FWS/OBS-77/48
September 1977

INTERIM HIERARCHICAL REGIONAL CLASSIFICATION SCHEME FOR COASTAL ECOSYSTEMS OF THE UNITED STATES AND ITS TERRITORIES

by

Terry T. Terrell

U. S. Fish and Wildlife Service
Office of Biological Services
Western Energy and Land Use Team
National Habitat Assessment Group
Room 206, Federal Building
Fort Collins, Colorado 80521

Performed for

National Coastal Ecosystems Team
Office of Biological Services
Fish and Wildlife Service
U. S. Department of the Interior

TABLE OF CONTENTS

PREFACE

This is a hierarchical regional classification scheme for coastal ecosystems of the United States and its territories based on biological and physical (such as hydrological, chemical, geological, and structural) characteristics of those areas. It is designed to answer the question "How can the coastline of the United States be partitioned to best separate ecosystems, when the purpose of defining these ecosystems is to make predictions about how specific types of perturbations in specific geographical areas will affect the ecosystems hydrologically, structurally, functionally, and, most important, biologically?"

This is not a structural classification, a functional classification, or a biogeographic regionalization. It is in draft form and comments are solicited.

INTRODUCTION

OBJECTIVES AND PURPOSES

The objective of this project is to formulate a hierarchical regional classification scheme for partitioning coastal ecosystems of the United States and its territories, based on the biological and physical (such as hydrological, chemical, geological, and structural) characteristics of those areas. The classification is based on a combination of the above named criteria rather than being specifically a phytogeographical or zoogeographical regionalization based on groups of organisms because the objective is to develop a classification scheme for ecosystems.

This classification should serve two purposes. It should first provide a structure for data collection both for organizing the storage of data and for demonstrating areas where additional data should be collected. Second, and perhaps more important, it should delineate geographical zones about which predictions on the functioning of ecosystems within those zones may be made at various levels of resolution. These geographical areas are analogous to the ecological land and ecological water units of the Wildland Planning Glossary (Schwartz et al., 1976) and should be regarded as operational definitions of the boundaries of ecosystems. Thus, predictions within any given division* of the regional classification should be more reliable than predictions spanning divisions (ecosystems).

It is anticipated that such a classification system should be useful to a broad range of users for the above reasons, however, two of the most likely are the National Coastal Ecosystems Project of the Office of Biological Services and the Division of Ecological Services, both of the U. S. Fish and Wildlife Service (USFWS), for the delineation of study boundaries of their Ecological Characterization Studies and Profiles (see Glossary), respectively.

REVIEW OF EXISTING COASTAL CLASSIFICATIONS

It is appropriate to review existing coastal classifications, and to explain why these were not suitable.

There are a number of classifications of coastal areas in existence, each serving a different purpose, and they fall into three categories: structural, functional, and regional (geographical). While these may not be totally mutually exclusive types of classification, each has very specific characteristics. Structural classification schemes classify the coastline by the structural components of the area, for example, geological structure (rocky beach, sandy beach) or surface cover or structure (sea grass beds, kelp beds). An example of this would be the main body of the Cowardin et al. (1976) wetlands classification system exclusive of the regional portion, as it applies to estuarine and marine systems. G. C.

*The term division is used in the same sense as the word taxon is used in taxonomy, i.e., any one of the categories such as Level I, Level II, etc., into which coastal ecosystems are classified.

Ray's (1975) classification "by habitat" and Hedgpeth's (1957) classification are structural.

A functional classification is one in which some aspect of the functioning (i.e. energy inputs, stratification and circulation patterns, or geological processes forming the coastline) is used to separate the systems. Examples of functional classifications are Shepard (1937) addressing geological processes forming beaches, Hansen and Rattray (1966) and Glenne and Asce (1967) addressing mixing and stratification in estuaries, and Odum et al. (1974) addressing energy inputs.

A regional classification system is one based primarily on geography. Areas which are contiguous may be in the same region, but those some distance apart, though they may be quite similar structurally or functionally, cannot be classified together regionally. Secondary attributes used in the classification may be biotic or physical, and thus a biogeographic regionalization or a physical regionalization would be produced. Examples of zoogeographic regionalizations are Ekman (1953), Briggs (1974), Ray's (1975:14) "by zoogeographic regions" classification, and Smith (1976). Examples of phytogeographic regionalizations are Earle (1969) and Humm (1969). Examples of regionalizations which include some physical factors, but which are chiefly biotic regionalizations, are Ketchum (1972), Cronin (1974), Ray's (1975: 19) "by coastal biotic provinces" classifications, and the coastal regionalizations of wetlands in Cowardin et al. (1976). Examples of regionalizations which include some biotic factors, but which are chiefly regionalizations based on physical parameters, are Wastler and de Guerrero (1968), U. S. Fish and Wildlife Service (1970), U. S. Senate (1970), and Lynch et al. (1976). An excellent example of classification of coastal areas on purely physical (chemical, geological, etc.) attributes is Dolan et al. (1972).

Each of the above types of classification may be put to a number of uses, and each is well suited to answering certain types of questions. However, information obtained by applying one type of classification may be useless in trying to solve problems best addressed by application of another type of classification system. A few examples will clarify this. If all coastal areas of the Untied States were classified according to Odum et al. (1974) and the question were posed, "What is the mixing pattern of estuary 'X'?", it could not be answered because Odum et al.'s (1974) classification only considered energy inputs. Again, if all coastal areas of the United States were classified according to Shepard (1937) and the question were asked, "How many surface hectares of coastline are covered by kelp beds?", it also could not be answered because Shepard only considered geological processes. The information collected for either classification would not be incorrect, but it would be inappropriate to answer the types of questions being asked. Thus it is obviously necessary to select a classification which best answers the question or questions being asked.

The objective of this project is to formulate a hierarchical regional classification scheme for coastal ecosystems of the United States and its territories, based on the biological and physical (such as hydrological, chemical, geological, and structural) characteristics of those areas. The question it is designed to address is the following: "How can the coastline of the United States be partitioned to best separate ecosystems, when the purpose of defining these ecosystems is to understand and subsequently to make predictions about how specific types of perturbations in specific geographical areas will affect them hydrologically, structurally, functionally, and, most important, biologically?".

Structural and functional classifications do not adequately address the above stated problem because they are not geographically oriented. Thus, a regionalization is necessary. Since delineation of ecosystems is the primary interest, a regionalization based on physical (geological, chemical, etc.) parameters is more appropriate than a biogeographical regionalization. While the argument is frequently made that the biota integrate all the physical attributes of their environment, two factors mediate against a biotic regionalization for answering the objective of the study. The first is historical accident of distribution and/or extinction. For example, a group of organisms might be absent from an area which they could inhabit simply because they were never distributed there or had become extinct in that area because of environmental or man-induced perturbations. Regionalization with respect to ecosystems should not be determined by historical accident. The second mitigating factor against biogeographical regionalization is the difficulty of selecting the group or groups to represent the whole ecosystem. Are benthic or motile forms more appropriate? Plants or animals? Vertebrates or invertebrates? Vascular or nonvascular? A regionalization based on physical parameters eliminates these problems and is most appropriate to answer the originally stated objective.

This does not mean that the distribution of biota should not reflect the distribution of coastal ecosystems. If the theory that biota integrate their physical environment is correct, then they should reflect by their own distribution the distribution of coastal ecosystems. In fact, this would provide an excellent method for testing a regionalization based on physical parameters.

The classification proposed by Dolan et al. (1972) is extremely well done and well documented. It was not used to satisfy the objective of this study because the elemental units are inconveniently small for the purpose of characterization. A great deal of information obtained from Dolan et al. (1972) was used in preparation of this document.

A limitation of classification of coastal areas which should be briefly mentioned is that of what specifically is being classified. Classifications have addressed only the beach (Shepard, 1937), estuaries (Hansen and Rattray, 1966) coastal waters including or excluding estuaries (Lynch et al., 1976), coastal ecosystems (Odum et al., 1974), or coastal and estuarine species associations (Briggs, 1974). Only one example of each is cited for the sake of brevity, although many more exist. As mentioned previously, the classification presented in this paper is concerned with coastal ecosystems in estuarine and coastal waters.

The major problem with this proposed scheme or any other classification scheme is that of drawing boundaries somewhere along what is all too frequently a continuum. Where there may be a distinct boundary between geological units along a coast, climate may well be continuous, but when geology intergrades, climate may fall into distinct units. Compounding this problem are those of shifting current, rainfall, and temperature patterns during the year, and the very nature of the coastal zone itself as an ecotone between the land and sea. Thus, while some of the different divisions specified may represent fairly distinctive ecosystems, others may not. Some divisions may be different from other divisions only because they are intermediate. This paper presents an attempt to regionalize and separate into similarly functioning ecosystems the coastal areas of the United States using the available ecological information and the expert opinion of numerous resource managers who work along the coast.

METHODS

In order to formulate a hierarchical regional classification scheme for coastal ecosystems of the United States and its territories, criteria were established which allow inspection of the characteristics of coastal ecosystems or clusters of ecosystems at various levels of resolution. Those criteria are as follows:

Level I: These divisions are the largest in geographical area and represent clusters of similarly functioning ecosystems. The main criteria for separating the different divisions of Level I are ocean or lake system upon which the coastline abuts, or the major ocean current or currents which wash the shore, or major differences in climate. Ocean currents and climate are the main forcing functions of ecosystems along the coastline and are thus appropriate parameters for the primary criteria separating these ecosystems.

Level II: These divisions are geographically smaller than Level I divisions, and represent a small number of interrelated and similarly functioning ecosystems. They are separated chiefly by geological structural properties of the coast, both above and below the waterline, with consideration given to hydrological, physical, and chemical properties. The structural geology of the coastal area is a major constraining factor on ecosystems and thus is an appropriate second level criterion for separation of these ecosystems.

Level III: These are the smallest divisions of the classification system with respect to geographical area. Each represents a logical unit or ecosystem. These have been most easily delimited in actual practice by individual drainage areas along the coast. Dolan et al.'s (1972) Elemental Units should also be considered for use as Level III divisions. For the purposes of this study, Level III divisions have not been delineated, but may be required in the future. The primary criterion for separation should be the homogeneity of response, considering the forcing functions and constraints, of the division to perturbation.

