Report on the Delineation of Regional Ecosystems

Produced by the

NOAA Regional Ecosystem Delineation Workgroup

as a result of the

Regional Ecosystem Delineation Workshop

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Preamble:

Our Nation's coastal areas are among the most developed in the country. More than half the population lives on less than one-fifth of the land in the contiguous United States. Coastal counties, including those along the Great Lakes, are growing three times faster than counties elsewhere, adding more than 3,600 people a day to their populations. Coastal and marine waters support over 28 million jobs and provide a tourism destination for 180 million Americans a year. The value of the ocean economy to the U.S. is over $115 billion. The amount added annually to the national economy by the commercial and recreational fishing industry alone is over $48 billion. With its Exclusive Economic Zone of 3.4 million square miles, the U.S. manages the largest marine territory of any nation in the world.

Because of the importance and complexity of these coastal and marine ecosystems, the NOAA Strategic Plan challenges NOAA to begin to fully implement ecosystem approaches to managing coastal and marine ecosystems. Further, NOAA has accepted the definition for an ***ecosystem*** as a ***geographically specified*** system of organisms, the environment, and the processes that control its dynamics. Humans are an integral part of an ecosystem. As such, NOAA must identify and delineate the geographic boundaries of the regional ecosystems as a first step to fully develop an ecosystem approach to managing these resources.

To meet this challenge, NOAA formed a Technical Workgroup to develop background information and recommendations for this purpose. Also, because NOAA has many federal, state and private partners in managing these resources, it makes sense to engage these partners in a process to delineate these regional ecosystems. Therefore, this Technical Report on the Delineation of Regional Ecosystems was developed specifically as background information for a Regional Ecosystem Delineation Workshop held on August 31 – September 1, 2004, in Charleston, SC, with participation from NOAA's major partner organizations. This Report was finalized only after the benefit of the exchange of information, discussion and results of the Workshop. A large portion of this report was brought into the workshop and compiled from various sources and contributors.

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I. Purpose for Delineating Coastal and Ocean Ecosystems

NOAA's responsibilities are summarized by four mission goals described in NOAA's 2004 Strategic Plan, of which one is the Ecosystem's Goal to "protect, restore and manage the use of coastal and ocean resources through ecosystem-based management." To apply ecosystem approaches to resource management, NOAA must understand the dynamics of ecosystems in which human use of the resources occurs, the types and amounts of human activities using or affecting resources, and the effects that human activities have on the resources being used and on other components of the ecosystem. To be successful in an ecosystem approach to resource conservation and management, it is clear that *NOAA must identify, in conjunction with our partners, the ecosystems for which NOAA and its partners have responsibilities*. Such identification organizes NOAA's management responsibilities, as well as serving as a framework for compiling the information necessary for informed management decisions.

The ecosystems for which NOAA has responsibility are widespread and range from the territorial seas of other countries to the Great Lakes watersheds to the inland distribution of diadromous fish on all coasts. Under domestic legislation implementing international agreements, NOAA is responsible for the management of fishing operations by U.S. vessels wherever these vessels fish, often including the territorial seas of other nations. Similarly, under international agreement, NOAA is responsible for international cooperation and coordination in the conservation of great whales through the International Whaling Commission and associated agreements and statutes. On the high seas, NOAA is responsible for U.S. activities related to fishing and any activities that may affect marine mammals or marine species (e.g., marine turtles) that are protected under the Endangered Species Act (ESA). NOAA has explicit statutory authority and responsibility related to citizens and vessels of any nation within the U.S. EEZ and waters under state jurisdiction. Moving inland, NOAA has direct management responsibility under the ESA to ensure that federally conducted, funded, or permitted activities do not have significant adverse impacts on threatened or endangered species or the habitats upon which they depend. NOAA also has direct authority under the Magnuson Stevens Fishery Conservation and Management Act, the Federal Power Act, and the Fish and Wildlife Coordination Act to consult with federal agencies to avoid, minimize, or mitigate adverse impacts on managed and anadromous fish species and their habitat. NOAA's National Marine Sanctuary in the Great Lakes also extends NOAA conservation and management responsibilities well inland in the north-central United States. NOAA also has indirect authority through the Coastal Zone Management Act to set policy and provide technical assistance and oversight of state actions under this Federal Act.

The resources provided by coastal lands and waters (e.g., recreation, food, and energy) have been exploited for decades. Because the use of these resources is in large demand, ensuring the sustainability of these resources is a significant challenge to NOAA and its federal, state and private partners. Management of the use of these resources has typically occurred on a fragmented or case-by-case basis. In addition, geography (e.g., watersheds and their boundaries), which plays an important role in the distribution of resources, frequently has been overlooked as a management element.

NOAA intends to develop a framework, in collaboration with our partners, for joint regional observation systems, research and eventually management strategies to ensure enhanced regional ecosystem sustainability and productivity in each of the delineated regional ecosystems.

The following definitions and principles have been incorporated by NOAA:

• An ***ecosystem*** is a geographically specified system of organisms, the environment, and the processes that control its dynamics. Humans are an integral part of an ecosystem.

• The ***environment*** is the biological, chemical, physical, and social conditions that surround organisms.

Regional coastal and ocean planning: A systematic decision-making framework designed to improve the management and sustainability of coastal and ocean ecosystems. The aim is to give more certainty and long-term security to ocean resource users by reducing current and potential conflicts between users and ensuring the ecological sustainability of those uses.

An ecosystem-based approach to management: Management that is adaptive, geographically specified, takes account of ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse societal objectives. The transition to an ecosystem approach to management needs to be incremental and collaborative.

