Coastal Zone: Occupance, Management and Economic Competitiveness

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ABSTRACT

The main characteristics of the coastal zone are reviewed, especially in relation to the problems it is subject to from the point of view of both natural and human-induced processes. Strategies for adaptation and management are discussed. The different types of activities in coastal areas and the conflicts between them are commented upon; possible lines of action to solve the conflict between development and maintenance of environmental quality are proposed. Planning, in order to adapt human actions to natural processes is considered essential, as well as stricter legislation and control.

1 THE CONCEPT OF COASTAL ZONE

For our purposes we regard the continental shelf as a physical reality and will not consider legal definitions. The labels coastal zone, littoral fringe, shoreline, and so on have been used to designate an area made up of terrestrial and marine facades, or on- and nearshore zones. The onshore zone poses few problems for inventories and its constituent elements, subject to variation, have been determined; it is often the site of traditional activities such as agriculture, animal husbandry and tourism, which locate in a space directly affected by economic considerations and whose tangible results are immediately perceived at the regional or national level.

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The marine sector is more difficult to handle, because it is subject to changes which can only be truly identified and quantified through a more specialized scientific approach.

1.1 Site and situation. Extension and expansion

Any study of a 'coastal zone' requires knowledge of some geomorphological concepts: shore, shoreline, nearshore zone, beach. Coasts can be made up of hard materials, making up cliffs, or unconsolidated rocks, giving us beaches of sand, clay, pebbles, gravel and the like. When beach material has accumulated offshore and permanently emerges, the formation is referred to as a barrier (and barrier islands along the Atlantic shores of the United States are currently a topic of major concern); otherwise it is designated as a bar.

The coast, a zone of varying width, extends inland and the 'land boundary' can be solid ground behind dunes, marshes or lagoons, the crest of a cliff or the head of the estuary of a tidal river. However, the concept of coastal zone has taken on an economic meaning which extends the 'coast' further inland, beyond its geological reality.

We shall limit ourselves here to marine coasts, but this should not overshadow the fact that lacustrine coasts play a major role in today's geological-economic concerns, particularly those of the North-American Great Lakes, of the East Africa Great Lakes, of Lakes Chad, Baikal and others.

1.2 Human and economic significance

The importance of the littoral fringe can be evidenced in many ways. The United States has allocated some $42.5 million to coastal zone management for the 1987 fiscal year, and this is barely $3.125 million less than the total budget earmarked for geodesy, cartography and the topographic survey together.¹

Demographic projections point to a probable shift of 80% of the world's population to within 50 km of the sea by 1990—a prediction which gains in probability since already some 45% of the US population are settled in coastal zones; and it is expected that by 1990, 75% of all Americans will live in a strip extending only 80 km from the coastline.

Already the location of several industries, the coastal environment is further stressed by private and public investors anxious to develop large harbor zones; the eventual economic rent tempts Third World countries to allocate their littoral fringes to a total industrial-and-port occupancy. In Africa, for instance, where in the past this fringe was often
exclusively used for agriculture, animal husbandry, fisheries and trade, and perhaps a very modest harbor activity, one can already witness the rapid implant of industry, transport and goods handling. A warning bell rang, not so long ago, at the Centre for Social and Economic Studies of the Third World in Mexico, and it is timely to pay heed to remaining unspoiled coastal zones. Such action can only occur through an understanding of the prevailing geologic, ecological, geographic, social and economic conditions, followed up by a healthy and realistic management program.

2 RISKS SUBJECTIVITY

The coastal zone is an area subject to natural evolution trends, and also to a wide variety of geological hazards. Their effects, compounded by human interference, threaten both the status quo and expansion of its occupance. The coastal zone is a threatened species, exposed to attack by nature and man. Anarchic settlement and use has not enhanced chances of even a limited equilibrium.

2.1 Natural hazards

Major hazards encompass a long list of risks to which coastal zones are exposed. They include: coastal erosion, storms, floods, estuary destruction, fires, volcanic eruptions, natural pollution. If black tides are man-made, red and green tides are natural phenomena.