A summary of the criteria are as follows:

At the first, most general level, the forcing functions of the systems were the chief criteria. At the second level, the major constraints on the system were the chief criteria. At the third, most specific level, the homogeneity of the response of the system to the forcing functions and constraints was the criterion for separation. Thus the criteria are: what makes the system work, what determines how the system can work, and last, how the system responds.

Boundary lines were drawn perpendicular to the coast, using the above listed criteria and manual overlay of maps exhibiting the necessary information, to separate divisions. The information used came mainly from Adams et al. (1975), Brooks (1973), Bureau of Land Management (1975a, 1975b, 1975c, 1975d, 1976a, 1976b, 1976c, 1976d, 1976e, 1977a, 1977b), Dolan et al. (1972), Earle (1969), General Land Office of Texas (1976), Great Lakes Basin Commission (1975), Joint Federal-State Land Use Planning Commission for Alaska (1973), Selkregg (1974a, 1974b, 1974c, 1974d, 1974e, 1974f), U. S. Geological Survey (1954, 1970), and Weaver et al. (1976). These boundaries were examined critically by the reviewers (see Appendix for list) of the first draft and other staff members in their respective offices. In many cases the expert opinion of these reviewers was used to slightly modify boundary lines.

RESULTS

The results of this project are the options for landward and offshore boundaries, the coastal regionalization Level I and Level II boundaries (Table 1), and the Level II descriptions.

OPTIONS FOR LANDWARD AND OFFSHORE BOUNDARIES

Landward Boundary Options

1. Meet the seaward boundary of Bailey's (1976) regionalization
   Pro-The regionalization is extant. Many federal agencies and states are committed to its use.
   Con-Not at all designed to give indications of coastal areas. No clear indication of seaward boundary. Does not include in coastal ecosystems Cowardin et al.'s (1976) emergent wetland class (marshes, swamps, etc.). Emergent wetlands would be included in uplands.

2. Adopt Coastal Zone Management (CZM) inland boundaries
   Pro-Most boundaries extant, information collected for characterizations would be directly applicable to CZM problems.
   Con-Not uniform around the country, thus problems of comparability of data.

3. Mean high water mark, high high tide, etc.
   Pro-Easy to determine.
   Con-Obviously leaves out a lot of what has traditionally been considered coastal.

Table 1. Coastal Regionalization Level I and Level II Boundaries

Level I	Level II	Boundaries
A. North Atlantic		A. Maine-Canada border to Cape Cod
	1. Gulf of Maine Coast	1. Maine-Canada border to Cape Elizabeth
	2. Northern New England Coast	2. Cape Elizabeth to Cape Cod at Monomoy Island
B. Middle Atlantic		B. Cape Cod at Monomoy Island to Cape Hatteras, but not including Pamlico, Currituck, or Albemarle Sound
	1. Southern New England Coast	1. Cape Cod at Monomoy Island to Montauk Point, including Long Island Sound
	2. New York Bight	2. Montauk Point to Cape May
	3. Delaware Bay	3. Cape May to Cape Henlopen
	4. Delmarva Shore	4. Cape Henlopen to Cape Charles, plus seaward shore from Cape Henry to Cape Hatteras
	5. Chesapeake Bay	5. Cape Charles to Cape Henry

Table 1. Continued

Level I	Level II	Boundaries
C. South Atlantic		C. Cape Hatteras to Fort Lauderdale plus Pamlico, Albemarle, and Currituck Sounds
	1. Pamlico Sound Complex	1. Pamlico, Albemarle, and Currituck Sounds
	2. North Carolina Coast	2. Seaward coast of Outer Banks from Cape Hatteras to Cape Lookout AND both estuarine systems and seaward islands from Cape Lookout to Cape Fear
	3. Sea Islands	3. Cape Fear to Jacksonville
	4. East Florida	4. Jacksonville to Fort Lauderdale
D. Southern Florida		D. Fort Lauderdale to Cape Romano including Florida Keys
	1. Biscayne Bay	1. Fort Lauderdale and Biscayne Bay including Biscayne Bay National Monument
	2. Florida Keys	2. From Biscayne Bay National Monument to Key West and to include Dry Tortugas
	3. Florida Bay	3. South tip of Biscayne Bay to Cape Sable
	4. Ten Thousand Islands	4. Cape Sable to Cape Romano

Table 1. Continued

Level I	Level II	Boundaries
E. Atlantic Insular		E. Puerto Rico and Virgin Islands
	1. Puerto Rico	1. Puerto Rico
	2. Virgin Islands	2. Virgin Islands
	3. Navassa Island	3. Navassa Island
	4. Serrana Bank and Roncador Bank[1]	4. Serrana Bank and Roncador Bank
F. Gulf of Mexico		F. Cape Romano to Texas-Mexico border
	1. Central Barrier Coast	1. Cape Romano to Tarpon Springs
	2. Big Bend Drowned Karst	2. Tarpon Springs to Alligator (Light House) Point
	3. Apalachicola Cuspate	3. Alligator (Light House) Point to Cape San Blas
	4. North Central Gulf Coast	4. Cape San Blas to Pascagoula-Horn Island
	5. Mississippi Delta	5. Pascagoula-Horn Island to, and including Vermillion Bay
	6. Strandplain-Chenier Plain System	6. Vermillion Bay to Galveston Bay
	7. Texas Barrier Island System	7. Galveston Bay to Texas-Mexico border (including Galveston Bay)

Table 1. Continued

Level I		Level II		Boundaries	
G.	Southwest Pacific			G.	California-Mexico border to Cape Mendocino
		1.	Southern California	1.	California-Mexico border to Point Conception
		2.	Central California	2.	Point Conception to Cape Mendocino
		3.	San Francisco Bay	3.	San Francisco Bay
H.	Northwest Pacific			H.	Cape Mendocino to Washington-Canada border
		1.	Pacific Northwest	1.	Cape Mendocino to the Straits of Juan de Fuca
		2.	Columbia River Estuary	2.	Columbia River Estuary
		3.	Puget Sound	3.	Puget Sound and the Straits of Juan de Fuca and Georgia
I.	Pacific Insular			I.	Hawaii, Guam, Samoa, Pacific Trust Territories, and other Pacific islands, administered, claimed, or in trust to the United States
		1.	Hawaii	1.	State of Hawaii
		2.	Guam and Pacific Trust	2.	Guam, Carolines, Marianas and the Marshalls
		3.	Samoa and Other U. S. Claims and Administered Islands	3.	Samoa, Wake, Midway Islands, Johnston Atoll, Kingman Reef, Palmyra Atoll, Howland Island, Baker Island, Jarvis Island, Canton Island, Enderbury Island, the Line Islands[2], Phoenix Islands[2], Ellice Islands[2], Northern Cook Islands[3], Tokelau (or Union) Islands[3]

Table 1. Continued

Level I	Level II	Boundaries
J. Panama Canal Zone		J. Panama Canal Zone
	1. Panama Canal Zone	1. Panama Canal Zone
K. Pacific Alaska		K. Alexander Archipelago to Unimak Island at Unimak Pass including Cook Inlet
	1. Alexander Archipelago	1. Alexander Archipelago to Cape Spencer
	2. Gulf of Alaska Coast	2. Cape Spencer to Kenai Peninsula at Cape Elizabeth, except Prince William Sound but including Montague Island
	3. Prince William Sound	3. Cape Hinchinbrook to San Juan-Latouche
	4. Cook Inlet	4. Cape Elizabeth to Cape Douglas
	5. Kodiak Island and Protected Coast	5. Kodiak Island, coast from Cape Douglas to Cape Providence, and Chirikof Island
	6. Wave Beaten Southwest Alaska Coast	6. Cape Providence to Unimak Pass
L. Aleutian Islands		L. Aleutian Islands
	1. Aleutian Islands	1. Aleutian Islands

Table 1. Continued

Level I	Level II	Boundaries
M. Bering Alaska		M. Unimak Island at Unimak Pass to Cape Prince of Wales including Pribilof Islands, Nunivak Island, St. Matthew Island, and St. Lawrence Island
	1. South Bristol Bay	1. Unimak Island at Unimak Pass to Cape Greig
	2. North Bristol Bay	2. Cape Greig to Jacksmith Bay
	3. Yukon, Kuskokwim Delta	3. Jacksmith Bay to Point Romanof including Nunivak Island
	4. Norton Sound Coast	4. Point Romanof to Cape Prince of Wales
	5. Bering Sea Islands	5. Pribilof Islands, St. Lawrence Island, St. Matthew Island, and Diomedes Islands
N. Arctic Alaska		N. Cape Prince of Wales to Alaska-Canada border east of Demarcation Point
	1. Chukchi Coast	1. Cape Prince of Wales to Barrow
	2. Beaufort Coast	2. Barrow to Alaska-Canada border east of Demarcation Point

Table 1. Concluded

Level I	Level II	Boundaries
0. Great Lakes		0. Great Lakes
	1. Lake Superior	1. Lake Superior and the St. Marys River
	2. Lake Michigan	2. Lake Michigan and the Mackinac Straights
	3. Lake Huron	3. Lake Huron and the St. Clair River
	4. Lake Erie	4. Lake Erie and the Niagra River
	5. Lake Ontario	5. Lake Ontario and the St. Lawrence River

[1]Both claimed by the United States and Columbia.

[2]Claimed by the United States and the United Kingdom.

[3]Claimed by the United States and New Zealand.

4. One hundred year flood and tidal innundation level
Pro-Fairly easy to determine.
Con-May include large areas not normally considered coastal or exclude those which are.

5. Some fixed distance from some tidal line such as 300 m from mean high tide
Pro-Easy to determine.
Con-May include or exclude inappropriate areas.

6. Some contour line such as the 10 m contour
Pro-Easy to determine.
Con-May include or exclude inappropriate areas.

7. Peak of the coastal mountain range
Pro-Easy to determine.
Con-Many coasts do not have mountain ranges.

8. Inland boundaries of coastal counties or parishes
Pro-Easy to determine.
Con-May include or exclude inappropriate areas.