Principles of an ecosystem-based approach to management:

- Based on scientific knowledge about the importance of marine ecosystems, and about impacts and societal benefits of alternative uses.
- Retains the capability of ecosystems to function within "acceptable" ranges of variability and the capacity to produce "desired" goods and services.
- Aimed at maximizing net societal benefits.
- Strives to balance diverse societal objectives and values.
- Driven by a public that understands issues concerning marine ecosystems, and participates in the processes that shape policies and stewardship decisions.

Delineation of Regional Ecosystems

NOAA intends to use the best scientific information available and the following principles:

- Define the ***scale of an ecosystem*** based on the spatial extent of the ecosystem characteristics and/or dynamic processes that are to be studied or influenced through management.
- Specify ***ecosystem boundaries*** based on discontinuities in the geographic distribution of ecosystem characteristics and based on management jurisdictions.
- Recognize that this will lead to ***ecosystems specified on a hierarchy of scales*** with boundaries that sometimes ***overlap***.

The delineation of the totality of the marine environment into regional "ecosystems" for use in science and management applications represents an abstraction of nature. In reality, oceanographic processes exist on continuums, and thus animals dependent on those processes also exist along spatial continua. Nevertheless, ecosystem delineation at the regional scale is necessary in order to manage stocks and populations, as well as to monitor various attributes of ecosystem function, including other human activities that influence the environment. For the purposes of living marine resource management, the size of regional ecosystems is determined by the geographic range of species of interest, and the importance and scale of interactions among species. At one extreme, there are highly migratory species such as tunas, billfishes and whales where biologically meaningful ecosystem scales are hundreds of square kilometers in size and at the opposite extreme, localized populations of sedentary animals without pelagic larvae may exist at several kilometer scales or less.

It is impractical to define ecosystems differently for each of the thousands of species in the marine environment, based on their differing geographic home ranges. In fact, even the species level of organization may be too crude for some management applications because several more-or-less independent management stocks of the same species may exist in contiguous proximity (e.g., there are 12 recognized management stocks of Atlantic cod in the western north Atlantic alone). Therefore, delineating regional ecosystems into a finite number of zones represents a compromise among the species of interest, human institutions and political geography, and oceanographic processes that affect living resources. The chief goal of any delineation scheme is to develop a geographic frame of reference that is useful for describing biological populations, their interactions, and the effects of human activities that influence ecosystem outcomes. Because of the factors noted above, there will always be conflicts at the margins of any delineation scheme, both in terms of species that occupy ranges straddling two or more defined ecosystems, and institutional or political interests that likewise straddle ecosystem boundaries. A good delineation scheme will use spatial discontinuities in as many species or stocks as possible, as well as discontinuities in oceanographic regimes, resulting in as few incompatibilities as possible. For those species that range between delineated ecosystems, special management procedures that coordinate protection across ecosystems are required. For this reason, using regional ecosystem delineations to inform the management of human activities will be a hierarchical process that is primarily determined by spatial discontinuities, but is flexible, coordinated, and adaptive to circumstances determined by the biology of animals and the flexibility of human activities.

II. Inventory of Delineated Ecosystems or Biogeographic Regions

NOAA has been involved in, or is aware of several ecosystem delineation schemes and/or regional biogeographic regions. Several delineation schemes currently utilized in the U.S. by governmental and non-governmental organizations were discussed at the NOAA Ecosystem Delineation Workshop. These delineation schemes were primarily selected by the Ecosystem Delineation Working Group and this list was augmented by the Workshop participants' contributions.

A. Large Marine Ecosystems

Description of Large Marine Ecosystems

Large Marine Ecosystems (LMEs) are natural regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves, enclosed and semi-enclosed seas, and the outer margins of major current systems. Large Marine Ecosystems are delineated using biological and physical criteria, and do not incorporate political, social or economic factors in the delineation process. There are 64 relatively large regions on the order of 200,000 km2 or greater, characterized by distinct bathymetry, hydrography, productivity, and trophically dependant populations (Figure 1).