Natural evolution trends must be assessed both in the short and long term. Studies dealing with a short term evolution provide an access to knowledge of dynamic processes and to their daily or seasonal oscillations; they account for modifications inside a coastal sector, the global sedimentary transit not being evaluated. However, the study of these seasonal phenomena proves to be important in the case of structures such as jetties, as construction of any hard points may favor an increase of erosion through intensification of the undermining processes at the bottom of the structure. On the other hand, to fight these seasonal effects, the coastal dunes should be kept in good condition. The dunal massif almost entirely prevents landward aeolian transport, and constitutes a sand reserve which allows it to limit naturally the effects of beach winter erosion.

Longer term evolution studies dealing, for instance, with decade, century or millenium periods, can be utilized to measure the impact of a coast adaptation or to evaluate the equilibrium degree of a littoral
sector. They also enable investigations prior to a scheme proposal or a scenario of the evolution's general process and disclose the relative importance of the different sedimentary movements. For example, the effect of wind acting on sandy sediments may appear negligible on an annual scale, but assumes a fundamental role on a millenia scale; the configuration of some islands bears this out, e.g. Long Island, NY.

2.1.1 Coastal erosion
Shorelines are migrating landwards worldwide due to natural causes, frequently exacerbated by man's actions. The phenomenon affects both rocky or unconsolidated coasts. Some French coasts retreat several meters per year, principally on the Atlantic coast—16% of the French coastline retreats over a meter per year. The Belgian coast experienced a spectacular loss in width during the last fifty years. The rising sea level is a major cause of the phenomenon. Counter measures can be taken but they are necessarily a temporary cure.

Coastal erosion caused, or at least accelerated, by man can only be stopped, or contained, by large scale measures, and necessitates geological studies.

2.1.2 Storms
Storms can destroy a beach in a matter of hours. They have been known to lift 25-ton boulders and carry them inland. Ships have been carried by tsunamis from their moorings to the center of a town (e.g. in Anchorage, Alaska). Storm frequency in some locations has led to the designation of high risk zones.

It is thus logical that man has erected structures to protect the shore. However, designing rubble-mound breakwaters does not suffice; they must be conceived for site conditions. Also, no sooner are they completed than they are subject to the onslaught of the waves; their destruction begins the very moment they are placed into service. An adequate design is not necessarily sufficient: toe protection must be sufficiently efficacious. The catalogue of rubble-mound breakwater accidents is a long one: Torshavn, Hvitshals, and Sines are examples of such failures. Furthermore, geological modifications can also lead to damage, as happened in Rotterdam, and Zeebrugge in Belgium.

Yet, the temptation to save on maintenance and management is strong, and this notwithstanding the fact that continuous surveillance of the structure will prevent far more costly subsequent damages. A rather sophisticated, and reputedly efficient, inspection system has been set up in Zeebrugge, and Mohammedia in Morocco.
2.1.3 Submergence
Coastal cities, harbors and estuaries are threatened by flooding. Protective steps can be taken, and indeed have to be taken if billions of dollars are not to be lost, particularly along the coasts of industrialized nations. During the fourteenth century, for instance, the Belgian coast witnessed a significant retreat of the shoreline, and several towns (including Harendijke) were lost into the sea.

Protection is a very costly undertaking, but often appears justified in socio-economic terms. Losses for Charleston, South Carolina, would amount to $10 million in 1990, increasing over the next four decades to $150 million; giving a cumulative total for the period 1980–2030 of some $355 million. The losses would decrease during the next four decades, nevertheless attaining $225 million—a total in excess of $580 million over a-hundred-year span.

2.1.4 Marshes, estuaries and wetlands
An integral part of the coastal zone, estuaries possess very specific characteristics which make them biologically unique. However, their geographical situation makes them particularly attractive to industrial development and thus they are threatened; were they to be tampered with, dire ecological consequences could be expected because estuaries are a major habitat for a widely varied fauna and a region of the highest productivity. Often surrounded by wetlands, serious concern must be voiced over further impingement, as these too are productive marine areas, and also constitute ramparts which protect against storms and unusually high water levels.

