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A REVIEW OF COASTAL ZONE BOUNDARY DEFINITION, LAND CLASSIFICATION AND MANAGEMENT APPROACHES RELATIVE TO THE BRITISH COLUMBIA SITUATION, WITH SUGGESTIONS FOR FUTURE DIRECTION

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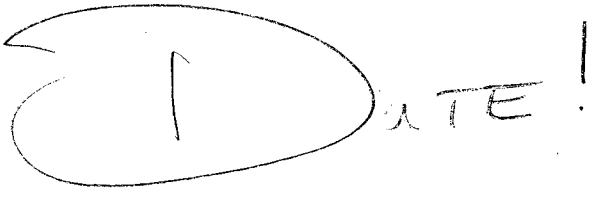

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INTRODUCTION

The various uses of British Columbias' coastal region require integrative management based on sound understanding of the physical and biological processes of the coastal system. Over 90% of the people of this province live within 45 km. of the coast and utilize it for various and not always compatible purposes. The intensity of use is expected to increase over time.

The importance of coastal lands has long been known in a general sense and various federal and provincial agencies have been involved with many aspects of coastal resource management for decades. However, most management effort is directed toward individual components of the coastal system and much of it has been reactive and designed to maintain or protect single resource components rather than to plan and manage the system on a broad, integrative basis. One of the primary reasons for this is the lack of an appropriate working definition of the coastal system or zone. This has been a more or less universal problem in coastal regions of the world that are attempting to initiate integrative management of their coastal zones.

Another hindrance to effective management of coastal lands is the selection of the most appropriate way to portray them for integrative management purposes. Efforts to analyse and describe coastal lands have been underway for considerable time in many parts of the world but considerable indecision still remains as to which method is most appropriate. This is at least

partly understandable however, when one considers the vast array of available methods and the various stages of development of world regions.

The purposes of this report are to review the various approaches to defining, classifying and managing coastal zones in other regions of the world and to relate them to the present "state of the art" in British Columbia. Special reference will be made to initial attempts to define, classify and provide management suggestions for the coastal system in British Columbia. Suggestions for future direction have also been provided.

METHODS

In order to accomplish this task, the literature was reviewed extensively, the subject was discussed with several coastal zone experts and a questionaire was sent to numerous coastal countries and states.

RESULTS

PART I: Delineating the Boundaries: A Review of Coastal Zone Definitions and Suggestions for a British Columbia Definition.

Perhaps the most important prerequisite to positive and effective management of the coastal zone is a sound working definition. If a coastal zone can be deliniated on the basis of an appropriate definition, the organization and condensation of knowledge concerning its fundamental biological and physical process components and condition or status in terms of use becomes more simplified. When this initial step is realized, it becomes much easier to sort out direction, develop systems of classifying various aspects of the coastal zone and identify necessary management needs

and methods to fulfill them.

For a coastal zone definition to be a useful management tool, it must satisfy at least three basic criteria:

1. It should clearly delineate the boundaries of the coastal zone.
2. It should recognize the orderly interplay of physical and biological process components of the coastal zone as a dynamic ecological system.
3. It should be understandable by the society it serves.

An evolving awareness of the nature of the coastal zone in the United States has resulted in increasing recognition of its importance. Several attempts have been made to develop legislation that could effectively deal with the problem of managing the coastal zone and, as a first step, a variety of definitions have been used to try to define the zone.

In 1969, a U.S. congressional bill using physical features, political boundaries and maritime influences defined the coastal zone as the: ". . . lands, bays, estuaries, and waters within the territorial sea . . and extending inland to the landward extent of maritime influences" (U.S. Congress, 1969).

This definition cannot clearly delineate the landward boundary of the coastal zone because the term "maritime influences" is open to a wide range of interpretations, especially where climate is concerned. It does however recognize that the coastal zone is more than just maritime lands and that an inland boundary exists somewhere.

Another U.S. congressional bill in 1971 expanded the above definition but with only slight gain in effectiveness. The territorial sea was main-

tained as the seaward limit but the landward boundary is still ambiguous: ". . . lands, waters and waterbottoms near the coastline extending to the . . territorial limits, including, but not limited to beaches, salt marshes, coastal and intertidal areas, sounds, embayments, harbors, lagoons, inshore waters, rivers, and channels" (U.S. Congress, 1971)

The terms "near the coastline" and "inshore waters, rivers and channels" are ambiguous and must lead to relatively subjective approximations of an inland boundary. The definition however does place emphasis on different coastal land types and indicates an awareness of the importance of biotic lands of the coastal zone. For these reasons, it is an improvement of the earlier definition.

The United States Government made at least two other attempts to define a workable coastal zone prior to 1972. The U.S. Commission on Marine Science, Engineering and Resources once again used the territorial limit of federal jurisdiction as the seaward boundary but failed to recognize any components other than water and water associated uses:
" (1) seaward, the territorial sea of the United States, and (2) landward, the tidal waters on the landward side of the low water mark along the coast, the Great Lakes, port and harbour facilities, marine recreational areas, and industrial and commercial sites, dependent upon the seas or the Great Lakes." (cited in Knight, 1970)

Another somewhat more meaningful definition was attempted by the same commission and, although it indicates an awareness that the coastal zone is a rather complex system, it is, once again, too vague and was not adopted:

"The coastal zone is a region of transition between two environments, the land and the sea. (It) has been defined as that part of the land affected by its proximity to the sea and that part of the ocean affected by its proximity to the land." (cited in Knight, 1970)

It was Washington State's Shoreline Management Act of 1971 that finally set a clear landward boundary for shorelines. It also includes freshwater systems not directly influenced by coastal processes: "Shorelines means all lakes, including reservoirs, over 20 surface acres, all streams where mean annual flow is over 20 cubic feet per second and all marine waters, plus an area landward for 200 feet measured on a horizontal plain from the ordinary high water mark, plus all associated flood plains, floodways, marshes, bogs, swamps and river deltas." (Shoreline Management Act of 1971) Major ommissions of this definition are that it fails to include a seaward limit and the 200 foot boundary adjacent to marine waters is arbitrary and does not relate to any particular process or land type. The definition does recognize the importance of various intergrade or transitional wetlands, however, but the 20 cubic feet per second limit eliminates many small streams.

In 1972, the U.S. Congress, having recognized "a national interest in the effective management, beneficial use, protection and development of the coastal zone" provided state and local governments with a plan for financial assistance and guidance for the planning and management of their coastal zones. Under the Coastal Zone Management Act of 1972, the seaward limit

of the coastal zone was set at the territorial boundary but the landward limit was not clearly defined. U.S. Congress recognized that, under the constitution, the states should define the landward extent, of their own coastal zones: "'Coastal zone' means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes transitional and intertidal areas, salt marshes, wetlands, and beaches. The zone extends, in Great Lakes Waters, to the international boundary between the United States and Canada and, in other areas, seaward to the outer limit of the United States territorial sea. The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters. Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of, or which is held in trust by the Federal Government, its officers or agents." (Coastal Zone Management Act, 1972) (Sec. 304 (a))

Clearly, this definition provides no more than general guidelines for establishing landward boundaries and is not an effective definition in itself. It does provide good direction however, and the U.S. Dept. of Commerce has provided accompanying guidelines to assist states in boundary identification:

1. "All shorelands, the uses of which have a direct and significant impact upon coastal waters, must be included within the landward boundary."

