels of measurement:
1. The existence of a sustainable development strategy with an ICOM chapter
2. The extent to which the ICOM chapter is being implemented and its effectiveness

The first level can be monitored by examining the national sustainable development strategy or, in its absence, other relevant strategies, plans, and activities.

The second level requires the examination of the monitoring and evaluation component of the strategy or, in its absence, ICOM activities themselves, in relation to other strategies, plans, and programs.

Limitations of the indicator

There are no internationally agreed standards regarding what constitutes a sustainable development strategy and the mainstreaming of ICOM in it. The indicator is essentially of a qualitative nature and additional criteria will have to be developed to measure the implementation and effectiveness of the ICOM component of the strategy. In addition, multiple strategies, plans, and programs may be in existence as supplement to the sustainable development strategy.

Status of the methodology

There is currently no internationally agreed methodology for this indicator.

Alternative definitions/indicators

There is a wide variety of planning and strategy formulation processes in use in different countries. What matters to the development of the indicator is the integration of the key economic, social and environmental dimensions of development into one or multiple strategies and specific priorities, targets, measures, and means of implementation for ICOM within these strategies.

Assessment of data

Data needed to compile the indicator

National country reports, policy reports, legislative reports, and various planning documents.

Data sources and collection methods

Reviews of documents from government planning and environment ministries, interviews and surveys.

Analysis and interpretation of results

Description and qualitative, and if possible quantitative, analysis of the importance of ICOM within sustainable development strategies. The output may consist in a narrative report.

Reporting scale and output

The indicator can be measured at the national scale. The output may consist in a narrative report.

Additional information

Organizations and programs involved in the development of the indicator

The UN Commission on Sustainable Development is the agency in charge with the monitoring of the implementation of national sustainable development strategies, including for oceans and the coastal zone.

References

Carew-Reid J., Prescott-Allen R., Bass S.M.J. & Dalal-Clayton D.B. *Strategies for National Sustainable Development: A Handbook for their Planning and Implementation*. London and Gland: IIED and IUCN, 1994.

Dalal-Clayton, B. & Bass, S. *Sustainable Development Strategies: A Resource Book*. London and Paris: IIED and OECD, 2002.

OECD. Strategies for Sustainable Development: Practical Guidance for Development Cooperation. Paris: OECD, 2001.

UN/DESA. *Guidance in Preparing a National Strategy for Sustainable Development: Managing Sustainable Development in the New Millennium*. DESA/DSD/PC2/BP13. New York: UN, 2002.

UN/GA. *Road map towards the implementation of the United Nations Millennium Declaration Report of the Secretary-General*. A/56/326. New York: UN, 2001.

Internet links

UN/DESA. National Information. *Sustainable Development Issues.* http://www.un.org/esa/sustdev/natlinfo/natlinfo.htm (06/05/2005).

UN. Sustainable Development. *Atlas of the Oceans.* http://www.oceansatlas.com/unatlas/uses/uneptextsph/wastesph/2240susdev.html (06/05/2005).

5 Ecological indicators

Table 5-1 Summary of ecological indicators

Goal	Code	Indicator	Page
Conserve enough components – at all levels of biological organization – so as to maintain the natural resilience of the marine ecosystem	**E.1**	Diversity	94
	E.2	Distribution	98
	E.3	Abundance	100
Conserve the function of each component of the marine ecosystem so that it can play its natural role in the food web	**E.4**	Production and reproduction	102
	E.5	Trophic interactions	105
	E.6	Mortality	107
Conserve the geological, physical and chemical properties of the ecosystem so as to maintain the overall marine environmental quality,(i.e. water, sediment, biota and habitat quality)	**E.7**	Species health	110
	E.8	Water quality	114
	E.9	Habitat quality	120
A detailed table with indicators and parameters is provided on page 93.			

5.1 Introduction

As indicated in the Sustainable Development definition, the overall goal of ICOM is to maximize economic and socio-cultural benefits, while avoiding compromise to the health of the ecosystems. This is what is referred to as an ecosystem-based approach to management and it is an essential part of the broad ICOM process. From an ecological perspective, this means that the management of human activities in oceans and coastal areas must take into consideration the core aspects of ecosystem health. This chapter sets out an ecological taxonomy or framework for the examination of marine ecosystems and, within that framework, sets out a suite of indicators that can be useful in providing ICOM managers with the information necessary to make informed conclusions with respect to marine ecosystem health.

5.2 Ecological taxonomy for ecosystem-based management

While the concept of ecosystem-based management is often presented as inordinately complex, there is a simple and useful taxonomy that can be used to simply the concept. In the first instance, the over-riding consideration is that of ***ecosystem health***. Integrated coastal and oceans management is striving to maintain healthy ecosystems. Healthy and naturally functioning ecosystems have value in their own right, and offer the greatest potential for maximization of the social and economic objectives of humans over the long term.

What are the elements that need to be considered in order to determine if an ecosystem is healthy and to track changes in ecosystem health? There are three: the ***organization*** of the ecosystem, the ***vigor*** of the ecosystem, and the ***physical and chemical properties*** of the ecosystem. These three concepts provide the ecological taxonomy of ecosystem-based management; and, they apply regardless of the type of ecosystem – be it a warm, tropical system, or a polar, ice-covered system; a near-shore coastal system, or an open-ocean, high-seas system. This simple taxonomy works for them all. It is critical, however, that indicators be developed and used for each of these three elements of a marine ecosystem. If ICOM managers are to do their job in implementing ecosystem based management, they must have information on each of these three sub-components of the ecosystem.

The *organization* of the ecosystem is concerned with the biological diversity (both species diversity and genetic diversity within species, as well as diversity of habitat and ecosystem types), the "vertical structure" of the system (i.e., length of food-webs or complexity of food chains), the trophic structure (including age structure, symbiotic relationships, and cohabitation relationships), and the spatial distribution of the marine life (continuous, patchy, or migratory). The general concept is that a higher degree of organizational complexity will define an ecosystem that is more resilient and more tolerant of stress. Indicators should be used to establish and track changes in the key elements of organizational complexity.

The *vigor* of the ecosystem is concerned with the productivity of the ecosystem – the energy flows within that system, and the interaction of the organizational components described above. Particular attention needs to be given to primary productivity, as well as with measures dealing with size (e.g., biomass), and reproductive capacity of species within the ecosystem. Closely related to the vigor of the system are measures dealing with the *physical and chemical properties* of the ecosystem. These measures will be concerned with the oceanographic processes, with water quality issues, and with issues related to quality of the habitat.

It is important to note as well that these are not discrete elements that can be examined independently. There are interactions between and among the three elements, and it is the interplay and synergy that determines the ecological integrity or health of the ecosystem and its natural resilience (or stability or reversibility) – i.e., the capacity of the ecosystem to recover from a stress and to bounce back to a previous stage after the impacting perturbation is stopped.

5.3 Approaches to ecosystem-based management: "top-down" or "bottom-up"

While each of the three sub-components of an ecosystem must be examined in order to provide ICOM managers with information on ecosystem health, there are two complementary approaches that can be used. Each of the approaches, however, relies on the same ecological taxonomy described above.

The ***"top-down" approach*** is based on the identification of the most important ecosystem properties and components and the subsequent development of ecosystem-based management objectives around these core components/properties to ensure they are conserved over time. Human activities which impact – or are suspected to have impacts on – marine ecosystems then have to be managed to meet these ecosystem objectives; indicators will be used to measure progress against these management objectives. It is called "top-down" because it takes an objective view of an ecosystem (as looked at from above) without prior regard to human activities that may be perturbing the ecosystem. This approach relies heavily on strong science support – oceanography and biology – of both people and systems ("hard science support"). Indicators used for this approach normally will be "hard science" type indicators as well because they are related to the state of the marine ecosystem, not to any particular human activity.

The ***"bottom-up" approach*** takes the opposite approach. It is the premised on establishment of ecosystem-based management objectives based on a review of which human activities may have significant impacts at the ecosystem level (large-scale) and identification of which ecosystem components or properties may be impacted by them. The same general framework for looking at the ecosystem should be employed as is done for the property-based approach (i.e., the organization of the ecosystem, the vigor of the ecosystem, and the physical and chemical properties of the ecosystem). To employ this approach, one is required to identify the potential impacts that an activity could have on a marine ecosystem (or a component thereof), and then develop ecosystem-based management objectives for that activity. To be effective, this requires consideration of all the activities that can affect a given marine ecosystem (noting that many of these activities will be land-based activities), keeping in mind that number of activities can affect the same ecosystem components (see for example Table 5-), i.e., may have cumulative impacts. Indicators used for this approach would ideally be "hard science" type indicators (related to the particular activity), but could also be "proxy measures" (e.g., fisheries landings volumes or unit effort as a proxy for productivity). In effect, this is a "bottom-up" approach that starts with human activities and relates those to ecosystem properties, as opposed to the "top down" approach that starts with the ecosystem properties.

Ideally, both of these approaches will be used together, but either one or the other is capable of guiding appropriate management actions and selection of indicators for integrated coastal and ocean management. The first approach relies more heavily on scientific capacity and understanding of the particular ecosystem under consideration. The second is more amenable to situations where less capacity may exist. In most circumstances, local/traditional knowledge is accumulated with respect to specific components which have been impacted (e.g., a commercial fish species and fish stock depletion, a heavily contaminated site around a coastal plant or harbor facilities, habitat losses due to the coastal /urban development, the degradation of the water quality, beach closures, shellfish beds closure, or any other restricted areas contaminated by local sewage, etc.). In these circumstances, local knowledge is more readily focused on activities that take place in the management area (it is the "bottom-up" approach). It is important to note, however, that the examination of the activity is the starting point, not the end in itself – the activity should be linked back to and ecosystem property and should be considered in relation to other activities that also have an effect on that ecosystem property. This is the "value-added" that ICOM adds to traditional approaches to management of activities; if this is not done, it will not be an ecosystem-based approach to management.

Combining both approaches for selecting indicators will increase the potential of developing indicator menus based on common indicators (i.e., same indicators used to address both ecological and socio-economic issues). This integration will foster linkages between scientists and managers and between natural, social scientists and economists. In this respect, the DPSIR framework and ecosystem property considerations will be helpful because they provide methodological frameworks to translate rigorous scientific process and the resulting data into understandable measures which are relevant to management and based on the best science available at the moment. This integration would also increase the acceptance and usefulness of the objective and of its associated management action and indicator. It is therefore recommended that attempts be made to combine the two approaches wherever possible. (See Figure 1)

It must also be noted that implicit in the concept of application of indicators for ICOM is the central idea that these indicators should be tied directly to management objectives, regardless of the approach used.

5.4 Methodology

As noted above, regardless of the approach that is followed (top-down or bottom-up), a general conceptual framework of a marine ecosystem is necessary for ICOM managers to use an ecosystem-based management approach. The following sections provide step-by step methodology that can serve to guide the selection of the most appropriate and relevant ecological indicator menus to EBM/ICOM for both the "top-down" (i.e., based on ecosystem properties) and "bottom-up" (i.e., based on activities) approaches.

Step 1 ***Delineate ecological regions as the science foundation to set up the spatial context for implementing the ecosystem-based management***

Ecosystem based management requires implementation on a geographic scale, based on marine ecosystems. Marine ecosystems, however, are complex systems which consist of innumerable components, properties, characteristics and interactions – some of them are not yet even known. In addition, they are nested and interconnected with each other through exchange of matter and energy, and undergo constant adaptation to changing environmental conditions over time. It is therefore very difficult to really define what an ecosystem is, and what it contains, and there is no obvious definition or unique statement to capture this ecological concept. A mix of oceanographic, biological, biophysical, geological, geographical and ecological concepts and parameters can be adapted and used to help guide scientists, managers and policy-makers when they have to look at, cope with, or address environmental issues at "ecosystem scales".

The delineation of marine ecological regions (eco-regions in short) is therefore an essential step before developing any management objectives and *a fortiori* associated metrics like ecological indicators. Eco-region delineation should, in the first instance be a science-based process, based on the best scientific knowledge available, such as large-scale oceanographic features (e.g., main currents, stratified water masses), homogeneous patterns (e.g., sea water temperature or salinity), obvious discontinuities (e.g., breaks in bathymetry, strong gradients or drastic changes in water properties or populations), as well as the biological characteristics and uses of the area by marine life. The delineation process may also involve sub-division into smaller scale management areas which are nested within the science-based eco-regions if natural substructures can be identified within eco-regions.

After the eco-regions have been delineated, other management considerations relevant for ICOM purposes should then be considered and boundaries of the ICOM area finalized (i.e., it is necessary to take account of other important considerations like socio-economic and cultural, historical, traditional use and management zoning in addition to ecological features). The critical point, however, is that adjustments based on socio-economic considerations should maintain the integrity captured within the science-based eco-region.

Once the management areas have been delineated in relation to the eco-regions, it is possible to begin the identification of the ecosystem-based management objectives, and develop relevant ecological indicators.

Step 2 ***Identify which are the critical characteristics of the ecosystem within the management area that define the "health of the ecosystem"***

The concept of ***marine ecosystem health*** is based upon conserving the properties of ecosystems (i.e., structural and functional properties) which should be maintained over time and should not be compromised by human activities. There are three main properties that need to be considered to ensure that the structure, function and overall environmental quality of the ecosystem are well captured:

- The ***organization*** of the ecosystem (such as its biological diversity, species composition of biological assemblages, spatial distribution of species and population, etc.);

- The ***vigor*** of the ecosystem (such as its productivity; trophic structure, predator-prey linkages, food-web interaction, etc.); and

- The ***physical and chemical properties*** of the ecosystem (such as the oceanographic processes, water quality, the habitat and biota quality).

Step 3 ***Develop overall ecosystem-based management goals***

For each of the properties noted above, there is a need to develop goals which provide management direction on the target state required to ensure that that property continues to provide its role in the structure and functioning of the ecosystem. Goals should be first developed at a large spatial scale, and based on ecosystem conditions that operate at that scale.

A limited number of goals will need to be developed to address core ecosystem properties. These goals could be expressed as high-level narrative statements; for example: to cope with maintaining the biodiversity of the marine environment as an aspect relating to the organization of the ecosystem the statement could read:

> "*Conserve enough components – at all levels of biological organization – so as to maintain the overall biodiversity and natural resilience of the marine ecosystem*"

The biological diversity (or biodiversity) has been defined as "the variety of living forms, the ecological roles they perform, and the genetic diversity they contain" (Wilcox, 1984). In the goal statement above, the wording **"**at all levels of biological organization**"** aims at capturing these various aspects that contribute to the overall biodiversity. In accordance with the Convention for the Biological Diversity (CBD) the 1992 Rio's Earth Summit agreed on, when management actions deal with the biodiversity, as an ecosystem property, they have therefore to consider the following components, based on the main organization levels and units for life on Earth:

- Genetic diversity ("within species" diversity, or diversity within populations)
- Species diversity ("between species" diversity, or diversity within communities)
- Ecosystem diversity (diversity of habitats or communities, ecosystem types, etc.)

By setting up this ecosystem-based management goal related to the conservation of marine biodiversity, we ensure that ICOM initiatives will also contribute to CBD overall goal and guiding principles in which an ecosystem approach to management is central to conserving the biodiversity and using biological resources in a sustainable manner.

As far as the three core components of overall biodiversity listed above are concerned, it is worth mentioning that the debate regarding the decline in biodiversity has, to date, essentially focused on the two last elements: the species and ecosystem diversity. Although for years specialists have agreed to say that the loss of genetically distinct populations – the genetic diversity – is at least as important as the loss of entire species – the species diversity. Even if it is not as easy to measure and interpret as the two other types of diversity, the genetic diversity should be considered as am important part of any EBM / ICOM approach to conserve the marine ecosystem and its biodiversity (i.e., set up goal, objectives, and indicators dealing with this aspect).

Similarly, the overall goal developed to address with maintaining the productivity of the marine environment may be expressed as:

> *"Conserve the function of each component of the marine ecosystem so that it can play its natural role in the food web"*

This statement means that activities affecting each component of the ecosystem must be managed in a way as to not cause any other component of the ecosystem to be altered to such an extent that it ceases to play its natural role within the ecosystem. The "natural" role of ecosystem components will have to be defined when this objective is developed and when management actions are taken to meet this objective. The natural role may be based on historical data if they are available and if the historical state (for example before any human activities occurred) is the one that is targeted by management. Alternatively, the reference state as for the natural role of ecosystem components could be a certain period in time, not necessarily very far in the past, when the ecosystem was considered as healthy, based on data and information available.

Finally, the goal to cope with maintaining the quality of the marine environment may be expressed as:

> *"Conserve the geological, physical and chemical properties of the ecosystem so as to maintain the overall marine environmental quality, i.e., water, sediment, biota and habitat quality"*

To ensure that this goal will be met, two different and complementary categories of objectives are needed: the first category has to deal with the natural properties, those properties that are integral parts of the ecosystem and characterize its components, as chemical (e.g. seawater salinity, nutrients and oligo-elements), physical (e.g., temperature, currents, structural habitat features), or geological properties (e.g. nature of bedrock, sediment grain size). These natural properties must be maintained over time, or even improved, because they characterize the targeted (desired) state of the ecosystem.

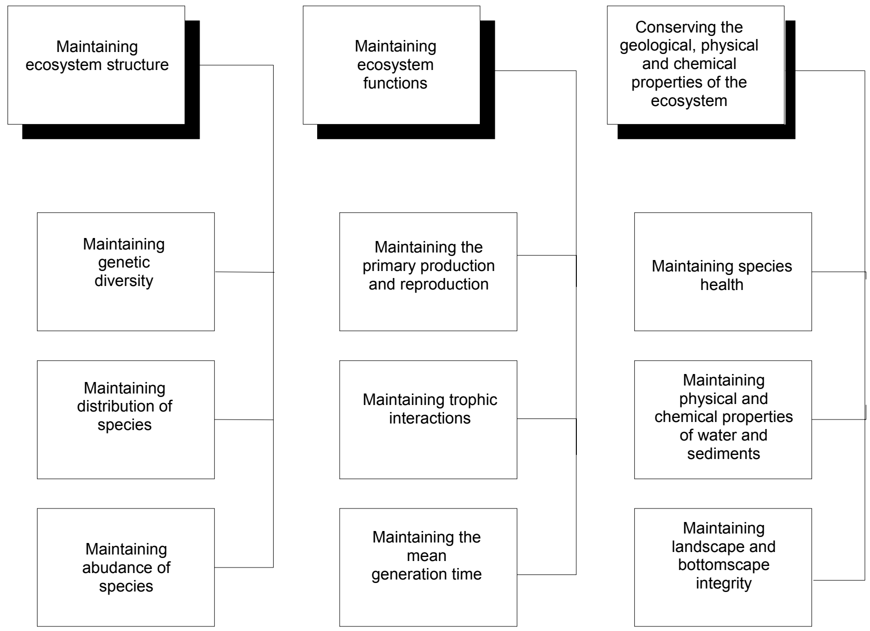

Figure 5-1 Ecological goals and objectives for ICOM

In contrast, the second category of objectives has to consider external elements which are not necessary part of the ecosystem, but are introduced (incidentally or accidentally; directly or indirectly), and then accumulate, into the marine environment. These objectives focus on those physical or chemical elements, such as contaminants, that contribute to the degradation of the overall quality of the environment and ultimately affect marine life. It must be noted that, in certain cases, a natural component of a marine ecosystem may also become a "contaminant" when it is in excess (e.g. trace-metals, nutrients) or a limiting factor when it is depleted by human activities-induced processes (e.g. dissolved oxygen). The natural content of oxygen or nutrients dissolved in the water column is needed to ensure the water quality (first category of objective), but at the same time, additional nutrient inputs must not be added to the water column (second category of objective) to prevent eutrophication, i.e., nutrient loads exceed "natural" level and stimulate an intense growth of certain algal species; then dissolved oxygen is depleted (hypoxia) after a drastic increase in biological oxygen demand due to massive mortalities of organisms.

Step 4: ***Refine these overall goal statements by developing specific ecosystem-based management objectives***

From the three overall goals identified, more details and specificity should be provided via the determination of specific objectives to better guide the management actions needed to maintain the target property. These ecosystem-based management objectives should deal with each of the overriding ecosystem properties. Examples of specific objectives are given in Figure 1.

These high-level (conceptual) objectives must be refined to be truly operational, i.e., used to ensure the effectiveness of the management actions. The process of breaking down conceptual EBM objectives into terms of increasing specificity ("unpacking" process) should continue until EBM objectives can be expressed in operational terms, i.e., as narrative and quantitative statement with indicator and associated reference points (limits and targets).