Tidal marshes have been put to use as pastures, sources of turf, agricultural land, tourism activities and scientific research in the field. Regrettably, tidal marsh areas have been reduced to a fraction of their original extent because of pollution and conversion to human occupancy; they have been used as a receptacle for sewage and waste treatment waters. Urgent consideration is required in providing management plans, and for their rehabilitation and even expansion, for instance by the deposition of dredged material.\textsuperscript{6-8}

Tidal estuaries have recently been proposed for the siting of electricity generating plants. No barrages nor sluices would be built: the kinetic energy of the tidal current would be extracted. A prototype of the KHECS (kinetic hydro energy conversion system), tested in New York City's East River, has yielded encouraging results.

2.2 Man-created and man-intensified problems
2.2.1 Anthropic coastal erosion
Remedial action against coastal erosion, whether due to natural or anthropic causes, necessitates familiarization with the genesis and the
history of the coast, and examination of the current state of the system and the natural evolution trends. In the case of the building of structures, an environmental impact assessment is necessary. Studies in paleogeography, sedimentology and sediment transport should be conducted, and the observed phenomena quantified. The quantification should include dissolved and suspended matter brought to the ocean by rivers, the transport capacity of the different dynamic agents (waves, currents, winds), rates of erosion or accretion along the coast, and the total volumes of sediments moved by tides, waves and winds. Precise knowledge of such volumes must precede any remedial work in the coastal zone. Additionally, the volume changes occurring along profiles perpendicular to the coast, at various scales (the scale of a tide, a season or a year) must be considered.9

In beach protection and restoration, short term remedies can be undertaken, but often they are not to the liking of either vacationers or residents.

Beach restoration requires efforts of both a social and geological nature; they include prohibition of 'wild' camping grounds and dune occupation by squatters, imposition of severe limits to construction, the building of groins, a limitation on coastal sand dredging, surveillance and maintenance of navigation channels, the anchoring of dunes by grass planting, and the artificial rebuilding of the beach by hydraulic pumping of offshore sands. Spectacular results have been attained in this respect along Belgium's east coast, e.g. at Zeebrugge harbor, where the beach has been restored to a level unequaled in half a century.

The repeated trampling of dunes by the passing recreationalists destroys lime-grass plantations, leading to the formation of a 'whistling path', which is then used and widened by the wind. Subsequently, aeolian erosion causes dune degradation, and eventually its destruction; in the same way protective structures for dune erected constructions will be counter-effective when built too close to the actual shoreline. Waves are reflected by vertical protection walls, so that the turbulence of counter-currents is reinforced. The final result is often a total destruction of the beach.

Among often unpopular measures increasingly recommended are strict building restrictions, even total abandonment of existing houses, and the establishment of a boundary line siting further development inland of the dune's internal face.

Structures undertaken on rivers have considerably reduced the volumes of sediment carried to seas and oceans. The most spectacular example is perhaps the retreat of the Nile Delta due to the construction
of the Aswan Dam, with a consequent reduction in the amount of nutritive materials brought to the sea. On some shores, sea pastures of *Zostera* and *Posidonia* play a primary role in ‘anchoring’ loose materials; disappearance of such sea pastures as a result of coastal water pollution may then cause a decrease in beach volume.

2.2.2 Pollution

Pollution and contamination of marine waters is partly caused by man and partly a natural phenomenon; but it has been intensified by anthropogenic activities such as the introduction of non-degradable chemical compounds and, especially for coastal regions, thermal discharges and discharges of municipal garbage and waste.

Pollutants which are potentially noxious for waters must be taken into consideration when a management plan for a coastal zone is devised. These play a primordial role in utilization planning of marine resources and where there is no clear policy, they determine the extent to which these resources may be developed. Among the first rank culprits are the chlorinated hydrocarbons such as insect killers (DDT, DDE, PCB); non-purified sewage effluent dumped on the shelf; municipal wastes, which reduce penetration depth of solar rays (and *ipso facto* photosynthesis) and the quantity of oxygen, causing eutrophication and red tides, which may propagate parasites, viruses and bacteria, and endanger flourishing coastal tourism spots, and fisheries and aquaculture operations.