9. Man-made structures such as roads, canals, etc.
Pro-Easy to determine.
Con-May include or exclude inappropriate areas.

10. Pleistocene/recent contact
Pro-Areas recently built are obviously coastal, and may be easy to discern.
Con-Not appropriate on beaches which are not aggrading.

11. Maximum inland or seaward range of any one species
Pro-Should be fairly easy to determine.
Con-No species distributed along entire United States Coastline. Historical accidents or distribution can cause erroneous results. Plasticity of the response of an organism to its environment and synergisms among environmental inputs may allow an organism to occur in a variety of coastal and noncoastal areas.

12. Soils - wetland/nonwetland boundary
Pro-Fairly easy to determine.
Con-Wetland soils may occur in areas which are no longer wetlands.

13. Boundary of wetland/nonwetland vegetation
Pro-Fairly easy to determine.
Con-Large number of species needed for coastal delineation of the entire United States. Not appropriate for unvegetated coast.

14. Salinity intrusion
Pro-Fairly easy to determine.
Con-Salinity is not the only influencing factor.

15. Tidal influx
Pro-Fairly easy to determine.
Con-Tidal influx is not the only influencing factor.

16. The inland boundaries for marine and estuarine in the Cowardin et al. (1976) system which has been adopted by the National Wetlands Inventory. These boundaries are based on vegetation, soils and salinity.

Pro-Will be mapped for the entire United States, large amounts of information already on this framework. Will probably be updated regularly.
Con-No information yet on how this applies to coastal processes. Updates will certainly change inland boundaries.

17. Determine the major coastal influences and make an inland boundary determination for each Level I, II, or III division based on the extent of the influences
Pro-Would most accurately reflect the functioning of coastal ecosystems in the area of interest.
Con-Would not be uniform around the coastline and would cause problems of comparison of information among divisions. Extremely difficult to determine.

Offshore Boundary Options

1. Territorial sea boundary
Pro-Easy to define. The United States controls this area, so management would be simplified.
Con-It is an artificial boundary having no demonstrable relationship to coastal ecosystem functioning.

2. Two hundred mile "economic zone" (322 km)
Pro-Easy to define. United States has some management control.
Con-Artificial boundary having no demonstrable relationship to coastal ecosystem functioning.

3. Line marking the 30 m (or any) depth contour
Pro-Fairly easy to define. Is somewhat more related to functioning of ecosystems.
Con-Line is still very artificial and would lead to poor data comparability around the coast.

4. Edge of the continental shelf
Pro-Fairly easy to determine. Much more related to ecosystem functioning.
Con-May not include all the important processes in ecosystem functioning. Is not completely controlled by the United States.

5. The seaward boundary of the Cowardin et al. (1976) classification scheme, which has been adopted by the National Wetlands Inventory. This is the edge of the continental shelf. (Pros and cons are the same as those listed for item 4.)

6. Line demarking the limit of the important processes in ecosystem functioning
Pro-Would best relate to and allow for modeling of coastal ecosystems.
Con-Would be very difficult to delimit, this would have to be done for every Level I, II, and III division along the coast. Might cause problems of comparability.

A major portion of the ideas and information used for the list of options for landward and offshore boundaries are derived from papers by Robbins and Hershman (1974) and McIntire et al. (1975).

LEVEL II DESCRIPTIONS

A. North Atlantic

A.1. Gulf of Maine Coast, Rocky, deeply incised "drowned" coastline with numerous bays, estuaries, islands. High tidal range, creating abundance of intertidal pool communities. Small areas of mudflats and marshes, few shallow areas.

A.2. Northern New England Coast. Some rocky shores, Cape Elizabeth to Cape Ann, mainly sandy beaches south of Cape Ann. Sandy or cobble beaches with high energy except those sheltered within Cape Cod Bay. Extensive marshes and mudflats.

B. Middle Atlantic

B.1. Southern New England. Fairly irregular coastline with several large islands, two large bays, and two sounds (one--Long Island Sound--very large, protected). Mainly sandy beaches, some high energy, with marsh areas behind, some barrier islands, some with dune systems.

B.2. New York Bight. Coastline dominated by wide, sandy, high energy beaches, often with dune systems on barrier islands protecting bays and extensive marshes.

B.3. Delaware Bay. Large embayment semiprotected from ocean. Extensive marshes on both sides to 80 km (50 miles) up bay. Some oyster reefs in mid and lower reaches.

B.4. Delmarva Shore. Dominated by series of barrier islands with some dune systems and high energy, wide, sand beaches. Extensive marsh systems in protected shallow waters behind islands.

B.5. Chesapeake Bay. Very large, "drowned coastline" estuary with several riverine subestuary systems. Largely protected from high energy ocean influence but with pronounced influence by saline waters, marine organisms, etc., on declining gradient northward into bay. Extensive marsh systems, especially on eastern shore, some oyster reefs. Sediment transport processes, turbidity highest in upper bay.

C. South Atlantic

C.1. Pamlico Sound Complex. Wide, sandy beaches with extensive marshy areas, but mostly characterized by very extensive outer bank and barrier island system which protects the sound complex. Reasonably high amount of freshwater inflow.

C.2. North Carolina Coast. Broad white quartz sand beaches, smaller estuary systems than Pamlico Sound Complex, protected by both long narrow and numerous small barrier islands. Also includes marine systems seaward of barrier islands from Cape Hatteras to Cape Fear.

C.3. Sea Islands. Barrier islands much smaller and more numerous, coastline less protected, fairly highly dissected coastline with high freshwater inflow, gently sloping, wide quartz sand beaches, and very extensive marshes.

C.4. East Florida. Low-lying beaches of calcareous sand, extensive marshy areas, some areas of very extensive barrier islands, freshwater inflow only from coastal plain.

D. Southern Florida

D.1. Biscayne Bay. Extremely low-lying swampy coastline generally mangroves (*Rhizophora mangle* L.) with hard bottom, marine influence from the Atlantic Ocean, freshwater inflow extremely variable.

D.2. Florida Keys. Low limestone islands with pinicle rock coasts or very narrow shell beaches, extensive shallow areas with soft marl or shell fragment bottoms extending out to coral reefs, very extensive seagrass and algal beds.

D.3. Florida Bay. Coastline part of Everglades National Park, area of numerous islands and very estensive swamps covering the whole southern tip of Florida. Marine influence from the Gulf of Mexico, but the area is fairly protected.

D.4. Ten Thousand Islands. Coastline dominated by a multitude of small mangrove islands and tidal channels, exteremly complex, direct marine action on the coast.

E. Atlantic Insular

E.1. Puerto Rico. Consists of the large, rugged island of Puerto Rico and several smaller islands. Faces both Atlantic and Caribbean but receives much greater wave action from Atlantic. Coastline mostly steep and rocky, however some areas with coral reefs and islands sheltering lagoons, with some mangrove swamp development.

E.2. Virgin Islands. Numerous islands mostly of volcanic origin, but a few of marine sediments. Areas of steep rocky cliffs, some areas with small sandy bays and rocky headlands, some areas of wide low coastal plain and wide shallow area covered by algae and turtle grass or mangrove swamps. Beaches mainly rocky or composed of calcareous sand. Well developed coral reefs.

E.3. Navassa Island. Small island of about 2.6 sq km (1 sq mi) located between Jamaica and Haiti in Caribbean Sea. Volcanic origin.

E.4. Serrana Bank and Roncador Bank. Coral reefs ca. 352 km (220 mi) east of Nicaragua in the Caribbean Sea.

F. Gulf of Mexico

F.1. Central Barrier Coast. Sandy beaches with a few rocky areas, extensive marshy and swampy areas present, narrow shallows area, Juncus, Spartina, or mangroves characteristic depending on latitude.

F.2. Big Bend Drowned Karst. Rugged shoreline, rocky bottoms, very wide shallows area, clear water, extensive sea grass beds and marshes, high fish production, oyster bars extensive.

F.3. Apalachicola Cuspate Delta. Smooth sand beaches, mud-bottomed bays, turbid water, barrier islands present, little or no sea grass.

F.4. North Central Gulf Coast. White sand beaches, clear water, extensive dune system, and barrier island system high energy beaches compared to others of the Gulf Coast.

F.5. Mississippi Delta. Extensive marsh systems, barrier island system, sediments silty, silt terrigenous, water turbid, very extensive shallows area, extensive influence from Mississippi River.

F.6. Strandplain-Chenier Plain System. Extensive marsh system, freshwater inflow from several small river systems, but lacking direct influence from Mississippi, cheniers present.

F.7. Texas Barrier Island System. Extensive lagoon system formed by drowned rivermouths and barrier islands; freshwater inflow regular on upper coast to limited with hypersaline condition on lower coast; marshes common along upper coast, submerged grass beds common along lower coast.

G. Southwest Pacific

G.1. Southern California. Fairly smooth coastline with a few large islands, both low and high cliffed beaches which are mainly sandy with a few rocky promontories sporadic seasonal high freshwater inflow, but generally low to no freshwater inflow, extensive algal communities, kelp beds.

G.2. Central California. Uniformly high-cliffed beaches, mostly rocky but some sandy with a high frequency of pocket beaches in some areas, moderate freshwater inflow, extensive algal communities, kelp beds.

G.3. San Francisco Bay. Highly protected from marine influence, some low cliffed beaches, but mostly low-lying mudflats with a few pocket beaches and marshes, moderate freshwater influence.

H. Northwest Pacific

H.1. Pacific Northwest. High-cliffed beaches mainly with numerous pocket beaches but a few extensive sandy or rocky beaches, in the northern part are lower rocky coastal flats, moderately dissected coastline, cool water temperatures, high freshwater inflow, numerous rocky islands, small bays, and estuary systems with mudflats and eelgrass beds.

H.2. Columbia River Estuary. Separated mainly due to high freshwater inflow generated far inland, extensive inland-marsh complex.