Step 5: ***Select indicators best able to track ecosystem properties reflected in EBM objectives***

Once objectives have been established and formulated with enough precision to deal with a property of the ecosystem that can be easily measured and monitored, selection of appropriate ecological indicators can proceed. If the objective is specific enough, usually one specific indicator can be used to monitor this objective. On the other hand, several specific indicators can serve to monitor a high level objective (i.e., general statement without sufficient specificity). The final choice of the most relevant indicator will be done after the objectives are refined, i.e. when operational objectives are developed, based on the regional ICOM context. At this time, a specific indicator may be likely selected from the proposed group of indicators, as the most pertinent for the give operational objective.

5.5 General considerations on the use of indicators

This section provides linkages between the scientific rationale (i.e., environmental issue), the significance of ecological indicators and their potential application for ICOM purposes. There are also several general considerations for each of the main elements of the ecosystem classification system described earlier (i.e., structure, vigor, physical and chemical properties) that should be considered in developing and using indicators, as follows.

Organization: maintaining the living structure of coastal/marine waters

Anthropogenic stress usually results in decrease of the overall biodiversity (e.g. species diversity decreases, as well as the size spectrum of organisms) and in increasing dominance of some species and/or communities (most of the time, they are highly reproductive species, i.e., with shorter life cycle). Introduction of invasive species (or exotic) and their prevalence will add to the stress on ecosystem biodiversity (e.g., increasing number of invasive species, extension of invaded areas, loss or moving of native species, modification of the natural environment). Each of these trends are actually measurable by means of relatively simple biodiversity indices (e.g. species richness, relative abundance or dominance of species) and are of particular importance to management since they may signal that the ability of the ecosystem to maintain a steady state over time has been broken down, i.e., its natural resilience may be affected with important consequences in sustainability of coastal/marine resources.

The real challenge from a management perspective is to strive to distinguish between the natural variability of the ecosystems (in both biodiversity and productivity) and anthropogenic sources of stress that cause significant impacts at the ecosystem level. In some cases, like nutrient enrichment of coastal /enclosed areas and the subsequent eutrophication with increase in micro algal blooms and biodegradation processes leading to hypoxia/anoxia in certain areas, it may be easy to link and correlate human activities to the observed state and/or impacts on water quality, biodiversity and/or productivity, through the use of indicators like nutrient concentrations (nitrates/nitrites, phosphates and ammonium), dissolved oxygen levels (or biological oxygen demand), occurrence and frequency of algal blooms (incl. harmful micro algae and biotoxins monitoring), etc. In other cases, however, it is not so easy to show good correlations because there may be multiple sources of impacts – particularly when biodiversity changes are the primarily focus.

Maintaining the vigor of marine ecosystems

Primary productivity is, of course, of great importance for assessing the ecosystem health and is usually an integral measurement of marine environmental quality monitoring programs. Given the ecosystem health problems resulting from excessive or depleted primary production, concerns have been expressed about the quantities (amount and rates of production) and quality (e.g., species composition of algal communities) of the primary productivity entering marine ecosystems. Excessive production is usually due to the presence of excessive nutrients loads (eutrophication), while depleted primary production may be due to various causes like presence of contaminants, increase in turbidity (diminished solar light, or increase in suspended particles), excessive grazing by higher trophic organisms (zooplankton, herbivorous and filter-feeding organisms, etc). For phytoplankton, chlorophyll-a is a good proxy for measuring the micro algal biomass available to higher trophic levels. As new technologies such as satellite imagery make progress and remote sensing data are made more broadly available and are included in monitoring programs, it will be increasingly possible to develop real-time pictures of the extent of chlorophyll -a in surface waters.

It is noticeable that good correlations usually exist between chlorophyll-a contents and the availability of nutrients, and also between the occurrence of phytoplanktonic blooms (measured by chlorophyll-a maximum peaks) and depletion in oxygen (dissolved oxygen concentrations or % saturation level) after microbial growth and biodegradation process are stimulated by large amount of organic matter available, coming from *in-situ* production or from inputs from land (e.g., river plumes, sewage, etc.). Such direct relationships may be used to monitor areas of concerns and address eutrophication-related problems, and the development and use of hydrodynamic models to calculate nutrient budgets, transport and dilution and predict effects on primary production is needed to better interpret data from phytoplankton monitoring and results from such correlations.

From a management perspective, specific objectives for primary production as such would be of limited value, since the phytoplankton components and attributes (species composition, biomass, and production rate) are not to be directly managed; however, they may be strongly influenced by management of human activities that have impacts on this ecosystem component.

As for higher trophic levels, the overall productivity of oceans has been essentially reported (to date) from a fishery perspective. Specific indicators, however, can be developed from research and models or based on commercial fish landings data, and also may be used in an ecosystem approach to fisheries management.

Monitoring and assessing the variability of natural physical (oceanographic) processes and properties

Oceanographic processes and properties (geological, physical and chemical) are the necessary variables that sustain the basic understanding of the structure, function and environmental quality of marine ecosystems. However, use of indicators to track oceanographic characteristics must be consider the fact that these characteristics are highly variable, both in space (e.g. major three-dimensional discontinuities exist in the marine environment) and time (regime shifts with various cycles). If these basic oceanographic measurements are included in monitoring programs, it is particularly important from a management perspective, that they be re-visited and interpreted with emphasis on natural variability.

Regime shifts and subsequent changes in biotic communities (including adaptation to environmental changes) however can be good indicators of deep transformations that have occurred within ecosystems under stress. On the other hand, they may also reflect long-term variability cycles and it may not be always possible to correctly interpret a regime shift based only on anthropogenic impacts. This is complex because a shift which is suddenly observed may be actually due to the consequence of long-term exposure to some chronic perturbations.

Monitoring and assessing the chemical properties of the ecosystem to minimize the introduction of contaminants and maintain water, sediment, biota and habitat quality

Monitoring major groups of contaminants (persistent organic pollutants, hydrocarbons, heavy metals) dispersed/dissolved into the water column and/or accumulated into surface sediments would provide a good measure of the extent of the anthropogenic pressure on the study marine environment. In addition, monitoring the bioaccumulation of toxic chemicals into the biota, and particularly into some key groups and indicator species at the top of food web (e.g. fish, birds and eggs, marine mammals as well as humans) would provide a good indication on cumulative impacts and the degree of exposure of marine organisms as well as local coastal populations. In this respect, it would be very informative to measure body burdens of representative contaminants into some indicator species. If these indicator species include commercial species (fish, shellfish) and species targeted by local recreational fishermen, such measurements could be used to make linkages to human health of local/coastal populations. Efforts therefore should be focused on tracking the levels of bio-accumulating substances.

In addition, even if they are not routinely included in monitoring programs, it is worth noting the usefulness of other eco-toxicological tools such as biomarkers which are based on the study of physiological processes and their responses to the presence of harmful substances in organisms, in target organs, tissues or cells. These biomarkers may serve as early warning signals in relation to global contamination issues. Also of interest in marine environmental quality assessments are the use of toxicity bio-tests (Wells, 1999) as tools to complement monitoring programs. These measures can be used to assess "danger" thresholds and serve as "alarm" signals, to set standards or guidelines and refine reference points associated to ecological indicators in management objectives.

Avoiding habitat loss or degradation to conserve coastal landscape/bottomscape integrity and habitat quality

In most of the cases, the habitat loss is assessed by a direct measure or approximation of the coverage of natural habitats and by tracking changes over time. The relative coverage of protected habitats is also commonly reported and it may serve to measure and report on the effectiveness of management. Degradation of habitat is much more complex to evaluate since various degree of degradation may be observed, from slightly altered to entirely lost. Actually, the habitat quality seems to be better covered by series of indicators that may be already used to monitor and assess other ecosystem components or properties or used to address other issues; e.g. biodiversity of benthic communities, productivity of key benthic species, physical or chemical properties of water column, geological properties of sediment, presence of contaminants in water, sediment or biota, etc.

As far as coastal landscape integrity is concerned, the record of coastal erosion, sediment transport, and change in coastal landscape diversity may be useful measures, for example to address coastal/urban development, development of marinas and harbors, building of coastal defense, etc. Coastal human population is another useful common indicator, actually not to directly assess impacts but the human pressure on coasts and fragile coastal ecosystems, giving a good example of indicator for linking both, the ecology and socio-economic aspects of ICOM.

Coping with global warming and climate change impacts

Global warming and climate change have impacts at the global-scale and *a fortiori* at the ecosystem scale by interfering with or breaking down natural processes, and potentially could cause irreversible changes. A number of ecological indicators may be used to track effects of climate change on marine ecosystems – mainly coastal – over time; e.g. sea level rise, increase in frequency and extent of violent climatic events like storms, hurricanes and coastal flooding,, decrease in ice coverage and ice period in high latitudes, etc. This task, however, will become very challenging because this is a global environmental issue, and management actions taken at regional, and even national scale would have little influence on the ecosystem response to climate change and its cumulative impacts, and results of management actions – even those taken at the global scale – will not be observed before a long period of time.

We can however assume that marine ecosystems, at least the ones in healthy condition, can to a certain extend adapt to this long term change. What is unknown is whether and how long the ecosystem will maintain a steady state and when it will shifts to an alternative state in response to stress from climate change. It is very difficult – and perhaps not possible – to predict the resilience of the ecosystem, i.e., the metric (amplitude, duration) of the response of the ecosystem to a specific perturbation or cumulative impacts. Nevertheless, climate change models would be useful to predict impacts on ecosystem under various scenarios, and likewise remote sensing data and new monitoring technologies will become useful ICOM tools as they are refined (regional-scale models) and their results are made available to all the scientific community, including in countries where a strong science support does not yet exist.

The use of ecological indices

Finally, in an effort to integrate, it is possible to develop a few indices, in addition to, or derived from a selection of ICOM indicators. The intent of an index is to aggregate scientific information, using validated calculations and formulae, which enable the information available from a certain number of variables or indicators to be integrated. This is done in order to handle and simply communicate a large amount of information on a complex (emerging) property of the ecosystem. Like single indicators, indices are numerical values which can be suitable for monitoring objectives and further guiding management actions, provided the index is properly designed and its ecological significance is well understood and interpreted by managers (Rice, 2002).

The usefulness of ecological indices may be reinforced when practitioners face a great number of indicators, each of them individually addressing an ecosystem property or component of interest and which individually, monitor specific ecosystem features and/or functions. An ecological index should be calculated from a cluster of indicators which taken together monitor the key ecosystem features and functions of importance for the emerging property to be quantified and tracked over time.

In this respect, thematic indices are useful to report on the state of ecosystems as they relate to ecosystem properties or impacts on ecosystem components. For example, a biodiversity index such as the Index of Biotic Integrity (Karr, 1981) has been used worldwide to assess the aquatic environmental quality based on fish biodiversity measurements. An example of an index which relates to the impacts on ecosystem components could be the environmental quality index recently proposed by Marvin et al., (2004) to numerically assess and score the sediment quality. This index integrates contaminant concentrations, the extent and levels of contaminated areas, and the meeting/failure of national or provincial sediment guidelines already in place to regulate contaminants in sediments.

5.6 Conclusion

Several constraints, including financial one, may limit or influence the science activities associated with ICOM, such as the design of the monitoring plans, selection of sampling equipment, "at sea" facilities, data interpretation and management. ICOM practitioners therefore need to select from the proposed list of indicators, those indicators that are the most appropriate and that can be implemented within the specific ICOM context of the given region.

The aim is to develop an indicator menu specifically tailored to the regional/national constraints and issues, while taking into consideration characteristics of "good" ecological indicators, the most pertinent approach (Top-down *versus* Bottom-up), as well as the scientific rationale and ecological significance behind the selected indicators.

Table 5-2 Major human activities and associated stressors, potential impacts on ecosystem properties and environmental issues associated with

DRIVERS *Uses of the Marine Environment*	PRESSURES *Human Activities of Concern*	STRESSORS *(incl. main sources, processes and pathways)*	ISSUES *Threats and impacts on ecosystem properties*
Land-based activities	Agriculture, forestry Chemical and fish processing plants Hydro-electricity (i.e., upstream dams)	→ Nutrients and contaminants inputs (e.g. pesticides) → Untreated or partially treated industrial sewage may cause an organic enrichment in waters and surface sediments; introduce toxic chemicals which degrade very slowly and bioaccumulate in biota and food web. → Changes in freshwater flows influencing coastal areas (estuaries, bays, etc.)	**=** Eutrophication of coastal waters (i.e., natural nutrient level exceeded) **=** Hypoxia**:** increase in BOD may cause direct mortalities and/or affect the biological components (**biodiversity and productivity**) and the overall **marine environmental quality**. **=** Pollution of coastal waters by organics and contaminants may affect the overall **marine environmental quality** **=** Regime shifts may affect key **physical properties** like salinity, local currents, or suspended materials, in turn influencing the **biodiversity** (species distribution) and **productivity** (biomass) of impacted areas.
Harvesting of biological renewable resources	Fishing Aquaculture (fish and shellfish)	→ Direct result of fishing is the removal of a significant part of the biomass otherwise available to the rest of the food web. When/where not properly managed (e.g. overfishing) extensive fishing results in fish stock depletion. → Commercial fishing also harvests non target species (reducing biomass available for higher trophic levels) and usually discards fish and fisheries wastes. → Fishing of forage species (e.g. industrial fisheries) removes a significant portion of fish biomass, otherwise available for predators and higher trophic levels → Bottom disturbance may be due to physical-chemical changes (e.g. organic enrichment under aquaculture facilities, smothering of sediment) or physical disturbance (e.g. bottom trawling)	**=** Overfishing has direct impacts on **productivity** of marine ecosystems, as well as on **trophic structure** and **food web** (e.g. unbalanced prey-predators relationships) **=** Incidental catches (by-catch issue) may have direct impact on **productivity** (fish) or **individuals** (marine mammals) of non target species or populations, incl. species at risk. = Fisheries discards contribute to pollute (addition of organic matter) the marine environment and locally affect the **seawater quality**. **=** May affect the **productivity** and **trophic structure** (e.g. change in composition of higher trophic levels and species dependent on these forage species, in predator-prey relationships) **= Habitat quality** is degraded (locally) by drastic changes in **physical and chemical properties of water and sediments** with consequences on local biota and ecosystem properties, **biodiversity and productivity** of impacted areas.

DRIVERS *Uses of the Marine Environment*	*PRESSURES* *Human Activities of Concern*	*STRESSORS* *(incl. main sources, processes and pathways)*	*ISSUES* *Threats and impacts on ecosystem properties*
	Marine mammals and waterfowl hunting Plant harvesting Bio-prospecting (i.e., research for new pharmaceutics)	→ A great variety of toxics from aquaculture (biocides and therapeutants and fishing (e.g. fuel, TBT) may be introduced in the marine (coastal) environment. → Disease vectors may be introduced or relayed by aquaculture → Wild population genetics can be widely affected by escapees from aquaculture facilities at sea. → Selective hunting can lead to threaten targeted species if not properly managed. → Removing a significant portion of the biomass of key species which have a structural and functional role in the ecosystem (e.g. *Fucus*, *Laminaria*) can lead to unbalance the benthic community. → The activity of harvesting can also disturb the upper portion of benthic habitats. → Bio-prospecting targets (harvests) specific individuals or populations	= Contaminants: Increasing levels of contaminants locally; therapeutants may also affect wild species with unknown impacts on **biodiversity**. = **Marine environmental quality** (Ecosystem health issue), and human health ultimately can be affected by marine diseases. = **Biodiversity (genetic diversity)** and health of wild populations may be impacted, = **Biodiversity** may be threatened (e.g. loss of species) if this activity is not properly managed or regulated = **Productivity** of the coastal environment may be affected, as well as physical habitat features. **=** Overall **productivity** and **trophic structure** of the ecosystem may be affected. **= Habitat degradation** (very local; affecting mainly the intertidal zone and upper) **=** Change in **biodiversity (genetic and species diversity)** overt time; may be a species at risk issue = Potential threat on **biodiversity**.
Extraction of non-renewable resources	Oil & Gas activities (incl., exploration, exploitation and decommissioning phases)	→ Oil spills: immediate and drastic impacts are due to physical effects on coastal habitats and communities, mainly benthos and seabirds (i.e., huge amounts of oil released within a very short period of time); whereas there are also delayed /chronic impacts due to chemical effects of toxic compounds like PAHs → Release of a great variety of contaminants (hydrocarbons, lubricants, metals, etc.) into the water column and surface sediments (locally) directly from the seafloor (oil seeps, waste and production waters).	= Acute effects: Ecosystem properties like **productivity, biodiversity and environmental quality** are impacted more or less (effects are located within the oiled area and may last from weeks to years, depending on the affected species) = Contaminants levels increase in areas around facilities and wells; **chemical properties** and **water and sediment and quality** are locally affected = Changes in **sediment properties** affect the **benthic habitat**

DRIVERS *Uses of the Marine Environment*	*PRESSURES* *Human Activities of Concern*	*STRESSORS* *(incl. main sources, processes and pathways)*	*ISSUES* *Threats and impacts on ecosystem properties*
	Mineral extraction, mining	→ Produced mud change the nature of sediment (e.g. smothering) around facilities → Physical disturbance of bottom (locally) by mineral extraction and mining activities, as well as oil & gas facilities, platforms, wells, etc. → Mineral extraction, mining, etc. may lead to an increase in suspended sediment and reduce the light availability (locally)	**quality**, in turn reducing the **biodiversity** of the impacted area = The bottom disturbance (locally) may lead to habitat loss and fragmentation = **Primary productivity** is likely affected locally
Transportation and communications *(i.e., corridor-based uses)*	Shipping (incl., cruise ships and ferries) Harbours and shipyards facilities Channel maintenance and dredging Cables and pipelines	→ Introduction of exotic species (alien invasive species) from ballast waters exchange → Sewage and wastewaters released from ships, mainly cruise ships (as little towns moving in pristine environments) → marine mammal harassment → Releases of contaminants (e.g. paints, solvents, TBT, oil spills, most of the time minor but continous) → Result in bottom disturbance (locally) and increase in suspended matter and turbidity (around) → physical disturbance of the bottom	= **Biodiversity** is affected by exotic species: Changes are expected in the **composition of communities** and **trophic structure;** **= Marine environmental quality** is likely affected in visited areas **=** May be important factor for species at risk **=** Affect the **water column and sediments quality** around **=** Lead to habitat fragmentation and loss of **coastal seascape integrity** **=** Turbidity may lead to reduce the **primary productivity** locally (and temporarily) = Habitat fragmentation
Public use of coastal environment *(i.e., coastal populations and recreational activities)*	Coastal development (e.g. marinas, coastal defense infrastructures, tourism, coastal cities and urban sprawl, roads and access to littoral) Municipal sewage	→ May lead to disturbance, degradation or loss of coastal habitats (incl., fragile, sensitive or critical habitats). \ → Increase in suspended sediments and turbidity (locally) → Untreated or partially treated sewage may lead to exceed safe levels of bacteria (coliforms),	= Habitat fragmentation, or habitats loss = Decrease in **ecosystem diversity**, **productivity and environmental quality** **=** Loss of **coastal landscapes integrity** **=** Decrease in **primary productivity** and indirect impacts on **higher trophic levels** = Introduction of various types of pollutants may have cumulative impacts (and even synergistic effects) on local **biota** and the overall **marine environmental quality** in relation

<u>DRIVERS</u> *Uses of the Marine Environment*	<u>PRESSURES</u> *Human Activities of Concern*	<u>STRESSORS</u> *(incl. main sources, processes and pathways)*	<u>ISSUES</u> *Threats and impacts on ecosystem properties*
		pathogens, and disease vectors in coastal waters, in addition to the release of high loads of organic matter and contaminants	with environmental issues like the <u>seafood quality</u>, <u>harmful algal blooms (HABs)</u>, <u>marine diseases,</u> and associated <u>threats on human health.</u>
	Recreational fishing and snorkeling Eco-tourism (e.g. access to marine protected areas/coastal parks, educational activities and wildlife observation), boating, kayaking, scuba-diving, etc.	→ Selective harvest of species may affect the biomass of targeted species or populations; and possible harassment of targeted species and individuals → Harassment of marine wildlife; pressures on fragile (coastal) ecosystems → Release of waste, debris, etc.	= The **productivity** of the ecosystem may be affected. = <u>Species/populations at risk</u> or their **critical habitat** may be affected. = Threatening the most sensitive/exposed species: this may be an important factor in relation to **biodiversity** and <u>species at risk issue</u>. = The **habitat quality**, incl. the **shoreline integrity**, may be affected.
Others sea-based activities	Energy production (wind power, tides, etc.) Supporting activities: e.g. Research and monitoring, research & rescue, surveillance and enforcement, ice-breaking, defense, etc. Ocean dumping	→ Harassment of marine wildlife (migratory species like fish, seabirds or marine mammals are particularly vulnerable. → Harassment of marine wildlife by ship traffic, noise, sampling, etc. e.g. repetitive activities within limited areas. → Release of toxic substances or materials in deep-sea environments; increase the level of toxic compounds in pristine environments	= <u>Species/populations at risk</u> may be affected. = Loss of coastal **landscapes/seascapes integrity** **=** Additional pressures, i.e. <u>cumulative impacts</u> on fragile and/or unique ecosystems, coastal and offshore (e.g. mangroves, hydrothermal vents, coral reefs) **=** <u>Pollution</u>**: Chemical properties of seawater and sediment** may be affected.
"Locally non controllable"[1] driving forces	Global warming and climate change Ozone hole and UV	→ Direct impacts are the sea level rise (which in turn can lead to more frequent flooding of coastal environment in estuaries and islands, accelerate erosion with an increase in turbidity, etc.; change in water temperature and regime shifts. → Change in UV spectrum available in surface waters	= Significant portions of **coastal habitat may be lost or degraded,** in turn affecting the **biodiversity and productivity** of the coastal ecosystem = Decrease in **water and habitat quality** = Impact o the **landscapes integrity** = **Primary productivity** may be directly affected at large

[1] That means pressures and stressors are not under direct control of management actions undertaken within a regional-scale ICOM initiative.