A major pollution problem is created by plastic materials. The US Center for Environmental Education has published a complete inventory of the sources of these wastes, and pinpointed the threat they pose for marine fauna, the coastal zone economy, and human safety. Plastics may cause strangulation of marine dwellers and their ingestion is often harmful; in fact, four marine turtle species, several types of whales and dolphins, and at least fifty species of sea birds are endangered by plastics in the sea.\(^\text{10}\)

Large quantities of solid matter are also discharged at sea: for example, dredged material, building material, and fine noxious particles carried by rivers, such as asbestos fibers. Occasionally, heavy metals find their way to the sea; among the most dangerous of which are mercury and cadmium, substances which have contaminated coastal areas of Japan. High copper, lead, arsenic, and other metal concentrations have been reported in some regions. The metals are ingested by marine animals, many of which are a source of human food. The disposal of radioactive waste in the sea has raised serious questions. Thermal pollution is caused by the discharge of heated waters and may
have, in some cases, nefarious consequences, though occasionally there can be benefits e.g. in mariculture.

3 ADAPTATION AND MANAGEMENT

Any human activity, albeit residential, industrial or commercial will have a more or less direct impact on the coastal zone (onshore, nearshore and offshore), and on the coastal shelf in general. The exploitation of this region must be carefully planned, its consequences duly examined, and its environmental impact assessed. Management of such region requires an in-depth study of the best resources to exploit, decision-making as to choice, and constant vigilance and monitoring.

3.1 Adaptation, planning and land-use

Planning for coastal zone management must consider proposed utilization, whether single or multiple. Conflicts inevitably ensue as urbanization, commercial and industrial development, tourism and traditional and even artisanal occupations vie for space. A general occupation scheme is required rather than a step-by-step policy or one of individual freedom. It must plan the exploitation at the chosen site of the proposed activities, which requires a study of human factors, adaptation to the local geographical conditions, and efforts to satisfy the space requests, while at the same time paying attention to esthetics, conservation and environmental protection of both the coastal zone and hinterland. From the economics viewpoint, planning will include a search for financing sources and an assessment of the comparative benefit–cost ratios.11–14

It is self evident, but not unimportant, that the nature of a coast will determine to a high degree the action to be taken and the scenario to be followed.

The coastal zone ought also to be managed with a view to its touristic and recreational potential, its transport, communication and even waste dumping possibilities. The proportion of beaches in recreation is steadily expanding as a result of improved public transportation, the ‘shortening’ of distances due to air travel, and the attractiveness of far-away places—all corollaries of social change following the two world wars. Yet, one may deplore the anarchy which marked the post-World War II touristic occupation of the coastal zone.15–18

If a touristic use is to be assigned to a coastal area, so that industrial and service jobs be created, the planning process should include site
reconnaissance, in-depth environmental study, exploitation, and management. As far as developing countries are concerned, coastal zone use decisions should be based on multidisciplinary scientific studies by a team made up of specialists from academia and industry. Only at a later stage should exploitation be considered. The expansion of coastal tourism, the use of the littoral fringe for recreation and parceling of the dunal belt have all helped to accelerate erosion by destroying dunes and by slowing down beach restoration after its winter regression.

3.2 Management and the multidisciplinary approach

Any attempt at economic development that is based on adaptation to, and conservation, of the littoral fringe can only be effectively carried out if a policy of fundamental and pluridisciplinary research is concurrently pursued. Such a global approach will allow an understanding of the especially complex and varied processes which operate in the coastal zone, and will also provide the basic information needed for a scientific and technical foundation for coherent management of the littoral fringe.

Management and use of the coastal zone require pluridisciplinary investigations which, although the disciplines involved all belong to the domain of oceanology sensu largo, necessitate expansion of the field of study generally considered as ‘marine science’.

The coastal fringe is the scene of many diverse and interactive processes, and it has to be borne in mind that any coastal project will produce perturbations in the environment.

In view of the complexity of the problems discussed above, the coastal environment obviously constitutes a unique milieu, wherein the various scientific disciplines able to help in improving the knowledge base cannot be separated. Any problem pertaining to a coastal zone must necessarily be studied through the efforts of teams made up of physicists, biologists, geologists, chemists, marine science specialists, geographers, economists and engineers.

Such collaboration often involves the pooling of techniques and data, depending on the magnitude of the actions to be deployed, and may call for cooperation on an international scale.