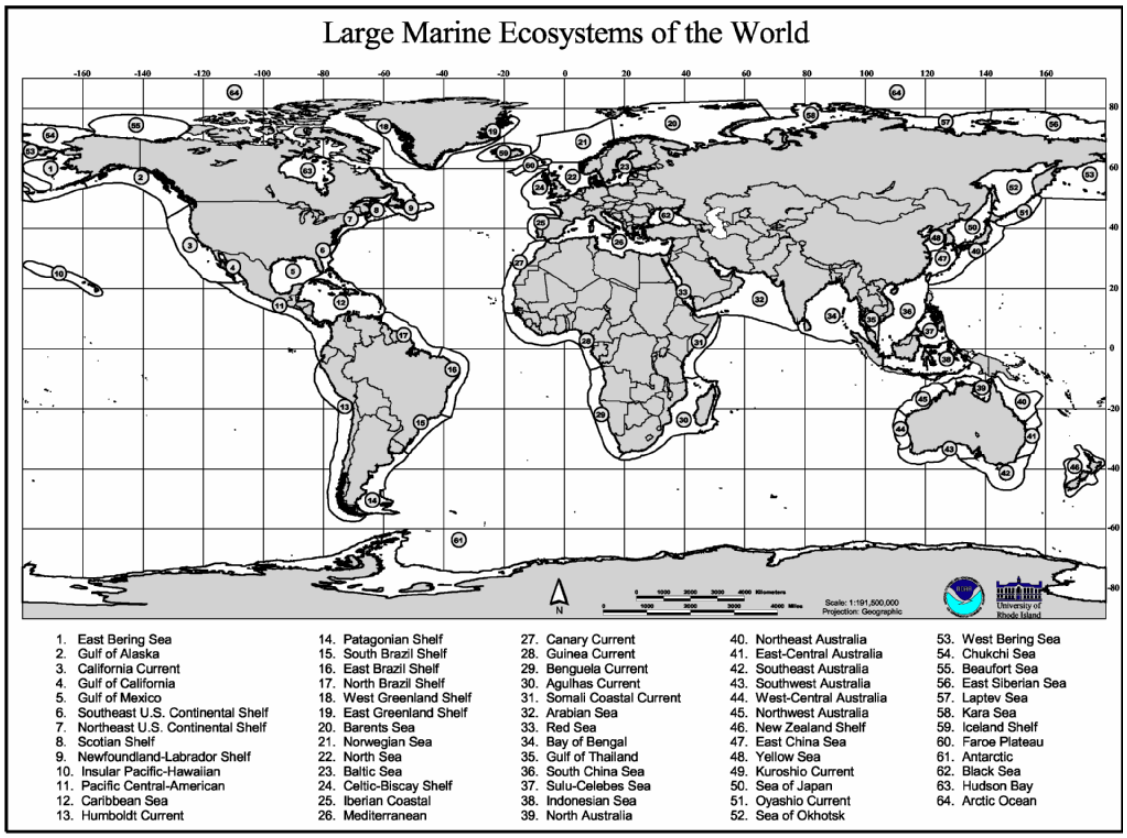

Figure 1. Large Marine Ecosystems of the world.

Source: http://www.lme.noaa.gov/

Large Marine Ecosystems are geographic areas designated for implementation of ecosystem based assessment and management practices. The theory, measurement, and modeling relevant to monitoring the changing states of LMEs are embedded in reports on ecosystems with multiple steady states, and on the pattern formation and spatial diffusion within ecosystems (Holling 1973, 1986, 1993; Pimm 1984; AAAS 1986, 1989, 1990, 1991, 1993; Beddington 1986; Mangel 1991; Levin 1993). From an ecological perspective, the concept that critical processes controlling the structure and function of biological communities can best be addressed on a regional basis (Ricklefs 1987) has been applied to ocean space in the utilization of large marine

ecosystems as distinct global units for marine resources assessment, monitoring, and management. The concept of assessment and management of renewable resources from an LME perspective has been the topic of a series of national and international studies, symposia and workshops initiated in 1984 and continuing to the present, wherein the geographic extent of each LME is defined on the basis of ecological criteria. Information on 300 published studies, in 12 published volumes including 40 LME case studies can be found at http://www.lme.noaa.gov/.

Criteria Used to Establish LMEs and their Boundaries

There are four distinct criteria used to determine, delineate, and establish Large Marine Ecosystems:

- Bathymetry
- Hydrography
- Productivity
- Trophic Interactions

These ecological criteria represent key components of ecosystem structure, function, and dynamics. One of the most significant criteria used for LME delineations is the level of primary productivity.

LMEs were categorized based on SeaWiFS global primary productivity estimates. Primary production levels are persistently higher around the margins of the ocean basins than for the open-ocean pelagic areas of the globe (Figure 2).

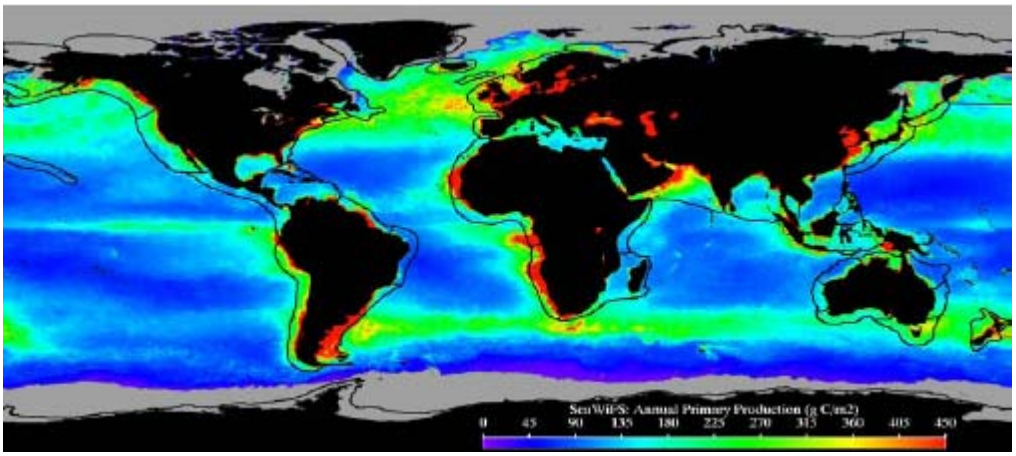

Figure 2. Global map of average primary productivity and boundaries of the 64 LMEs of the world.[1]

Source: http://www.lme.noaa.gov/

[1] The annual productivity estimates are based on SeaWIFS satellite data collected between September 1998 and August 1999, and the model developed by M. Behrenfeld and P.G. Falkowski (Limnol.Oceangr. 42(1):1997, 1-20). The color-enhanced image provided by Rutgers University) depicts a shaded gradient of primary productivity from a high of 450 g Cm2yr-1 in red to less than 45 g Cm2yr-1 in purple.