DRIVERS *Uses of the Marine Environment*	*PRESSURES* *Human Activities of Concern*	*STRESSORS* *(incl. main sources, processes and pathways)*	*ISSUES* *Threats and impacts on ecosystem properties*
	radiation Long-range transport of pollutants	can affect primarily plankton organisms, mainly micro algae which need specific wavelengths to develop and are sensitive to other (damageable) ones. → Introduction of a great variety of contaminants in specific areas far away from sources (incl. remote areas)	scales, with direct consequences on secondary and **higher trophic levels** and **trophic structure. Biodiversity** may be also affected. Pollution of large scale marine areas; very difficult to go back to sources and know contaminants pathways and processes; **seawater, sediment and biota quality** (e.g. bioaccumulation in food web up to humans; human health issue) can be affected.

Figure 5-2 A general framework to combine the "Top-down" (i.e., based on ecosystem properties) and "Bottom-up" (i.e., based on impacting activities) approaches when selecting ecological indicators and indicators suite to ICOM

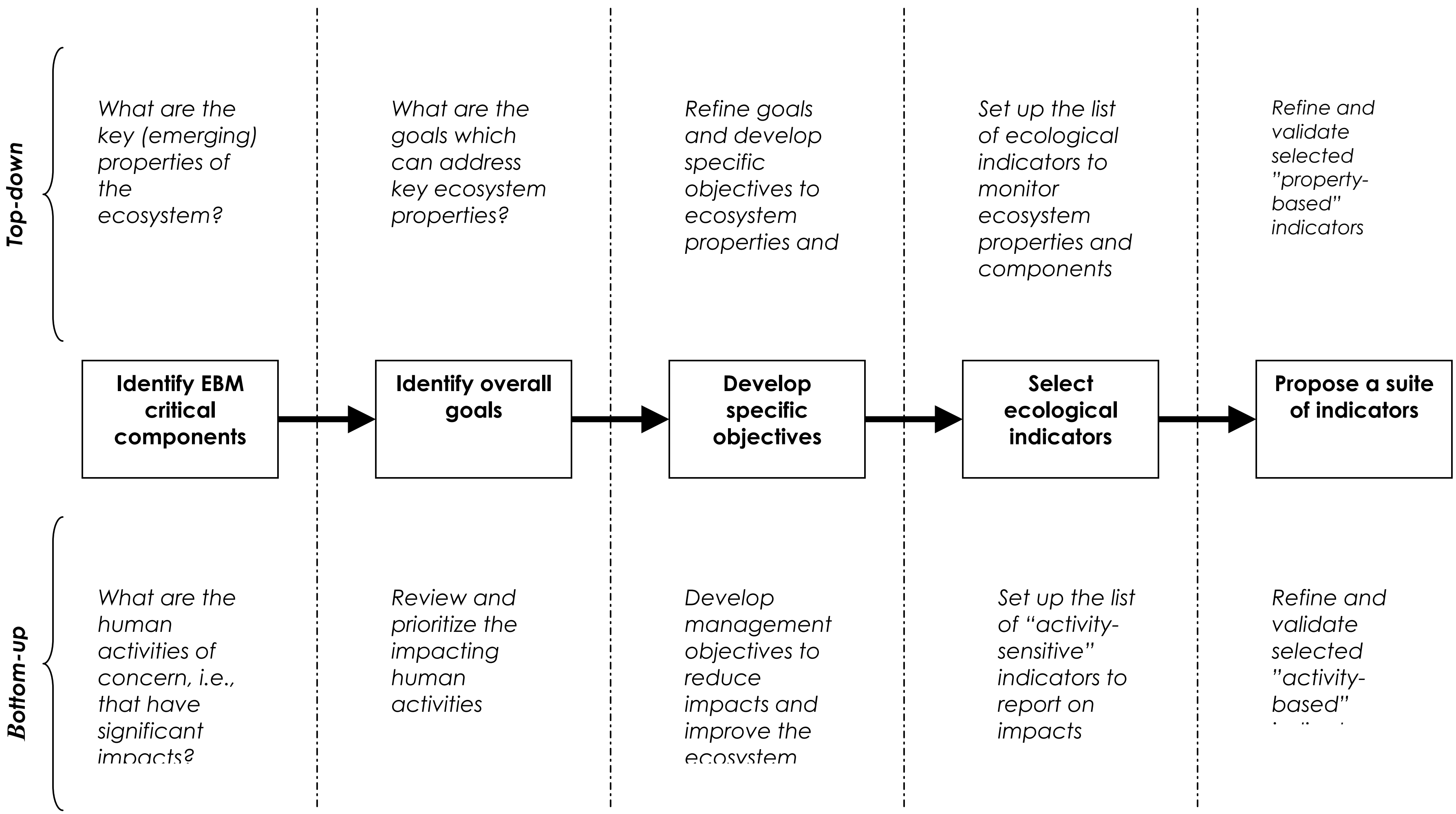

Table 5-2 Detailed list of ecological indicators

Goal	Objective	Indicator (and parameters)
Maintaining ecosystem health	**Organization**: *Maintaining ecosystem structure*	**E.1 Diversity** - Diversity of communities - Diversity of populations - Diversity of species - Genetic diversity - Invasive species/pests
		E.2 Distribution - Horizontal distribution (patchiness, aggregation) - Vertical distribution (food web/trophic structure)
		E.3 Abundance - Biomass (key populations) - Number of individuals (marine mammals) - Density (plants, benthic org.)
	Vigor: *Maintaining ecosystem function*	**E.4 Production and reproduction** - Primary productivity: quantity (biomass) and quality (e.g. Harmful algal blooms) - Secondary productivity - Life-stage history - Reproductive parameters - Spawning survival rates (survivorship) - Mean generation time (longevity)
		E.5 Trophic interactions - Complexity of food web - Key predator/prey interactions - Keystone species - Size spectra
		E.6 Mortality - Fishing mortality - Incidental mortalities (by-catch) - Natural mortality (predation)
	Quality: *Maintaining physical and chemical properties*	**E.7 Species health** - Species at-risk of extinction - (Bio)accumulation of toxic compounds - Diseases and abnormalities - Seafood quality
		E.8 Water quality - Water column properties - Oceanographic processes & variability (and regime shifts) - Sedimentation (e.g. Transport of suspended sediments) - Pollutants and contaminants - Eutrophication parameters
		E.9 Habitat quality - Habitat types - Habitat alteration - Sea level change - Landscape and bottomscape integrity - Sediment quality (nature/properties of sediments)

5.7 Detailed description of ecological indicators

E.1	Biological diversity

Nature of indicator

Definition
The biological diversity (or biodiversity) is the variability among living organisms from all sources, including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes the genetic diversity, species diversity, and diversity of ecosystems.

Unit of measurement
Biological data at the species level (i.e., individuals and populations), community level (e.g. biological assemblages of several species and taxonomic groups), as well as sub-species level (cellular measurements).

Relevance

Purpose
Biodiversity is a key component of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the organization of the ecosystem. This assessment is needed to make sure that the management objective of maintaining the ecosystem structure is met.

International conventions, agreements and targets
- Convention on Biological Diversity (CBD) – United Nations Environment Program (UNEP, 1992); and:
- CBD Jakarta Mandate on Marine and Coastal Biodiversity (CBD-COP, 1995)

Methodological description

Underlying definitions and concepts
Genetic and species diversity. The genetic diversity is the "within species" diversity whereas the species diversity is the diversity between species. Although true genetic diversity measurements (e.g., genetic markers like DNA) are fundamental in aquaculture R&D (e.g. breeding strains for best marketable products) as well as in discriminating commercial populations for fisheries management purposes (Waples *et al.,* 2001; McPherson *et al.,* 2001), most of biodiversity indices which are routinely used to monitor the marine biodiversity relate to the species diversity (Costello *et al.,* 2004).

Ecosystem diversity. The CBD has provided the following definition of an ecosystem: a dynamic complex of plants, animal and micro-organism communities and their non-living environment interacting as a functional unit. The ecosystem diversity may be therefore define as the degree of variety of attributes that may characterize an ecosystem; these attributes are based on the geology (e.g. bathymetry, bottomscapes features, nature of sediments), biology (species composition, variety of communities, high productivity or biodiversity), ecology (e.g. habitat types, functional areas) or physical oceanography properties (e.g. water masses, mixing or stratification areas, physical-chemical properties of the water column).

Invasive alien species**.** The biological diversity may be also greatly affected by the introduction and widespread of non native invasive alien species (exotic species) and pest species. They can lead to significant changes in the ecosystem structure and function (see also: Indicators E.4 and E.5): e.g. can affect trophic structure, species size spectrum, and some native species may disappear (see: E.7). Within the broad context of an ecosystem approach to ICOM, the monitoring and reporting on invasive species should be considered as an integral part of the assessment of threats on the overall biodiversity within the ecosystem.

Measurement approaches
There are five categories of measurements related to the biodiversity indicator:
- Diversity of communities
- Diversity of populations
- Diversity of species
- Genetic diversity
- Invasive species and pests

Limitations of the indicator

Most of biodiversity measurements are for measuring the species diversity. Comparatively, very few 'indicators' have been developed and tested for assessing the two other aspects of the biodiversity, i.e., at gene and ecosystem levels. Although the ecosystem diversity may be captured by the number and diversity of habitat types and features, biological communities, as well as the variety of physical oceanographic attributes that characterized an ecosystem, it's unlikely that monitoring only higher levels of biodiversity (species and ecosystem levels) can adequately assess the genetic diversity, and so a complete biodiversity reporting and assessment framework ideally should also include indicators like genetic markers to actually report and assess on the overall condition of the biological diversity (Australia's Department of the Environment, 1998). However, these types of measurements require a strong science support and sophisticated/costly equipments which are not available everywhere.

State of the methodology

See the review of Costello *et al.,* (2004)

Alternative definitions

Assessment of data

Data needed to compile the indicator

To make biodiversity measurements as informative and reliable as possible, all key components of the ecosystem should be considered i.e., main taxonomic groups in pelagic and benthic domains like plants, algae, plankton, invertebrates, fish, reptiles, sharks, marine mammals, sea birds, etc. and living in various types of habitats (see: Indicator E.8).

Measuring the genetic diversity for ICOM purposes will not necessarily require costly genetic analysis *per se* (like genetic markers and DNA analyses) because phenotypic measurements (i.e., based on morphological and physiological attributes, most of them are visible attributes) actually result from both, the environmental interactions and genetic influence, reflecting life history traits, and therefore can be considered as acceptable proxies for assessing the "within species" diversity in the marine environment (Costello *et al.,* 2004). On the other hand, measuring the diversity of species is to count the number of individuals or the relative abundance of species within a given community (or any other sampled reference unit). The species richness and the species dominance are the simplest, most useful and also most widely used indices of diversity (Costello *et al.,* 2004). Very simple measurements like the presence/absence, dominance (or the opposite, evenness or rarity) of an indigenous species in a given area may be considered as the very first indication of the species diversity.

As far as the ecosystem diversity is concerned, it's noteworthy that most of the ecosystem-level attributes and properties will be covered by the other ecological indicators proposed in this suite of indicators to ICOM. In the management context, these attributes may be also used as criteria for the delineation of ecological regions, the spatial framework and science-based foundation, for further implementing an ecosystem-based management (Powles *et al.,* 2004).

Data sources and collection methods

Data will be compiled from species inventories, series of samplings, monitoring programs, etc. The focus should be put on species of interest (that may include alien species) and of ecological importance (keystone species), species at risk, fragile or sensitive species, species exposed to a specific threat, commercial stocks. Etc. The various measurements of species diversity should be monitored over time to allow the comparison with reference sites and assessments of changes in biodiversity.

As soon as invasive species are detected within the management area, a systematic monitoring is needed to assess their extent and inform managers and stakeholders that further must take appropriate management actions (i.e., preventing or reducing the extent, protecting the most sensitive areas) and/or adapt the integrated management accordingly. However, the monitoring of invasive species, mainly for early warning purposes, presupposes that the indigenous flora and fauna are enough known in the management area, i.e., an extensive species inventory may have been previously conducted or observations based on local and traditional ecological knowledge (e.g. from coastal communities, fishermen, etc.) may have been compiled and served as reference data. Then, a systematic tracking of the most frequently reported invasive species worldwide, supported by a literature review and knowledge about the main vectors and optimum ecological conditions for those species (in parallel with Indicators E.8 and E.9), can help address this issue.

Analysis and interpretation of data
In a context of environmental changes, we can predict that populations with greater genetic diversity may likely be the most adaptable to changing environmental conditions mainly when/where changes are increasing (e.g. climate change, contaminated areas). In contrast, populations isolated by human activities (e.g. over-fishing, habitat loss) may face a higher risk of extinction because they are less adaptable and resilient. So it's of fundamental importance to develop and use genetic diversity indicators within ICOM so that managers know if the objective and overall goal of maintaining the natural resilience of the ecosystem are well met.

When biodiversity indicators are to be used for management purposes (i.e., used by non-experts to monitor, assess and track changes in biodiversity), graphical methods may be very useful approaches to complement basic measurements; the most popular approach is the plotting of species abundance curves (e.g. the so-called 'k-dominance' curve). The comparison of these curves between sampling sites or at the same site over time may be of great interest for assessing a change in biodiversity, either natural or caused by human activities.

Measuring the ecosystem diversity (i.e., within and between ecosystems) actually implies that a large variety of attributes and properties has to be taken into consideration at the ecosystem level. In the ICOM context, this type of measurement is likely one of the best approaches to come up with a truly integrating assessment of the structure and function of the marine ecosystem as a whole.

Measurements of invasive species can be simply as early warning signals (e.g. presence/absence of invasive species in a given area), may indicate how important is the threat (e.g. number, diversity and life history of invasive species), or may be used to assess the spatial extent (e.g. number and coverage of areas colonized by invasive species). In addition, changes in these parameters over time are very informative to assess current trends and predict future impacts on/within the threatened communities or ecosystem. In ICOM plans, it's fundamental therefore to have at least an "early warning" indicator for signaling invasive species introduction and be able to warn stakeholders and oceans users about this threat on biodiversity. The role of management is particularly crucial when it's to manage the harvesting of living resources which are suspected to be impacted by invasive species.

Reporting scale and output
The biodiversity is actually an emerging property of the ecosystem, i.e., a property that emerges at the ecosystem level and plays a key role in the structure and resilience of the ecosystem (Costanza et al., 1998). It must be therefore reported at scale as large as possible (that is: the management area or larger when it's possible).

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (e.g. species inventories), figures and graphs (statistics on species, trends), maps (species distribution). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator

- Australia's Department of the Environment. (See for example the report cited in the text)
- Census of Marine Life (CoML)
- Global Ocean Observing System – Coastal Oceans Observation Panel (GOOS-COOP)
- H. John Heinz III Center. See for example the report entitled: – *The State of the Nation's Ecosystems* / Coasts and Oceans chapter (2002)
- International Council for the Exploration of the Seas (ICES). See for example the proposed framework for monitoring the status of ecosystem components. ICES Advisory Committee on Ecosystems 2004 Report.
- Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP). See for example the following reports: *A Sea of Troubles (2001)* by GESAMP and Advisory Committee on Protection of the Sea, IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP, Reports and Studies No. 70, 35 p; *Biological indicators and their use in the measurement of the condition of the marine environment* (GESAMP Report No. 55, 1995); *The state of the marine environment* (GESAMP Report no.39, 1990).
- OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic. See for example the OSPAR Quality Status Reports (QSR) series.

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Internet links

Census of Marine Life:
Commission for the Protection of the Marine Environment of the North-East Atlantic (OSPAR):
Convention on Biological Diversity:
International Council for the Exploration of the Seas:
Global Ocean Observing System:

E.2 Distribution of species

Nature of indicator

Definition
Distribution of species may refre to both, the spatial extent and trophic level of the species. In the three dimensional marine environment, the spatial extent includes both the horizontal (distance) and vertical (depth) distributions. The trophic level of the species may be considered as the "vertical" place of the species within the marine food web.

Unit of measurement
Biological data at the species, population and community levels

Relevance

Purpose
Species distribution is a key component of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the organization of the ecosystem. This assessment is needed to make sure that the management objective of maintaining the ecosystem structure is met.

International conventions, agreements and targets
- FAO Code of Conduct (1995)
- Reykjavick Declaration on Responsible Fisheries (2001)

Methodological description

Underlying definitions and concepts
This indicator is based on the over-arching concept of species as the fundamental unit of life (CBD, 1992). The concept of species is then used (i.e., species are quantified) on two key dimensions: the spatial scale (spatial distribution of species in the marine environment) and interrelations between species.

Measurement approaches
There are two categories of measurements related to this indicator:
- Horizontal distribution of species (i.e., patchiness, aggregation)
- Vertical distribution (trophic level) of species (i.e., within the food web)

Limitations of the indicator
Up to date, the development and use of this indicator has been made essentially within the context of fisheries management, to report on the status and ecology of commercial species (e.g. fish stock assessments) or on top predators-preys relationships. Now scientific investigation on the ecology of species at risk and invasive species are increasing. As result, most of the knowledge is about the distribution of commercial species (fish and shellfish), at risk species (e.g. marine mammals) or invasive species which were not part of the ecosystem. Very few is know on the other groups of species. Also, from a spatial perspective, the heterogeneity in scientific efforts to study certain areas of the marine environment may have introduced a bias in terms of comparison between areas (i.e., data rich *versus* data poor areas) and the risk may be that the resulting assessment of this indicator will not truly reflect the actual picture of the communities and ecosystems (i.e., in terms of species distribution) but the result of specific interests in certain areas of the marine environment which results in a better understanding of the biology and ecology in these areas (e.g. fishery zones, traditional activities, scientific interest, pilot management areas, accessibility of the area).

State of the methodology

Alternative definitions

Assessment of data

Data needed to compile the indicator
Data needed to compile the species distribution are essentially the same as for the measurements of the biodiversity (indicator E.1). This indicator will be based upon the knowledge of local species and groups of species (e.g. communities and assemblages) in the key compartments of the ecosystem (i.e., inventory of plants, algae and animals, in pelagic and benthic domains, such as planktonic organisms, invertebrates, fish, reptiles, marine mammals, seabirds). Note that vertical distribution measurements have to be done in conjunction with trophic interactions (Indicator E.5).

Data sources and collection methods

Data sources and collection methods are essentially the same as for the measurements and monitoring of the biodiversity (indicator E.1). Data will be compiled from species inventories, series of samplings, monitoring programs, etc. The focus should be put on species of interest or of concern, and/or of ecological importance: species at risk, fragile or sensitive species, species exposed to a specific threat, commercial species (fish and shellfish), keystone species (e.g. forage species), etc.

Analysis and interpretation of data

In certain areas or regions, the lack of data should not be interpreted as a lack of species, but as the disparity of scientific research and monitoring efforts or local/regional community interests.