Rational management of the coastal region requires, at the outset, a detailed study of the marine topography and the compilation of surface geological maps. Knowledge of the sediments, and of sedimentary processes is needed; among them the study of the benthic boundary layer, the carbonate cycle, geochemistry and sediment diagenesis, and
the role played by organic substances. Equally important are facies analysis and paleo-oceanography inclusive of a biostratigraphic study.

### 3.3 A bird's eye view of legislation

A management program is usually launched by a government agency reacting to resource degradation, exposure to major hazards, utilization conflicts, or to the need for social-economic development. Such a program should be carried out on a continuous basis rather than being a one-off undertaking. If implemented, a policy of decision allocation must be established. Programs will be designed on the basis of, and follow, a pluri-sector approach, taking into account the reciprocity between the coastal environment systems and public services. The program will have flexible landward limits, which may vary with time. Three decades ago, the Belgian ‘littoral’ was a strip 1–2 km wide, rapidly grading into pastoral landscapes shielded by the dunal barrier. Present-day development has removed farms, destroyed traditional occupations, and impacted the hinterland, in places affecting cities situated far inland.

Planning may involve a single district, or, if there are several of them, may still consider them individually neglecting the overall approach. ‘At present, programs to study coastal processes · · · tend to set up independent surveillance activities that ignore the interactions and so overlook the biological processes. This is an area where greater inter-disciplinary interaction is badly needed · · · there are broad zonal patterns in ecosystems that transcend · · · local variations.’

In South America, for instance, all countries, with the exception of Suriname, established management programs for coastal fisheries, and nearly all provided for the preservation of parks and nature reserves, but without coordination between these two sectors. In practice, therefore, only Brazil, Ecuador, Colombia and Costa Rica have ‘real’ programs.

North Sea riparian states have paid small heed to the management of their coastal zones; however, a determined approach is gaining momentum to protect and control the future development of tourism, habitat, industry, and to insure coast protection. Coastal activities in each country are often un-coordinated, and the matter is left to the national government, although area utilization falls within the municipal jurisdiction.

The United States’ Coastal Zone Management Act (CZMA) mirrors a national concern to harmonize the demands of urbanization, recreation, industry and energy development in the littoral fringe, and
recognizes the recurrent incompatibility of these uses. The Act under-
scores the nefarious role of anarchic development generated by
repeated development demands. More than 56 million ha are affected
by this legislation; it provides a financial inducement to regional
jurisdictions to set up rules aiming at solving opposing requests
involving the coastal zone, to establish a priority order for its use, and
to determine by whom and how final decisions will be made.

4 USE OF THE COASTAL ZONE

Undoubtedly, an economic conflict exists between those who champion
the total utilization of the coast for industrial, mining and commercial
expansion, and the partisans of a 'balanced' occupance between, on the
one hand industry, and on the other tourism and habitat interests.

4.1 Types of economic activities

Some activities have been long established, but many of these are now
being displaced by newcomers. Today, these include fisheries and
mariculture, port-related, commercial and industrial complexes, energy
production, the exploitation of mineral resources, and so on.24,25
Fisheries may be artisanal or industrial, while mariculture is a broad
term covering 'new aquaculture', such as fish husbandry in sea farms,
conchyliculture and algae harvesting.

Almost everywhere, industrial activities develop, sometimes linked to
maritime transport, such as naval construction and repairs, but embrac-
ing diverse demands such as steel and iron works, refineries and
petrochemical installations, agrifood industries and so on.

Electrical power stations on the coast are fairly common on sites near
harbors and estuaries, because of the increased demand for energy in
these areas. The construction of nuclear power plants reflects the need
for cooling water. In fact, the coastal zone is often suitable for the
construction of tidal-, wave-, and ocean thermal electrical plants.

Tourism activity flourishes over an ever-increasing mileage. Coastal
zones in Third World countries are no exception. The steadily growing
demand for tourist facilities triggers the important development of
coastal accommodation (villas and other buildings, camping grounds,
pleasure harbors) and also an increase in environmental quality
problems.