2. "Transitional and intertidal areas, salt marshes, wetlands, and beaches must be included within a state's coastal zone."

3. "A state's coastal zone must exclude the lands the use of which is by law subject solely to the discretion of, or which is held in trust by the Federal government, its officers and agents. The state must indicate those Federally owned lands, or lands held in trust by the Federal government, and over which the state cannot or does not exercise jurisdiction as to use."

4. "The state must be capable of applying the policies, objectives and controls of its coastal zone management program consistenly within the entire coastal zone, or consistently within each "section", in cases where the coastal zone is divided into "sections" by multiple boundaries."

5. "Final inland boundaries for program approval must be determined after a clearly defined and documented procedure, which incorporates permissable uses and particular concern has been applied." (U.S. Dept. of Commerce, Office of Coastal Zone Management, 1975)

Of the five guidelines or principles, three deal with logistic requirements in terms of what must or must not be included in the coastal zone and two deal with criteria for boundary approval. In terms of helping define the zone, the principles add nothing that isn't already in the Act and are not of effective assistance in this regard. The onus remains on the states.

In threshold papers following, the Office of Coastal Zone Management provides more guidance. According to the OCZM, the <u>minimum</u> coastal zone

of a state must include:

1. the territorial sea
2. coastal waters
3. transitional and intertidal areas
4. salt marshes and wetlands
5. beaches
6. upland areas — ". . . inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on coastal waters."

The definition of these key terms is the heart of the process of identifying the coastal zone boundary in the United States and definitions vary widely from state to state.

The territorial sea is clearly defined. The U.S. territorial sea extends three nautical miles from base lines established by international law. Therefore there is no problem in establishing a seaward boundary.

Coastal waters are considered to be "those waters, adjacent to shorelines, which contain a measureable quantity or percentage of sea water, including, but not limited to, sounds, bays, lagoons, bayous, ponds and estuaries". U.S. Coastal Zone Management Act of 1972, Section 304 (b). Many states have apparently defined their coastal waters as those inside the territorial sea to the inland extent of tidal influence or seawater intrusion with, in some cases, a designated buffer zone of an arbitrary nature. (Texas, New Jersey, Washington, 1976) This aspect of the coastal zone definition appears relatively simple with only small variation as to what constitutes the exact inland mark. Salt tolerant vegetation, soils, high water marks, tidal fishing boundaries which are generally set at standard elevation above

mean high tide in water courses have all been used or considered as legal inland boundaries of coastal waters.

It is the other necessary minimum inclusions of the coastal zone (with the exception of beaches) which have caused considerable difficulty for the coastal states.

Types of acceptable inland boundaries for coastal lands have also been outlined by OCZM. They are termed biophysical, biophysical as a base for administrative, and multiple (OCZM, 1975).

A biophysical boundary can be defined in terms of natural features such as biological, geological, physical or a combination. Drainage basins, floodplains, ecosystems, and ridges of coastal mountain ranges were suggested. It was suggested that this type of boundary would meet the intent of the act but may not be effective in establishing controls because it may cross many existing administrative frameworks. A combination of biophysical delimiting features and existing political - administrative boundaries termed biophysical as a base for administrative was suggested as a possible method for combining the merits of both systems. A multiple boundary would define the coastal zone on the basis of functions and resource bases and incorporate the provisions of existing state programs and regulations. It appears that a reasonably wide scope for inland boundary identification of coastal lands has been provided for. However, the statement "inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on coastal waters" strongly limits this scope and may conflict with the inclusion of trans-

itional and wet lands because many of these, while obviously coastal lands, are not influenced by seawater directly and would not be considered coastal waters and uses of these may not have direct and significant impact on coastal waters.

It is therefore not surprising that inland boundary indentification has been difficult for coastal states and territories of the U.S.

One thing does seem clear however: a multi-tier concept which divides coastal waters, coastal lands and uplands seems to be emerging as a most appropriate way of defining and categorizing the coastal zone.

Washington has, as a first tier, "resource" lands and waters which are defined by the Shoreline Management Act of 1971 (previously cited). The second tier is one of planning and administration and is the inland boundary of the fifteen coastal counties. The use of two tiers provides the state a basis to differentiate in terms of both the need for and intensity of control as outlined by the OCZM in its discussion of the merits of a multiple boundary system. The most immediate and direct control is exercised in the tier adjacent to the waters edge (inside the resource boundary). Should a proposal in the second tier have the potential to have direct and significant impact or directly effect the first tier, other state programs could be invoked. Of the thirty eligible coastal states and four territories, only Washington has gained federal approval of its program. Most other states are in various stages for coming to grips with the inland boundary of their coastal zone.

Georgia has reviewed the kinds and extent of activities which could effect coastal waters (which, you will recall, are easily defined) directly

and significantly and proposed an array of biophysical alternative tiers ranging from coastal watersheds and geologic coastal Georgia to tidal marshes. Coastal watersheds and geologic coastal Georgia are rather wide while tidal marshes are relatively narrow. Several intermediate zones are also provided. The merits of the various alternatives were discussed, but none were recommended as being most appropriate to the Georgia situation (State of Georgia, 1976).

California's inland boundary is "generally 1000 yards from the mean high tide line of the sea. In significant coastal estuarine, habitat and recreational areas it extends inland to the first major ridgeline paralleling the sea or five miles from the mean high tide line of the sea, whichever is less, and in developed urban areas the zone generally extends inland less than 1000 yards." (State of California, 1976).

Other states and countries have taken the simple route. Delaware has recommended that the entire state be considered the coastal zone (State of Delaware, 1976). Delaware considered the usual array of biophysical (inland extent of coastal wetlands, salt marshes, beaches and intertidal areas, wetland drainage areas, flood hazard zones and watersheds) and institutional options and, being a small state, opted for a simple way. Similarly, the State of Maine has declared its first tier of coastal towns the coastal zone (State of Maine, 1977). Florida chose the inland boundary of census enumeration district which most closely matched and specifically included coastal resource areas needing treatment as part of the coastal management program. (State of Florida, 1977)

Oregon with some exceptions, has defined their inland boundary as the crest of the coast range. (State of Oregon, 1976) Alaska is considering the 200 foot elevation contour in its initial planning stages, but is in the process of inventorying and mapping important resource units (coastal wetlands, streams and lakes with anadromous fish runs, and migratory waterfowl nesting areas and "other such areas") (State of Alaska, 1977). I get the impression that the Alaskan coastal zone will be more flexible as this work progresses. Norway has defined its coastal zone for the purpose of planning tourist and recreational development (Norway Royal Ministry of Environment, 1977). It is defined as "areas extending inland as far as the sea and shoreline are of significance for the siting of holiday dwellings and tourist developments". However, coastal areas of particular value for wildlife or vegetation, science or education may also be protected according to provisions of the Nature Conservation Act. Despite the apparent inadequacies for coastal land management in the legislation, the Shore and Mountain Management Act (which defines the coastal zone) has a general rule that prohibits construction within 100 metres of the shoreline. Turkey prohibits any new construction within 10 kilometres of coastlines (A.H. Acara, pers. comm.). Japan and the United Kingdom have no coastal management programs per se however coastal development can be controlled by existing legislation or local planning authorities (Environment Agency, Japan and United Kingdom Dept. of the Environment, London, England).