Reporting scale and output

Like biodiversity measurements, the reporting scale should be as large as possible, covering all the management area. However, within coastal management areas, where fine-scale distribution patterns are observed and deemed important from an ecological point of view (e.g. aggregations, patchiness, unique habitats, structural or functional areas) they should be clearly identified, for example as biologically and ecologically significant areas for further management actions (DFO, 2004) or even as the resulting impact of an activity (e.g., habitat fragmentation, recolonization of impacted substrates). (see also Indicator E.9)

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (quantitative data), figures and graphs (histograms, comparisons of sites or periods), maps (species distribution and patterns), images (e.g. aerial photographs for reporting on marine mammals or seabirds aggregations). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator

- Fifth International Conference on the Protection of the North Sea. (Bergen Declaration, 2002). See the Ecological Quality Objectives (ECOQOs) proposed to the North Sea pilot project.
- International Council for the Exploration of the Seas (ICES). See for example the proposed framework for monitoring the status of ecosystem components. ICES Advisory Committee on Ecosystems 2004 Report.
- Food and Agriculture Organization of the United Nations (FAO). See for example: *Fisheries Management – 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries, 4, Suppl. 2, Rome, 2003, 112 p.

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Internet links

International Council for the Exploration of the Seas:
Convention on Biological Diversity:
Food and Agriculture Organization of the United Nations:

E.3 Abundance

Nature of indicator

Definition
.The abundance of living organisms may be expressed as the quantity of living matter (i.e., the biomass, new organic matter produced by marine organisms) which is present in a given unit – population, area or volume of water column; as number (e.g. number of individuals in a marine mammals population); or as density (number of individuals in a reference volume of water column (e.g. number of planktonic organisms per Litre) or within a reference area or unit (e.g. number of benthic plants or algae per surface unit such as m^2 or larger).

Unit of measurement
For this indicator, the focus is on species (individuals and populations) and assemblages (communities of species) quantified relatively to a spatial (area or volume) reference unit.

Relevance

Purpose
Abundance is a key component of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the organization of the ecosystem. This assessment is needed to make sure that the management objective of maintaining the ecosystem structure is met.

International conventions, agreements and targets

Methodological description

Underlying definitions and concepts

Measurement approaches
There are three categories of measurements related to this indicator:
- Biomass (of key populations)
- Number of individuals (marine mammals)
- Density (plants, benthic organisms)

Limitations of the indicator
This indicator gives the current snapshot of the abundance of species or biomass which are present in the ecosystem at the time when the measurement is done. The abundance (e.g. biomass or number of individuals in a given population) greatly varies over time, for example depending on seasonal and life cycles, and biological and physical processes like grazing and predation, availability of food, changes in oceanographic properties, environmental conditions, etc.

State of the methodology

Alternative definitions

Assessment of data

Data needed to compile the indicator
The same sort of data as for other biological indicators is needed to compile the indicator: the abundance is based on scientific data and knowledge (including local and traditional ecological knowledge) on species, populations and communities living in the management area.

Data sources and collection methods
Most of data will come from systematic monitoring programs and surveys. Here again, it will be likely easier to collect data on commercial species than on species or populations which have not been directly targeted by human activities up to now.

Analysis and interpretation of data
This indicator is just a measure of the quantity of living organic matter available to higher trophic levels or for harvesting but it gives any indication on how the ecosystem is structured or how it works. In this respect, the abundance should be monitored and interpreted in complement with other biological indicators of the ecosystem structure (organization) and function (vigor).

Reporting scale and output
Since the abundance of species or biomass are measured in a given reference unit, it may be wise to report on this indicator at various scales, or selecting the most appropriate scale based on both, the types of measurement and species distribution (see: indicator E.2); for example, the abundance of marine mammals should be measured within their distribution area which can be even larger than the management area under consideration; the biomass of fish stocks will be measured in populations of interest, with the scale therefore adjusted to the scale of area frequented by the population, whereas the density of benthic organisms may be reported at finer scales such as a specific habitat like a bay, a shellfish bed, a eelgrass bed, coral or sponge reef, etc.

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (quantitative data), figures and graphs (histograms, comparisons of sites or periods, statistics, trends), maps (species abundance and patterns), images (e.g. aerial photographs for counting number of individuals in marine mammals populations). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator
See other Biodiversity Indicators (E.1 and E.2)

References
See other Biodiversity Indicators (E.1 and E.2)

Internet links
See other Biodiversity Indicators (E.1 and E.2)

E.4 Production and reproduction

Nature of indicator

Definitions
Production is the formation of living organic matter from basic chemicals like nutrients and carbon dioxide (primary production by vegetal organisms) or the transformation of living organic matter from vegetal to animal organisms (secondary production).

Reproduction is the natural process that support and ensure life and continuity of species. Actually, this generic term includes a lot of associated biological concepts (e.g. life stages, survival rate, mean generation time) that all refer to important processes or properties which all have a key role in the reproductive process at a certain period of the life-cycle and that managers may want to consider for assessing the ecosystem functioning.

Unit of measurement
Measurement will be conducted at species, populations or communities levels.

Relevance

Purpose
Production and reproduction are key components of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the vigor of the ecosystem. This assessment is needed to make sure that the management objective of maintaining the ecosystem function is met.

International conventions, agreements and targets
- Convention on Biological Diversity (CBD, 1992) – United Nations Environment Program (UNEP).

Methodological description

Underlying definitions and concepts
Primary production is the energy basis for the marine food chains. In the marine environment, photosynthetic organisms, mainly the phytoplankton in pelagic domain and macroalgae in the benthos, produce living organic matter – from nutrients and carbon dioxide – that is available to secondary producers. From an ecosystem health point of view, the primary production should be assessed in terms of both, the quantity (e.g. biomass of phytoplankton) and quality (e.g. species composition in algal communities). Chlorophyll-a concentration in the water column is the most commonly used surrogate to quantify the phytoplankton abundance (see also Indicator E.3), the main source of new organic matter available to the pelagic food web. In the benthos, the biomass of macroalgae as well as the growth rates and production rates are often measured to assess the primary production available to grazing by secondary consumers. The quality of the primary production is also important in terms of energy flows and transfer to higher trophic levels. It may be drastically altered when the phytoplanktonic community is unbalanced, for example by an excess of nutrients (eutrophication) or contaminants (see: Indicator E.8). That may lead to catastrophic events like the so-called "red tides" or "harmful algal blooms".

Harmful algal blooms (HABs). An excess in nutrients, or changes in the relative amounts of different nutrients can stimulate the growth (and leading possibly to intense blooms) of phytoplankton species, producing the well known "red-tides". On the other hand, very few phytoplanktonic species produce toxins; their blooms are called "harmful algal blooms" (HABs). These "biotoxins" can accumulate in shellfish and poison animals or people who eat them. Toxic algae can also affect other marine life like fish and marine mammals, and have the potential of damaging commercial fish stock and aquaculture species. There are indications that HABs are increasing worldwide (GESAMP, 2001a). Because high concentrations of toxins can accumulate through the trophic chain especially in flesh of filter-feeder organisms, the HABs impacts on other organisms (incl. humans that feed poisoned shellfish) may be very damageable when algal toxins involved are the "paralytic shellfish poisoning" (PSP), "amnesic shellfish poisoning" (ASP) or "diarrhetic shellfish poisoning" (DSP).

Secondary production is achieved essentially by zooplankton in the pelagic domain, and filter-feeding and grazing organisms in benthos that transform the primary production into organic matter which is further available to higher trophic levels, i.e. consumable by larger organisms up to top predators (fish, marine mammals, birds).

Measurement approaches
There are three big categories of measurements related to this indicator:
- Primary production: quantity (biomass) and quality (e.g. HABs)
- Secondary production (e.g. zooplankton, invertebrates)
- Reproduction parameters: i.e., measuring life-stage history (in relation with genetic diversity measurements; indicator E.1), reproduction success (e.g. fecundity, maturity, sex ratio), survivorship (e.g. spawning survival rates), longevity (e.g. mean generation time of populations).

Limitations of the indicator
When using such indicators for management purposes, it`s important to keep in mind that most of these measurements are actually indirect measures and proxies to assess the marine productivity. Also, it should be stressed that both the production and reproduction are natural processes that cannot be managed directly. Therefore, ICOM should not use management objectives based on these indicators and types of measurements (e.g. primary production, spawning survival rates) when implementing an ecosystem approach to management (DFO, 2004). The management of activities that may have impacts on these ecosystem properties and processes, in turn, will result hopefully in maintaining these key ecosystem properties.

State of the methodology

Alternative definitions

Assessment of data

Data needed to compile the indicator
Various types of data are needed, such as:
- Data on phytoplankton and benthic plants and algae (primary production); the occurrence, frequency, intensity and duration of catastrophic events like red-tides or HABs in the ICOM area should be also monitored over time.
- Data on zooplankton and benthic invertebrates (secondary production).
- Data on species and populations in higher trophic levels (reproduction parameters).

Data sources and collection methods
Note that progress in development of remote sensing and satellite imagery technologies tends to make *chl-a* and surface water color the standard surrogate for assessing the primary productivity in marine and coastal surface waters; *chl-a* and water color maps produced from satellite imagery become more and more available worldwide while data management networks and global observing systems like GOOS are being developed and are now accessed by an increasing number of users and stakeholders involved in ICOM initiatives.

As far as HABs are concerned, monitoring and surveys programs should be set up in all coastal areas since the potential for HABs is everywhere, with an increase in occurrences of blooms and closures of impacted areas (shellfish beds, aquaculture sites) worldwide (GESAMP, 2001a).

Analysis and interpretation of data
Measuring simultaneously the primary and secondary production will be the basic data to assess the efficiency of energy transfer between lower trophic levels, providing an indication about the ecosystem structure and functioning, and biological relationships within (indicator E.5).

Reporting scale and output
The reporting scale for this indicator is greatly variable since it has to capture biological units (species and populations), functions (production and reproduction), and should be scaled within a spatial framework i.e., distinction between pelagic and benthic domains, or based on large scale biological patterns (Powles *et al.*, 2004).

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (quantitative data), figures and graphs (histograms, comparisons of sites or periods, trends), maps (e.g., primary production patterns), images (satellite imagery providing seawater color and chlorophyll-a content). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator

- Environmental Indicators for National State of the Environment Reporting. Australia: State of the Environment. See the Environmental Indicator Report on Estuaries and the Sea, 80 p. (1998).
- European Environment Agency (EEA) Environmental Signals. (series of reports published since 2000). See for example the report entitled: Benchmarking the Millennium (2002), Chapters on Fisheries and Inland and coastal waters. See also the EEA Signals 2004: A EEA update on selected issues.
- Fifth International Conference on the Protection of the North Sea. (Bergen Declaration, 2002). See the Ecological Quality Objectives (ECOQOs) framework proposed to the North Sea pilot project.
- Global Ocean Observing System – Coastal Oceans Observation Panel (GOOS-COOP)
- Health Ecological and Economic Dimensions (HEED) of Global Change Program. See for example the report entitled: Marine ecosystems: Emerging diseases as indicators of change.– Year of the Oceans Special Report, 1998, 78 p.
- H. John Heinz III Center. See for example: The State of the Nation's Ecosystems / chapter on Coasts and Oceans, published in 2002.
- Intergovernmental Oceanographic Commission (IOC, UNESCO). See for example: A reference guide on the use of indicators for integrated coastal management (2003). IOC in collaboration with DFO, CSMP and NOAA. Manuals and Guides 45, ICAM Dossier no.1, 127 p.
- International Council for the Exploration of the Seas (ICES). See for example the proposed framework for monitoring the status of ecosystem components. ICES Advisory Committee on Ecosystems 2004 Report.
- Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) and Advisory Committee on Protection of the Sea, IMO / FAO / UNESCO-IOC / WMO /WHO / IAEA / UN / UNEP.
- OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic. See the Quality Status Report (QSR) series.

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GESAMP (2001a). *A Sea of Troubles (2001)* by GESAMP and Advisory Committee on Protection of the Sea, IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP, Reports and Studies No. 70, 35 p

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E.5 Trophic interactions

Nature of indicator

Definition
Trophic interactions essentially refer to the trophic links (e.g. predators-prey) between all organisms in the marine ecosystem, whereas the trophic structure is the way the architecture of the marine food web (trophic chains) is designed. Trophic interactions are essential in maintaining the structure and function of the ecosystem as well as ecosystem properties like productivity and resilience.

Unit of measurement
Species (individuals and populations) and community levels

Relevance

Purpose
Trophic interactions are a key component of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the vigor of the ecosystem. This assessment is needed to make sure that the management objective of maintaining the ecosystem function is met.

International conventions, agreements and targets
- Food and Agriculture Organization of the United Nations (FAO). Code of Conduct (1995)

Methodological description

Underlying definitions and concepts
Trophic structure and interactions can be characterized by the number of trophic levels in selected marine food web (prey level, predator-1 level, predator-2 level, etc.) and number of key species in each of these trophic levels (number of prey species, number of predator-1 species, number of predator-2 species, etc.).

Measurement approaches
There are four categories of measurements related to this indicator:
- Complexity of food web (trophic levels and interactions between and within)
- Key predator-prey relationships
- Keystone species
- Size spectra (i.e., number of individuals at given weight or length)

Limitations of the indicator
Although this indicator is theoretically useful for capturing the overall ecosystem structure and function, measurements will be likely difficult to achieve (complexity of marine food web) or to be used in ecological assessments, in terms of significance and reliability of results. This indicator monitors ecosystem properties which are not directly under management control. That means that the result and effectiveness of management actions for maintaining trophic interactions in the ICOM area will be observed indirectly, probably after a long enough period of time that will depend on the complexity of interactions, importance of impacts (e.g. by fishing) and resilience of the ecosystem. On the other hand, if an activity would have an impact on the trophic structure and interactions (e.g. over-fishing of forage species, introduction of exotic species), it would take probably a certain time before this indicator shows significant changes to alert managers.

State of the methodology

Alternative definitions

Assessment of data

Data needed to compile the indicator
In order to assess the complexity of the food web, measurement will have to capture species interactions within and between trophic levels. To achieve that, measurements will have to be diversified, focusing of key groups of species that are representative of the food web and ecosystem structure like predators, their prey, and mid-trophic levels like forage species; for example, the presence and abundance of top-predators, identification of forage species, size spectra in each trophic level, inventory of dominant species in given biological communities, average weight and average/maximum length of the fish community (incl. the proportion of large fish), abundance of alternate preys for a given species of importance, predator-induced mortality rates on key prey populations, biomass of key dependant predators for a given prey species, diet composition (e.g. index of diet complexity) of species of interests (e.g. species at risk, marine mammals), etc

Data sources and collection methods
Fish communities and mainly commercial fish stocks have been usually the most investigated components of the ecosystem. Because of socio-economic reasons, the monitoring and stock assessments for fisheries management purposes have produced long-term and continuous series of data. With the increasing interest for conservation issues (e.g. species at risk, marine protected areas) one can also expect to get information on non commercial species and their trophic interactions with other ecosystem components.

Analysis and interpretation of data

Reporting scale and output
Measurements and use of this indicator should be done at large spatial scales (i.e., probably at the management area scale or even larger) to ensure that all trophic interactions within the food web are captured and processes such as populations dynamics are likely to dominate over extrinsic (finer scale) factors like migration (DFO, 2004).

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (quantitative data), figures and graphs (flow chart figures), models (functional model of the ecosystem, conceptual model of the food web). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator
- Fifth International Conference on the Protection of the North Sea. (Bergen Declaration, 2002). See the Ecological Quality Objectives (ECOQOs) framework proposed to the North Sea pilot project.
- Food and Agriculture Organization of the United Nations (FAO). See for example: *Fisheries Management – 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries, 4, Suppl. 2, Rome, 2003, 112 p.
- International Council for the Exploration of the Seas (ICES). See for example the Proposed framework for monitoring the status of ecosystem components. ICES Advisory Committee on Ecosystems 2004 Report.

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DFO (2004). Habitat Status Report on Ecosystem Objectives. Department of Fisheries and Oceans (Canada) – Canadian Science Advisory Secretariat (CSAS), Habitat Status Report No. 2004/001. 11 p. (report available at: www.dfo-mpo.gc.ca/csas/)

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E.6 Mortality

Nature of indicator

Definition
Mortality of marine organisms that results in a decrease in numbers of individuals or in the biomass of populations. In extreme cases, massive mortalities may lead to the depletion of entire populations and make these species at risk of extinction (see also Indicator E.7).

Unit of measurement
Measurements at the species/population level

Relevance

Purpose
Mortality is a key component of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the vigor of the ecosystem. This assessment is needed to make sure that the management objective of maintaining the ecosystem function is met.

International conventions, agreements and targets
- Convention on Biological Diversity (CBD, 1992) – United Nations Environment Program (UNEP).
- Code of Conduct for Responsible Fisheries (FAO, 1995)
- Reykjavick Declaration on Responsible Fisheries in the Marine Ecosystem (2001)
- Agreement on the Convention and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, UNFA (UNCLOS, 1995)
- The International High Seas Task Force to address Illegal, Unreported and Unregulated (IUU) fishing on the high seas (OECD, 2003).

Methodological description

Underlying definitions and concepts
In the marine environment, mortality may be caused by natural predation, change in environmental conditions, or is the result of harvesting or fishing. When the cause of mortality is unknown, usually it`s named 'unusual mortality' (e.g. stranding of marine mammals; massive mortalities of fish), although in most cases, changes in environmental conditions, including poor water quality is likely the cause, whereas mortality of non-target species caused by fishing (fishery by-catch) will be reported as "incidental mortalities".

Measurement approaches
There are three categories of measurements related to this indicator:
- Fishing mortality
- Incidental mortalities (by-catch)
- Natural mortality (predation)
- Other causes (incl. unknown and inappropriate environmental conditions)

Limitations of the indicator
In contrast to fishing mortality which has been well documented for obvious reasons, very few is known on the other categories of mortality cause and they will be likely the weakness point when reporting on and using this indicator.

State of the methodology

Alternative definitions

Assessment of data

Data needed to compile the indicator
Statistics of major commercial fish and shellfish species, as well as of recreational fishing where it's an important activity, will be needed; for example landing amount of target species expressed in market value or volume (e.g. tons per year), size spectra (i.e., numbers of fish at length/weight in catch) and/or age-length relationships. As well, parameters used for fisheries management (e.g. Maximum Sustainable Yield, fleet capacity, types of gears) will be good surrogates for assessing the fishing mortality (see socio-economic indicators). In addition, it would be wise to collect data on by-catch and discards to assess impacts of local fishing practices on ecosystem productivity (E.4) and water quality (E.8).

As far as unusual mortalities are concerned, species like marine mammals whales, dolphins) and reptiles (e.g. marine turtles) can be good integrators of the overall ecosystem health. The assessment of unusual mortalities should looked at species involved, number and frequency of events, number of individuals involved per event, are they species at risks? etc.

Data sources and collection methods
Monitoring this indicator should focus on species harvested by commercial and recreational fishing, as well as non target species frequently caught, forage species, and species of interest (keystone species, species at risk). As far as fisheries are concerned, the mortality measurements can be done on various types of fish stocks (fully exploited, overexploited, or depleted). Fisheries related data may come from "at sea" surveys and landing records. In the absence of any monitoring data to support fishery science and stock assessments, landings (in terms of volume or value) and fishing efforts (e.g. number of vessels, types and number of nets, gear, etc.) may be a useful proxy to assess the quantity of resources harvested in the management area and in turn, the fishing mortality; it may be an indication, although indirect, on the status of local fisheries and fish stocks. Mortality measurements will be also useful to assess the reproductive status and success of populations (indicator E.5), for example, by calculating species size spectra**,** age/size structure of populations, age at maturity, early-life history survival rate, spawning biomass, mortality rate, etc. Both types of indicators, the mortality and reproduction have close enough measurements and data should be therefore collected and interpreted in an integrated assessment context.

Analysis and interpretation of data
This indicator should be monitor in parallel to the other biological indicators involving common (or complementary) measurements on the ecosystem structure and function like species diversity (E.1), distribution (E.2) and abundance (E.3) as well as trophic interactions (E.5) because any change in mortality patterns, whatever the cause, environmental conditions, predation or fishing, will have a direct impact on these properties and therefore will be likely reflected through other indicators as well. In this respect, it will be important to consider this set of biological indicators within an integrated assessment framework, to address inherent uncertainties and science gaps around biological interactions and ecosystem processes, and inform ICOM based on the best science. This integration of measurements and indicators will be particularly critical in management areas where fishing is one of the most important activities.