Coastal tourism adds new dimensions to coastal development. If
investors are willing to risk making substantial investments, one can
only conclude that customers are willing to pay steep fees. At Key Largo (Florida), Jule’s Undersea Lodge is at 10 m depth and can accommodate, in 2.5 × 3.3 m rooms, guests who are willing to pay $300 a night per person double occupancy. Sea life can be observed through a 1.07 m porthole; snorkeling excursions can be arranged. Near Freeport (Bahamas), a proposed development will enclose a reef so that tourists will be able to enjoy dry-land viewing through portholes with 75 m visibility, at depths between −1 and −5 m. Amateur divers will be allowed to swim in the lagoon. In Australia’s Great Barrier Reef such viewing portholes exist already on stationary platforms and semi-submersibles. However, one has not yet heard of any environmental impact report regarding such undertakings.

Exploitation of biological resources, once an artisanal endeavor, is now industrialized in many developed nations, and the same situation will apply to the developing countries in the near future. It will be accompanied by the construction of more sophisticated harbor facilities, ships and electronic equipment repair shops, new factories and cold storage warehouses. The exploitation of mineral resources, offshore and in the open ocean, will call for the construction of treatment facilities, refineries, oil and gas pipeline terminals.

Mineral resources susceptible to mining operations in the coastal zone include coal (worked underneath the sea-floor since the sixteenth century), petroleum, natural gas, sulfur, tin, sand and gravel, magnesium, bromine, phosphorite, barites, salt and heavy metals. Sands can be exploited near coasts for gold, silver and platinum recovery (e.g. Alaska); for diamonds (e.g. Namibia); magnetite, ilmenite, zircon, rutile, chromite (e.g. Australia, New Zealand, Japan); cassiterite (a 75-year old industry in South-East Asia); tungsten, monacite, quartz, limestone, (e.g. the North Sea, Lebanon). Hot brines are potential sources of iron, zinc, copper, lead, bauxite, silver, manganese (e.g. Red Sea). Salt, extracted for centuries from coastal zones, has become a waste product of desalination operations.

The economic importance of sand, gravel and coquina has steadily increased due to the demand for building materials where land supplies are depleted or in short supply. Mining must be carefully monitored since it may severely alter benthic life on the seabed, while equilibrium may be endangered. Gravel extraction is more problematic than sand extraction, because layers of 10–50 m thickness frequently overlie the gravels. Sea-shell deposits (often exploited for cement) are an important source of calcium; and may be prolific in bays, lagoons and estuaries.

Nearshore mining of sand or other minerals can disrupt beach stability and endanger barrier islands, accelerating erosion processes.
by removing the sand that naturally replenishes beaches. The matter was examined several decades ago in connection with operations along the coasts of Lebanon and Israel.\textsuperscript{29}

The removal, treatment and tailings rejections of all such materials can seriously influence the benthos, filterers, beach stability and water clarity.

Sea water itself is an important resource. Desalination costs remain high, and such operations are economic only where water supplies on land are limited, especially in petroleum-rich countries.

The relatively shallow continental shelf is highly favored for the exploitation of fish, crustaceans and other invertebrates. Consumer fisheries share the markets with industrial fisheries used for animal feed and food industries, ink, glue, and paint manufacture. Many marine plants are harvested. Coastal zone management needs to protect these activities as long as they remain economically sound.

The currently modest exploitation of ocean energy is potentially expandable. Small plants of regional or insular significance may replace costly fossil fuels, a heavy burden for non-petroleum producers.

\subsection*{4.2 Conflicting interest}

Beyond matters physical and geological, exploitation of a coastal zone triggers off many economic and social consequences. Whether an activity is coastal, offshore or open ocean, such activities as processing, transportation and marketing of a marine product will have socio-economic and political ramifications. Economic and environmental conflicts between various types of users of the coastal zone are often inevitable, and deep-seated. Priorities always create a dilemma for coastal zone management.\textsuperscript{28,29}

An area used for touristic purposes may be ideally suited for the establishment of a harbor, a petroleum terminal, or an unsightly but sorely needed artificial island with a waste processing factory. As a result the real estate values soar to unprecedented heights; the local inhabitant sells his property and moves away; at the same time, other, professional people may move into expensive coastal areas, creating a new and very different stratum. The London Dockland development would be a case in point.