Obviously, there are a wide variety of ways to define the coastal zone and, ultimately, the definition and following management methods and

regimes depend on the individual needs and objectives of the area involved.

Attempts to define the coastal zone have not been limited to government bodies. The academic community has also been fairly active in persuing problems of coastal management.

A Coastal Zone workshop at Woods Hole in 1972 is representative of academic involvement. The Woods Hole group attempted to: "provide an interdisciplinary assessment of the effects of man's various activities on coastal zone processes, a definition of what is known and what needs to be learned, both about man's activities and about the natural processes which are affected, and the identification of scientific, legal, social, or economic constraints, that prevent the rational management of coastal zone resources." (Ketchum, 1972) Suprprisingly, the Woods Hole team did not include an ecologist, but ecological, geographical and social components were included in a relatively broad and lengthly working definition: "The coastal zone is the band of dry land and adjacent ocean space (water and submerged land) in which ecology and use directly affect ocean space ecology, and vice versa. The coastal zone is a band of variable with which borders the continents, the inland seas, and the Great Lakes. Functionally, it is the broad interface between land and water where production, consumption and exchange processes occur at high rates of intensity. Ecologically, it is an area dynamic biogeochemical activity, but with limited capacity for supporting various forms of human use. Geographically, the landward boundary of the coastal zone is necessarily vague. The oceans

may affect climate far inland from the sea. Ocean salt penetrates estuaries to various extents, depending largely upon geometry of the estuary and river flow, and the ocean tides may extend even farther upstream than the salt penetration. Pollutants added even to the freshwater part of a river ultimately reach the sea after passing through the estuary.

The seaward boundary is easier to define scientifically, but it has been the cause of extensive political argument and disagreement. Coastal waters differ chemically from those of the open sea, even in areas where man's impact is minimal. Generally, the coastal water can be identified at least to the edge of the Continental Shelf (depth of about 200 meters), but the influence of major rivers may extend many miles beyond this boundary. For the purposes of the Coastal Zone Workshop, the seaward boundary has been defined as the extent to which man's land-based activities have a measurable influence on the chemistry of the water or on the ecology of marine life." (Ketchum, 1972) This definition comes close to saying what the coastal zone is and indicates a sound understanding and awareness of the complex nature of coastal lands and waters. Establishing the seaward boundary on the basis of the extent of freshwater influence has a good deal of merit scientifically but it would be difficult to put into practice and may not be practical because the boundary would vary considerably from place to place and season to season. The definition does not really attempt to define a landward boundary.

Closer to home, in a 1972 Master of Science thesis at U.B.C., Spencer

defined the coastal zone in two phrases:

1. Coastal Waters: From the seaward limit of the continental shelf, defined as the point of submerged land at a depth of 200 metres, to the line marked by the point of mean low water.

2. Coastal Lands: Landward from the point of mean low water to the furthest extent of marine influences such as water salinity, climate and marine salt air affecting vegetation growth and land and water use activities dependent upon coastal resources.

Spencer's definition sets a clear seaward boundary but the landward extent of his coastal zone, while indicating an awareness of the complexities involved, is nebulous.

Of the definitions reviewed, very few can be said to satisfy the stated criteria in a comprehensive way. It is evident that coastal regions are having difficulty coming to grips with just what it is that constitutes a coastal zone. It appears that definition problems in the United States result from two major sources:

1. The restraints imposed by the federal Coastal Zone Management Act.

2. The feeling that a "pure and precise" definition that will satisfy both the CZMA and scientific precision is necessary.

A sound working definition of the coastal zone must be flexible and highly qualified or directed by management needs.

It is evident that there are at least two dimensions or broad concerns in coastal management and that they are clearly different in terms of their characteristics and management needs:

1. Offshore concerns such as shipping, fish harvesting, mineral and energy exploration and so on.

2. Onshore or nearshore concerns such as commercial and industrial use of shorelands, recreational use, visual values, protection of resource lands and so on.

Therefore, any definition of the coastal zone must recognize and accomodate this as well as satisfy the other criteria . We therefore suggest that the following definition of the coastal zone be considered for use in British Columbia: "The coastal zone of British Columbia includes all lands and overlying waters from the limit of the territorial sea as its offshore component and all lands and waters from the six fathom mark to the inland boundary of the coastal fringe, which is an area of variable width inland from mean higher high water or from the inland edge of shore intergrade lands as its nearshore component."

The concepts of shore intergrade lands and the coastal fringe require further elaboration (they have been discussed at some length by Burns, 1977). In describing the biotic coastal system of the Western Communities, the senior author recognized three separate land components:

1. Marine lands from six fathoms to mean higher high water.

2. Intergrade lands which are transitional wetlands between marine lands and upland and are defined by vegetation characteristics and groundwater levels.

3. The coastal fringe habitat which is a continuous habitat belt around marine and/or intergrade lands which is living space for shore oriented wildlife forms. The coastal fringe habitat was subjectively judged

to be 500 feet wide in the Western Communities because, in this area, no place could be found where it was any wider. In most instances, it was judged to be near 500 feet or considerably less. In other areas where other wildlife forms are present, the zone is likely to be much more variable in width.

The objective of the Western Communities study was to separate coastal biotic lands (or coastal resource lands) and their management needs from upland and offshore waters which are entirely different regimes in terms of their characteristics and management needs. Coastal biotic lands were differentiated from upland on the basis of biotic character and degree of wetness as a feature defining their character. We consider this to be an appropriate approach because it defines the coastal zone on a rational basis of obvious characteristics rather than nebulous phraseology such as "inland extent of maritime influences" (which could be taken as the entire globe, where weather is considered a maritime influence). The coastal land manager need not directly concern himself with things fifty or one hundred miles inland or offshore, even though they may effect coastal resources or use patterns, because there are generally existing administrative regimes to deal with these kinds of activities.

What is required in British Columbia is more intense management of the nearshore component of the coastal zone and this can only be accomplished by definitive study to describe this component in terms of its extent, basic characteristics and specific management needs, in a manner similar to the Western Community study.

When this kind of information is available, understood and accepted by people and governments, management of the critical component of the coastal zone will improve considerably.

PART II: A Review of Coastal Zone Land and Water Classification Systems

The history of coastal land and water classification includes a variety of approaches. For the most part, they have not been judged successful (Odum, 1974, Bird, 1969). This was due to the complexity and vast area and extent of a zone where boundaries were not clear and where dominant chemical and biological processes were mainly invisible (Odum, 1974).

Attempts to classify the coastal zone have come from a wide range of disciplines and date back to Gulliver's work in the previous century. The various approaches are categorized here then reviewed in reference to the management needs in British Columbia.

1. Existing Human Use
2. Geology

   Morphology

   Origin

   Stability

   Erosion - Deposition
3. Oceanographic Factors
4. Geohydraulic Processes
5. Coastal Wave Climate
6. Ecological Character

   Dominant Energy - Stress

6. (continued)

Indicator Species

Biophysical Elements

This review only considers the merits of these various approaches relative to coastal zone management. Their value in other contexts will not be explored directly.