The prototype for the designation of a Large Marine Ecosystem is off the New England and Mid-Atlantic states. It is an area characterized as a distinct geographic region based on bathymetry, hydrography, productivity, and trophic linkages. The Scotian Shelf to the north and the Southeast U.S. Continental Shelf to the south have distinctly different bathymetry, hydrography, productivity, and trophic linkages (Sherman, Grosslein, Mountain *et al*. 1988; Mills and Fournier 1979; Yoder 1991, Link *et al.* 2003). The data for the Northeast Shelf LME prototype was obtained from several sources or studies that are available for the 64 LMEs. The distinct bathymetry of each of the 64 LMEs are available in Geographic Information System (GIS) format. Hydrography of the LMEs has been described in 13 volumes of peer reviewed published case studies which show time series changes on seasonal and decadal scales. Summaries of the productivity (means, standard deviations and coefficient of variability) for each of the LMEs and Ecopath/Ecosim trophodynamic models are in preparation with funding provided by the Global Environmental Facility. Nitrate flux models funded by the GEF are also in preparation for all 64 LMEs. An LME database is available for ichthyoplankton, zooplankton, and commercially valuable fish species, as well as hydrography for the ecosystem from the NOAA Northeast Fisheries Science Center. Fish catch data that include 12 taxonomic groupings for all LMEs have been analyzed and graphically illustrated by the Fisheries Center at the University of British Columbia for a 50-year period 1950-2000 (http://www.seaaroundus.org). In addition, Food and Agriculture Organization of the United Nations (FAO) is providing an update of these fish species groupings for the period 1990-2002 (Garibaldi and Limongelli, 2003). NOAA Fisheries in collaboration with the EPA has reported on fisheries assessments for the Gulf of Mexico, Southeast U.S. Continental Shelf, and the Northeast U.S. Continental Shelf LMEs (National Coastal Condition Report, 2004). The National Ocean Service Office of Oceanography and Marine Assessment in collaboration with the NMFS conducted a six-month study in the late 1980's in the application of the four ecological criteria used in the designation of LMEs adjacent to the United States. Following extensive visits with scientists and managers, and analysis of available data, the NOS produced a "National Atlas" for purposes of fisheries resource assessments that delineated seven LMEs bordering the coastal United States (USDOC, NOAA 1988). Assessments of all 64 LMEs in relation to their productivity, fish and fisheries, pollution and ecosystem health, socioeconomics, and governance can be found on the LME website (http://www.lme.noaa.gov/). LME descriptions have been reviewed by hundreds of experts from countries around the margins of the Pacific basin, the Indian Ocean, and the Atlantic Ocean at a series of LME conferences, symposia, and workshops held in collaboration with AAAS**,** the Intergovernmental Oceanographic Commission of UNESCO (IOC), FAO, the World Conservation Union (IUCN), and the World Bank.

Methods Used to Validate the LMEs

Each LME designation undergoes a rigorous review. An LME subcommittee meets to discuss and formulate each new designation, or to modify existing boundaries based on new case studies, peer reviews, scientific cruise data or other critical information. This information is reviewed and either approved or rejected at annual meetings of the LME Consultative Committee which are conducted in cooperation with the IOC and IUCN.

LMEs of the United States

The LMEs provide linkages between the coastal ocean, its coastal margins and associated freshwater basins. Ten LMEs are in U.S. jurisdictional waters: Beaufort Sea, Chukchi Sea, East Bering Sea, Gulf of Alaska, California Current, Gulf of Mexico, Caribbean Sea, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, and Insular Pacific Hawaiian (Figure 3). More detailed information on Large Marine Ecosystems can be found at http://www.lme.noaa.gov/.

Figure 3. Large Marine Ecosystems of the United States.

Source: http://www.edc.uri.edu/lme/maps.htm

The Caribbean Sea LME includes U.S. jurisdictions (Puerto Rico, U.S. Virgin Islands). The Great Lakes are considered a freshwater ecosystem given their spatial extent and distinct characteristics.

Northeast U. S. Continental Shelf LME – The Northeast U.S. Continental Shelf Large Marine Ecosystem is characterized by its temperate climate. It extends from the Gulf of Maine to Cape Hatteras along the Atlantic Ocean. Efforts to examine changing ecosystem states and the relative health of this LME are underway in four major sub-areas: the Gulf of Maine, Georges Bank, Southern New England and the estuarine-dominated waters of the Mid-Atlantic Bight. This LME is structurally very complex, with marked temperature and climate changes, winds, river runoff, estuarine exchanges, tides and complex circulation regimes. It is historically a very productive LME of the Northern Hemisphere.

This LME is bounded on the east or seaward side by the Gulf Stream. Its complex circulation with meanders and rings greatly influences the LME. The gyre systems of the Gulf of Maine and Georges Bank, and the nutrient enrichment of estuaries in the southern half of the LME contribute to the maintenance on the shelf of relatively high levels of phytoplankton and zooplankton prey fields for planktivores including fish larvae, menhaden, herring, mackerel, sand lance, butterfish, and marine birds and mammals. The Northeast U.S. Continental Shelf is

considered a Category I (>300 gC/m2-yr), highly productive, ecosystem according to SeaWiFS global primary productivity estimates.

Southeast U. S. Continental Shelf LME - This LME is characterized by its temperate climate. It borders the Atlantic Ocean, extending from the Straits of Florida to Cape Hatteras, North Carolina. It contains many bays and sounds, and extensive coastal marshes that provide unique habitats for living marine resources. Upwelling along the Gulf Stream front and intrusions from the Gulf Stream cause short-lived plankton blooms. The offshore upwelling regime is not as intense as in the higher latitude regions (see Yoder, 1991 and NOAA, 2002). The Southeast U.S. Continental Shelf LME is considered a Class II (150-300 gC/m2-yr), moderately productive ecosystem based on SeaWiFS global primary productivity estimates. The seaward boundary of the Southeast U.S. Shelf Large Marine Ecosystem is located along the area of confluence between the 200 m isobath and the landward margin of the thermal front of the Gulf Stream as it meanders along the coast between Cape Hatteras and the Florida Straits.

