results from local forcing and from arriving waves, bringing the influence of forcing (e.g., upwelling) 'forwards' from the 'backward' direction. In the Peruvian upwelling regime, for example, variable currents are not well correlated with local winds but include internal Kelvin-like features coming from nearer the equator. This is hardly compatible with (common) simplifications of a zero alongshore pressure gradient. Moreover, the waves carry the influence of assumed 'backward' boundary conditions far into a model. The same applies for steady flow. Friction introduces a 'forward' decay distance for a coastal-trapped wave; this distance has a definite low-frequency limit. Currents decay over these distances according to their structure as a wave combination. Thus alongshore evolution or adjustment of flow (however forced) is affected by coastal-trapped waves whose properties should guide model design.

## Summary

This article considers waves extending across the continental shelf and/or slope and having periods of the order of one day or longer. Their phase propagation is generally cyclonic, with the coast to the right in the Northern Hemisphere, a sense denoted 'forward'; cross-slope displacements change water-column depth and relative vorticity, causing cross-slope movement of adjacent water columns. At short-scales, energy propagation can be in the opposite 'backward' sense. Strict trapping occurs only for periods longer than half a pendulum day; shorter-period waves leak energy to the deep ocean, albeit only slowly for some forms. The waves travel faster in stratified seas and on broad shelf-slope profiles; speeds can be affected, even reversed, by along-shelf flows and reverses of bottom slope. Large amplitudes and abrupt alongshore changes in topography cause distortion and transfers between wave modes. The waves form a basis for the behavior (response to forcing, propagation) of shelf and slope motion on scales of days and the shelf width. Hence, they are important in shelf and slope–sea responses to forcing by tides, winds (e.g., upwelling), density gradients, and oceanic features. Their propagation (distance before decay) implies nonlocal response (over a comparable distance), especially in the 'forward' direction.

## See also

**Coastal Circulation Models. Internal Tides. Internal Waves. Regional and Shelf Sea Models. Rossby Waves. Storm Surges. Tides. Upper Ocean Responses to Strong Forcing Events. Vortical Modes. Wind Driven Circulation.**

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# COASTAL ZONE MANAGEMENT

**Seoung-Yong Hong**, Ministry of Maritime Affairs and Fisheries (MOMAF), Seoul, South Korea
**Chan-Wen Lee**, Kyungnam University, Masan, South Korea



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## Introduction

Developed and developing nations alike depend significantly on the resources and transportation opportunities in the marine environment. In most countries with a marine coast, development-oriented national policies have led historically to the concentration of populations and industrial activities in areas adjacent to the ocean known as the coastal zone. For many developing nations, shipping, fishing, aquaculture, and coastal tourism are vitally important to their economies.

Notwithstanding this importance, coastal resources are often developed with a land-oriented perspective that fails to consider the unique physical and environmental characteristics of the coast. Increasing urbanization and population growth, primarily in the coastal zone, has resulted in higher levels of pollutant loading, general environmental degradation, loss of biological diversity, risks to human health, effects on tourism development, and costs for resource management and regulatory activities. Time-after-time in many jurisdictions, it has been shown that these problems are unlikely to be addressed effectively by a sectoral and somewhat fragmented coastal governance system.

In recognition of the daunting challenges of managing coastal resources and their uses, the concept of coastal zone management was first introduced in mid-1960s as an innovative land-use paradigm. The paradigm was novel in that it incorporated both land and marine components, it was concerned with both development and conservation, and it involved various economic sectors and academic disciplines.

## Integrated Coastal Management

The importance of integrated coastal management (ICM) was recognized formally in 1992 by the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. ICM is an approach that holds much promise for effective, systematic management of the coastal environment. Recognizing that the coastal zone is a complex system, ICM moves beyond traditional approaches to employ a holistic, systems perspective, which recognizes the interconnections between coastal systems and uses. ICM methodologies are not explicitly technical, but also involve institutional, financial, and policy dimensions, with a focus toward addressing a wide range of coastal issues in a comprehensive fashion. Ideally, ICM is an ecologically based, iterative process for identifying, at a regional scale, environmental objectives and cost-effective strategies for achieving them. Management actions need to be developed based on the best scientific knowledge available about ecological functions as well as a comprehensive understanding of the institutional framework.

The unique features of ICM include: the integration of sea-use planning into coastal land-use plans; the strengthening of local government capacity; the creation of an institutional arrangement for interagency and stakeholder consultation; the harmonization of legislative requirements and enforcement; and the application of scientific knowledge and technology for management interventions. It should be emphasized that the 'integration of policies' is not synonymous with the 'centralization of authority.' A great deal of coordination occurs in an invisible fashion by standardizing information requirements, review procedures, and permit stipulations, through the skills of those involved in the process, and through informal communication between key actors. It should be also borne in mind that ICM anticipates something more than mere interagency collaboration.

### Methods of Integration

To achieve improved policy integration, policy makers should be well informed on what problems exist among sectors, what implications they pose, and how much they will cost to resolve. Two methods for achieving integration have been suggested: (1) direct methods, such as specific policy directives for government agencies to follow; and (2) indirect methods, such as either intellectual strategies that seek policy integration through initiating research, training, and socialization, aiming at the development of a more comprehensive and holistic perspective on the part of decision makers, or institutional strategies, involving some types of organizational change.