EXISTING HUMAN USE

An existing use classification of coastal areas has been used for some time in many states and most often for the purpose of regulating waste disposal (Odum, 1974). Washington state has established existing land and water use as part of its shoreline inventory under the Shoreline Management Act of 1971. This inventory categorizes both use and ownership patterns. Inventory and classification of land treatment and ownership status is a necessary prerequisite to coastal management but the information must be implemented in conjunction with good biophysical information in a clearly defined area to be of maximum management value. In Washington, part of this gap is being filled by a "survey of Natural Characteristics" which is discussed under Ecological Systems - Biophysical status. A number of other states are at a similar stage. California's Coastal Plan is now at a stage where existing use in broad terms (i.e. developed area, cultivated land) is being compared, in a broad sense, to the resource value of these lands.

GEOLOGY

The earliest attempts to classify coastal lands utilized various aspects

of geology. Landforms were categorized to various degrees by Guilcher (1958), Powers (1958) and others. Powers system recognized over 600 forms and provided a great deal of detail. Recent work by the Forestry Service of Environment Canada (Eis, et al, 1976), although not specifically concerned with coastal lands, provides a good example of how landscape feature analysis can be used for land planning. This system describes landscape units on the basis of physiography, exposure, slope, soils, drainage and vegetation and provides a good physical background for land treatment planning. When more biological information is considered in conjunction with this kind of knowledge, a good picture of the true character of land emerges.

Classification systems based on the genesis and evolution of shoreline topography (Gulliver, 1899, Johnson, 1919, Shepard, 1963) are interesting and provide some valuable perspective on coastal lands. Elaboration of the genetic system provided a stability/mobility component (Valentin, 1952) and considered erosion and deposition. Subsequent work by McGill (1958) became increasingly comprehensive. These systems are of good historical and perspective value but do not focus sharply enough on the problem at hand and are very theoretical in nature relating more to long term possible trends than short term realities.

OCEANOGRAPHIC FACTORS

A number of researchers in the general field of oceanography have concerned themselves with identifying and classifying discrete coastal water regions on the basis of characteristics such as salinity, temperature,

nutrient levels, tidal patterns and so on. These factors seem to have a great deal of bearing on the productivity of near shore waters and near shore marine lands and should be considered to some degree in classifying marine lands. Local physical features such as depth or slope, substrate type, and degree of protection from wave shock are judged to be more important in determining benthic community development but the broad regional ocean factors should be understood as part of the background information necessary for coastal management. Herlinveaux and Giovando, 1969, have elaborated on previous work by Waldichuk (1957) and Tully and Dodimead (1957) and proposed that coastal waters of the inside passage between Vancouver Island and the mainland could be divided into six different domains based on water characteristics mainly. Pritchard (1952) used a similar system to classify estuaries. The main value of this kind of information is that it provides background information on broad regional factors that help determine the kinds of biotic activity that occurs on marine lands in much the same way that climate information is helpful in understanding terrestrial ecology.

GEOHYDRAULIC PROCESSES

The interaction processes of land and water have been extensively studied to explain shoreland behaviour and development. Wolf Bauer has refined and augmented this information (very considerably) to a point where he is able to classify and describe shores on the basis of degree of interaction between land and water primarily along with the kind of shore materials

involved. From this, he has evolved a rational and relevant beach classification system along with similar systems for rivers and estuaries and treatment guidelines for each system. The Bauer System, in a coastal management context, is most appropriate for beach management and should be an integral part of any coastal management plan. The estuary system as described by Bauer is also extremely worthwhile, particularly when biological processes or zones are "overlain". For broad planning and management, Bauer's estuary portrayals are thought to be unnecessarily complicated but for intensive site or area management involving estuaries or any coastal wetlands, they are invaluable. This is particularly true in rehabilitation studies (Burns, 1976).

COASTAL WAVE CLIMATE

Hayden and Dolan (1975) have attempted to classify coastal wave climates and relate them to marine faunal province boundaries. Fundamental to the scheme is establishing the structure and organization of atmospheric windfields in open oceans and coastal regions. They postulate that the interaction of shore waves with land would be manifest in a system of inshore currents and drift generating a particular thermal structure.

These workers believe their results indicate a relatively high level of coincidence between hydrodynamics and marine faunal boundaries and suggest both be used to establish marine provinces of the coastal zone.

Under this system, British Columbia falls into only two provinces which are very broad. Thus, this system at its present scale is not useful. Wave energy is likely the dominant single feature affecting marine land biotic activity and beach behaviour but it is best considered at a smaller

scale in conjunction with other factors as in the manner of Bauer, 1976 and Burns, 1977.

ECOLOGICAL CHARACTER

DOMINANT ENERGY/STRESS

An innovative approach to classification of coastal ecological systems has been taken by Odum and workers (1974) who believed that all previous classification systems have suffered from their consideration of only one component of the coastal system.

"Elsewhere in the affairs of science and man, complexity of different processes have been amenable to unified consideration by the use of concepts of energy flow. Energy is a great common denominator measuring processes of all kinds. Thus we attempt to combine the roots of historical contributions to classification through a general energy classification." (Odum, 1974)

Such a classification allows various system features such as harvest, fertilization, insolation, tides and pollution to be considered on the basis of their potential energy flow. The type of energy flow is reflected by the ecological systems diversities and adaptions.

Any biotic process is measureable in calories and dominant processes or relative strength or productivity of communities could be measured in theory.

Under Odum's system, the B.C. coast could be broken into 37 types under 5 main categories based on dominant energy stress or source.

Odum's system appears somewhat complicated in determining ecotypes, then

oversimple in terms of management implications. It does provide a good deal of insight on the hows and whys of ecotype existence and is highly interesting reading but does not relate strongly enough to management except in the background understanding dimension.

INDICATOR SPECIES

A number of workers have attempted to classify coastal systems according to distributions of pre-selected lifeforms. The most useful organisms were those specialized in adapting to specific energy and stress factors. Thus Shelford (1930) looked at distributions of barnacles, Doty (1957) studied intertidal algae while Parker (1959) concentrated on molluscs.

Nichols (1974) followed several other workers in studying the distribution of forminifera. Characteristic forminifera have been identified for different coastal habitats ranging from high energy beaches to marshes. While this kind of information is interesting, it doesn't have important management implications since only small components of the system are identified.

BIOPHYSICAL ELEMENTS

The major historical attempts to classify lands in Canada have been based on broad scale biophysical elements of terrestrial systems. On the basis of climate, geology, soils, vegetation and slope and aspect, capabilities have been estimated for a variety of potential utilizations such as agriculture, forestry, wildlife and recreation. Similarly, sensitivities for various treatments have been predicted based on similar considerations in the manner of Eis et al which has been previously mentioned. Therefore biophysical information can provide direction for utilization in two sets: <u>it can suggest what uses are appropriate based on the natural</u>

character of the land and it can predict the impact of these uses and others which are not appropriate.

Spencer (1972), has developed what is essentially a biophysical classification system and has used it to derive capability ratings for potential uses of the coastal zone of Washington's Whatcom County. Spencer's capability evaluation methodology covers residential, industrial, acquaculture and recreational uses.