Caribbean Sea LME - The Caribbean Sea Large Marine Ecosystem is a semi-enclosed sea located in the Western Hemisphere between North and South America, and bounded by Central America to the west. It encompasses an area of 2,515,900 square kilometers and is the second largest sea in the world. It is noted for its many islands, including the Leeward and Windward Islands situated on its eastern boundary, Cuba, Hispaniola, Puerto Rico, Jamaica and the Cayman Islands. There are numerous banks and breaking shoals. The LME is comprised of four deep basins: the Venezuelan Basin in the east, the Colombian Basin in the west (from which it is separated by a ridge), the Cayman Trough in the northwest, and the Yucatan Basin in the north. There is little seasonal variation in surface water temperatures.

The Caribbean Sea LME is considered a Class III (<150 gC/m2-yr), low productivity ecosystem, according to SeaWiFS global primary productivity estimates, although upwelling along the northern coast of Venezuela contributes to relatively high productivity in that area. Other factors contributing to the greater productivity of South America's northern coast are the nutrient input from rivers and estuaries. The remaining area of the LME is mostly comprised of clear, nutrient-poor waters. Key components of the shallow water ecosystem are the coral reefs of the Caribbean Sea. There is some background information available on this area thanks to a multidisciplinary study called the Cooperative Investigations in the Caribbean Sea and Adjacent Areas (CICAR), which was completed during the 1970's (see Richards and Bohnsack, 1990). There is still a need for better understanding of the role of physical and biological offshore processes.

Gulf of Mexico LME - This LME is characterized by its tropical climate. The Gulf of Mexico is partially isolated from the Atlantic Ocean. The continental shelf is topographically diverse, and includes slopes, escarpments, knolls, basins and submarine canyons. Ocean waters enter from the Yucatan channel and exit from the straits of Florida, creating the loop current which is associated with the upwelling and the high level of nutrients flow of this LME (for more information on what controls primary production in this LME, see Lohrenz *et al*., 1999). There is an additional major fresh water source, from rivers in the U.S.A. and from Mexico. Productivity ranges from eutrophic conditions in coastal waters to oligotrophic in the deeper ocean. Overall, The Gulf of Mexico Large Marine Ecosystem is considered a Class II (150-300 gC/m2-yr), moderately

productive, ecosystem based on SeaWiFS global primary productivity estimates. The productivity of the LME is complex. The region of the Mississippi River outflow has the highest measured rates of primary production in the Gulf of Mexico LME (see Sklar and Turner, 1981 and Lohrenz *et al.*, 1990). Hurricanes may increase phytoplankton biomass and primary production because they increase the vertical advection of nutrients into surface waters (see Iverson, 1977).

California Current LME – This LME is characterized by its temperate climate. It is a transition ecosystem between subtropical and subarctic water masses with an upwelling coastal phenomenon. The California Current Large Marine Ecosystem is separated from the Gulf of Alaska LME by the Subarctic Current, which flows eastward from the western Rim of the Pacific Ocean. The California Current system is very complex and is further described in major currents of the North Pacific Ocean. The coastal upwelling phenomenon, El Niño, and the El Niño-Southern Oscillation (ENSO) result in strong interannual oscillations of the productivity of the ecosystem. ENSO events are characterized locally by an increase in; sea temperature, a rise in coastal sea level, diminished upwelling and increased coastal rainfall (see Bakun, 1993). The California Current Large Marine Ecosystem is considered a Class II (150-300 gC/m2-yr), moderately high productivity ecosystem based on SeaWiFS global primary productivity estimates. California Cooperative Oceanic Fisheries Investigations (CalCOFI) is a program that has sampled zooplankton biomass almost continuously from 1956 to1980. There is a need for a better understanding of the climate's role and seasonal change in the regulation of populations and communities, and of the feedback loops that determine community structure, regulate energy flow and population dynamics.

Gulf of Alaska LME - The Gulf of Alaska Large Marine Ecosystem lies off the southern coast of Alaska and the western coast of Canada. It is separated from the East Bering Sea LME by the Alaska Peninsula. Its climate is sub-Arctic. The cold Subarctic Current, as it bifurcates towards the south, serves as the boundary between the Gulf of Alaska and the California Current LME. The Gulf of Alaska Large Marine Ecosystem is sensitive to climate variations on time scales ranging from the interannual to the interdecadal. The climate of the North Pacific is known to change sharply over periods of decades, centuries and millennia, in concert with climatic processes in other parts of the world, such as in the North Atlantic. This has an effect on plankton production and plankton species composition. The Gulf of Alaska LME is a Class I (>300 gC/m2-yr), highly productive ecosystem based on SeaWiFS global primary productivity estimates. It presents a significant upwelling phenomenon linked to the presence of the counterclockwise gyre of the Alaska Current (see NOAA, 2002). The LME's cold, nutrient-rich waters support a diverse ecosystem. Large-scale atmospheric and oceanographic conditions affect the productivity of this LME.