In areas where unusual mortalities of species like marine mammals for example occur or when frequency of incidental mortalities increases may be an indication of the degradation of the marine environmental quality, i.e., environmental conditions are probably not as good as expected or targeted since certain species, acting as "sentinel", likely the most sensitive or exposed to stressors, are affected.

Reporting scale and output
The reporting scale for this indicator will greatly vary and depend on the aspect that is to be considered. Actually, the reporting scale will be adjusted to the distribution area of the population or fish stock for which the fishing mortality is to be assessed, or the distribution area of a given species or populations when incidental or unusual mortalities are the issues. When causes of mortality are unknown or when poor environmental quality is suspected (see: Indicators E.7 and E.8), the reporting scale should be as large as possible to capture complex processes involved (contaminants, climate change, habitat degradation, etc.)

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (quantitative data), figures and graphs (histograms, comparisons of sites or periods, statistics and trends), models (for refining predictions). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator

- Environmental Indicators for National State of the Environment Reporting. Autralia: State of the Environment. See the Environmental Indicator Report on Estuaries and the Sea, 80 p. (1998).
- European Environment Agency (EEA) Environmental Signals. (series of reports published since 2000). See for example the report entitled: Benchmarking the Millennium (2002), Chapters on Fisheries and Inland and coastal waters. See also the EEA Signals 2004: A EEA update on selected issues.
- Food and Agriculture Organization of the United Nations (FAO). See for example: *Fisheries Management – 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries, 4, Suppl. 2, Rome, 2003, 112 p.
- Fifth International Conference on the Protection of the North Sea. (Bergen Declaration, 2002). See the Ecological Quality Objectives (ECOQOs) framework proposed to the North Sea pilot project.
- Global Ocean Observing System – Coastal Oceans Observation Panel (GOOS-COOP)
- H. John Heinz III Center. See for example: The State of the Nation's Ecosystems / chapter on Coasts and Oceans, published in 2002.
- Intergovernmental Oceanographic Commission (IOC, UNESCO). See for example: A reference guide on the use of indicators for integrated coastal management (2003). IOC in collaboration with DFO, CSMP and NOAA. Manuals and Guides 45, ICAM Dossier no.1, 127 p.
- International Council for the Exploration of the Seas (ICES). See for example the Proposed framework for monitoring the status of ecosystem components. ICES Advisory Committee on Ecosystems 2004 Report.
- Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) and Advisory Committee on Protection of the Sea, IMO / FAO / UNESCO-IOC / WMO /WHO / IAEA / UN / UNEP.
- OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic. See the Quality Status Report (QSR) series.

References

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E.7 Species health

Nature of indicator

Definition
A species is in good health when biological processes like feeding, reproduction, growth, behavior, etc. are not significantly affected and the population remains within the natural range of variability so that the species continues playing its natural role in the ecosystem, food web and ecological processes.

Unit of measurement
Species is the basic unit for this indicator. All basic measurements will be conducted at the species level; e.g. representative species, test species, sentinel species, exposed species, species of concern, etc. However, another approach for assessing species health is to use laboratory micro-scale biomonitoring and biotesting, which may require consider the sub-species level (i.e., tests conducted at the cellular level).

Relevance

Purpose
The species health is a key component of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the marine environmental quality. This assessment is needed to make sure that the management objective of maintaining physical and chemical properties of the ecosystem is met.

International conventions, agreements and targets
- Convention on Biological Diversity (CBD, 1992) – United Nations Environment Program (UNEP).

Methodological description

Underlying definitions and concepts
Micro-scale toxicity bio-tests (micro-biotests). They are based on the response of a variety of indicator species (unicellular or young life stages of multicellular species) sensitive to certain groups of toxic chemicals and kept in controlled (standardized) conditions; the test medium (sample) may be water or sediment and test species may be bacteria (e.g. Microtox© test), macroalgal cysts, microalgae in cultures, invertebrates (e.g. Daphnia test, rotifers), marine crustaceans, larvae and embryos (fish species), etc.

Biomarker assays**.** Many types of biomarker assays have been developed, for example: biomarkers of general biological distress (e.g. cardiac activity in molluscs), behavioral bioassays (e.g. swimming behavior in Mysids), and chemical biomarkers to detect the presence of –or assess the exposure to– various types of pollutants: e.g. fluorescence assays (PAHs), *Imposex* in certain species (Endocrine Disruptors, TBT), Cytochrome P-450 (oil hydrocarbons, PAHs),Protein assay/metallothionein (heavy metals), Cholinesterase inhibition assay (Pesticides), micronuclei assay (genotoxins). These biomarkers should be monitored in sentinel species, in exposed species living in contaminated environments, in sensitive species, species at risk, etc.

Measurement approaches
There are four categories of measurements related to this indicator:
- Species at-risk of extinction
- Bioaccumulation of toxic compounds (incl. use of biotests and biomarkers)
- Diseases and abnormalities (incl. pathogen bacteria, viruses and parasites)
- Seafood quality

Biomass removal by fishing, habitat degradation and presence of contaminants from numerous sources are among the most important threats on species health and biodiversity. In this respect, the worst scenarios i.e., over fishing and stocks depletion, habitat losses, bioaccumulation of toxic compounds and occurrence of diseases and abnormalities have been already observed worldwide (GESAMP, 2001a). The aim of this broad indicator is to capture these stressors through this series of various measurements. However, these measurements should be fully integrated (in terms of monitoring and data interpretation) to make the indicator reliable and useful to management. For example, in parallel with *in-situ* observations and measurements, micro-scale toxicity tests may be particularly pertinent to ICOM in developing countries because commercial kits have been developed and standardized with the aim at being designed as simple procedures (i.e., relatively easy to run even when any strong science support or equipment is available), portable kits (i.e., measurements can be done in the field, close to sampling sites for example), low cost, practical and repetitive (i.e., allowing self-training) and fast-reading. On the other hand, when very few is known about the degree of contamination of the management area, the best use of biomarkers is as screening techniques for preliminary assessment, using a battery of assays as integral part of field monitoring, that is the Rapid Assessment of Marine Pollution (RAMP) approach.

Limitations of the indicator

When and where the contamination of the biota and seafood is an issue, the monitoring strategy will have to carefully select sentinel species that are well known in terms of their biology and ecology (i.e., need a strong science support), exposed to contaminants of concern, not too much sensitive to be able to survive in contaminated waters, well distributed in the management area and representative of the local biota (an example is the UNEP-led "mussel watch" program which has been extensively used for assessing the marine environmental quality worldwide). Furthermore, it will not be easy to monitor and sample species at risk, although non destructive techniques may be developed.

Although they are based on promising approaches, existing biomonitoring and biotesting tools have to be conducted under standardized laboratory conditions (i.e., requiring minimum skills and equipment) and are sensitive to certain categories of toxics only that is not necessary representative of the actual environmental conditions prevailing in the study area. Managers must keep in mind that results from laboratory tests are not very meaningful by them-selves and should be validated by field data or *in-situ* observations to be reliable and useable in a management context.

State of the methodology

For the use and relevance of toxicity micro-biotests see the review done by Wells (1999). For the use of biomarker assays within a management context, see for example the RAMP approach (Depledge and Bowen, in progress)

Alternative definitions

Assessment of data

Data needed to compile the indicator

The complementary use of toxicity tests and biomarker assays with measurements of contaminants levels in the environment (Indicators E.8 and E.9) would give a direct indication on actual damages caused by the presence of contaminants at the species level and how they affect, or could affect ultimately, all the ecosystem.

In addition to reporting on the exposure of biota to toxic compounds (biomarker assays), quantifying the degree of contamination (concentrations of contaminants), and assessing the toxicity of these contaminants (toxicity tests), the collection of data on marine diseases and abnormalities, incl. biological vectors like pathogens, viruses and parasites (HEED, 1998) would provide useful information to confirm the threats and impacts on species health and their consumers, the top predators, and ultimately make linkages with human health, particularly in heavily polluted areas (see: Indicators E.8 and E.9).

Data sources and collection methods

Seafood quality is impacted by contaminants accumulated in animal tissues, like heavy metals and POPs, but it`s impossible to monitor all the species and looked at all the chemicals that are released into the marine environment, even in limited areas. The monitoring strategy around this indicator will therefore have to focus on toxic chemicals which are: (i) present in high concentrations in the study area; (ii) known to be bio-accumulated through the food chains; (iii) of global/national and regional concerns. Also the selection of indicator species will be of critical importance. When/where seafood quality is an issue, these sentinel species should be first selected from commercial and recreational fishing species, in fish and shellfish groups. Other species however, like certain non-commercial sediment dwelling organisms or filter-feeders at mid-trophic levels (forage organisms) are an important source of food for higher levels. Measuring their condition (i.e., how healthy or contaminated they are) is a good indication of the quality of the environment in which they live and would help predict the importance of bioaccumulation through local food chains. In this respect, top-predators like fish, marine mammals and seabirds (and their eggs) are likely the best sentinel species, although these species may be more difficult to be sampled and monitored.

Analysis and interpretation of data

The occurrence of species at risk, and *a fortiori* an increase in the number of species considered at risk under various listings (of concern, threatened, endangered, etc) or in their spatial extent over time will reflect that the biodiversity of the ecosystem and its key functional units (species) are threatened.

In environmental assessments, microscale toxicity tests have been best used as laboratory tools conducted in complement with *in-situ* studies and measurements. They may provide useful information on the potential harm and probable effects of contaminants on marine biota. Biomarkers assays may be used for assessing the general environmental stress after measuring the actual distress and effects caused by the presence of contaminants in the marine environment. Chronic and acute effects measured by biomarkers may be diverse, for example reflecting immunological effects, dysfunctions or behavioral changes.

Reporting scale and output

Scale is dependent on the species health measurement; for example reporting on species at risk will require that their distribution areas and habitats they frequent and use are captured; reporting on contaminants may vary from very local "hot spots" to large areas contaminated; reporting on seafood quality would be at the appropriate scale where seafood is harvested (e.g. shellfish beds, fish stock areas); and marine diseases may be disseminated over large regions of oceans, with impacts observed at the ecosystem-scale (HEED, 1998).

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (e.g. quantitative data from biomarkers), figures and graphs (histograms for reporting on biotests, comparisons of sites or periods for seafood quality, trends), maps (e.g. reporting on species at risk, diseases occurrence), models (e.g. modeling the bioaccumulation through food chains). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator

- Environmental Indicators for National State of the Environment Reporting. Australia: State of the Environment. See the Environmental Indicator Report on Estuaries and the Sea, 80 p. (1998).
- Fifth International Conference on the Protection of the North Sea. (Bergen Declaration, 2002). See the Ecological Quality Objectives (ECOQOs) framework proposed to the North Sea pilot project.
- Global Ocean Observing System – Coastal Oceans Observation Panel (GOOS-COOP)
- H. John Heinz III Center. See for example: The State of the Nation's Ecosystems / chapter on Coasts and Oceans, published in 2002.
- Intergovernmental Oceanographic Commission (IOC, UNESCO). See for example: A reference guide on the use of indicators for integrated coastal management (2003). IOC in collaboration with DFO, CSMP and NOAA. Manuals and Guides 45, ICAM Dossier no.1, 127 p.
- International Council for the Exploration of the Seas (ICES). See for example the Proposed framework for monitoring the status of ecosystem components. ICES Advisory Committee on Ecosystems 2004 Report.
- Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) and Advisory Committee on Protection of the Sea, IMO / FAO / UNESCO-IOC / WMO /WHO / IAEA / UN / UNEP.
- OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic. See the Quality Status Report (QSR) series.
- Rapid Assessment of Marine Pollution (RAMP) programme. United Nations Environment Programme (UNEP).

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Wells, P.G. (1999). Biomonitoring the health of coastal marine ecosystems – The roles and challenges of microscale toxicity tests. *Marine Pollution Bulletin*, 39: 39-47.

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E.8 Water quality

Nature of indicator

Definition
This indicator is to describe the physical-chemical and oceanographic properties of the water column and assess the seawater quality, in terms of its ability to sustain the marine life and biological processes.

Unit of measurement
Measurements involved in this indicator are essentially physical-chemical types of measurements, but for diseases and abnormalities which are based on biological data. Basic oceanographic measurements are the surface seawater temperature (SST), salinity and concentrations of suspended matter ((or surrogates like turbidity or surface water color). In addition to these basic oceanographic data, measurements of levels of nutrients and dissolved oxygen (eutrophication parameters) as well as concentrations of contaminants will provide a good indication on the degree of pollution of the water column in coastal zones. The major groups of contaminants of concern worldwide are: heavy metals, Persistent Organic Pollutants (POPs)*, hydrocarbons, organo-tins, waste and debris. Even marine debris are not just aesthetics; marine species may be entangled or strangled by plastic bags, fish nets or polystyrene foam pellets.

Relevance

Purpose
The water quality is a key component of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the marine environmental quality. This assessment is needed to make sure that the management objective of maintaining physical and chemical properties of the ecosystem is met.

International conventions, agreements and targets
- Convention on Biological Diversity (CBD, 1992) – United Nations Environment Program (UNEP).
- Stockholm Convention on Persistent Organic Pollutants (2001). The list of banned POPs contains a dozen of very toxic substances which have accumulated in the marine environment worldwide like pesticides, PCBs, dioxins and furans.

Methodological description

Underlying definitions and concepts

Physical oceanographic features and processes strongly influence the marine biology, as well as the ecosystem structure and function (Field *et al.,* 2002). For example, the distribution of species (Indicator E.2) is primarily based on the optimum range of water temperature and salinity. As far as the plankton is concerned, the abundance of species (Indicator E.3) and primary and secondary productions (Indicator E.4) are driven by currents, light availability, nutrients, etc. Biological processes like reproduction (Indicator E.4) and biological interactions (Indicator E.5) also need specific oceanographic conditions (e.g. current velocity, turbulence and mixing processes) and/or chemical properties of seawater varying within bounds of natural variability (dissolved oxygen, nutrients, etc.) to occurred at appropriate spatial and temporal scales. Fisheries management also needs these basic measurements for conducting fish stock assessments (Indicator E.6). Oceanographic processes are emerging at ecosystem-scale (e.g. upwellings, gyres) and, in turn, can help assess the diversity of ecosystems (Indicator E.1). This information is also needed to report on the state of the oceans and the natural variability, in addition to better understanding and addressing complex environmental issues like the decline of water or habitat quality (E.8 and E.9).

Marine pollution and contaminants. Concern about the health of the oceans historically has been generated by pollution. Still nowadays, the presence of contaminants in the marine environment is one of the most important environmental issues that almost all coastal regions in the world are facing (GESAMP, 2001a). This is also true for those regions and countries that are not as industrialized as developed countries. Contaminants and pollutants are of concern, essentially because they are toxic compounds or may be harmful to marine life by interfering with biological processes and vital functions. These contaminants usually come from point-source discharges (e.g. sewage, outfalls) as well as diffuse sources of contamination, mainly from land-based activities and shipping. Shipping is one of the most increasing activities worldwide and accidents may lead to various types and degrees of impacts in coastal/oceans waters (GESAMP, 2001a). They may be assessed by recording the frequency of events (e.g. oil spills), type, amount and toxicity of cargo released, the number of species or individuals affected (e.g. oiled birds), the importance of coastal impacts (e.g. length of shoreline impacted by an oil spill), occurrence at sea (oil slicks, tar-balls, floating debris) etc. When/where marine debris and solid waste are an issue, it may be useful to conduct systematic surveys at sea and/or based on observations on shore, to record their occurrence and amount (or volume) of each category (i.e., type, or origin, of debris) in "sampling" areas, in order to assess the importance of such materials and species and habitats which are the potentially affected, depending on the nature of such debris.

Eutrophication. Algal and plants need nutrients for growing and producing primary biomass; they have a key role in the ecosystem function, and are an integral part of the seawater quality. However, when nutrients are in excess (e.g. nutrient loads from river discharges) usually the microalgal growth is stimulated (initial phase), the resulting increase in production of organic matter, in turn enhances the biodegration process with an increase in oxygen consumption (eutrophication).

Biological vectors of diseases. Measurement/assessment of discharges, levels and prevalence of faecal bacteria, parasites, pathogens, disease agents will give a good indication of the water quality and the associated risks to human health like recreational activities (e.g. bathing) or related to seafood quality insurance

Measurement approaches

There are five categories of measurements related to this indicator:

- Water column properties
- Oceanographic processes, variability and regime shifts
- Sedimentation (e.g. transport of suspended sediments)
- Pollutants and contaminants
- Eutrophication parameters

Limitations of the indicator
Observing and interpreting regime shifts will require a good knowledge and a strong science support (equipments, at-sea facilities, expertise) and the monitoring of complex oceanographic processes (e.g. currents and water masses, sedimentation). Furthermore, it may be very difficult to assess and distinguish the natural variability of oceanographic properties from changes caused by human impacts, including climate change and cumulative impacts.

Once they are discharged at sea, contaminants may be found in a variety of forms that will influence their transport and fate in the marine environment, e.g. dissolved components, or transported as adsorbed onto suspended particles –either organic matter or mineral. If they remained in the water column, they will be disseminated, sometimes over large areas, by currents and turbulence and will be difficult to monitor. The coastal waters may be either impacted by direct discharges into the area, or by human land-based activities that might be far enough from the coastal management area, e.g. after transport by atmospheric processes, rivers and watersheds, currents, etc). Coastal waters may also act as a trapping zone for certain pollutants, and processes involved in pathways and behavior of contaminants (e.g. adsorption, sedimentation, bioaccumulation) may be complex, dependent on environmental conditions and therefore difficult to capture at large scale. Assessing contaminant levels in water bodies needs the support of well structured science monitoring programs and facilities/analytical capacity to provide meaningful measurements and reliable data on these chemical indicators. When monitoring toxic chemicals (e.g. heavy metals, POPs), it's important to well know the environmental chemistry of such compounds, i.e., their fate and effects after they are introduced into the marine environment. For example, certain forms of heavy metals (speciation) are more reactive – and more toxic – than others; certain chemical forms like organo-metals for example, may be more easily bio-accumulated than the "parent" or precursor compounds (e.g. Mercury/methyl-mercury).

State of the methodology

Alternative definitions

Assessment of data

Data needed to compile the indicator
A great variety of data is needed to monitor this indicator and asses the overall water quality; these data are physical oceanography data (e.g. temperature, turbidity), chemical data (e.g. nutrients, contaminants) and biological data (e.g. bacteria and parasites).

Data sources and collection methods

Analysis and interpretation of data

Key oceanographic variables are essential to characterize different water masses and currents and track freshwater inputs (e.g. river plumes). These water properties are also influenced by regime shifts induced by climate change for example. Concentration of total suspended matter and light attenuation (e.g. using the Secchi disk technique) are likely the simplest ways for measuring the water turbidity, in relation with the solar light available which is necessary for the primary production (Indicator E.4). These variables are strongly affected by both, natural processes (e.g. transport of sediments, algal blooms) and human activities (e.g. resuspension of sediments due to bottom disturbance, coastal development, dredging).

Although eutrophication parameters and contaminants may also characterize different water masses in the coastal zone (e.g. river discharges), they are essentially used to assess the degree of pollution and track the influence of land-based activities. Dissolved oxygen (expressed in mg per L or percent of saturation level) is a key chemical component that supports marine life and aerobic processes associated with (e.g. degradation of organic matter) in oceans. It comes mainly from photosynthesis process run by plants and algal during the primary production (Indicator E.4), as well as turbulence and mixing process that happen in surface waters. As such, the dissolved oxygen level is also a key indicator that measures the natural physical-chemical properties of the ecosystem. However like nutrients, when organic matter (e.g. dead organisms, sewage, organic contaminants) is in excess in seawater or sediments, the aerobic degradation is stimulated and results in an increase in oxygen consumption. Oxygen depletion (areas of hypoxia) may locally occur with decline in the overall environmental quality and drastic impacts on biota can be observed like massive mortalities of sessile species (Indicator E.6) or displacement of mobile species (E.7).