This raises the dilemma of choosing between creation of new long term, and well-paid, jobs, and seasonal work for the fisherman or for service jobs during the holiday season.

Among the economic aspects of a mining operation in the coastal zone, one must consider the nature of risks involved, alternative
solutions of resource allocation and indemnities to be paid to the resource owner, types of benefits to be drawn from mining, and the economic rent. Furthermore, responsible parties must scrutinize resource conservation problems and ensure that the resource be extracted at an acceptable level. This means a tailored mineral extraction plan as a function of its environmental location and the extraction technology. This is a considerable task requiring a high level of competency.

To reiterate the underlying situation, the problem to solve is to establish how economic development of the marine milieu can be reconciled, and how to simultaneously protect the environment; while avoiding, or at least reducing, conflicts between various competing ocean-user groups.

There is an international dimension. Every state or region is responsible for activities within its territory. Pollution of the kind that occurred off Corsican coasts a decade ago is now prohibited under the Law of the Sea; yet the use of more sophisticated technology by one party may be unfavorable to another.

Beyond the primary pollution, changes in the social fabric of one state may influence the life and work conditions in an adjoining state; economic territorial conflicts flare up; changes in a commercial vocation may plunge a neighboring region into an economic depression. Cooperation in counteracting beach erosion and coastline retreat must ideally be on a regional or national level. A one-sided effort is doomed to limited effectiveness.

Developing countries should act jointly in matters of coastal pollution and shoreline protection. This latter aspect could encompass a common economic program and an equilibrated geographic distribution of ports, industrial and commercial activities, and tourism and recreation development. In many countries, particularly in the Third World, the demand for water, the pressure of industrial expansion—no matter how modest—and search for oil, gas and minerals often only short distances offshore, have already brought about pollution that is detrimental to recreation facilities and living space, a situation worsened where the state has no shoreline eminent domain.

It is necessary, therefore, to view any action of maintenance, adaptation, conservation, remedy and counteraction in a framework of international cooperation. This implies that industrialized nations with technological proficiency should transfer to less developed countries the know-how, through technical aid and personnel.

In short, the pluridisciplinary enquiry is required to understand the economic and social impact and to assess the international implications of any action taken.
5 ENVIRONMENT AND DEVELOPMENT

Conflicts that exist between the various users of the coastal zone make it difficult for planners and ecologists to make the right decisions. Further conflict arises in trying to reconcile development and the environment. This is reflected in the philosophy of the (US) Coastal Zone Management Act which aims not so much at saving the status quo as in harmonizing environmental protection and development.\textsuperscript{31}

5.1 Preservation, protection and environmental equilibrium

5.1.1 Pollution management

Even though pollution management should be on an international scale, regional management may of itself protect and improve. It is necessary to draw chemical, physical and biological baselines, to determine distribution and dispersion mechanisms, to monitor pollution levels, and to gather valid prognoses about the effect, upon the environment, of new activities and of the introduction of new technologies in the coastal zone.\textsuperscript{32}

There are several international and national organizations, both governmental and non-governmental, which concern themselves with ocean pollution; some of these are scientific (e.g. IUGS, IUGG, IUBS). A large number of international meetings dealt with the topic in the period from the Washington Conference of 1926 until the International Decade for Ocean Exploration and the Law of the Sea Conferences.

Within the United Nations Organization, some twenty specialized agencies are concerned: e.g. UNEP, UNITAR, UNDP, WMO, WHO, UNESCO. The United States took measures as long ago as 1899, when coastal pollution first became serious (note the Rivers and Harbors Act).

Management of the coastal zone has to face both occasional pollution incidents and more continuous pollutant emissions.

5.1.2 Coastal erosion management

To properly monitor the coast, profiling, at frequent intervals during each year, has to be undertaken. The profiles should be taken close to protective structures. Aerial photographs, at a precise scale, can be taken to survey changes in the shoreline, but they provide less information because the camera does not penetrate at sufficient depth under the water's surface to reveal submarine topographic changes. However, observations made from satellites hold a great deal of promise.
Besides the 'do-nothing' and the 'retreat' approaches, now favored in many cases, coastal protection may involve building of hard defenses such as groins, breakwaters, sea-walls, murrazzis, and tetrapods, the application of soft methods, i.e. artificial nourishment; or (often) a combination of several methods.\textsuperscript{33-36}

5.2 Environmental impact

Some fundamental questions must be answered in devising a protective plan:

—What is the genesis and history of the area?
—What is the present state of the system?
—What are the natural evolution trends?
—What will the impact of the proposed action be?