East Bering Sea LME - This LME is characterized by its Sub-Arctic climate. The East Bering Sea Large Marine Ecosystem is bounded by the Bering Strait on the north, by the Alaskan Peninsula and Aleutian island chain on the south, and by the Alaskan coast on the east. The LME is characterized by a wide shelf and by a seasonal ice cover that reaches its maximum extent of 80% coverage in March. Temperature, currents and seasonal oscillations influence the productivity of this LME. The Eastern Bering Sea LME is considered a Class II (150-300 gC/m2-yr), moderately high productivity ecosystem, based on SeaWiFS global primary

productivity estimates. This LME is experiencing a regime shift. There is still much to understand about the levels of natural variability in many of the species abundance, mainly because of the limited time series of unbiased observations.

Chukchi Sea LME - The Chukchi Sea Large Marine Ecosystem is characterized by its Sub-Arctic climate. It is a high-latitude marine region situated off of Russia's East Siberian coast and the Northwestern coast of Alaska (U.S.A). Pacific waters enter this Arctic LME via the Bering Strait. The LME is characterized by its extreme environment, and by major seasonal and annual changes in ocean climate. The region is driven by climatic conditions and by the annual formation and deformation of sea ice. Sea ice dynamics help explain the productivity of the region. This LME is relatively shallow with an extensive continental shelf. The coastline has many islands, shallow bays, gulfs and inlets. The ice-cover varies considerably during the year and inter-annually. The annual formation and melting of sea ice impact the productivity of the region. Climatic conditions and temperature influence the distribution, growth and recruitment of the major fish species and other living marine resources. The Chukchi Sea LME is considered a Class II (150-300 g C/m 2-yr), moderately high productivity ecosystem based on SeaWiFS global primary productivity estimates.

Beaufort Sea LME - The Beaufort Sea Large Marine Ecosystem is characterized by its Sub-Arctic climate. It is a high-latitude marine region situated off the coast of northern Alaska, in the United States, and of Canada. The LME is characterized by its extreme environment, and is driven by major seasonal and annual changes in Arctic climate conditions. It is covered with ice for most of the year. The Beaufort Gyral Stream forms a clockwise drift pattern. Other relevant ecological criteria are bathymetry and trophodynamics. An LME book chapter pertaining to this LME is Carleton, Ray and Hayden, 1993, which describes marine biogeographic provinces of the Bering, Chukchi and Beaufort Seas. During the winter there is limited light penetration because of ice cover. In the summer when the ice melts, productivity estimates are significantly higher. The coastal region supports a wide diversity of organisms, some of which are unique to this coast. The Beaufort Sea LME is considered a Class III (<150 gC/m2-yr), low productivity ecosystem based on SeaWiFS annual global primary productivity estimates.

Insular Pacific – Hawaiian LME – The Insular Pacific-Hawaiian Large Marine Ecosystem is characterized by its tropical climate. This LME includes the main Hawaiian Islands of Hawaii, Maui, Lanai, Molokai, Oahu, Kauai, and Niihau, as well as the outer northwest islands and their near-shore boundaries. The region is influenced by equatorial currents (see NOAA, 2002) and predominant northeasterly trade winds. The Hawaiian Islands were formed by successive periods of volcanic activity, and are surrounded by coral reefs. Ocean surface temperatures range from 21 to 29 degrees C. The LME waters have a high diversity of marine species; however, they have relatively low sustainable yields due to limited ocean nutrients (see NOAA, 1999). The Insular Pacific-Hawaiian LME is a Class III (<150 gC/m2-yr), low productivity, ecosystem according to SeaWiFS global productivity estimates. The LME has a high percentage of endemic species: about 18%-25% of the LME's shore fishes, mollusks, polychaete worms, seastars, and algae exist only in the Insular Pacific-Hawaiian LME. It is an important habitat for the North Pacific humpback whale. The LME's important algal habitats and coral reef ecosystems are used by a variety of organisms for food, shelter, and nursery grounds.

Purpose and Uses

LMEs serve as place-based, ecologically defined areas for which stakeholder support for integrating essential national reforms and programs can be mobilized into a cost effective, collective response to an array of commissions and conventions. Ecosystem-based management approaches, which focus on LMEs, are used to foster community driven commitments to policy, legal, and institutional reforms for changing the way human activities are conducted within coastal ecosystems. The LME approach involves determining root causes of transboundary issues centered on integrated coastal zone management (ICZM), overfishing, eutrophication and nutrient fluxes, habitat destruction, and global climate change. A Strategic Action Program is used to develop a community based action plan to address these priorities, based on the application of the five-module LME assessment and monitoring strategy. The five modules are indicators of changing conditions in ecosystem productivity, fish and fisheries, pollution and ecosystem health, socioeconomics and governance. The modular approach is used to assess and recover depleted fish stocks and protected resources. The approach supports coastal zone management activities to improve degraded habitats and reduce coastal pollution. The LME approach engages stakeholders, the scientific community, and stewardship agencies with actions that lead to the development of adaptive management practices for recovering and sustaining marine resources and environments.

International Use of LMEs

Since 1984 NOAA has been developing and implementing the Large Marine Ecosystem approach to assess and manage marine resources and environments. In recognition of NOAA's expertise in the LME approach, the GEF/World Bank and UN partner agencies including UNEP, UNDP, and UNIDO requested assistance in the development and implementation of the LME approach in response to interests from developing countries to introduce the ecosystems-based management model to direct integrated coastal zone management activities, control coastal pollution, restore degraded habitats (mangroves, corals, sea grasses), and recover and sustain depleted fish and fisheries resources. Since 1994 NOAA has increased the provision of scientific and technical assistance to the country driven GEF funded project planning and implementation activities. The core activities are based on NOAA's five module LME assessment and management approach.