As a first step, Spencer divided the coastal zone into three belts:

1. The Coastal Marine Belt which includes only the subtidal portion of the neritic zone.
2. The Estuary - Shore Belt which includes the estuarine habitat and the intertidal and backshore portions of the neritic zone. The estuary - shore belt is composed of terrestrial, estuarine and marine habitats because of their close biological and physiological relationship.
3. The Terrestrial Belt which should include those terrestrial activities that are oriented to the marine environment and life processes influenced by the sea . . ."an area 2 or 3 miles inland from the sea."

Spencer's next step is to categorize the coast into a hierarchy of biophysical regions, subregions, components and subcomponents.

He defines the coastal region as "the occurrence of major coastal landforms in association with biogeoclimatic communities along the coast". (e.g. mountainous coast) The coastal subregion is a subdivision of the coastal region based on the separation of major physiographic and geologic patterns which characterize the region as a whole (e.g. smooth cliff faces

on a mountainous coast). The coastal component is composed of the discrete land features and water properties within the coastal subregion (e.g. intertidal platform at base of smooth cliff face). Then each coastal component is composed of coastal subcomponents that are recognizable and measureable features of the coastal component (e.g. cliff height). Obviously, Spencer's system is unnecessarily complex for coastal zone management. His "belt concept" is similar to the marine, intergrade and coastal fringe habitat land designations used in the Western Communities however.

In Corpus Christi Bay, Texas, lands and waters were separated into 34 units based on their biophysical character and their different responses to environmental stresses (State of Texas, 1973). An advantage of this approach is that no value judgements or relative productivity merits are assigned and lands would be managed solely on their ability to accept use. Texas termed these units "composite resource areas" (Fig. 1) since they group together into functional units of various physical features and lifeforms which are typically associated in nature. Theydescribe these areas as "mappable entities defined by local characteristics of processes, substrate, landforms, soils, biota and other factors that naturally support certain levels of human activities without appreciable environmental harm or human hazard. Each composite resource area can be described in terms of its "sustaining parameters" -- that is, specific energy and material inputs, products and characteristic features which, in combination, make that area a functional unit. Resource areas are interconnected by movements of materials, organisms and energy".

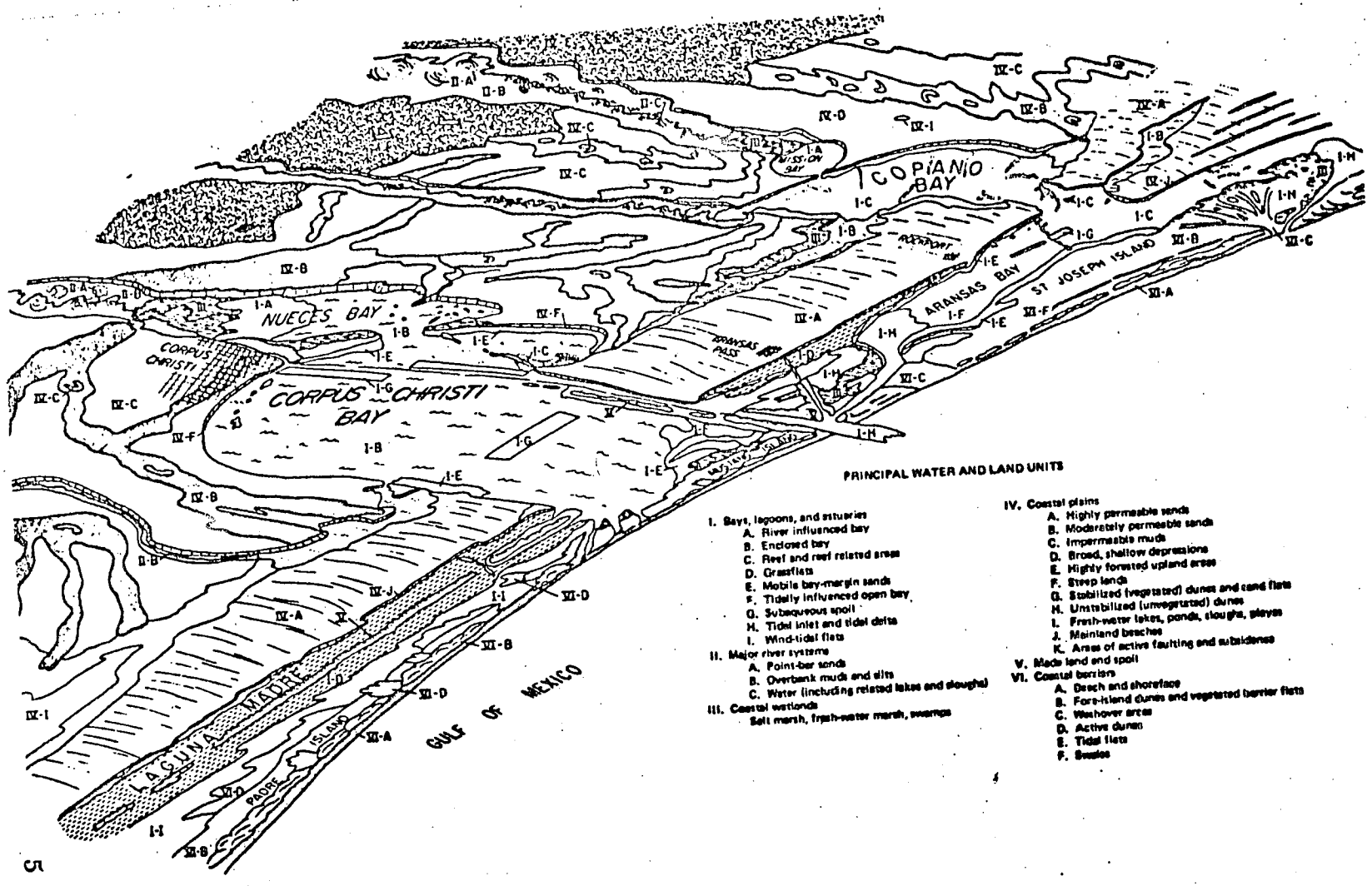


Figure 1. Environmental Capability Units in and around Corpus Christi Bay, Texas.

Although the variety of shoreforms and habitat types on the Pacific Coast is not nearly as great as on the Gulf Coast which is in much more advanced successional stages, it would seem that, for general management and planning purposes, the Corpus Christi Bay exercise has subdivided land and water units to an unnecessary degree. The same sort of subdivision and mapping could occur on a large B.C. estuary (although it would probably not be possible to come up with as many subunits) by grouping marsh vegetation, drawing lines around eel grass and oyster beds, mapping substrates and so on. The only useful purpose this would serve would be to ease the unemployment situation just a little unless it was done in the reference frame of site specific, problem - directed research. For management planning, it is better to describe ecological units in as broad a manner as possible to reduce confusion and promote understanding for the people who will ultimately decide the acceptability of a plan - people in general and their elected representatives.

A similar but somewhat less micro-detailed approach is utilized in Maine, New York and, closer to home, the State of Oregon. Oregon is classifying its coastal lands on the basis of broad habitat types such as benthic - muddy sand, eel grass, salt marsh, wet meadow, riparian and so on then relating things like vulnerability and resiliency for both the habitat and the animal community it supports on these habitat units to develop a treatment plan (State of Oregon, 1976). This is similar to the approach utilized in the Western Communities (prev. cited).