H.3. Puget Sound. Relatively protected from direct marine influence by Olympic Peninsula, highly complex coastline with numerous islands, high freshwater inflow.

I. Pacific Insular

I.1. Hawaii. Tropical volcanic islands rising sharply from ocean, coral reefs present; includes high wet islands and low dry islands, has several species of endemic fauna and flora.

I.2. Guam and Pacific Trust Territories. Tropical islands, some having mountains but mainly with wide sandy beaches and extensive coral reefs, all lying north of the equator; includes high wet islands and low dry islands, fauna typical Indo-Pacific, characteristic storm patterns.

I.3. American Samoa and Other U. S. Claimed and Administered Islands. Tropical and subtropical islands on both sides of the equator, a few with mountains, but mainly low sandy beaches with extensive coral reefs; includes high wet islands and low dry islands, fauna typical Indo-Pacific.

J. Panama Canal Zone

J.1. Panama Canal Zone. Receives marine influence from the Gulf of Panama and from the Caribbean Sea, and freshwater influence from Gatun and Madden Lakes, tropical climate. Unique situation due to human disturbance in the form of the Panama Canal. By definition, the Level I division of "J. Panama Canal Zone" ought to have at least two and perhaps three Level II divisions because of the water masses involved--the Caribbean, the Gulf of Panama, and the Canal itself. However, for the purpose of this study, due to the small size of the area, it will be considered one Level II division.

K. Pacific Alaska

K.1. Alexander Archipelago. Extremely complex shoreline due to glacier-formed fjords. In numerous cases glacial formation of coastline presently occurring. Shoreline may receive direct wave action from Pacific Ocean or may be protected and facing one of numerous straits and passages.

K.2. Wave Beaten South Central Alaska Coast. Receives wave action from Pacific Ocean, as well as large amount of glacial action on shoreline. Much of the shoreline has exposed sand beaches which receive strong onshore currents and a lot of drift.

K.3. Prince William Sound. Fjord-type shoreline protected from Pacific Ocean by Montague and Hinchinbrook Islands. Extensive glacial action presently occurring on coastline.

K.4. Cook Inlet. Tide mixed estuary, extensive marshy lowlands, water very salty, little glacial action on shoreline. Tide very dominant with tidal bore exceeding 9 m (30 ft) in some places, currents up to 12 knots.

K.5. Kodiak Island and Protected Coast. Unit contains three types of coastline--that which is wave beaten by the Pacific, that which faces the Shelikof Strait and has fjords, and that facing the Shelikof Strait and protected from direct Pacific wave action but not greatly affected glacially.

K.6. Wave Beaten Southwest Alaska Coast. Rugged, mountainous coastline of the Alaska Peninsula, little glacial activity, gets direct wave action from Pacific. Large numbers of small islands and rocks with numerous small areas of protected coast. Large numbers of crabs, sea otters, and birds present.

L. Aleutian Islands

L.1. Aleutian Islands. Island chain receiving direct wave action from both Pacific and Bering Oceans, however, wave action much greater from Pacific.

M. Bering Alaska

M.1. South Bristol Bay. Coast may or may not be ice-locked during winter, receives wave action from Bering Sea, beaches of black volcanic sand, interspersed with dune type headlands, backing onto low-lying wet tundra, flanked by mountainous volcanic terrain.

M.2. North Bristol Bay. Coast ice-locked in winter and is subject to ice-scouring, area adjacent to coast either mountainous or low-lying wet tundra, with black volcanic mud beaches, receives direct wave action from the Bering Sea, but is more protected than South Bristol Bay.

M.3. Yukon-Kuskokwim Delta. Very extensive marsh systems extending hundreds of miles inland, receiving varying amounts of freshwater and saltwater influence, coastline ice-locked during winter, water turbid.

M.4. Norton Sound Coast. Coastline mainly mountainous, but a few low-lying areas present, icebound in winter, receives wave action from Bering Sea but somewhat protected.

M.5. Bering Sea Islands. Volcanic type islands with pocket beaches, precipitous cliff-type shoreline, backing onto grassy highlands often rising to volcanic peaks of 3,050 m (10,000 ft), but may have extensive areas of marshy lowlands and well-developed barrier islands and spits, receiving wave action on all sides from Bering Sea. Ice influenced in all cases, islands may be ice-locked up to half the year, extensive ice-scouring.

N. Arctic Alaska

N.1. Chukchi Coast. Receives wave action from Chukchi Sea, some mountainous coastline, but mostly low-lying, marshy areas, with some areas having extensive barrier islands. Some sounds and inlets protected from wave action. Ice-locked during winter, ice-free during summer, receives extensive ice-scouring.

N.2. Beaufort Coast. Receives wave action from Beaufort Sea, ice-locked during winter, usually ice-free in summer, very extensive ice-scouring. Coastline very low with extensive marshy areas. Some barrier islands.

O. Great Lakes

O.1. Lake Superior. Has the most rugged uninhabited and unaccessible shorelands of all the Great Lakes. The shore type of Lake Superior and the St. Marys River varies from the steep rock cliffs of the Pictured Rocks National Lakeshore Area to the sandy beaches of White Fish Bay, Michigan to the low-lying clay and gravel bluffs near Duluth, Minnesota and in Wisconsin to the marshlands of Munuscong Bay, Michigan. Lake Superior and the St. Marys River contain major islands and island groups.

O.2. Lake Michigan. Large expanse of sand dunes extending almost continuously from the Indiana Dunes National Lakeshore northward to the tip of the Leelanau Peninsula in Michigan. They result from the prevailing westerly winds that cause an almost continuous washing and separation of shore soil material by wave action. Wide, sandy beaches are often associated with the dune areas, especially during years of low water levels on the Great Lakes.

O.3. Lake Huron. Mainly a rock and boulder shore in the northern area with some high bank beaches extending landward into a rolling upland area. From Sand Point in outer Saginaw Bay to the most northern part of Huron County, the shore is composed of sandy beaches backed by low dunes and bluffs. This shore type also predominates in Sanilac County. From Northern Huron County east and south approximately to the Huron-Sanilac County line, exposed bedrock, and very rocky shorelands replace the sandy shore type. The shorelands of Lake St. Clair are predominantly artificial fill, erodible low plain, and a smaller wetland contingent (15%).

O.4. Lake Erie. Eastern Lake Erie has glacial till and raft-shale bluffs. The Pennsylvania portion comprises shore bluffs of 15 to 23 m (50 to 75 ft) and rise to 30 m (100 ft) in places. Bluffs are composed of clay, silt, and granular material with shale bedrock occurring at about water level. To the east of Erie Harbor, the shale bedrock is frequently 5 to 11 m (15 to 35 ft) above lake level and the upper part of the bluff is composed of silt, clay, and granular material. Sand and gravel beaches up to 46 m (150 ft) wide extend along the toe to the bluffs. The shoreline of western Lake Erie consists mainly of wetlands, low plains, artificial shore types, and low rocky bluffs. Lake Erie is subject to impressive seiches.

0.5 Lake Ontario. The U. S. shoreline consists generally of bluffs of glacial material ranging from 6 to 18 m (20 to 60 ft) high. Narrow gravel beaches border the bluffs, which are subject to erosion by wave action. The bluffs are broken in several places by low marshes. The shore in the vicinity of Rochester and Irondequoit is marshy with sand and gravel barrier beaches separating the marshes and open ponds from the lake. The shoreline from Sodus Bay east to Port Ontario is a series of drumlins and dunes separated by marsh areas. North of the Oswega-Jefferson County line for a distance of 16 km (10 mi), the shorelands are composed of dunes and barrier beaches. At this point the shore type changes abruptly to rock outcrop at the water's edge. This rock shore extends north to the St. Lawrence River interrupted only by a few pockets of beaches and marshes at the inner end of the deep bays.

RECOMMENDATIONS

A list of options was presented in Results for landward and seaward boundaries of Level I, II, and III divisions, along with the pros and cons of adopting each option. The ideal landward and seaward boundaries of divisions would be those which delimit the major coastal processes which occur in each division. This would most accurately reflect functioning of real-world ecosystems. Unfortunately, these are extremely difficult to delimit. In actual practice the landward and seaward boundaries described by the Cowardin et al. classification (1976) as described in Results, are probably as close to these ideal boundaries as can be drawn. The real advantages to adopting the boundaries used by the National Wetlands Inventory are that they are being mapped presently and that a large amount of data is being stored in this format. All other options listed are unacceptable due to the problems inherent in each as previously described under con under the subheading Boundary Options.

Concerning lateral (perpendicular to the shoreline) boundaries of Level I and II divisions, those which end at the political boundaries of the United States are obviously artificial. They were delineated in that manner due to the scope of the study. It is obvious, however, that the boundaries of coastal ecosystem should logically not resemble political boundaries. Thus Table 2 lists more rational boundaries for Level I and II divisions which abut the political boundaries of the United States and overlap into other countries.

In some instances it may be necessary or useful to lump or further subdivide Level II divisions for the purpose of producing characterizations or Profiles. For example, one might lump the North and South Bristol Bay divisions into a Bristol Bay characterization. In the case of lumping, it is advisable to lump Level II divisions which are within a Level I division, rather than those from two different Level I divisions, Level II divisions within a Level I division are by definition more similar, and thus may have predictions made about them more reliably, than Level II divisions from different Level I divisions. Thus lumping should occur only within Level I divisions.