An ICM process needs to accommodate interactions among uses and resources, to recognize new problems, to respond to new knowledge, and to recognize and correct mistakes. The process is necessarily iterative, involving choices about how to anticipate and resolve conflicts and set priorities among multiple uses before environmental harm is done. The response of a coastal ecosystem to stresses, including pollution, overfishing, sedimentation, or encroachment on habitat, is often not well understood. Thus, ICM should function in a context that is responsive to scientific uncertainty, and to expected or unforeseen changes and events.

### Environmental Domain

ICM involves the specification of a relevant environmental domain with appropriate aquatic, terrestrial, and atmospheric components. The overall goal in adopting a domain is to minimize the number of significant physical causes and effects taking place outside the domain and thereby to enhance the effectiveness of management measures that can be taken within the domain. In practice, however, social and political factors such as existing administrative boundaries may have more influence in determining the management boundary. Therefore, in addition to physical linkages, the inclusion of strong common regional identities – and even conflicts – should be allowed, and, where appropriate, social, economic, political and institutional interests should be recognized.

### Priority Setting

ICM is a process of resource allocation. This allocation must be based on priorities established by society. The presence of enormous environmental and social uncertainties and physical changes argue strongly against the idea that a master plan for the repair and maintenance of coastal environment, which might be implemented mechanically by impartial government officials, would be feasible. Focusing on many different issues or treating all of the issues as if they are of equal importance makes it very easy to lose what should be a focus on the priority environmental problems of the coastal ecosystem. Thus, setting management priorities is crucial for the successful implementation of an ICM program.

To be successful, management priority setting must depend on the ability of an ICM process to satisfy the wide range of interests of both present and future generations and to provide a common denominator (sometimes referred to as an 'integrating objective') to the different actors whose expectations often diverge or oppose each other. In practice, however, it is difficult to characterize the needs of future generations. Further, given the present level of understanding about coastal ecosystems, it is also not an easy task to measure the carrying capacity of coastal waters.

## Adaptive Implementation

Decision making for coastal environments requires an interactive learning process, combining the participation of appropriate scientists, political interests, and the public to make decisions that govern the management of resources. Adaptive implementation is the establishment of a process that allows policy to be modified, specified, and revised. The use of an iterative and interactive decision-making process helps governing institutions arrive at decisions that are politically feasible. Characteristics of adaptive implementation include: active participation by relevant actors; adjustment of policy to the constraints of the policy situation; policy deliverers learning by doing rather than mechanically following a 'how to' procedure; and implementation used as a means to clarify policy.

### Environmental Monitoring

Establishing linkages between the planning process and scientific research, environmental monitoring, and data management is critical to the success of a continuing, iterative ICM program. For example, monitoring can strengthen coastal management in several ways: defining the extent and severity of problems; evaluating actions and detecting emerging problems; supporting integrated decision making, when coupled with research and predictive modeling; and guiding the setting of priorities for management programs. The ICM process is designed to make the fullest use of information relating to coastal systems and their management. It is an information-intensive process that requires effective data and information management. Information and data should be collected and maintained in forms that are accessible to users and compatible with other data in the system.

## Summary

The movement toward a process of integrated coastal management requires a continuing effort to press forward on scientific, engineering, regulatory, and management frontiers. Success is not always assured, however. Local decision makers often may be more concerned about new economic development opportunities than they are about environmental protection. Users and owners of the coastal resources often engage in excessive exploitation because of short-term perspectives or inadequate assignments of property rights. One key to success is to identify and incorporate incentives for the involvement of all interested parties. Decision makers, coastal stakeholders, and the public should all understand the seriousness of the coastal management problem, because coastal resource systems are valuable natural endowments that need to be managed for present and future generations.

## See also

**Coastal Topography, Human Impact on. Coral Reefs. Corals and Human Disturbance. Fishery Management. Fishery Management, Human Dimension. Law of the Sea. Mariculture, Environmental, Economic and Social Impacts of. Marine Policy Overview. Oil Pollution. Pollution Control.**

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# CONSERVATIVE ELEMENTS

**D. W. Dyrssen**, Gothenburg University, Göteborg, Sweden



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## Introduction

If 1 kg of sea water is evaporated and ignited according to a special procedure 35 g of solids are obtained. This is the normal (standard) salinity. Since the salinity is mainly changed by evaporation or by dilution with practically ion-free rain water the composition of the major ions in sea water is not changed by such processes. These constituents are considered to be conservative, and as a consequence their ratios are constant. Thus the concentration of a conservative constituent (element) at a salinity S is obtained by multiplying the values in **Table 1** by S/35.

## Determinations

The salinity can be determined with five significant figures from conductivity measurements as well as by potentiometric titration of chloride + bromide in m g of sea water with v ml of t molar silver nitrate. Thereby the chlorinity is given by:

$$\mathrm{Cl} = \mathrm{vt} \cdot 107.87 \cdot 328.5233/1000\mathrm{m}$$

where 107.87vt/1000 represents the mass in grams of pure silver that is necessary to precipitate the halogens in 328.5233 g of sea water. The relationship between salinity and chlorinity is:

$$\mathrm{S} = 1.80655\mathrm{Cl}$$

Sodium cannot be determined with four significant figures and the value in **Table 1** has been calculated from the ion balance

$$\sum \mathrm{n}[\mathrm{X}^{\mathrm{n}+}] = \sum \mathrm{n}[\mathrm{X}^{\mathrm{n}-}]$$

Potassium can be determined gravimetrically with a precision of 0.26% by precipitation with sodium tetraphenylborate.

Calcium ( + strontium) and magnesium can be determined with four significant figures by titration procedures.