High concentrations of pollutants show that coastal waters in the management area act as the receiving water body for these pollutants, and that the water quality has been likely degraded or is degrading, with direct consequences on the health of organisms living in this water body (see Indicator E.7). Contaminated particles/sediments dispersed into the water column contribute to the decline of the overall quality of the marine environment (see also: Indicator E.9). The sources of contamination in sediments may be very diverse as well as processes involved, depending on the chemical reactivity and affinity of contaminants to sediments (e.g. mineral particles, high content of organic matter, grain size, etc.). Some local activities like dredging, dumping or trawling, cause direct physical disturbance of the sediment and may drastically change the levels of contaminants after re-suspending contaminated surface sediments in a certain area. High concentrations of bacteria that originate from sewage (e.g. *E. coli*) is an early warning that swimming or shellfish harvesting are unsafe activities and should be prohibited in this area until concentrations of coliforms decrease below a certain threshold as predefined by management or regulatory bodies. However, most of pathogens and diseases vectors are not well known yet in the marine environment (HEED, 1998). And when systematic surveys are set up, like for alerting on harmful algal blooms (see: Indicator E.4), they are still very difficult to predict and controlled.

Reporting scale and output
Scale will be greatly dependent on the type of measurement for this indicator.
Basic oceanography data: should be reported at large scale (i.e., management area or larger). Because these data are usually the set of data that have been collected and recorded everywhere and over longer time, they can be used therefore to track large scale processes (e.g. long range transport of sediments and contaminants) and long term changes (regime shifts, climate change).
Contaminants: may be reported at scale smaller than the management area, for example to identify "hot spots" of contamination within the management area. If no hot spots have bee reported up to date in the management area, the monitoring of contaminants should therefore be conducted and reported over the whole management area, as a sort of first screening to further assess the degree of contamination of the area and eventually identify the areas of concerns, the most polluted ones.
Eutrophication parameters: these data may be reported at finer scales because sources of excess loads of nutrients and hypoxia areas (oxygen depletion) usually are localized and relatively easy to identify at small scale.
Sedimentation data: should be collected at large scale to ensure that sedimentation processes like the coastal transport of sediments are captured. However, in some cases, finer scale reporting may be useful for example, when it is to refine the knowledge on local processes (e.g. area of high sedimentation) or re-suspension of surface sediments.

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (quantitative data), figures and graphs (e.g. histograms for reporting on contaminants, comparisons of sites or periods, trends), maps (oceanographic variables, contaminated areas, etc.), models and animations (predictions of physical oceanographic variables, analysis of historical data series and assessment of the natural variability, scenarios for regime shifts), images (e.g. aerial photographs showing freshwater plumes in coastal zones) and satellite imagery (SST maps, seawater color as a proxy of turbidity of surface waters). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator

- European Environment Agency (EEA) Environmental Signals. (series of reports published since 2000). See for example the report entitled: Benchmarking the Millennium (2002), Chapters on Fisheries and Inland and coastal waters. See also the EEA Signals 2004: A EEA update on selected issues.
- Environmental Indicators for National State of the Environment Reporting. Autralia: State of the Environment. See the Environmental Indicator Report on Estuaries and the Sea, 80 p. (1998).
- Fifth International Conference on the Protection of the North Sea. (Bergen Declaration, 2002). See the Ecological Quality Objectives (ECOQOs) framework proposed to the North Sea pilot project.
- Global Ocean Observing System – Coastal Oceans Observation Panel (GOOS-COOP)
- Health Ecological and Economic Dimensions (HEED) of Global Change Program.
- H. John Heinz III Center. See for example: The State of the Nation's Ecosystems / chapter on Coasts and Oceans, published in 2002.
- Intergovernmental Oceanographic Commission (IOC, UNESCO). See for example: A reference guide on the use of indicators for integrated coastal management (2003). IOC in collaboration with DFO, CSMP and NOAA. Manuals and Guides 45, ICAM Dossier no.1, 127 p.
- International Council for the Exploration of the Seas (ICES). See for example the Proposed framework for monitoring the status of ecosystem components. ICES Advisory Committee on Ecosystems 2004 Report.
- Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) and Advisory Committee on Protection of the Sea, IMO / FAO / UNESCO-IOC / WMO /WHO / IAEA / UN / UNEP.
- OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic. See the Quality Status Report (QSR) series.

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E.9 Habitat quality

Nature of indicator

Definition
This indicator is to describe the different types of habitats and assess their quality, in terms of ability to sustain the marine life and provide biota with biological and physical features that are necessary for supporting life processes.

Unit of measurement
Habitat quality measurements to help identify and quantify habitat types (number and extent, percent coverage), spatial patterns of key habitats, i.e., the diversity at the ecosystem-level); such measurements will be helpful first to review the current status of coastal habitats in terms of natural versus disturbed habitats, in addition to marine protected areas (incl., marine reserves, sanctuaries, conservation areas, national heritage areas, etc.).

Because a great variety of marine organisms are benthic and live directly on the surface sediment or are filter-feeders, the monitoring strategy should include the selection of indicator species as "sentinel" species (See Indicator E.7) in addition to direct measurements of contaminants in sediment samples. The major groups of contaminants of concern worldwide are: heavy metals, Persistent Organic Pollutants (POPs)*, hydrocarbons, organo-tins, waste and debris.

Relevance

Purpose
The habitat quality is a key component of the overall marine ecosystem health. Monitoring this indicator will contribute to the assessment of the marine environmental quality. This assessment is needed to make sure that the management objective of maintaining physical and chemical properties of the ecosystem is met.

International conventions, agreements and targets
- Convention on Biological Diversity (CBD, 1992) – United Nations Environment Program (UNEP).

Methodological description

Underlying definitions and concepts
Surface sediment is a key structural ecosystem component that strongly influences the species distribution and diversity of benthic communities (benthic organisms are adapted to specific types of sediment) as well as the productivity of certain resources living in the benthos and, ultimately the overall benthic habitat quality. It is therefore very important to monitor natural properties (geological, physical and chemical properties) of surface sediments in coastal areas.

Sea level change is one of the most expected impact at the regional/local level due to the global warming; some countries or regions of the world have already experienced trends that could be related to these global / long-term issue.

Measurement approaches
There are five categories of measurements related to this indicator:
- Habitat types
- Habitat alteration
- Sea level change
- Landscape and bottomscape integrity
- Sediment quality (natural properties and contaminants)

Limitations of the indicator

State of the methodology

Alternative definitions

Assessment of data

Data needed to compile the indicator
Measurements should focus on ecologically significant areas (migration routes, spawning or rearing areas, etc.) and shoreline types (e.g. sea cliffs, sand dunes, coral reefs, salt marshes, eelgrass beds, mangroves, intertidal mud flats). This assessment may be based on ecological considerations (e.g. inventory of the various natural types of habitats, in terms of structural and functional aspects) as well as taking account of human influence in impacting or modeling the natural habitats (e.g. man-made habitats, protected, disturbed - lightly vs heavily – threatened, "at risk", etc.). In this respect, it would be useful to categorize "at risk" habitats into "high", "medium" and "low" risks (re: potential threats)**;** e.g. extent of coastline at risk of erosion, extent and impact of "seawalls", shoreline armoring, industrial/urban areas).

As far as the contamination of sediments is concerned, the calculation of a *Sediment Quality Index* (Marvin *et al.*, 2004) integrating and comparing scientific information (i.e., chemical data collected *in-situ*) and current management status (i.e., existing regulations and policies for controlling the environmental quality) would be useful for reporting purposes within the ICOM context.

Data sources and collection methods
Habitat types, habitat alteration and measurements of the landscape/bottomscape integrity will come mainly from field observations and will be essentially a mixture of qualitative (narrative) and quantitative measurements, whereas sediment properties and quality may be more easily sampled and quantified. Ideally, sea level measurements should be based on historical records and trends (if data are available) and/or scenarios-based predictions (if there is a strong science support, i.e., models and experts are available).

Analysis and interpretation of data
<u>Habitat type inventory</u> and associated measures will help assess the habitat (ecosystem) diversity and impacts of human activities on habitats (e.g. bottom disturbance, habitat destruction of biotic structures like deep-sea sponge, coral reefs, hydrothermal vents, and should give pertinent information to make sound linkages with spatial patterns and related issues (fragmentation, patchiness, connectivity) as well as impacting human activities (e.g. trawling, dredging/channeling, mining, oil & gas, exploration/production, cable or pipeline and maintenance corridors)

Changes in sea level actually result from the natural variability over time (e.g. geological process like subduction) and the recently increase of sea level rise induced by climate change and global warming.

<u>Sediment properties</u> may be affected by a great variety of activities which may have direct impacts like physical disturbance (e.g. bottom trawling, mineral extraction, dredging) or indirect impacts like changes in flow regime, sediment transport and sedimentation process (e.g., after diverting freshwaters or building coastal infrastructures, or degrading habitats). When the natural properties or nature of sediments has been changed, the modified sediment may become no longer appropriate as substrate for sustaining the indigenous benthic community; many benthic species will probably disappear and will be replaced by species that are able to adapt to new environmental conditions. Such changes in sediment properties will likely result in drastic changes in the overall biodiversity and productivity of the benthic communities. The sediment quality may be also affected by the presence of contaminants that accumulate in surface sediments; in such a case, cumulative impacts may occur and must be taken into consideration in managing the impacting activities in the study area.

Reporting scale and output
Overall, habitat and sediment quality needs to be assessed at scales as fine as possible to provide ICOM with reliable and useful information. Reporting on habitat types and features may be done at small scale if it's possible to conduct a detailed inventory of habitats in the management area. However, when this is not possible, habitats should be first classified in broad categories, with an initial screening covering all the management area, then refining the habitat classification and assessment in areas of interest for management purposes, e.g. areas of concern, area with ecological significance like spawning or breeding areas, area exposed to threats, areas disturbed by activities or restored, etc. Sea level change may be observed at very small scale however, data should be reported and inserted into databases that are larger in scope than the management area, for example such data collected locally should be interpreted in the light of large scale (regional and even global) trends.

Technical reports for ICOM purposes should contain a brief narrative text to comment on highlights and trends shown by the indicator. Supporting results from associated monitoring and measurements should be displayed mainly by means of tables (quantitative data), figures and graphs (histograms, comparisons of sites or periods, statistics on habitats, trends), maps (for habitat types inventory, ecological patterns, etc.), images (e.g. aerial photographs to capture large scale disturbed habitat, erosion process, etc.), models (for sea level rise predictions, scenarios for assessing climate change impacts). Ecological Indicators reports should be regularly updated to capture environmental changes, impacts of activities as well as progress done (evaluation of the ICOM effectiveness) and fill knowledge gaps.

Additional information

Organizations and programs involved in the development of the indicator
- European Environment Agency (EEA) Environmental Signals. (series of reports published since 2000). See for example the report entitled: Benchmarking the Millennium (2002), Chapters on Fisheries and Inland and coastal waters. See also the EEA Signals 2004: A EEA update on selected issues.
- Environmental Indicators for National State of the Environment Reporting. Australia: State of the Environment. See the Environmental Indicator Report on Estuaries and the Sea, 80 p. (1998).
- Global Ocean Observing System – Coastal Oceans Observation Panel (GOOS-COOP)
- H. John Heinz III Center. See for example: The State of the Nation's Ecosystems / chapter on Coasts and Oceans, published in 2002.
- Intergovernmental Oceanographic Commission (IOC, UNESCO). See for example: A reference guide on the use of indicators for integrated coastal management (2003). IOC in collaboration with DFO, CSMP and NOAA. Manuals and Guides 45, ICAM Dossier no.1, 127 p.
- Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) and Advisory Committee on Protection of the Sea, IMO / FAO / UNESCO-IOC / WMO /WHO / IAEA / UN / UNEP.
- OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic. See the Quality Status Report (QSR) series.

References
Marvin, C., L. Grapentine and S. Painter (2004). Application of a sediment quality index to the lower Laurentian Great Lakes. Environmental Monitoring and Assessment, 91: 1-16.

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6 Socioeconomic indicators

Table 6-1 Summary of socioeconomic (quality of life) indicators

Goal	Code	Indicator	Page
Maximize sustainable wealth generation and the reduction of poverty	**S(QL).1**	Total economic value	131
	S(QL).2	Total employment	133
Minimizing environmental degradation from human activities	**S(QL).3**	Sustainably managed exploitation and use	135
	S(QL).4	Pollutants and introductions	136
	S(QL).5	Habitat alteration	137
Protect human life, public and private property, and establish or maintain equitable population dynamics	**S(QL).6**	Disease and illness	138
	S(QL).7	Weather and disaster	140
	S(QL).8	Population dynamics	141
A detailed table with indicators and parameters is provided on page 130.			

6.1 The role of socioeconomics in ICOM

Discussion on the role of socio-economics in integrated coastal and oceans management potentially engages a broad and diverse set of themes. While it is certain that local conditions will define specific indicators choices, there are substantial similarities across regions and cultures that allow for the development of general guidelines that address a few large themes that can be collectively related to one general "quality of life theme". This general theme has four main dimensions – an economic dimension, an environmental dimension; public health and safety dimension; and, a social dimension.

These four dimensions are discussed below in relation to nature and scope of integrated coastal and oceans management. While it may seem self-evident, it is nonetheless worth reinforcing, that these socio-economic or quality of life indicators must relate to what makes the makes the coastal zone unique. In every country, people organize themselves to live, work and interact, regardless of whether they are in to coastal zone or not. It is the interaction between marine and terrestrial environments, however, that distinguishes the coastal zone from human settlement and human activity in other areas of a country, and it is this interaction that ICOM is concerned with. Accordingly, indicators should be designed to capture information for management purposes on this interaction.

As for other types of indicators, socio-economic indicators should:

- Allow managers and decision-makers (public and private) to have an information base that will allow for rational and informed decisions;

- Provide information on either a cost or a benefit basis (i.e., the cost of taking (or not taking) an action, or the benefit derived from taking an action, or both;

- Include both direct and indirect societal costs and benefits ("externalities"); and

- Be amenable providing and tracking information on both long-term and short-term costs and benefits.

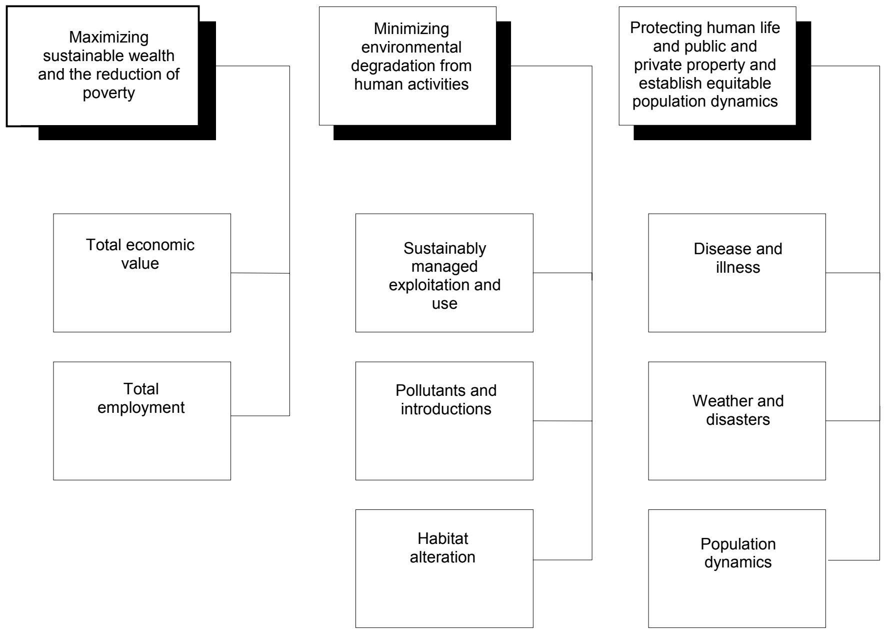

Figure 6-1 Socioeconomic goals and dimensions for ICOM

6.2 Economic

At its most basic level, the importance of an economic indicator is that it provides information that is easily understood and provides a common basis of comparison of economic activity -- within a country, among countries and between sectors. Economy is what drives virtually all uses of the marine environment, so its importance cannot be overstated.

There are a few main considerations with respect to economy. First, the ICOM process should provide information to allow informed and rational decision-making with respect to the importance of the coastal and ocean area vis-à-vis other areas of a country. It is often stated that the oceans and coasts do not get the political and management attention "that they deserve". It is reasonable to conclude that is a result of not having adequate information on the economic value of the oceans and coastal area. A key goal of ICOM therefore should be to provide that information to decision-makers to allow them to make informed choices and decisions from an economic perspective.

Second, it is important to remember that in most instances ICOM is a supplement to sectoral management, not a replacement for it. ICOM must therefore be seen to be providing a "value-added" service. One important area where ICOM can provide a value-added function is via the provision of information on the relative importance, from an economic perspective, of one activity vis-à-vis another. In many if not most instances of coastal and marine management, historic and traditional use is given preference over new or non-traditional use. This preference is often given without informed consideration of the economic contribution of one activity versus another. While there may well be a social/societal reason for providing preference for traditional activities or uses over new uses, the ICOM intent should be to provide an economic basis for allowing comparison of the value of one activity versus another. This can facilitate what has been sometimes referred to as "best use" decision-making. The provision of this type of information in the ICOM process will also provide valuable information on economic diversification. Just as biological diversity is an important ecological feature of the marine environment, so too is economic diversity an important feature from an economic perspective. Economic diversity decreases the risk of economic collapse (with attendant social consequences), and can be important in reducing ecological impact as well.

Third, the generation of economic activity is not free – it has costs associated with it. Sometimes these costs indirect and difficult or impossible to quantify (e.g., "opportunity costs" of choosing one use over another), but in many instances the costs are quantifiable. Just as ICOM should be providing information on the economic value of each activity, so too should it be providing information on the direct economic cost associated with that activity. Without this information, decision-making on relative value of one activity versus another may be badly flawed as the management and administration associated with that activity may significantly affect its net economic value. For example, the cost of science and management advice for the management of sustainable commercial fisheries may be very significant (up to or beyond 50% of the economic value of the activity), whereas the science and management costs or a recreational fishery for the same species might be significantly lower. ICOM, because it is designed to look at inter-sectoral uses, can provide valuable information on management and administration costs that will be important for rational and informed decision-making.

Accordingly, three of the most relevant economic indicators for ICOM are:

- Total economic value
- Total employment
- Management and administration costs.

Each of these indicators must be comprehensive to be truly effective and should therefore each indicator should be compiled for the following main subdivisions:

- The exploitation of the living resources of the coastal and ocean area;
- The exploitation of the non-living resources of the coastal and ocean area;
- The non-consumptive use of the coastal and ocean area, including the use of the coastal and ocean waters for moving people and goods.

Further sub-classifications may be necessary to construct this indicator in order to be relevant to the particular local, regional or national circumstances. Keeping the general system of classification described above, however, is important for comparative purposes.

Ideally, total economic value will include both gross value and net value (value added).

Similarly, total employment will include both economic value of employment and the number of persons employed. Again, these measures should be developed using the classifications described above.

6.3 Environment

While the previous section dealt with the direct economic benefits and costs of the generation of wealth in the ICOM area, this section deals with the indirect costs in relation to the effects on the environment resulting from those activities. In addition, this section deals with the effects of coastal population and other coastal development not necessarily directly associated with wealth-generating activities.

The overall goal of the ICOM process in this context should be that coastal development should ensure that coastal habitats and resources remain sustainable and viable, and the interaction between coastal biophysical dynamics and human uses of the environment should be understood and managed in an integrated fashion. This will require consideration of overarching objectives:

- Changes to land use/land cover patterns should minimize environmental impacts such as habitat loss, habitat fragmentation, loss of permeable surface, groundwater recharge, etc
- Physical alteration to the coastline should minimize changes to coastal storm protection, loss of barrier beach and other natural barriers, coastal wetlands, and dune systems;

- Authorized use of the marine environment should minimize impacts on habitat, especially in biologically sensitive and productive marine areas; and

- Physical alteration of the benthic environment (e.g., though dredging or dumping) should be done in consideration of cost-benefit analysis which includes the long-term and secondary impacts directly or indirectly associated with the disturbance.

Readers should note these are presented as socio-economic objectives; that is, the extent to which our "systems of society" and resource use decisions have an effect on the environment, and the extent to which this has direct or indirect effect on coastal economies. The specific indicators related to the environmental or ecological impacts and functioning of oceans and coastal ecosystems are presented in Chapter 3. As crises in fisheries around the world have demonstrated, social, economic, and environmental aspects of the marine environmental are irrevocably linked. The fisheries, for example, are as much about people as they are about fish, and the same is true for all other uses of the marine environment. Marine ecosystems support complex social, cultural, and economic human systems and the two are interdependent. The health of ecosystems directly affects the health of economies and societies.

As humans expand the intensity and reach of our imprint on the environment (coastal or inland) a few simple concepts deserve a central place in the management debate.