Table 2. Proposed Actual Boundaries of Level I and II Divisions
Which Abut Political Boundaries of he United States

Level I	Level II	Boundaries
A. North Atlantic		A. Cape Cod to St.Johns, Newfoundland, including Nova Scotia and the Bay of Fundy
	1. Gulf of Maine	1. Cape Elizabeth to Lancaster, New Brunswick, and the east coast of Nova Scotia, but not including the Bay of Fundy
F. Gulf of Mexico		F. Cape Romano to the Cape off Matamoras, Mexico
	7. Texas Barrier Island System	7. Galveston Bay to the Cape off Matamoras, Mexico
G. Southwest Pacific		F. Cape Mendocinao to Cabo San Lucas
	1. Southern California	1. Point Conception to the coast of El Rosario
H. Northwest Pacific		H. Cape Mendocino to and including Vancouver Island
	3. Pudget Sound	3. Puget Sound and the Straits of Juan de Fuca and Georgia (already included in definition)
K. Pacific Alaska		K. From, but not including Vancouver Island, to Unimak Island at Unimak Pass including Cook Inlet
	1. Alexander Archipelago	1. Queen Charlotte Island and the Alexander Archipelago to Cape Spencer
N. Arctic Alaska		N. Cape Prince of Wales to Cape Bathurst
	2. Beaufort Coast	2. Barrow to Demarcation Point

Criteria are outlined in the Methods section for separating Level III divisions, thus subdividing Level II divisions. In practice either the Elemental Units described by Dolan et al. (1972) or individual drainage areas along the coast should be suitable for Level III divisions, if the need arises for them.

SUMMARY

The objective of this project is to formulate a hierarchical regional classification scheme for coastal ecosystems of the United States and its territories based on the physical, hydrological, chemical, biological, geological, and/or structural characteristics of those areas. The question it is designed to address is the following: "How can the coastline of the United States be partitioned so as to best separate ecosystems, if the purpose of defining these ecosystems is to make predictions about how specific types of perturbations in specific geographical areas will affect them hydrologically, structurally, functionally, and, most important, biologically?" The primary intended users of this classification are the National Coastal Ecosystems Team and Ecological Services, both of the United States Fish and Wildlife Service, for locating their Characterization Studies and Profiles, respectively.

Existing coastal classification schemes were examined to determine if any were suitable for fulfilling the above stated objective. Coastal classifications were found to fall into essentially three types--structural, functional, and regional. Structural and functional classifications do not address geographical problems and are thus not appropriate. Of the three above named types, only regional classifications address the question being asked.

There are two types of regionalizations--one type based on biogeography, and one based on physical (chemical, geological, etc.) parameters. Biogeographical regionalizations are based on the actual distribution of one or a few groups of organisms and do not address distribution of coastal ecosystems per se; regionalizations based on physical parameters do. The only regionalization found which is based on physical parameters (Dolan et al., 1972) was rejected because of the size of its Elemental Units. Thus it was appropriate to develop a classification scheme to answer the question stated.

The criteria used for separation of Level I, II, and III divisions are as follows:

Level I	The forcing functions of the system
Level II	The major constraints of the system
Level III	The homogeneity of response to the system

A list of the lateral (i.e. perpendicular to the shore) boundaries of Level I and II divisions, determined by the above criteria, and descriptions of these division are given. Level III division separations are not made. A list of options for landward and seaward boundaries of Level I, II, and III divisions is given with the pros and cons of using each of the options.

Recommendations are made concerning lateral boundaries for Level III divisions, and for selecting among the landward and seaward boundary options. Also a comment is made concerning the artificiality of using political boundaries as lateral boundaries of coastal ecosystems.

It has been recommended that Elemental Units as defined by Dolan et al. (1972) or individual drainage areas along the coast would probably be the most appropriate Level III divisions.

The most appropriate landward boundary for Level I, II, and III divisions is either the landward boundaries for marine and estuarine, as defined by the NWI classification scheme (Cowardin et al, 1976) or the landward limit of the major coastal processes which occur in each division. These two lines may be the same.

Seaward boundaries should be set as either the edge of the continental shelf (as indicated by Cowardin et al., 1976) or at the seaward boundary of the major coastal processes which are occurring in each division. In both cases, landward and seaward boundaries, the line delimited by the NWI classification system (Cowardin et al., 1976) is the more practical option.

Because of the chief use of the regionalization, in some cases the political boundaries of the United States are regarded as boundaries of coastal ecosystems. This is obviously highly artificial. A list is given of what is believed to be more realistic lateral boundaries of coastal ecosystems which happen to cross political boundaries of the United States.

LITERATURE CITED

Adams, J. B., L. C. Gerhard, J. C. Ogden, J. Bowman. 1975. Potential National Natural Landmarks, U. S. Virgin Islands. West Indies Lab., Fairleigh Dickinson Univ., for the Natl. Park Serv. 82 pp.

Bailey, R. G. 1976. Ecosystems and Ecoregions of the United States. Map, Scale 1:7,500,000, U. S. Forest Serv.

Briggs, J. C. 1974. Marine Zoogeography. McGraw-Hill, N. Y. 475 pp.

Brooks, H. K. 1973. Geological Oceanography: Historical Background and Regional Relationships. In: A Summary of Knowledge of the Eastern Gulf of Mexico: 1973. J. J. Jones, R. Ring, M. Rinkel, and R. Smith, eds., State Univ. System Florida, Inst. Oceanography, St. Petersburg, Florida. pp. IIE-1 to IIE-49.

Bureau of Land Management. 1975a. Visual Graphics, Offshore Southern California, Outer Continental Shelf Lease Sale 35.

Bureau of Land Management. 1975b. Visual Graphics, Northern Gulf of Alaska, Outer Continental Shelf Lease Sale 39.

Bureau of Land Management. 1975c. Visual Graphics, Gulf of Mexico and Atlantic Ocean, Outer Continental Shelf Lease Sale 41.

Bureau of Land Management. 1975d. Visual Graphics, Eastern Gulf of Mexico, Outer Continental Shelf Lease Sale 41.

Bureau of Land Management. 1976a. Visual Graphics, Offshore the Mid-Atlantic States, Outer Continental Shelf Lease Sale 40.

Bureau of Land Management. 1976b. Visual Graphics, Cape Hatteras Planning Unit, Outer Continental Shelf Lease Sale 43.

Bureau of Land Management. 1976c. Visual Graphics, Western and Central Gulf of Mexico, Outer Continental Shelf Lease Sale 47.

Bureau of Land Management. 1976d. Visual Graphics, Lower Cook Inlet, Outer Continental Shelf Lease Sale.

Bureau of Land Management. 1976e. Visual Graphics, Western Gulf of Alaska, Outer Continental Shelf Lease Sale 46.

Bureau of Land Management. 1977a. Visual Graphics, Offshore the North Atlantic States, Outer Continental Shelf Lease Sale 42.

Bureau of Land Management. 1977b. Visual Graphics, Blake Plateau Planning Unit, Outer Continental Shelf Lease Sale 43.

Corliss, J. F. 1974. Ecoclass: a Method for Classifying Ecosystems. In: Foresters in Land-use Planning. Proc. Natl. Conv. Soc. Am. Foresters, Portland, Oregon. 1973.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1976. Interim Classification of Wetlands and Aquatic Habitats of the United States. U. S. Fish Wild. Serv. Office Biol. Serv. Washington, D.C. 109 pp.

Cronin, L. E. 1974. Scientific Workshop Summary. In: Marine and Estuarine Sanctuaries, M. P. Lynch, B. L. Laird, and T. F. Smolen, eds. Proc. Natl. Workshop on Sanctuaries. Nov. 1973. Washington, D.C. Spec. Sci. Rep. 70, Virginia Inst. Marine Sci., pp. 165-185.

Dolan, R., B. Hayden, G. Hornberger, J. Zieman, and M. Vincent. 1972. Classification of the coastal environments of the world. Part 1. The Americas. U. S. Office Naval Res., Geogr. Programs Tech. Rep. 1. Natl. Tech. Inf. Serv. Dept. Commerce, Springfield, Va. 163 pp.

Durrenberger, R. W. 1973. Dictionary of the environmental sciences. Natl. Press Books, Palo Alto, California. 282 pp.

Earle, S. A. 1969. Phaeophyta of the Eastern Gulf of Mexico. Phycologia 7 (2):71-254.

Ekman, Sven. 1953. Zoogeography of the Sea. Sidgwick and Jackson, Ltd., London, 417 pp.

Ford-Robertson, F. C., ed. 1971. Terminology of forest science, technology, practice and products. Soc. Am. Foresters, Washington, D.C. 349 pp.

General Land Office of Texas. 1976. Texas Coastal Management Program Hearing Draft. 114 pp.

Glenne, B., and A. M. Asce. 1967. Classification system for estuaries. Am. Soc. Civ. Eng. J. Waterw. Harbors Div. 93:55-59.

Gove, P. B., 1963. Webster's Third New International Dictionary of the English Language. Unabridged. Ed. in chief. G. and C. Merriam Co., Springfield, Massachusetts. 2662 pp.

Great Lakes Basin Commission. 1975. Appendix 12: Shore use and erosion. In: Great Lakes Basin Framework Study, Public Inf. Office Great Lakes Basin Comm., Ann Arbor, Michigan. 111 pp.

Hansen, D. V., and M. Rattray, Jr. 1966. New Dimensions in Estuary Classification. Limnol. and Oceanog. XI(3):319-326.

Hanson, H. C. 1962. Dictionary of ecology. Philos. Libr. New York. 382 pp.

Hedgpeth, J. W. 1957. Classification of marine environments. Geol. Soc. Am. Mem. 67(1):17-28.

Humm, H. J. 1969. Distribution of Marine Algae Along the Atlantic Coast of North America. Phycologia 7(1):43-53.

Joint Federal-State Land Use Planning Commission for Alaska. 1973. Major Ecosystems of Alaska. Map, Scale 1:2,500,000.

Ketchum, B. H., ed. 1972. The Water's Edge: Critical Problems of the Coastal Zone. MIT Press, Cambridge, Mass., and London, England. 303 pp.

Lynch, M. P., B. L. Laird, N. B. Theberge, and J. C. Jones, eds. 1976. As Assessment of Estuarine and Nearshore Marine Environments. SRAMSOE 93, U. S. Fish and Wildl. Serv., Office Biological Serv., Washington, D.C. 132 pp.

McIntire, W. G., M. J. Hershman, R. D. Adams, K. D. Midboe, B. B. Barrett. 1975. A Rationale for Determining Louisiana's Coastal Zone. Cent. for Wetland Resour., Louisiana State Univ., Baton Rouge, Sea Grant Publ. LSU-Y-75-006. 91 pp.