Presently there are 17 LME projects being supported across the globe by GEF, donor and national funding at a level of $650 million. A total of 121 developing countries in Africa, Asia, Latin America, and Eastern Europe are involved in assessment and management projects now being implemented or in preparation. In the North Atlantic, studies have been completed on the principal driving forces controlling productivity and biomass yields of 10 LMEs. Included in the participants in this effort are senior scientists from Canada, Denmark, Iceland, Norway, United Kingdom, Spain, and Portugal, Germany, and Baltic countries. Norwegian scientists have undertaken a long-term study of the principal causes of change in biomass yields for the Nordic Sea LMEs (East and West Greenland Shelf, Iceland Shelf and Norwegian Sea). Australian scientists have focused on LMEs around their continental margins as management units for their marine resources (see http://www.oceans.gov.au/regional_marine_plan_overview.jsp for more information). Recently the Executive Director of the European Environmental Agency has expressed interest in the LME approach to environmental assessments of each of the 11

European marine ecosystems. The global extent of LME activities includes all of coastal Africa, western South America, Baltic Sea, Yellow Sea, South China Sea, and the Bay of Bengal. A growing network of marine experts from China, India, Thailand, Mexico, Chile, Peru, South Africa, Angola, Ghana, and Senegal, along with counterparts in Norway, Sweden, UK, Iceland, Germany, and the U.S. are supporting this global activity. Descriptions of the GEF-LME project activities can be found at www.gefweb.org.

Additionally the World Conservation Union (IUCN) and the Intergovernmental Oceanographic Commission (IOC) have formed a partnership with NOAA on ecosystem-based management activities, particularly associated with global marine conservation of coral reefs and other marine protected areas. The Chairman of the IUCN Marine Program and Executive Director of IOC/UNESCO sit on the GEF-LME steering committee and, and each year cosponsor the LME Consultative Committee Meetings held at the IOC/UNESCO in Paris, France.

The LME approach is at the leading edge of ecosystem based assessment and management practices. The UN Atlas of the Ocean now includes the LME approach to ecosystem based management and has provided special coverage of large marine ecosystems on their website. (http://www.oceansatlas.org/index.jsp)

LME Regional Complexes and Sub-areas

For management purposes, it may be necessary to combine several LMEs into a "regional complex". For example, the four LME's in Alaska may best be managed by a single mechanism, although the ecosystem health indicators of each LME would be monitored and managed separately. Additionally, regional ecosystem complex management could be effective for the Pacific Island region, when additional LMEs are identified.

Conversely, a single LME could and should be subdivided into scientifically characterized domains or subsystems. For example, the U.S. Northeast Continental Shelf has four subsystems—the Gulf of Maine, Georges Bank, Southern New England, and the Mid-Atlantic Bight (Sherman et al. 1988). For LMEs with narrow shelf areas and well-defined currents, the LMEs are bounded by the outer margins of the major coastal currents. Most of the world's 64 LMEs have not been subdivided through the LME characterization and classification; however, such subdivision would be necessary for stakeholders to work together effectively.

LME Attributes and Drawbacks

Through discussion at the Workshop, several pros and cons of LMEs were highlighted. These issues included the LME of the Insular Pacific, the LMEs surrounding Alaska, and the LME and EEZ disjunctions. A more detailed summary of the Workshop discussion on the Insular Pacific LME is provided below.

In the central and western Pacific Ocean, (Figure 4) the U.S. has jurisdictional responsibilities for several islands and island chains ranging over thousands of miles. The Insular Pacific-Hawaiian LME does not encompass all of the U.S. Pacific island protectorates, but covers only the Hawaiian Islands. Therefore, other potential insular LMEs are under investigation in relation to their distinctive bathymetry, hydrography, productivity, and trophic relationships. These include: Insular Pacific – Johnston LME, Insular Pacific – Wake LME, Insular Pacific – Samoa

LME, and the Insular Pacific – Marianas LME. This set of LMEs could be grouped in a "regional complex" of Pacific Island LMEs, should the regional stakeholders choose to manage these ecosystems as a group.