First, new human settlements, by definition, replace the settlement of other organisms and habitats. When human populations move into new areas they displace what was there before. With the increased intensity of human migration into new coastal areas the issue of coastal habitat change requires more active and intense scrutiny. Habitat modification and loss are among the clearest affects of increasing human activities in the coastal zone.

Second, humans not only displace habitat, but, through their actions can influence the viability of non-human habitat in both near and distant geographies. It is increasingly clear that the world around us can include places quite distant from where we live. The way we live our lives, build commerce, use resources leaves behind chemical and physical residue that changes the world around us.

Urban development has resulted in rapid increases in the flux of nutrients, pollutants and pathogens associated with sewage inputs to coastal waters. In addition, a major consequence of urban development and the associated construction of roads and other hardened surfaces are their affects on permeability of the land surface to water. Developed land produces more surface runoff per unit area than do undeveloped areas, an affect that leads to increases in the transport of water, sediments, nutrients and contaminants to coastal aquatic ecosystems. This is not an assertion that humans should avoid building in new areas or establishing new communities. Rather, the argument is that an information-driven management system should help mitigate the environmental costs of those developments without significantly imposing broad losses in development value.

The construction of transportation infrastructure has been shown to destroy critical coastal habitats, such as coral reefs, mangrove forests and tidal marshes. Roads can act as dams impounding freshwater flowing seaward or block tidal flows within estuaries. The construction of highways through tidal wetlands has effectively separated upper reaches from lower reaches of tidal marshes, a practice that has significantly altered circulation patterns within these systems. Destruction and modification of tidal wetlands increases the susceptibility of coastal populations and ecosystem to storm surges and coastal flooding.

The construction of seawalls, revetments, and bulkheads can also cause environmental problems when their design and construction do not consider how they will affect coastal circulation, sediment budgets, and the movements of and interactions among plants and animals. As static structures, they alter natural dynamics of sediment transport and impede dune-beach interactions, i.e., the land-sea exchange of sediments. On the beach side of a sea wall, wave reflection is likely to transport material seaward. This increases the erosion of sand and causes the beach at the foot of the wall to become narrower and steeper resulting in deeper water nearshore. Consequently, large storm waves, which normally break in the offshore bars, now reach the beach and the seawall resulting in an increase in wave energy.

Without sustained maintenance (the cost of which can be high an often prohibitive), the seawall is weakened, undermined, and destroyed. Change in beach profiles can also result in the development of strong rip currents increasing safety risks to swimmers as well as increasing risks to natural habitats and their animal and plant inhabitants. Periodic and routine replenishment of coastal beaches can be motivated or caused by the frequency of major storms, the construction of coastal jetties and groins, the desire to sustain or increase tourist income, and natural changes in coastal geomorphology.

Dredged sediments currently constitute between 80 and 90 % (by volume) of all anthropogenic materials dumped into the ocean. Several hundred million m3 of coastal sediments are dredged and disposed of annually worldwide. Coastal dredging is most prevalent in depositional environments where the fine fraction is often contaminated by toxic chemicals (e.g., oil, trace metals, pesticides, herbicides, PCBs) from industrial, municipal, agricultural, and domestic sources. Remobilization of bottom sediments can (1) increase the exposure marine organisms to chemical contaminants through direct contact or through ingestion which may have far reaching ecological consequences (e.g., Section 2.3.2); (2) increase sedimentation rates in seagrass beds or coral reefs smothering them or, in the case of mobile organisms, forcing them to move elsewhere; and (3) increase oxygen demand depleting the water of oxygen, a phenomenon that stresses benthic organisms and may lead to mass mortalities. When high concentrations of suspended sediment are sustained due to bottom re-suspension or dredge overflow, light penetration is reduced resulting in lower plant productivity, the loss of sea grass beds, and/or the loss of coral reefs.

In addition to dredging, bottom trawling can have a significant impact on soft bottom habitats and the organisms that inhabit them. It has been estimated that about 60% of the global continental shelf area has been swept by bottom trawls. The long-term impacts of this are unknown but are likely to be substantial.

6.4 Public health and safety

The oceans affect human health risks via both the ocean-climate system and physical-biological-chemical processes within marine and estuarine ecosystems that store, distribute and concentrate human pathogens and toxic chemicals. Although this section focuses on the latter, it should be noted that global weather patterns, such as those associated with ENSO events, have been shown to increase the risk of contracting diseases such as malaria and cholera in tropical and sub-tropical regions where coastal populations are most at risk.

The overall goal of the ICOM process should be that public health and safety risks directly or indirectly associated with coastal and ocean activities are reduced. This will require that at least the following aspects be considered:

- Point and non-point sources of pollutant discharges (including thermal) to the coastal and ocean area should be minimized;
- Where discharges are made or authorized, treatable and non-treatable pollutants should be segregated, with treatable pollutants treated and non-treatable pollutants removed from the discharge;
- Natural sources of harmful toxins should be monitored; and
- Public and private infrastructure should be positioned so as to minimize human and public health and safety risks.

Consumption of contaminated seafood is the primary route of human exposure to illness, but illness also occurs through direct exposure to contaminated seawater and inhalation of aerosols. Four categories of contaminants directly contribute to human health risk via these routes: (1) naturally occurring biotoxins produced by marine organisms; (2) indigenous bacteria (3) non-indigenous viruses and bacteria; and (4) chemicals contaminants (metals, hydrocarbons, POPs, radionuclides). The distributions of and human exposure to waterborne contaminants depend on interactions between human activities (e.g., sewage discharge, swimming, seafood consumption), ocean circulation, the growth and distributions of marine organism, and the weather (NRC, 1999). This reality underscores the importance of developing an integrated approach to monitoring and controlling public health risks in the coastal zone that encompasses the effects of ocean processes on the distribution and abundance of human pathogens and toxic agents (Knap et al., 2001).

As shown by the examples below, human exposure to these contaminants and the associated health risks are clearly related to ocean processes ENSO events and the effects of currents and mixing on the distribution of contaminants to the concentration of contaminants by marine organisms.

Harmful algal events

The most significant source of naturally occurring biotoxins are harmful species of microalgae that produce saxitoxins (paralytic shellfish poisoning), brevitoxins (neurotoxic shellfish poisoning), domoic acid (amnesic shellfish poisoning), okadaic acid (diarrheic shellfish poinsoning) and ciguatoxin (an operational term for lipid-soluble toxins that accumulate in tropical reef fish). With the exception of domoic acid which is produced by species of the genus Pseudo-nitschia, all of these toxins are produced by dinoflagellate species. The growth, distribution and toxicity of these organisms are influenced by water movements (currents, turbulent mixing, fronts), water temperature and nutrient enrichment. There is evidence that the frequency and extent of harmful algal events are increasing due to human activities including overenrichment of coastal waters, increased utilization of coastal waters for aquaculture, and introductions of non-native species of harmful algae in the ballast water of ships or through the translocation of shellfish stocks from one region to another. It is noteworthy that increases in the incidence of ciguatoxin poisoning associated with the consumption of reef fish (e.g., barracuda, grouper, snapper) occured in coastal populations of the Indian Ocean following the ENSO-coral reef bleaching events of 1997-1998.

Indigenous bacteria

Indigenous or autochthonous bacteria are usually commensals of marine organisms, although some may be free living. The most common species are Vibrio cholerae (causes cholera) and V. parahaemolyticus (causes gastroenteritis), both of which occur on the surfaces of copepods and increase in abundance with copepod abundance and temperature. Consequently, environmental factors that promote the growth of copepods such as nutrient enrichment and increases in water temperature, are also likely to increase the risk of human exposure, primarily through the consumption of raw or under cooked oysters and other filter feeding bivalves. In addition, these organisms can be introduced to new marine environments via shipping and the discharge of ballast water.

Non-indigenous bacteria and viruses

Non-indigenous or allochthonous bacterial and viruses are associated with fecal contamination from sewage outfalls, septic tanks and surface runoff. Enteric bacteria can survive for extended periods in seawater (days – weeks) and are concentrated by filter feeding bivalves such as oysters and clams (also see sections 2.4.2, 2.6.4) . Likewise, although viruses require living cells to reproduce, some viruses (e.g., hepatitis A and E, poliovirus) can also survive in seawater for long periods (over 1 year) and are also concentrated by marine bivalves. Most waterborne and seafood-borne diseases are caused by viruses.

Chemical contaminants

Metals, hydrocarbons, POPs and radionuclides are distributed globally by both ocean and atmospheric circulations. For example, POPs are distributed world-wide by an iterative process of deposition, remobilization into the atmosphere, and redeposition. This process of “global distillation” explains the high concentration of POPs in piscivorous fish (e.g., Arctic cod, Greenland halibut), marine mammals, and breast milk of indigenous populations living in polar regions.

The cost of marine-vectored public health risk is substantial. Globally, Shuval (2000) estimated that exposure to pathogens by bathing in contaminated seawater and consuming contaminated seafood resulted in losses of $8.8 billion USD/year during the 1990s. Most of this can be attributed to the discharge of untreated sewage. Although such estimates are rough, they illustrate that the potential socio-economic value of an integrated ocean observing system significantly exceeds the required investment.

Seafood-borne risk

Seafood consumption accounts for 11%, 20% and 70% of food-borne diseases in the U.S., Austalia and Japan, respectively. A recent review of the reported outbreaks of food-borne disease in the U.S. concluded that seafood consumption is the major source of food-borne disease in general (CSPI, 2000). Shuval (2001) estimated the global disease burden and associated costs of consuming raw or lightly steamed shellfish from waters contaminated with wastewater and natural marine biotoxins. Preliminary estimates suggest that economic losses are on the order of

$16 billion USD annually. Although high, this estimate is not inconsistent with similar estimates on smaller scales, e.g., an analysis by Bowen and Terkla (1990) suggests that the cost of seafood-borne disease in Massachusetts, U.S. (population about 6 million) is on the order of $60 million USD annually. Scaling this up to the global population gives an estimate of about $60 billion USD.

The use of synthetic, inorganic fertilizers has increased by nearly 10 fold over the last 50 years on a global scale, a trend that has lead to a rapid increase in the flux of nitrogen and phosphorus to coastal waters. This, and increases in the discharge of sewage wastes, are the primary causes of coastal eutrophication and associated declines in water quality and loss of critical habitats such as coral reefs and sea grass beds. Over-enrichment of coastal waters may also be increasing the probability of harmful algal events and the growth of non-native species. Consequently, the flux of nutrients from land-based sources is considered to a major cause, if not the major cause, of environmental degradation in coastal marine and estuarine ecosystems.

6.5 Population dynamics

One of this century's most intriguing and important population trends has been migration to the coast. Some estimates place between one-half and two-thirds of the world's population within a few tens, to hundreds, of kilometers of the coast (GESAMP, 2001a; Shuvall, 2001), although the range of those estimates are remarkably broad (from a low of 37% to a high of 80%).

The goal of the ICOM process should be to ensure that population dynamics and culture values are considered and their implications are linked to our understanding of potential effects on the coastal and ocean ecosystem.

It is important to note that trends in coastal population represent not only indigenous growth rates but also represent a substantial migration to the coast from inland areas. In some instances, population growth in coastal areas exceeds by several times growth rates measured nationally. Indeed, the present population of coastal areas exceeds the total global population of just fifty years ago (Bowen and Crumbley, 1999). Take, for example, the population of China. In a country of nearly 10 million square kilometers close to 60 per cent of population lives in 12 coastal provinces, along the Yangtze River valley, and in two coastal municipalities – Shanghi and Tianjin (Hinrichsen, 1998). Along the Chinese coast population densities average between 110 and 1,600 per square kilometer, with Shanghi densities above 2000.

This coastal migration also represents a significant cultural transformation in the countries experiencing it. Most of that migration also represents a move from to rural to urban environments. Today, fourteen of the world's largest cities are coastal. The descriptor "megacities" has been termed to characterize cities with populations in excess of 10 million and the unique problems, including environmental, that evolve from them.

These trends, then, not only mean an increased population within the coastal zone, but also a population concentration within very confined areas of the coastal system; that is, coastal cities. The consequences of this population concentration, in many ways, define that challenges faced in defining and implementing sustainable environmental strategies for the coastal zone. Indeed, many of the environmental stressors imposed on coastal systems result from too many people in too small a space.

Communities and individuals also have important social and cultural as well as economic attachment to the coastal and marine environment. Cultural and aesthetic factors often transcend the view of nature as a collection of marketable objects. Natural systems hold intrinsic values that can only be articulated in their contribution to social, cultural, psychological, and aesthetic needs. It is only through recognition that natural systems provide value through all three of these classes that an effective assessment can be made of their value to society.

Table 6-1 Detailed list of socioeconomic (Quality of life) indicators

Goal	*Objective*	*Indictors and parameters*
Maintaining or enhancing the quality of life	**Economy:** *Maximizing sustainable wealth generation and the reduction of poverty*	**S(QL).1 Total economic value** - Exploitation of living resources (commercial fisheries; artisanal fisheries; recreational fisheries) - Exploitation of non-living resources (oil and gas; minerals and metals) - Non-consumptive uses (shipping; tourism and eco-tourism) - Economic value-added - Value of exports - Management and administration costs
		S(QL).2 Total employment - Number employed - Employment payroll value - Same sub-categories as total economic value
	Environment: *Minimizing environmental degradation from human activity*	**S(QL).3 Sustainably managed exploitation and use** - Environmental assessments conducted - Fisheries with management plans
		S(QL).4 Pollutants and introductions - Population served by wastewater treatment - Volume, number, and type of point-source discharges - Non-point-source nutrient loading (e.g., fertilizer use) - Discharged sediments and nutrients - Volume of ballast and bilge discharge - Litter and debris
		S(QL).5 Habitat alteration - Land use/land cover patterns and composition - Population density - Extent of hard-surface areas - High-impact fishing gear/practices - Dumped and dredged material (e.g., shipping channel maintenance)
	Society: *Protecting human life, public and private property, and establishing or maintaining equitable population dynamics*	**S(QL).6 Disease and illness** - Fecal chloroform counts - Days of beach closure - Extent of contaminated species - Extent of contaminated water - Seafood-vectored illnesses
		S(QL).7 Weather and disaster - Economic value of loss from marine weather-related events - Lives lost from weather and marine disasters
		S(QL).8 Population dynamics - Degree of public access - Resident and total (seasonal) population - Marine attachment

6.6 Detailed description of socioeconomic (quality of life) indicators

S(QL). 1	Total economic value

Nature of indicator

Definition
Using neo-classical economic terms, these are the direct benefit values of products and services derived from the coastal and ocean management areas.

Relevance

The indicator can provide for comparison to national accounts for the total economy, and for comparison to other national or regional geographic economic areas, and for inter-country comparisons. The focus of the indicator should be on those activities that distinguish the coastal and ocean area from other areas within the nation or region.

The total economic value likely is the most important indicator of the importance of the coastal and management area to the region and its peoples; it also allows for comparisons of intersectoral/relative economic importance, and allow for comparisons between one coastal/oceans area and another, and between one or several coastal areas and non-coastal areas within a country or region – it is therefore of defining importance.

Methodological description

Measurement approaches
To be most effective, the indicator should include all economic activities within the management area. While various classification or characterization schemes are possible, a useful generic "manner of construction" of the indicator is as follows:

1) For the Coastal Zone (land-based activities dependent on the marine environment):
   i) Fish and seafood processing
   ii) Tourism and recreation (local and visitors)
   iii) Port and shipping (people and goods) activities, including ship-building
   iv) Other activities that are "water-dependent"

2) For the marine environment (for the extent of the ICOM area out to the boundary of the EEZ or the continental shelf):
   a) Living resource exploitation
      i) Fishing (commercial, recreational, artisanal) activity
      ii) Aquaculture and mariculture activity
      iii) Pharmacological or genetic activity
   b) Non-living resource exploitation
      i) Oil and gas activity
      ii) Sand, gravel and mineral (e.g., salt) extraction
   c) Non-consumptive use
      i) Electricity generation from wind, tidal or wave energy

Each sub-component above should ideally consider both the raw economic value, and the value added. One particularly important aspect with respect to value added is the management costs associated with the generation of the economic activity. Information on public management and administration costs associated with the generation of and management of economic activity in the coastal and ocean area should be compiled. Elements to be considered are as follows:
1) Local, regional, or national public costs, including
   a) The cost of scientific research and advice
   b) Management and administration costs of all government agencies associated with the economic activity
   c) The cost (annual or amortized) of public infrastructure required for the facilitation of commerce (e.g., wharves and other public port facilities)
2) International or other donor costs or contributions
3) Sectoral or other user charges or contributions
4) The value of voluntary contributions, by citizens, non-governmental organizations, or industry

Limitations
Total economic value can also incorporate "derived values", but caution is warranted in the use of these

values, and their construction should be "methodologically rigorous"; an example of a "derived value" is the value of using the marine environment for sewage or wastewater discharge in lieu of the investment required for treatment of these discharges.
Similarly, "spin-off" economic values should be avoided
While any one or several subsets of the categories described above will provide very useful management information, anything less than total will not allow the full utility of the indicator to be achieved.

Assessment of data

Analysis and interpretation
Time series analysis; assessment of relative changes in economic/industrial structure; seasonal variation; comparisons between and among sector/uses; comparisons with non-coastal areas; comparisons between the coastal (on-shore; near-shore) and the marine components (Territorial Sea; EEZ; continental shelf) of the management area

Reporting scale
National, regional, local.

Output
Tables and maps accompanied by narrative reports

Additional information

Data sources
Various source on regional use and economic value associated with habitat derived products. Assessment methods can be derived from a broad variety of sources, including: R.K. Turner and W.N. Adger, Coastal Zone Resources Assessment Guidelines, LOICZ Reports and Studies, No. 4 (1995).

S(QL).2	Total employment
Nature of indicator	The indicator is a description of the total direct employment associated with oceans and coastal activities in the management area. Like total economic value, it can provide for comparison to national accounts for the total economy, and for comparison to other national or regional geographic economic areas, and for inter-country comparisons.
Relevance	Total economic value and total employment are "companion indicators" and should typically be created, compiled and analyzed together. Changes in employment within industry classes can be an effective indicator of changes to broader social and cultural dynamics. Changes indicating worker movement out of traditional coastal industry sectors such as fishing and shipping can signal longer-term changes in cultural dynamics.
Methodological description	**Measurement approaches** Total employment should use the same "manner of construction" for the indicator as that used for total economic value (a general classification scheme is described above). The information developed for the indicator should include both direct employment (numbers of employed) as well as payroll. The data collection process for the indicator can also be used to collect other socially-relevant policy information, such as: - Education levels of persons employed; - Gender dynamics; - Training or certification levels required; - Self-employed vs employee - Average size of "establishment" - Tax (property, income or payroll) contributions. In all instances this information should be collected for each sector or sub-sector as per whatever general sectoral/sub-sectoral classification schema is used. **Limitations** "Spin-off" and indirect employment attributions should be avoided in the compilation and analysis.
Assessment of data	**Analysis and interpretation** Time series analysis; assessment of relative changes in economic/industrial structure; seasonal variation; comparisons between and among sector/uses; comparisons with non-coastal areas; comparisons between the coastal (on-shore; near-shore) and the marine components (Territorial Sea; EEZ; continental shelf) of the management area Both total employment and the value of employment (payroll) should be included in analysis wherever possible. **Reporting scale** National, regional, local **Output** Tables and maps accompanied by narrative reports.
Additional information	**Data sources** Data will normally have to be developed specific to the management area, but some general information is available at the following sources: UN Department of Economic and Social Affairs http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=8&Lg=1 European Advisory Committee on Statistical Information in the Economic and Social Spheres (CEIES) http://epp.eurostat.cec.eu.int/portal/page?_pageid=1193,1440015,1193_1440022&_dad=portal&_schema=PORTAL

North American Industry Classification System (NAICS)
http://www.bls.gov/bls/naics.htm
Global Industry Classification Standard (GICS)
http://www.msci.com/equity/gics.html

S(QL).3	Sustainably managed exploitation and use
Nature of indicator	**Definition** The indicator is a description of the extent to which deleterious or potentially deleterious effects of human activity that directly or indirectly the coastal and ocean area are understood, managed, and their effects minimized.
Relevance	The indicator is relevant because it provides information as to what extent the "sustainable" part of "sustainable development is practiced. Ecosystem-based management is premised on the management of human activity (exploitation and use), not on the direct management of ecosystems; to understand the effects of human activity, the ecological consequences of each activity should be examined. This indicator is an examination whether or not that is done in any given coastal or management area.
Methodological description	**Measurement approaches** An underlying concept is that human activities in the coast zone should be managed; at the very least, the potential of negative effects should be examined. *Note: implicit in management is an assumption (that should be tested in all cases) that management plans for human activities (such as fisheries management plans) are premised on an implicit or explicit analysis of the effects of that activity on the marine environment, which may not be true. The management may be directed towards other objectives.*) A main component of the indictor, therefore, should be collection of information on the proportion of human activities in the coastal zone that have management plans. It is recognized, however, that not all activities have management plans; in those instances, the indictor should collect information on other management actions that provide an assessment of the impact on the activity on the coastal or ocean area (i.e., a project environmental assessment (EA) or a strategic environmental assessment (SEA)). The measurement is one of proportion – the proportion of total activities in or affecting the marine environment for which an assessment is done indirectly (via a management plan) or directly (via an environmental assessment). The data should be collected and assembled by industry and type of management action (plan or EA). As well, the data should be characterized by whether it is a land-based activity (in the coastal zone) or a sea-based activity. **Limitations** The indicator will provide information on the total (additive) effects of human activity; it will not (necessarily) provide information on the cumulative effects of human activity; because the totality of human activities (or even a sub-set of total activities) may have synergistic ecological consequences, some caution is warranted. Nonetheless, even without consideration of cumulative effects, the indicator will provide clear information on which to base management measures and interventions. As well, the indicator does not provide an efficacy or quality assessment of the management plans or environmental assessment, or an indication as to what extent the actions called for in the plans or assessments are implemented.
Assessment of data	**Analysis and interpretation** The indictor will provide raw data on whether or not environmental effects of activities are being considered or management; assessment and management of effects is, in effect, a "minimum standard" approach that should be employed. Knowledge of whether or not that is done will provide coastal zone managers and policy makers the information necessary to press for such a minimum standard to be used. **Data sources** Sectoral management activities (e.g., fisheries managers; FOA; oil and gas managers; managers of aquaculture activities; etc). National, or sub-national Environment Departments or environmental agencies. **Reporting scale** Local, regional, national **Output** Tables accompanied by narrative reports
Additional information	

S(QL).4	Pollutants and introductions

Nature of indicator

Definition
The indictor is a measure to the total volume and sources of all types of pollutants, discharges, and introductions in the coastal zone.