Odum, E. P. 1971. Fundamentals of ecology. 3rd ed. W. B. Saunders Co., Philadelphia and London. 574 pp.

Odum, H. T., B. J. Copeland, and E. A. McMahan, eds. 1974. Coastal Ecological systems of the United States. Conserv. Found. Washington, D.C. 4 vols.

Ray, G. C. 1975. A Preliminary Classification of Coastal and Marine Environments. IUCN Occas. Paper 14, Morges, Switzerland. 26 pp.

Reid, J. E. 1972. The resource capability system. In: Proceedings, symposium on watersheds in transition, Fort Collins, Colorado, 1972. Am. Water Resour. Assoc. and Colorado State Univ., Urbana, Illinois. p. 145-152.

Robbins, J. M. and M. J. Hershman. 1974. Boundaries of the Coastal Zone: A Survey of State Laws. Coastal Zone Management J. 1 (3):305-331.

Schwartz, C. F., E. C. Thor, and G. H. Elsner. 1976. Wildland Planning Glossary, U. S. Dept. Agric., Forest Serv., Pacific Southwest Forest and Range Exp. Stn., General Tech. Rep. PSW-13/1976. 252 pp.

Selkregg, L. L., ed. 1974a. Alaska Regional Profiles: Southcentral Region, Vol. I, Univ. Alaska, Arctic Environ. Inf. and Data Cent., for the State of Alaska in cooperation with the Joint Federal-State Land Use Planning Comm. for Alaska. 255 pp.

_____. 1974b. Alaska Regional Profiles: Arctic Region, Vol. II, Univ. Alaska, Arctic Environ. Inf. and Data Cent., for the State of Alaska in cooperation with the Joint Federal-State Land Use Planning Comm. for Alaska. 218 pp.

_____. 1974c. Alaska Regional Profiles: Southwest Region, Vol. III, Univ. Alaska, Arctic Environ. Inf. and Data Cent. for the State of Alaska in cooperation with the Joint Federal-State Land Use Planning Comm. for Alaska. 313 pp.

_____. 1974d. Alaska Regional Profiles: Southeast Region, Vol IV, Univ. Alaska, Arctic Environ. Inf. and Data Cent. for the State of Alaska in cooperation with the Joint Federal-State Land Use Planning Comm. for Alaska. 233 pp.

_____. 1974e. Alaska Regional Profiles: Northwest Region, Vol. V, Univ. Alaska, Arctic Environ. Inf. and Data Cent. for the State of Alaska in cooperation with the Joint Federal-State Land Use Planning Comm. for Alaska. 265 pp.

_____. 1974f. Alaska Regional Profiles: Yukon Region, Vol. VI, Univ. Alaska, Arctic Environ. Inf. and Data Cent. for the State of Alaska in cooperation with the Joint Federal-State Land Use Planning Comm. for Alaska. 346 pp.

Shepard, Francis P. 1937. Revised classification of marine shorelines. J. Geol. 45(6):602-624.

Smith, G. B. 1976. Ecology and Distribution of Eastern Gulf of Mexico Reef Fishes. Florida Marine Res. Publ. 19.

U. S. Fish and Wildlife Service. 1970. National Estuary Study. U.S. Department of the Interior, Bur. Sport Fisheries and Wildl. and Bur. Commercial Fisheries, U. S. Govt. Printing Office, 7 Vols.

U. S. Geological Survey. 1954. Alaska, Map E. Map, scale 1:2,500,000.

_____. 1970. The National Atlas of the United States of America, 417 pp.

U. S. Senate. 1970. The National Estuarine Pollution Study. Rep. of the Sec. of Interior to the U. S. Congr. Pursuant to Public Law 89-753, The Clean Water Restoration Act of 1966. U. S. Senate Doc. 91-58. U. S. Gov. Printing Office, Washington, D.C. 633 pp.

Wastler, T. A. and L. C. deGuerrero. 1968. National Estuarine Inventory-Handbook of Descriptors. U.S. Department of Interior, Fed. Water Pollution Control Adm.

Weaver, J. D., B. Beck, G. Drewry, N. Schneidermann, and R. Woodbury. 1976. Inventory of Potential National Natural Landmarks in Puerto Rico. Geol. Soc. Puerto Rico for Natl. Park Serv.

GLOSSARY

Biogeographic regionalization--a regional classification based secondarily on the distribution of some group or groups of organisms. Ekman's (1953) zoogeographical regional classification of marine areas is an example.

Coastal Biotic Province--delineations of coastal associations based on biotic components, water mass characteristics, and coastal geomorphology, with emphasis on the biotic components (Ray, 1975).

Division--used in the same sense as the word taxon is used in taxonomy, i.e. any one of the categories such as Level I, Level II, etc., into which coastal ecosystems are classified.

Ecological characterization studies--studies being performed by the National Coastal Ecosystem Team of the U. S. Fish and Wildlife Service which provide a description of the important resources and processes comprising a coastal ecosystem. They also provide an understanding of the functional and dynamic relationships in coastal ecosystems through integration of existing environmental and socioeconomic resource data into an ecological unit. These studies follow a holological approach (J. Johnston, NCET, pers. comm.).

Ecological land unit (ELU)--"1. U. S. Forest Service usage. One of the lowest levels of the Ecoclass system of classifying ecosystems into subdivisions for forest description and management. An ELU is a composite of elements from the land subsystem and vegetation subsystem which together define a homogeneous unit (After Corliss 1974).

2. U. S. Forest Service Resource Capability System (RCS) usage. Units of land having strong uniformity in slope steepness, aspect, microclimate, rock types and conditions, geomorphology, soil characteristics and productive capabilities, type, density and age of vegetation and ground cover, and drainage characteristics.

The basic physical unit of land that scientific disciplines agree must be delineated and examined as a separate entity (for use-evaluation or management purposes).

The basic unit that is used in the analysis of on site potentials, capabilities, and limitations. The most significant level of land stratification which best communicates the basic (inherent) capabilities and limitations (Reid 1972).

Land (or water) units which because of their strong uniformity in physical and biological characteristics respond similarly to management activities or other stimuli. Sometimes called response units." (Schwartz et al., 1976:64-65).

Ecological water unit (EWU)--"U. S. Forest Service usage. One of the lowest levels of the Ecoclass system of classifying ecosystems into subdivisions for forest description and management. An EWU is a composite of elements from the land and aquatic subsystems, where aquatic type and adjacent land types together define a homogeneous unit. (After Corliss 1974)" (Schwartz et al, 1976:65).

Ecosystem--"1. The system formed by the interaction of a group of organisms and their environment. (Durrenberger 1973)

2. A complete, interacting system of organisms considered together with their environment, e.g., a marsh, a watershed, a lake, etc. (After Hanson 1962)

3. An ecological community considered together with the nonliving factors of its environment as a unit. (Gove 1963)

4. Any spatial unit that includes all of the organisms (i.e., the biotic community) in a given area interacting with the physical environment so that a flow of energy leads to clearly defined food and feeding relationships, biologic diversity and biogeochemical cycles (i.e., exchange of materials between living and nonliving parts) operating as an integrated system.

Ecosystem is the preferred term in English while biocoenosis or biogeocoenosis is preferred by writers using or familiar with the Germanic and Slavic languages. (After Odum 1971)

Some (Ford-Robertson 1971, Hanson 1962) make a distinction between the two terms by using bio(geo)coenosis to refer to actual biological units (such as a certain bog) and ecosystem when referring to conceptual units. Others (Odum 1971) make no such distinction. We prefer Odum's lumping of the terms, while recognizing that in some technical, ecological literature the distinction is significant. (C.F.S.)

5. Any complex of living organisms taken together with all the other biotic and abiotic factors which affect them, that are mentally isolated for purposes of study. (After Ford-Robertson 1971, citing Tansley)" (Schwartz et al., 1976:67).

Functional classification--a classification of systems based on some aspect of the functioning of the system. An example would be the system of Odum et al. (1974) which classifies coastal ecosystem by energy inputs.

Physical regionalization--a regionalization based secondarily on some physical feature or features of the environment. The classification by Dolan et al. (1972) of coastal areas by climate, water mass, and geology is an example of a physical regionalization.

Phytogeographic regionalization--a regional classification based secondarily on the distribution of some group of plants. Humm (1969) presents a regionalization based on the distribution of marine algae along the Atlantic coast of North America.

Profiles--studies being performed by Ecological Services of the U. S. Fish and Wildlife Service which review and synthesize the existing information into a compendium of information on a coastal area. In some cases the information is restructured into a format which will facilitate the making of use decisions about land and water. (L. Goldman, ES, pers. comm.).

Regional classification--a classification of systems based primarily on geography. Areas which are contiguous may be in the same region, but those some distance apart, though they may be quite similar structurally or functionally, cannot be classified together regionally. Secondary attributes used in the classification may be biotic or physical. Briggs' (1974) book on marine zoogeography features a regional classification based secondarily on zoogeographic features.

Structural classification--a classification of systems based on some structural feature such as geology or surface cover. Ray's (1975) classification "by habitats" of coastal environments is an example of a structural classification. It includes such classes as exposed environments with highly calcareous, rocky substrate (1.(a)(i)).

Zoogeographic regionalization--a regional classification based secondarily on the distribution of some group or groups of animals. See the discussion of Briggs' (1974) under Regional Classification in this glossary.