The State of Georgia has developed a system where a number of natural

features (beaches and dunes, island woodlands, marshes and estuaries, coastal plains and floodplains) are generally portrayed by their treatment sensitivities relative to construction. The basic biophysical elements are explained along with the effects of intrusion upon or modification of these elements. Also explained is where structures can occur within these natural features (Fig. 3 and 4), without interference with natural processes (State of Georgia, 1975).

need to place recommendations into perspective

This is just one aspect of planning (resource capability method) that Georgia recognizes as being important in terms of biophysical planning.

In Georgia four different types of resource planning methods have been organized for coastal land use planning (Fig. 2) (State of Georgia, 1976). The methods deal with distinct resource concerns including:

1. The ability of the individual site to support development (resource capability).*
2. The ability of a dynamic resource system to support development (resource system capability).
3. The ability of air and water resources to support development (air and water quality planning).
4. The ability of wildlife resource to withstand development.

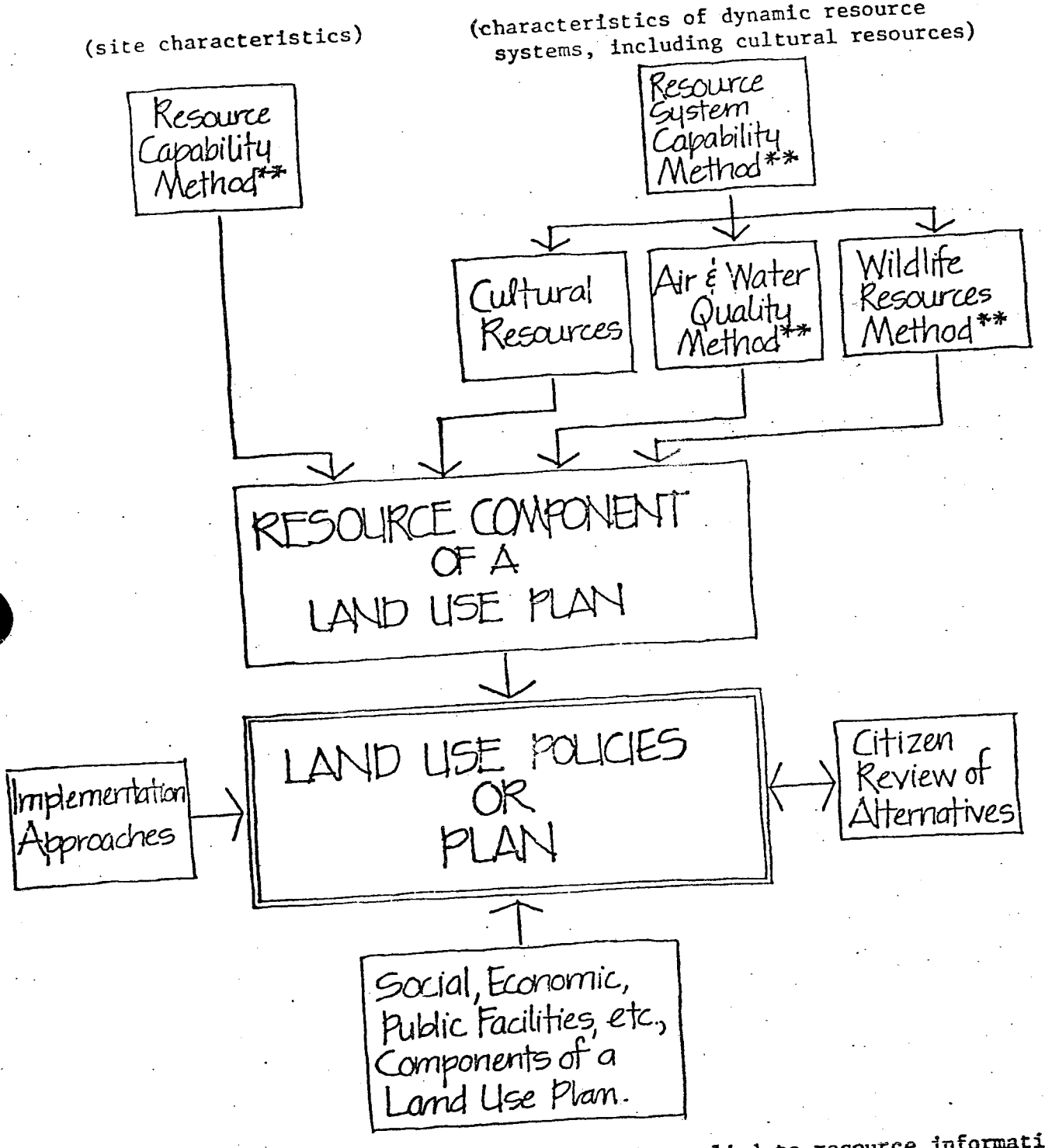
The listing below is a summary of the planning methods, indicating the general scope and purpose of the methods:

1. Resource capability method: The application of this method provides information about the ability of a particular area to support certain

* In our opinion, a better term would be site sensitivity.