Once the answers are known, the limits of the natural milieu tolerance, in relation to the planned installations, must be determined. The follow-up stage, once a project is completed, monitors the environment's adaptation and reaction.

The understanding of the spatial scale of phenomena requires a site study. The site's evolution must be explained through the study of a series of parameters which quite often go beyond the immediate geographic zone. Hence, answers to a particular problem frequently come from parameters and characteristics geographically some distance from the site itself. In similar vein, the environmental impact may be felt, favorably or otherwise, some distance away from the site in question.

The time-scale involved in environmental responses (physical and biological) to natural and man-made events may vary considerably. A catastrophic pollution event can lead to a rapid and almost total destruction of the flora and fauna in the contaminated zone. Again, excessive exploitation of biological resources, exceeding the natural capacity of the species to reproduce, may result in a gradual extinction of these species. At sea, discharges of toxic products, even in relatively small quantities, can (over a period of years) have equally catastrophic consequences, particularly when toxic substances enter food-chains and concentrate to high, and increasingly toxic, levels. In coastal sedimentology, beach evolution provides an excellent example of the diversity of time scales. Indeed, sediment transport phenomena on the littoral fringe may be recognized, operating at different scales from near-instantaneous transport such as sediments placed in suspension due to waves, to a millenium variation of the shoreline, with yearly and seasonal changes in between.
A first step is the formulation of a 'health report' for the coast, in which three types of zone can be identified:

1. zones that are still intact and able to undergo some development in the near future;
2. endangered zones, because they are particularly fragile, such as estuaries, deltas, lagoons, or sandy shores undergoing continual evolution;
3. already damaged zones, because of chemical and/or biological pollution, or because of insensitive development (e.g. sites of camping grounds or construction at the sea's edge liable to erosion).

Based on this identification, two kinds of action can be undertaken: continuous and individual. So far, France, for example, has achieved:

**Continuous actions:**
- type 'Réseau National d'Observation de la Qualité du Milieu Marin': survey and control of water quality in clearly bounded zones;
- type 'Surveillance écologique du Blayais': establishment of an ecological reference state prior to development, followed by monitoring of the milieu's evolution after development (e.g. a nuclear power station near Blaye);
- the case of an unconsolidated littoral in continual evolution, with on-going surveillance in the form of a sedimentary dynamic study (collection of beach profiles at regular intervals, determination of volumes of eroded or accreted sediments, and so on).

**Individual actions:**
- impact study prior to implementation of any new development;
- impact assessment of various discharges upon the quality of water which could lead to ecosystems modification, even though the marine environment can 'absorb' waste far better than its land counterpart through dilution, dispersion and degradation;
- assessment of impacts of new constructions near the edge of the sea on the shoreline's evolution;
- managing pollution; limitation of discharges, purification stations, etc.
- managing coastal erosion: provision of defense structures.

Finally, the development of protected areas is necessary. One must define 'control zones' and monitor their integrity, in order to safeguard a part of the natural patrimony, so that it can be conserved for future generations, and also to preserve the equilibria that are necessary, e.g. in fish spawning grounds.
6 CONCLUSIONS

The coastal zone is coming under increasing pressure. What measures can be taken?

Crucial choices must be made, and they must not be shortsighted. If some areas are to be safeguarded for public enjoyment of nature, planners must not think exclusively in terms of sheer economics, job creations, and greater returns. Realism must also govern coastal protection schemes: man cannot halt the inexorable turn of events; he can at best delay shoreline retreat, and it is thus prudent to select methods that most closely resemble nature's own processes.

Pollution can and must be curtailed. Anarchic coastal development cannot be tolerated, and legislation as well as executive agencies must be created to counter it, even at the price of somewhat curtailing individual freedom.

REFERENCES