APPENDIX

The following persons* gave input on the first draft of the regionalization presented in this paper:

Name	Affiliation	Commented on
R. Andrews	FWS, RAL-CE, Reg. 5	Atlantic, Great Lakes, Alaska
L. Barclay	FWS, ARAL-OSC, Reg. 4	Atlantic Coast
J. Barkuloo	FWS, ARAL-CE, Panama City	Florida, Gulf Coast
B. Brun	FWS, ARAL-CE, Reg. 5	Atlantic Coast
J. Byrne	FWS, ARAL-CE, Portland	Pacific insular, Pacific northwest, California
J. Carrol	FWS, Vero Beach FO	Florida
V. Carter	USGS	Classification in general, Atlantic coast
R. Chabreck	LSU, Baton Rouge	Regionalization in general, Gulf coast
H. Coulombe	FWS, HAG	Panama Canal Zone
D. Dobel	FWS, Galveston FO	Texas coast
R. Folker	FWS, Laguna Niguel FO	California coast
L. Goldman	FWS, ES, WO	Regionalization in general
R. Hays	FWS, HAG	Classification in general
H. Hyatt	FWS, RAL-CE, Reg. 3	Great Lakes, Alaska, Pacific coast
J. Johnston	FWS, NCET	Regionalization in general, Gulf coast
J. Kirkwood	FWS, RAL-CE, Reg. 4	Classification in general
G. Kline	FWS, Olympia FO	Pacific coast
C. Laffin	FWS, ARAL-OCS, Reg. 5	Atlantic coast, Florida, Atlantic insular

*Each person was asked to request input to his review of the regionalization from all parties in his office who might care to comment.

APPENDIX (CONT.)

Name	Affiliation	Commented on
E. LaRoe	State of Oregon/NOAA	Regionalization in general, Florida, Texas, Alaska
C. Lensink	FWS, RAL-CE, Anchorage AO	Alaska coast
P. Lent	FWS, Anchorage AO	Alaska coast
F. Smith	FWS, Sacramento FO	California coast
R. Swanson	FWS, Mayaguez FO	Atlantic insular
T. Talley	FWS, Panama City FO	Florida coast
R. Wade	FWS, RAL-CE, Reg. 2	Gulf coast
J. Watson	FWS, RAL-CE, Reg. 1	Pacific coast
W. Wilen	FWS, NWI	Regionalization and classification in general

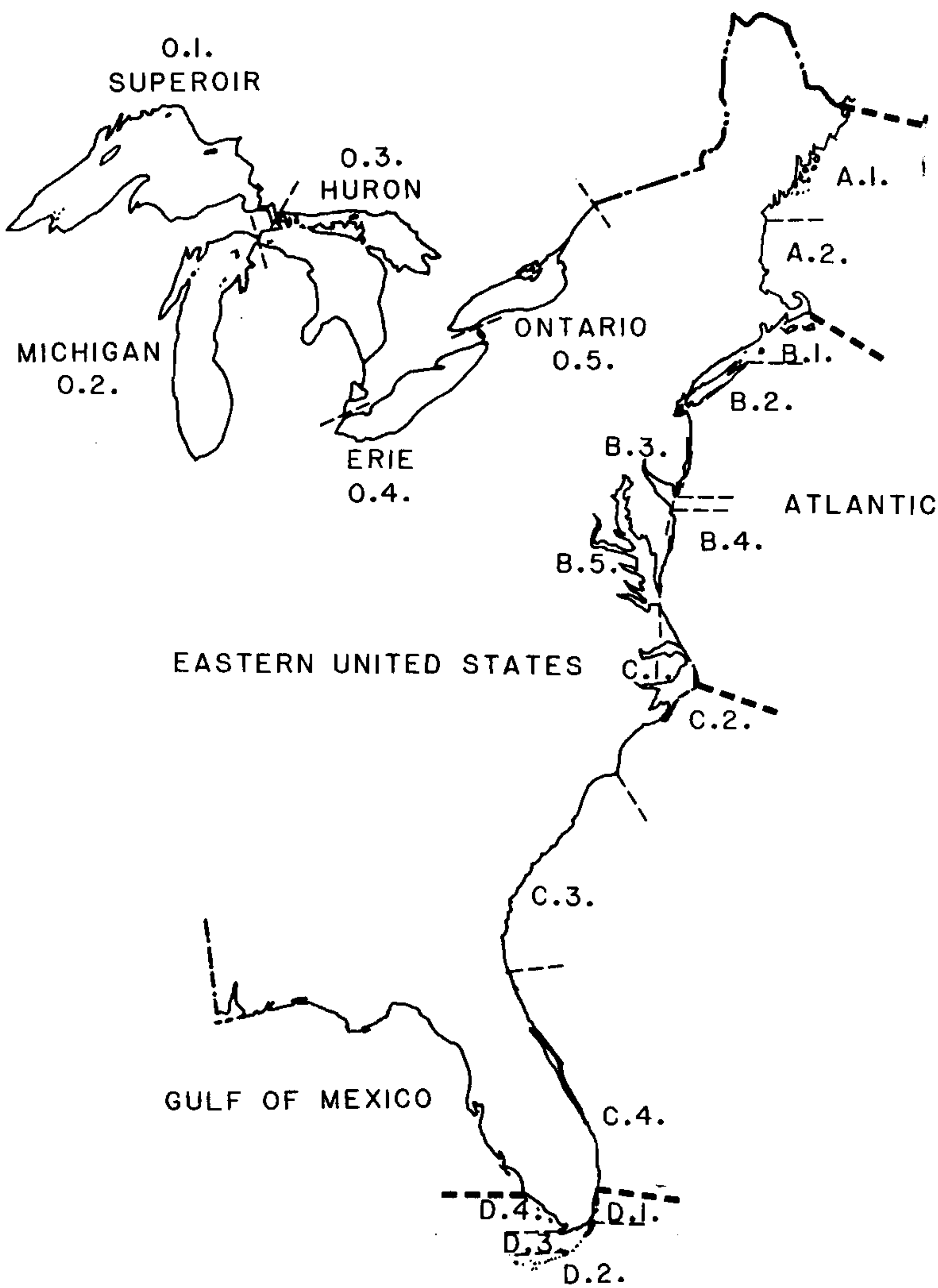
FIGURE CAPTIONS

Fig. 1 Great Lakes and the Atlantic coast of the United States showing Coastal Regionalization Level I and Level II divisions, designated by letters and numbers respectively corresponding to the letters and numbers of Table 1.

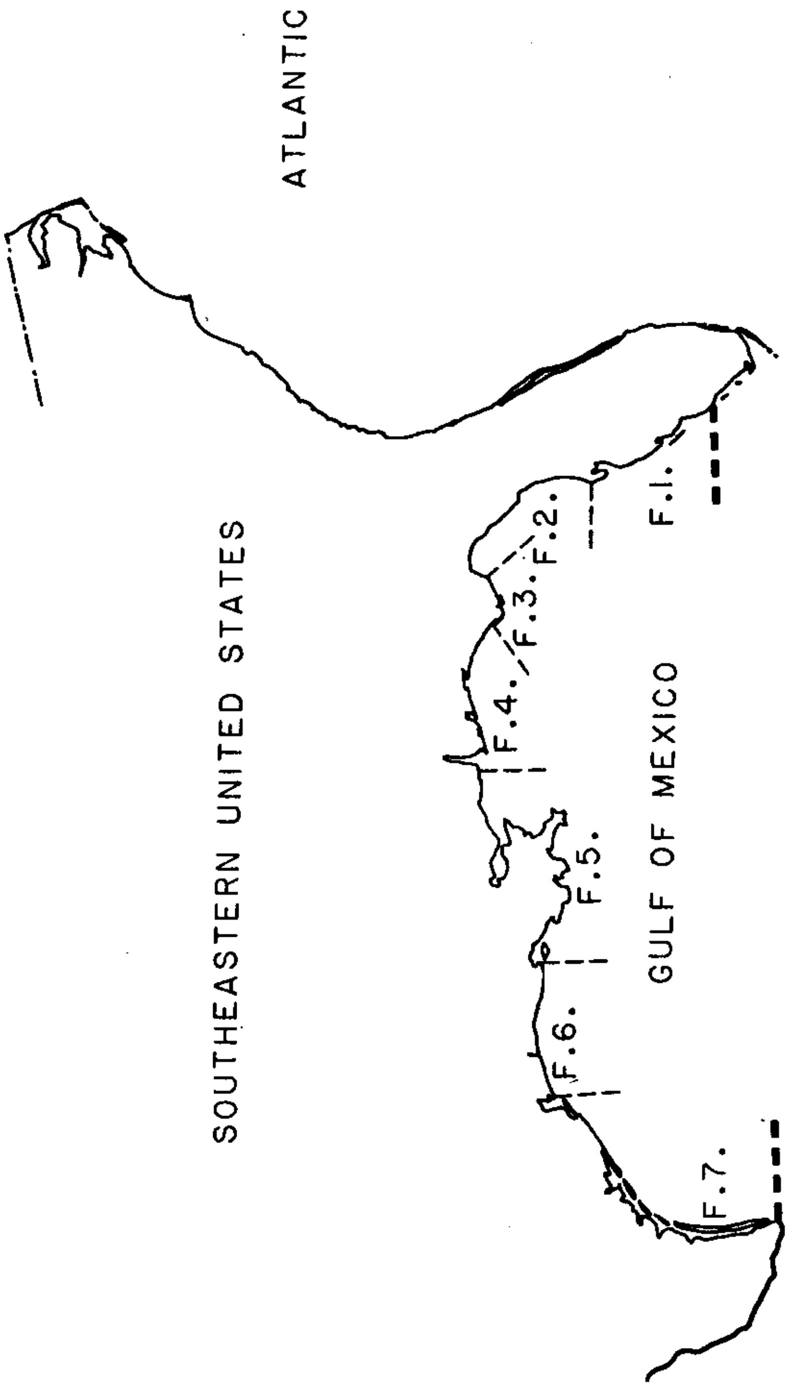
Fig. 2 Gulf coast of the United States showing Coastal Regionalization Level I and Level II divisions, designated by letters and numbers respectively corresponding to the letters and numbers of Table 1.