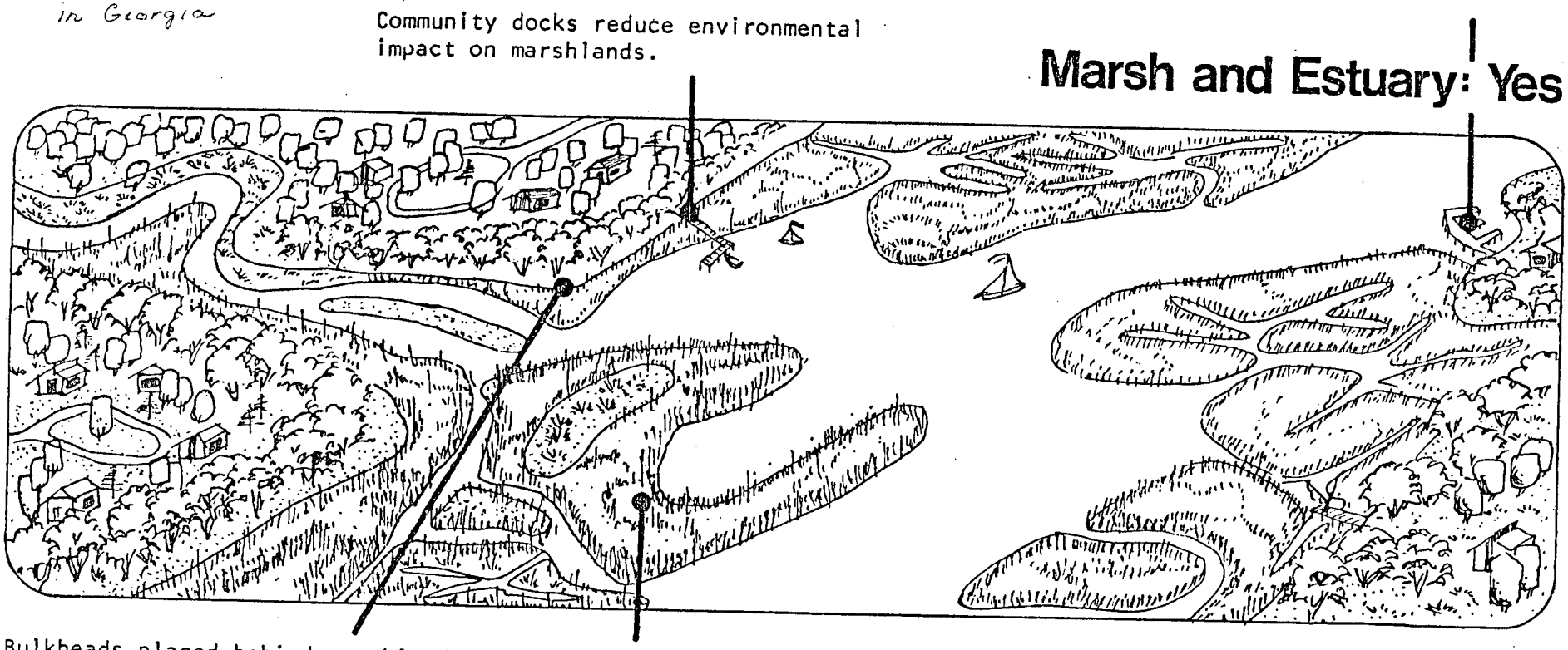
Figure 2

RESOURCE PLANNING METHODS*



* Resource planning methods are tools which can be applied to resource information to develop the resource component of a land use plan. Although the resource component of a land use plan is separated from social, and economic components of land use, as well as from implementation approaches, a land use planner would usually develop all components together. It is not always necessary to have a special resource component in a land use plan if resource considerations have been utilized in developing a plan.

Fig. 3 Acceptable Marsh and Estuary Development in Georgia

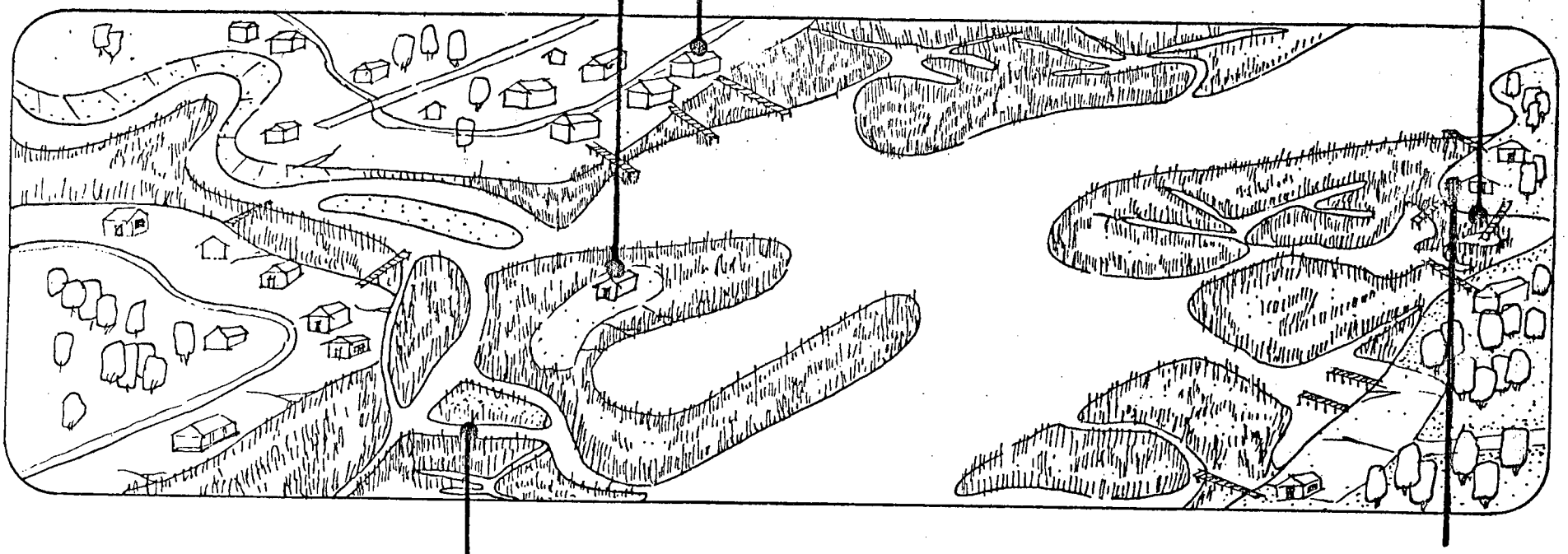


To obtain access by navigation channels, the construction of piers and docks is recommended. Dredging of small channels will alter valuable marshlands and create a maintenance problem. When possible, community docks should be utilized to reduce visual obstruction of marshland and to reduce maintenance costs.

Marshlands and estuaries are intolerant to filling for construction purposes. Filling destroys the natural vegetation and hence the natural productivity of the marshland system. Development should take place on dry, upland areas.

Fig. 4 Unacceptable Marsh and Estuary Development in Georgia

Marsh and Estuary: No



Coastal marshlands and estuaries form a natural buffer between the ocean and areas on the mainland. They enhance shoreline property values by protecting against erosion, slowing the force of storm surges, and providing visual and recreational amenities.

Marshlands in their natural state provide nutrients which support a diversity of fish, shellfish, and wildlife. One acre of marshland may produce ten tons of material in one year, making it one of the most productive natural systems on earth. One acre of estuarine habitat may in turn yield more than 500 pounds of fish in the open ocean.

Coastal marshlands and estuaries also provide important nursery areas and places of shelter for many fish and shellfish. In turn, marshes are a source of food for birds and other animals.

types of development. Physical properties of the site such as soil, slope, and water-table conditions, are major considerations of the method. The relationship between each of these properties and land uses is expressed as a "capability function".

"Capability functions" useful for planning in coastal Georgia are outlined in the method. Specific techniques for preparing a series of overlays to graphically illustrate the ability of a particular site to support development are also explained.

The specific area on which the land activity will take place is the focus of this method. Secondary environmental effects resulting from development, such as runoff or increased erosion, are not analyzed. (They are considered in the air and water quality planning method.) Dynamic resource systems (including wildlife) which may be affected by the development are also not included.

2. Resource system capability method: This method guides the land use planner through a step-by-step process of considering resource information on value (benefits to the public), vulnerability (the susceptibility of the resource to change), and laws and regulations which may influence development in fragile resource areas.

The method is based upon resource maps, and scientific background papers on The Value and Vulnerability of Coastal Resources prepared for the Georgia Coastal Zone Management Program. A careful analysis of "actions" and "activities" associated with certain land uses is an

important step in this method, since the environmental impact of any land use is a function of the land-disturbing characteristics of the use; not the fact that it is a particular type of land use (such as industrial, commercial, residential, etc.).

This method is an important complement to the resource capability method. While the resource capability method focuses on a specific geographic area, this method includes considerations of how activities in one component of the resource system (such as river swamps) affects other components in the same resource system (such as the river channel). Similarly, activities in sand dune areas may affect the beach or offshore sand bar environments. The ability of the total resource system to support a given activity is a concern.