Relevance

The degree of complexity of assembly of the indicator will determine its relevance; simple basic measures may provide very useful information to stimulate stronger environmental protection strategies or policies; at its most basic, the indicator can stimulate public awareness and attention to a problem or a potential problem. With greater degrees of complexity (and associated analysis) the indicator, or its sub-components, may provide sufficient data to direct management actions (such as targets or reference points).

Methodological description

Measurement approaches
Measurement should include both land-based sources or pollutants and sea-based sources of pollutants; some of the major sub-categories to be considered include:
- Population served by wastewater treatment
- Volume, number, and type of point-source discharges
- Litter and debris (including lost fishing gear)
- Non-point-source nutrient loading (e.g., fertilizer use)
- Discharged sediments and nutrients
- Volume of ballast and bilge discharge.

To be effective, all sources within or affecting the management area should be included; data is often gather for individual sources, but indications of the totality are rarely provided.

Limitations
Data on far-field sources and on air-born sources may be very difficult to accumulate and management measures with the resultant information difficult to effect. Cumulative effects and absorption capacity are useful concepts to enhance the analysis, but can be difficult and costly to determine.

Assessment of data

Analysis and interpretation
The total accumulated assault of pollutants will provide a strong indication of expected overall water quality for the marine environment, and a general indication of the impact of human activity. The collection of the information may also stimulate attention to the problem in total, as well as specific problems within each or any of the sub-categories. It may require further analysis beyond "gross level indicators" to determine which amongst the sources of pollutants is the most important immediate or long-term threat (in order to set priorities for action).

There are methodologically-sound measures that can be employed for greater analysis, such as maximum absorption capacity of the receiving environment, that can enhance the analysis and allow for more sophisticated regulatory or management actions.

Data sources
Environment departments; beach programs and community monitoring programs; sectoral management agencies; environmental non-government organizations; local or regional water and waste-water management agencies; agencies or companies responsible for or providing electrical generation; government statistical agencies.

Reporting scale
Local regional national

Output
Narrative reports accompanied by tables and maps

Additional information

S(QL).5	Habitat alteration
Nature of indicator	**Definition** The indicator is a measure of to what extent the habitat has been changed or altered by human activity; habitat should include both coastal and riparian habitat, and offshore marine habitat.
Relevance	Habitat quality is a critical component of the quality of the marine environment, and essential to ecosystem structure and function – the equation is simple: no habitat; no sustainable marine life. Having an understanding of the extent to which human activity is having an effect on habitat is therefore critical to managing those activities sustainably. The distribution and changes in population density can be as or more important than total population; the spread of population into new, previously uninhabited areas can increase the destruction and fragmentation of coastal habitat, contaminate coastal waters with a variety of pollutants and expose new resources to exploitation; the dynamics of "sprawl" is different from increased population within the existing footprint of human habitation, and the differences need to be understood and managed.
Methodological description	**Measurement approaches** There are several components of should be included in order to provide a comprehensive indication of the extent of habitat impact, as follows: - Land use/land cover patterns and composition - Population density - Extent of hard-surface areas - Artificial barriers or constructions - Coastal (e.g., beach, mangrove) alteration - High-impact fishing gear/practices - Dumped and dredged material (e.g., shipping channel maintenance) **Limitations** Not all habitat alterations are harmful or destructive, and human-generated habitat may be beneficial to improved marine environmental quality outcomes; great care, however, should be exercised in making such conclusions – they should only be derived from solid scientific analysis.
Assessment of data	**Analysis and interpretation** The amalgamation of the subcategories noted will give an overall indication of the "human footprint" in the marine environment. There are interpretive measures that are available that may assist managers (such as the % hard-surfaced rule) that can give an indication of particular problem areas. **Data sources** Environment departments; beach programs and community monitoring programs; sectoral management agencies; environmental non-government organizations; local or regional water and waste-water management agencies; systematic survey of the coastal zone to measure habitat alteration. **Reporting scale** The one kilometer Global Land Cover Characteristics Database (GLCCD) has developed a classification listing 15 different kinds of landcover. Each classification has been placed along a dimension from "natural" (least altered) through "semi-altered", to "altered" (most impacted by humans). **Output** Tables and maps accompanied by narrative reports.
Additional information	Global Land Cover Characteristics Database http://edcaac.usgs.gov/glcc/glcc.html

S(QL).6	Disease and illness

Nature of indicator

Definition
The indicator is a measure of the extent to which human health has been negatively affected by the water quality and the species quality in the marine environment.

Relevance

The indicator is relevant to understand the both the short-term and the long term consequences of marine environmental quality. The most immediate relevance is with respect to human health, but there are also economic consequences that are also important (the economic value of days lost due to illness, the short and long term economic cost of areas closed to fishing, the short and long-term impact on tourism). The information is also relevant for cost/benefit analysis (e.g., of enhanced wastewater treatment.) The introduction of under- or un-treated human waste is in many areas the primary source of lost fishing value, lost coastal recreational value and increased marine-sourced public health risk (see indicator QL4 above).

Methodological description

Measurement approaches
Measurement should consider a mixture of "source" and "consequence" information
- Fecal chloroform counts
- Days of beach closure
- Extent of contaminated species
- Extent of contaminated water
- Seafood-vectored illnesses (including chronic long-term accumulations)

Limitations
Measurement of terms like "improved" sanitation may differ from region to region even when reported by a single international organization. In some instances it may mean no access to any sanitation while in other others the term may mean that the existing facilities fall short of regional norms.

Assessment of data

Analysis and interpretation
International standard for bathing water quality have been developed through the a group of experts headed by the WHO. The so-called "Annapolis Protocol" is being used by an increasingly large number of countries to establish both standards and measurement protocols.

Measurement of contaminants may be particularly important for indigenous populations which have a high reliance on marine-sourced food sources.

More sophisticated economic modeling is available to determine the economic consequences of disease and illness (see GESAMP: *A Sea of Troubles*, for example)

Data sources
Public health authorities, environment departments of governments (national, sub-national); hospitals; World Health Organization; Food and Agricultural Organization

Reporting scale
Local, regional, national, international

Output
Narrative reports accompanied by tables and maps

Additional information

Guidelines for Analysis and interpretation are available through the WHO.
http://www.who.int/entity/ water_sanitation_health/bathing/Annapolis.pdf

World Bank Group. Water Supply and Sanitation Program.
http://www.wsp.org

World Health Organization: Water, Sanitation and Health
http://www.who.int/docstore/water_sanitation_health/

U.S., Environmental Protection Agency, BEACON, Beach Advisory and Closing On-line Notification http://oaspub.epa.gov/beacon/beacon_data.about_beacon

European Blue Flag System
http://www.blueflag.org/BlueFlagMap.asp

S(QL).7	Weather and disaster
Nature of indicator	**Definition** The indicator provides information on the extent to which human lives and human property are affected by natural marine weather and marine disaster events.
Relevance	Understanding the consequences, economic and social, of living in a coastal environment is fundamental. Such an understanding usually predates management actions to control or mitigate the consequences of these events. It is also often required to stimulate necessary investment in oceanographic prediction and control devices and associated modeling and analysis. It is also relevant for an assessment of the consequences of human-induced coastal habitat alteration that may exacerbate the impact of natural marine weather events.
Methodological description	**Measurement approaches** - Economic value of loss from marine weather-related events - Lives lost from weather and marine disasters **Limitations** Causal relationships between human coastal habitat alteration and weather related impacts (or the exacerbation on weather-related impact) may be difficult to prove definitively.
Assessment of data	**Analysis and interpretation** Direct loss (economic or human lives) from weather related events is generally straight-forward; long-term and indirect consequences can be more difficult to provide. **Data sources** Government emergency preparedness and planning agencies; insurance companies; hospital and public health authorities; eNGOs **Reporting scale** Local, regional, national **Output** Narrative reports accompanied by tables and maps
Additional information	

S(QL).8	Population dynamics
Nature of indicator	**Definition** The indicator of the linkages between the humans and the coastal and marine area (over and above the linkages that are implicit in an economic sense as provided in "total economic value, QL 1)
Relevance	Understand the importance of the linkage to the coastal and marine environment is important for oceans and coastal management purposes, and for creating within the population (and governments) an empirical sense of the importance of the area. The distribution and changes in population density and changes in the composition of the population can be as or more important than total population. The spread of population into new, previously uninhabited areas can increase the destruction and fragmentation of coastal habitat, contaminate coastal waters with a variety of pollutants and expose new resources to exploitation. The dynamics of "sprawl" is different than increased population within the existing footprint of human habitation.
Methodological description	**Measurement approaches** - Resident and total (seasonal) population - Marine attachment/water dependant use - Degree of public access The unit of measurement population is in number of persons – population estimates are usually based on national population censuses and revised (in-between) censuses which have data of various kinds on births, deaths and migration. Resident population alone is a core variable; however, trend analysis, spatial distribution dynamics, population class analysis, and non-resident and seasonal population datea are all essential for substantial insight for managers. The term marine attachment or water dependent use means a use, activity, or project that requires direct physical siting on, or proximity or access to, an adjacent body of coastal water. While water dependency is met solely because of a requirement for water, marine attachment is determined by economic advantages that may be gained from a coastal waterfront location; social dynamics (intrinsic "value") may need to be determined from social surveys of the population, but is still an important consideration for managers and governments. Another measure of attachment may be given by the degree of public access to the coastal area; in many jurisdiction land-ownership rules and deed restrictions preclude full and open access to coastal areas and resources. Public access points are those along the coastline where individuals hold direct rights of way to the coast. **Limitations** The quality of census data varies broadly from country to country and within countries from region to region
Assessment of data	**Analysis and interpretation** Understand the importance of the linkage to the coastal and marine environment is important for oceans and coastal management purposes, and for creating within the population (and governments) an empirical sense of the importance of the area. **Data sources** Population census data; local governments; surveys **Reporting scale** Local and regional **Output** Narrative reports accompanied by tables and maps
Additional information	

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Acronyms

BAP	Best available practices
BAT	Best available techniques
CBD	Convention on Biological Diversity
CBO	Community-based organization
CCA	Carrying capacity assessment
CMP	Center for Marine Policy
COOP	Coastal Ocean Observation Panel (GOOS)
COP	Conference of the Parties
CP/RAC	Regional Activity Centre for Cleaner Production (Mediterranean Action Plan)
CSAS	Canadian Science Advisory Secretariat
CSD	Commission on Sustainable Development (United Nations)
CSPI	Center for Science in the Public Interest
DEAT	Department of Environmental Affairs and Tourism (South African Government)
DESA	Department of Economic and Social Affairs (United Nations)
DFO	Department of Fisheries and Ocean (Canadian Government)
DPSIR	Driving forces-pressure-state-impact-response
DSR	Driving forces-state-response
EBM	Ecosystem-based management
EC	European Commission
EEA	European Environment Agency
EEZ	Exclusive economic zone
EIA	Environmental impact assessment
ENSO	El Niño - Southern Oscillation
ETC/TE	European Topic Centre for Terrestrial Environment
EU	European Union
EUCC	The Coastal Union
FAO	Food and Agriculture Organization
GA	General Assembly (United Nations)

GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GMA	Global Marine Assessment
GOOS	Global Ocean Observing System
GPA	Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities
ICAM	Integrated Coastal Area Management
ICM	Integrated coastal management
ICES	International Council for the Exploration of the Sea
ICOM	Integrated coastal and ocean management
ICZM	Integrated Coastal Zone Management
IOC	Intergovernmental Oceanographic Commission
IUCN	The World Conservation Union
NGO	Nongovernmental organization
NMFS	National Marine Fisheries Service (United States Government)
NOAA	National Ocean and Atmospheric Administration (United States Government)
OECD	Organisation for Economic Co-operation and Development
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PAP/RAC	Regional Activity Centre for Priority Actions Programme (Mediterranean Action Plan)
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
PSR	Pressure-state-response
SCOR	Scientific Committee on Oceanic Research
SEA	Strategic environmental assessment
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
WCD	World Commission on Dams
WSSD	World Summit on Sustainable Development
WTO	World Tourism Organization

Glossary

Accountability
Obligation to demonstrate that work has been conducted in compliance with agreed rules and standards or to report fairly and accurately on performance results vis-à-vis mandated roles and/or plans.

Assessment
A process (which may or may not be systematic) of gathering information, analyzing it, then making a judgment on the basis of the information.

Biological diversity
The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Catchment management
Management of land usages in the coastal stream and river runoff areas for lagoons, bays, and estuaries.

Coastal population
Numbers and locations of people in coastal towns, cities, and agricultural regions.

Compliance
The act of meeting set rules, regulations or agreements.

Cost-effectiveness
Comparison of the relative costs of achieving a given result or output by different means (employed where benefits are difficult to determine).

Descriptive indicators
Descriptive indicators, often based on the DPSIR framework, describe the state of the environment and environmental issues at the scale for which they are measured.

Driving force indicators
Indicators for driving forces describe the social, demographic and economic developments in societies and the corresponding changes in life styles, overall levels of consumption and production patterns.

Driving forces-Pressures-States-Impacts-Responses (DPSIR)
The causal framework for describing the interactions between society and the environment adopted by the European Environment Agency: driving forces, pressures, states, impacts, responses (extension of the PSR model developed by OECD).

Ecosystem
A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

Ecosystem approach
The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is based on the application of appropriate scientific methodologies focused on levels of biological organization that encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems.

Effectiveness
The improvement of the quality of life of coastal communities while maintaining the biological diversity and productivity of the ecosystem through an ICM program.

Effects
Intended or unintended changes resulting directly or indirectly from a development intervention.

Efficiency
A measure of how economically inputs (funds, expertise, time, etc.) are converted into outputs.

Environmental indicators
Environmental indicators reflect trends in the state of the physical environment, help the identification of priority policy needs and the formulation of policy measures, and monitor the progress made by policy measures in achieving environmental goals.

Evaluation
A systematic (and as objective as possible) examination of a planned, ongoing or completed project. It aims to answer specific management questions and to judge the overall value of an endeavor and supply lessons learned to improve future actions, planning and decision-making. Evaluations commonly seek to determine the efficiency, effectiveness,

impact, sustainability and the relevance of the project or organization's objectives. An evaluation should provide information that is credible and useful, offering concrete lessons learned to help partners and funding agencies make decisions.

Governance
The process by which policies, laws, institutions and decision-makers address the issues of concern to a society. Governance questions the fundamental goals, and the institutional processes and structures that are the basis of planning and decision-making.

Governance indicators
These indicators measure the progress and quality of the governance process, the extent to which a program is addressing and solving the issue/s that led to the creation of the program.

Impacts
The changes in the lives of rural people, as perceived by themselves and their partners at the time of evaluation, plus sustainability-enhancing change in their environment to which the project has contributed. Changes can be positive or negative, intended or unintended. In the logframe terminology these "perceived changes in the lives of the people" may correspond either to the purpose level or to the goal level of a project intervention.

Impact indicators
Indicators that describe intended or unintended changes in environmental, social and economic conditions as an effect of management actions.

Indicator
A parameter or a value derived from parameters, which provides information about a phenomenon.

Input
The financial, human and material resources necessary to produce the intended outputs of a project.

Integrated coastal and ocean management (ICOM)
A dynamic, multidisciplinary, iterative and participatory process to promote sustainable management of coastal and ocean areas balancing environmental, economic, social, cultural and recreational objectives over the long-term. ICOM entails the integration of all relevant policy areas, sectors, and levels of administration. It means integration of the terrestrial and marine components of the target territory, in both time and space.

Logical Framework Approach (LFA)
A project indicator framework used by the World Bank, based on the Input-Output-Outcome-Impact model.

Management
Process by which human and material resources are organized to achieve a known goal within a known institutional structure or governance. Management typically refers to organizing the routine work of a unit of a company or a governmental agency.

Management capacity evaluation
Evaluations carried out to assess the adequacy of structures and processes to perform ICM tasks and activities.

Marine protected areas
Geographically delimited coastal or marine area, managed according to an established set of conservation or sustainable development oriented principles, rules and guidelines.

Outcome
The results achieved at the level of "purpose" in the objective hierarchy. Outcomes of the ICM governance process can be broken down into intermediate and final and measured at different geographic scales: local, regional, and national levels.

Outcome evaluation
Evaluations that aim at assessing the impacts of developmental and environmental management efforts in environmental physical environment and socioeconomic terms.

Output
The tangible (easily measurable, practical), immediate and intended results to be produced through sound management of the agreed inputs. Examples of outputs include goods, services or infrastructure produced by a project and meant to help realize its purpose. These may also include changes, resulting from the intervention, that are needed to achieve the outcomes at the purpose level.

Performance
The degree to which a development intervention or a development partner operates according to specific criteria/standards/guidelines or achieves results in accordance with stated goals or plans.

Performance evaluation/measurement
A system for assessing performance of development interventions against stated goals.

Performance indicator
A variable that allows the verification of changes in the development intervention or shows results relative to what was planned.

Pressure indicators
Indicators that describe the pressures exerted by human activities on the environment in terms of release of pollutants, physical and biological agents, use of resources and land.

Pressure-State-Response (PSR)
A typical analysis of causes and effects, driving forces, and responses. It is part framework of an environmental policy cycle that includes problem perception, policy formulation, monitoring, and policy evaluation.

Process evaluation
An evaluation of the internal dynamics of implementing organizations, their policy instruments, their service delivery mechanisms, their management practices.

Proxy indicator
An appropriate indicator that is used to represent a less easily measurable one.

Qualitative information
Information that is not summarized in numerical form, such as minutes from community meetings and general notes from observations. Qualitative data normally describe people's knowledge, attitudes or behaviors.

Quantitative information
Information that is measured or measurable by, or concerned with, quantity and expressed in numbers or quantities.

Response indicators
Indicators that refer to responses by groups (and individuals) in society, as well as government attempts to prevent, compensate, ameliorate or adapt to changes in the state of the environment.

State indicators
Indicators that describe in quantitative and qualitative terms physical, chemical and biological characteristics and phenomena in a certain area.

Sustainability indicators / Sustainable development indicators
Indicators that measure the likelihood that the positive effects of a project (such as assets, skills, facilities or improved services) will persist for an extended period after the external assistance ends.

Validity
The extent to which something is reliable and actually measures up to or makes a correct claim. This includes data collection strategies and instruments.

I ntegrated
C oastal
A rea
M anagement

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