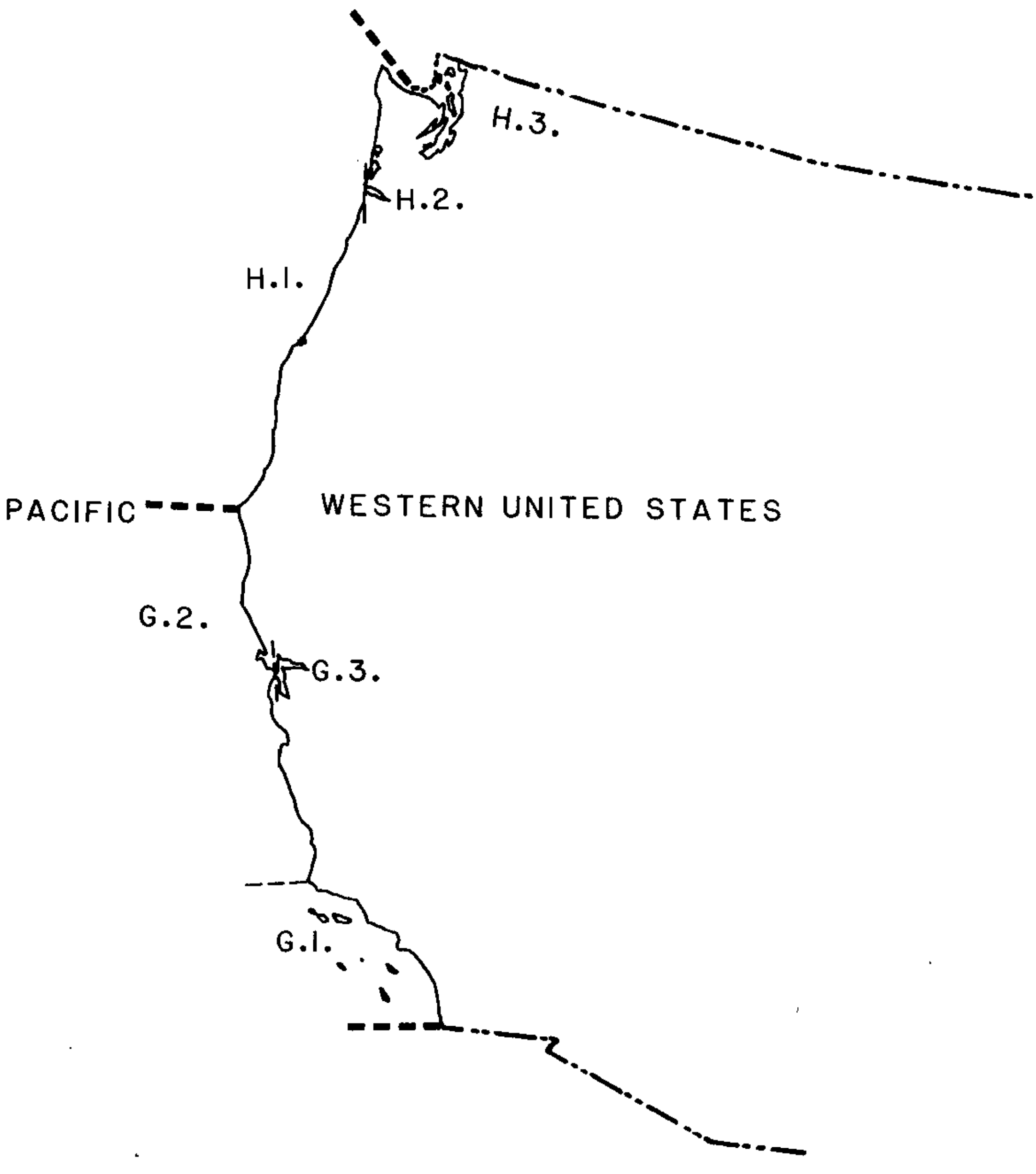
Fig. 3 Pacific coast of the United States showing Coastal Regionalization Level I and Level II divisions, designated by letters and numbers respectively corresponding to the letters and numbers of Table 1.

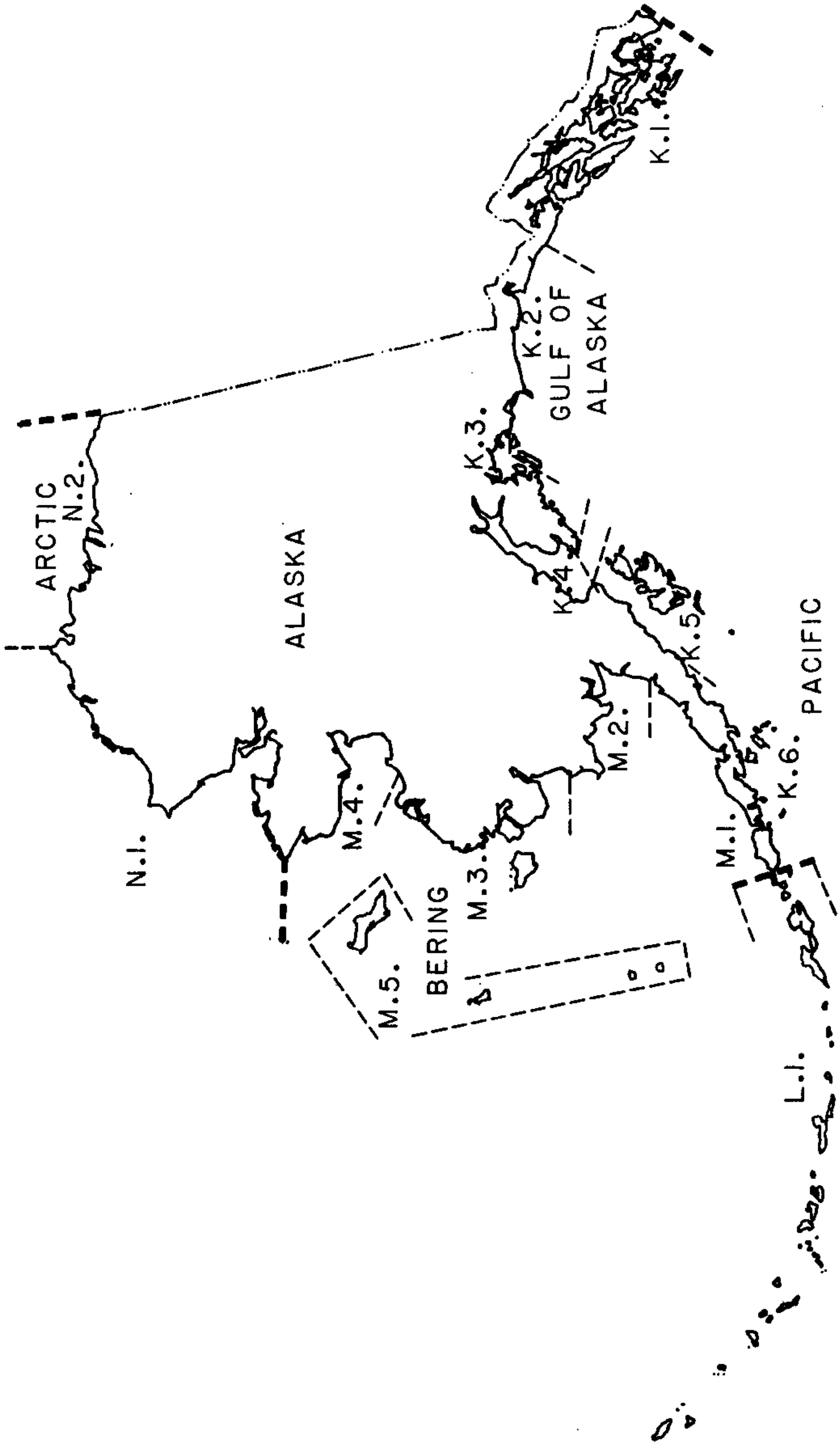
Fig. 4 Coast of Alaska showing Coastal Regionalization Level I and Level II divisions, designated by letters and numbers respectively corresponding to the letters and numbers of Table 1.



O.I.
SUPEROIR
O.3.
HURON
A.I.
A.2.
MICHIGAN
O.2.
ONTARIO
O.5.
B.I.
B.2.
ERIE
O.4.
B.3.
ATLANTIC
B.4.
B.5.
EASTERN UNITED STATES
C.I.
C.2.
C.3.
GULF OF MEXICO
C.4.
D.4.
D.I.
D.3.
D.2.


ATLANTIC
SOUTHEASTERN UNITED STATES
GULF OF MEXICO
F.1.
F.2.
F.3.
F.4.
F.5.
F.6.
F.7.


H.3.
H.2.
H.I.
PACIFIC
WESTERN UNITED STATES
G.2.
G.3.
G.I.


ARCTIC
N.2.
ALASKA
N.1.
M.4.
M.3.
BERING
M.5.
M.2.
M.1.
K.1.
K.2.
GULF OF
ALASKA
K.3.
K.4.
K.5.
K.6.
PACIFIC
L.1.

BIBLIOGRAPHIC DATA SHEET

1. Report No. FWS/OBS-77/48

2.

3. Recipient's Accession No.

4. Title and Subtitle

INTERIM HIERARCHICAL REGIONAL CLASSIFICATION SCHEME FOR COASTAL ECOSYSTEMS OF THE UNITED STATES AND ITS TERRITORIES

5. Report Date September 1977

6.

7. Author(s)

Terry T. Terrell

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

National Habitat Assessment Group
Western Energy and Land Use Team
Room 206, Federal Building
Fort Collins, Colorado 80521

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address

National Coastal Ecosystems Team
Office of Biological Services
U.S. Fish and Wildlife Service
National Space Technology Laboratories, NSTL Station, MS 39529

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

The literature on coastal classifications is reviewed. Those existing classifications classify coastal areas on functional, structural, or regional (geographical) attributes. The problem of predicting impacts on coastal ecosystems by various types of perturbations, such as offshore mineral development or reduced freshwater inflow into estuaries, at various levels of resolution is posed. A classification system which will permit and aid in data collection to address this problem is necessary for solving this problem. Existing systems are found wanting, and a hierarchical regional classification scheme for coastal ecosystems of the United States and its territories, based on the physical, hydrological, chemical, biological, geological, and structural characteristics of those areas is presented.

17. Key Words and Document Analysis. 17a. Descriptors

Classification
Regionalization
Coastal
Ecosystems
Coastline

17b. Identifiers/Open-Ended Terms

U.S. and territories
Coastline
Coastal ecosystems

17c. COSATI Field/Group

18. Availability Statement

Release unlimited

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 38

22. Price

U. S. Department of the Interior

Fish and Wildlife Service

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.