This method provides a broad umbrella for two more detailed resource concerns: air and water quality, and wildlife. Specific methods have been developed for these concerns and included in this System. Additional methods for specific types of resources, such as cultural resources or recreational resources, could also be developed. These more detailed methods, however, generally focus on the organization of information and procedures, as opposed to steps in a broader planning process.

3. Air and water quality planning method: Air and water quality protection is an additional resource planning concern. Air and water quality laws (both State and Federal) represent adopted policy related to these environmental problems. The land use planning process can

assist in supporting environmental protection policies (expressed in laws) by recognizing the natural resource systems (such as rivers and adjacent swamplands), that are known to have some pollutant assimilative capacity. This capacity has the effect of improving water quality. In addition, land use planning can address environmental quality problems directly. For example, runoff and erosion (processes which increase water pollution) can be reduced through proper planning and construction guidelines. This methodology provides suggestions to assist in the development of such guidelines.

To assist the user, matrices which correlate land use categories with potential water quality problems, and summaries of relevant State and federal legislation, are included.

4. Wildlife resource planning method: Due to lack of readily available information, wildlife resources are usually not thoroughly evaluated in land use planning. In addition, the dynamic nature of wildlife communities makes it difficult to develop a detailed data base about the life cycles of animals in a certain area. This method addresses these two central problems.

The method employs two separate card files; one for vegetation, and one for animals. The first card file relates categories of vegetation to types of wildlife; the second file summarizes the available information about each animal (including associated animals, and food and habitat requirements). The planner can therefore use the method if either vegetation or wildlife data is available.

Information on wildlife communities and habitats is a prerequisite

for the proper application of this method. Since much additional wildlife information must be collected for Georgia's coastal region, the card files have been structured so that they can be updated easily. These card files cannot be considered a substitute for professional evaluation of the interrelationships among wildlife species, and among wildlife and their habitats. Only a trained professional can assess the significance of the wildlife community in a region. There is no way that professional experience and training in wildlife biology can be summarized in a step-by-step method. Rather, the wildlife planning method makes it possible for the land use planner to describe the wildlife potential for a certain area, and to integrate this information into a land use plan.

These examples point out the broad, two dimensional value of classification systems based on biophysical elements of land units: they can predict which uses are appropriate based on the natural character of the land and they can also point out those that are not and clearly define why.

The only possible drawback to most systems of this type is that they may not be entirely suitable for predicting the broader impacts of a use that may fit in one land unit but may effect adjacent areas, especially if the particular unit is an integral component of a broader system. Example: In terms of key biophysical elements of the land, it is possible to locate a fairly dense housing development within a designated distance of an estuary. However, the estuary is an integral component of a much broader animal system with some of its members having a very low tolerance

for human contact. Therefore these species are unable to utilize this most important portion of their range and eventually die off. It is probable then, particularly in wilderness areas such as much of the British Columbia coast where wilderness animals are common, that broader system planning is necessary to fully accomodate all ecological considerations. This is why the coastal fringe habitat zone was considered to be a necessary component of the Western Communities plan. The zone was narrow in this area because sensitive, wide ranging animals like grizzly bears and wolves are no longer present but, in much of the rest of the coast, the zone will have to be much broader around important coastal habitat components of these kinds of animals if they are to be protected.

A system which strives for integration of land and ecosystems was attempted by the Service des Ecologiques Regionale (Jurdant, Gerardin, Belair and Ducruc, 1976). The biophysical elements of land were integrated with associated waters in a study of the James Bay project and the results appear to have considerable merit for broad system planning.

Another shortcoming of many biophysical analysis systems is that they have yet to be applied to marine lands in a comprehensive sense although, Spencer, Oregon and Corpus Christi Bay approaches are applicable and do include some marine lands.

WHICH APPROACH FOR B.C.?

Most of the reviewed systems to coastal land inventory and classification are useful for some purposes. In themselves, none are judged entirely suitable for use in this province. What is required here for best possible coastal

management is a system that recognizes and describes the physical and biotic character of coastal lands and nearshore waters and lands and their sensitivities to various forms of use. In our view, the best way to accomplish this is to simply describe lands in terms of their basic physical components, in terms of the habitat these components form and in terms of the biotic community expressed upon them in both and narrow and broad sense. The sensitivities of a land unit or system or units would then be described on the basis of both habitat and community impact. Example: Wolf Bauer identifies functional land units on the basis of geohydraulics and a Wolf Bauer driftway is a land unit based on this and its basic physical character (e.g. unstratified sand and gravel of morainal till or fluvial outwash). This driftway is also a habitat unit with a certain kind of community expressed upon it because of its physical character and other local influences. Its management needs have two dimensions: the physical dimension and the biological dimension, and they are of course interrelated. When both of these are described, it becomes possible to manage this land unit on a rational basis. In British Columbia, coastal land units are of only three basic types in marine and intergrade lands: Rock, sand and mud or various combinations of these. The communities expressed on these units are basically a function of this, slope and exposure. The coastal fringe habitat is upland and a different regime due to soil moisture primarily. (Upland has been defined as lands where groundwater almost never reaches the surface as opposed to intergrade and marine lands which have different degrees of wetness which is a prime factor in determining their nature.)

It should therefore be relatively simple to classify these lands, their habitats and communities and devise management plans based on the land-community sensitivity. The coastal fringe habitat is more complex but still easily manageable with the suggested approach which we view as simple and rational and answers the two questions one must ask of any piece of land: What is? What ought to be?

FOR THE FUTURE

For coastal management to be successful, there are a wide range of necessary tasks to be performed.

1. The coastal zone must be described in terms of its biophysical character and sensitivities. A team approach with emphasis on coastal Geology and Biology is necessary.

2. Incompatible uses must be inventoried and attempts made to fit them in appropriate sites.

3. The question of native people's lands must be seriously considered. Many of the most suitable biotic and potential industrial lands on this coast are Indian Reserves and serious land use conflicts are sure to develop unless a mutually agreeable management plan is evolved soon.

4. There should be an ongoing program of basic research on the natural capability of coastal lands. Biophysical analysis needs more support to better understand the ecological processes occurring; particularly on marine lands. Our research to date has been too heavily slanted toward physical oceanography and commercial lifeforms.

5. Administration of the coastal zone should be considered in depth.

5. (continued) We could proceed with the present system indefinitely if regional plans were available for the entire coast but they are not. It is our judgement that coastal management with much more thrust might be possible with a separate agency with solid public commitment. Hopefully this would allow coastal management to progress from the single component reactive stage to a true integrative management stage.

6. Much more public education is necessary. For any program to be successful, it needs public commitment based on sound understanding of the need. Perhaps more than any other government program in history, coastal management will affect the opportunity for people to treat both public and private lands as they feel necessary. Most marine lands on our coast are public land but much intergrade and coastal fringe habitat is private domain.

7. Finally, our coastal zone should be zoned based on its biophysical character and intertwined ecosystems and the social and economic character of individual coastal regions. Zoning would separate coastal lands by their character and the uses they may accept tempered with the knowledge of what uses are likely to occur in the region. The coastal zone management team could consist of biologists, geologists, economic and social planners, industrial representatives, public representatives and native Indians.

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