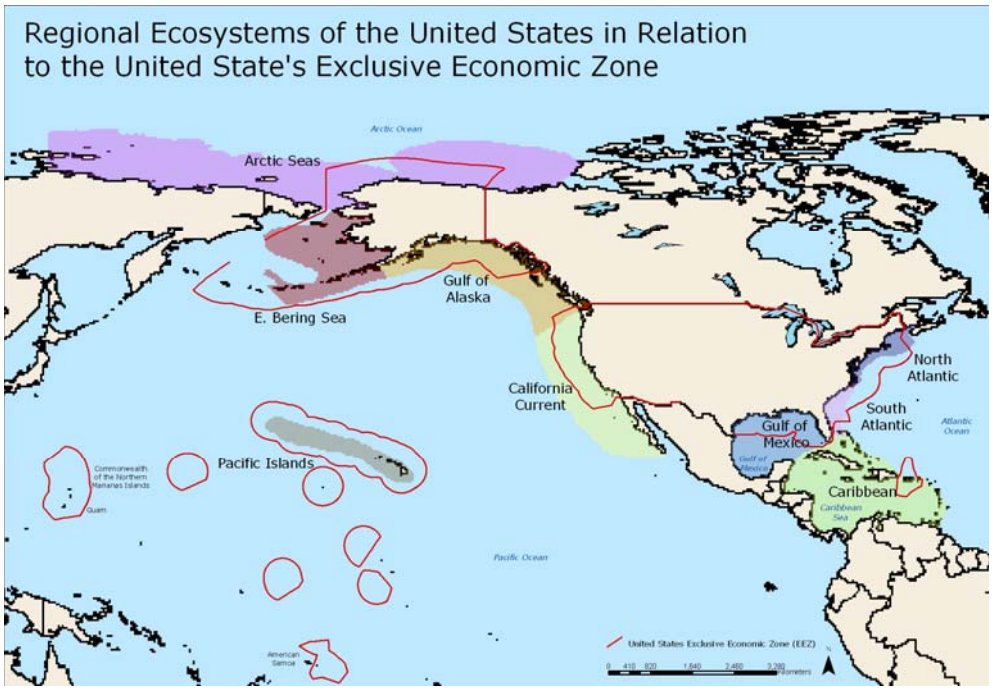

Figure 4. U.S. Exclusive Economic Zone overlay on LME boundaries

B. National Estuarine Research Reserve (NERR) Biogeographic Regions (Nested Zonation Delineations)

Description of the Zones Delineated

The National Estuarine Research Reserves (NERR) system is a network of 26 areas representing different biogeographic regions of the United States delineated by experts. The Coastal Zone Management Act of 1972, as amended, established the NERR system and each reserve is a partnership between NOAA and the host state.

The NERR system defines biogeographic region as a geographic area with similar dominant plants, animals, and climate, which is a commonly used definition for this term. The NERR system recognizes 11 biogeographic regions along the coast of the U.S. and its island territories: Great Lakes, Acadian, Virginian, Carolinian, West Indian, Louisianan, Californian, Columbian, Fjord, Subarctic, and Insular (Figure 5). Up to four sub-regions are recognized within each region, yielding a total of 29 sub-regions (Table 1). The 26 NERR sites are distributed across 18 of the 29 sub-regions.

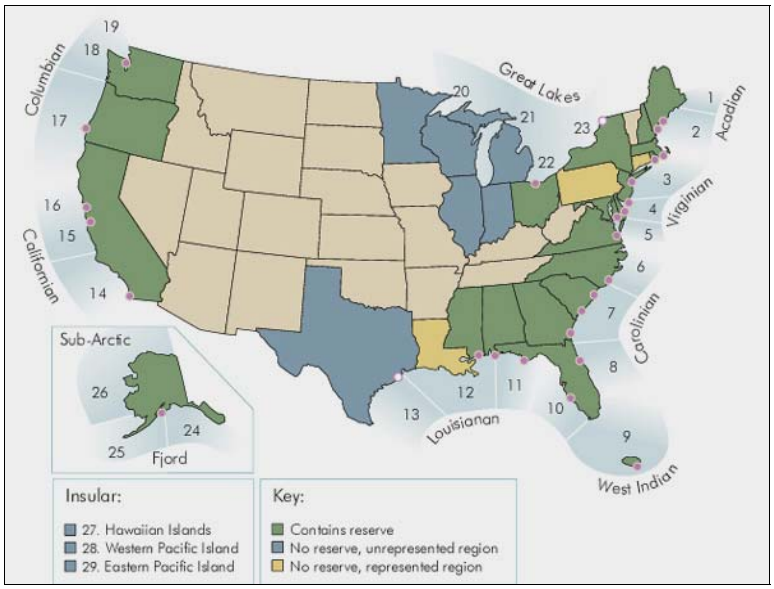

Figure 5. NERRS 11 biogeographic regions and 29 sub-regions.

Source: NERRS.NOAA.gov/Bioregions/Coverage.html

Table 1. Biogeographic Regions and Sub-Regions Used by the National Estuarine Research Reserve System.

Acadian 1. Northern Gulf of Maine (Eastport to Sheepscot River) 2. Southern Gulf of Maine (Sheepscot River to Cape Cod) **Virginian** 3. Southern New England (Cape Cod to Sandy Hook) 4. Middle Atlantic (Sandy Hook to Cape Hatteras) 5. Chesapeake Bay **Carolinian** 6. Northern Carolinas (Cape Hatteras to Santee River) 7. South Atlantic (Santee River to St. Johns River) 8. East Florida (St. Johns River to Cape Canaveral) **West Indian** 9. Caribbean (Cape Canaveral to Ft. Jefferson and south) 10. West Florida (Ft. Jefferson to Cedar Key) **Louisianan** 11. Panhandle Coast (Cedar Key to Mobile Bay) 12. Mississippi Delta (Mobile Bay to Galveston) 13. Western Gulf (Galveston to Mexican border) **Californian** 14. Southern California (Mexican border to Pt. Conception) 15. Central California (Pt. Conception to Cape Mendocino) 16. San Francisco Bay	**Columbian** 17. Middle Pacific (Cape Mendocino to Columbia River) 18. Washington Coast (Columbia R. to Vancouver Island) 19. Puget Sound **Great Lakes** 20. Lake Superior, including St. Mary's River 21. Lakes Michigan and Huron, including Straits of Mackinac, St. Clair River, and Lake St. Clair 22. Lake Erie, including Detroit River and Niagara Falls 23. Lake Ontario, including St. Lawrence River **Fjord** 24. Southern Alaska (Prince of Wales Island to Cook Inlet) 25. Aleutian Islands (Cook Inlet to Bristol Bay) **Sub-Arctic** 26. Northern Alaska (Bristol Bay to Demarcation Point) **Insular** 27. Hawaiian Islands 28. Western Pacific Islands 29. Eastern Pacific Islands

Source: 15CFR921This list follows Clark (1982) except that Clark listed only two sub-regions (Western Lakes and Eastern Lakes) for the Great Lakes. Also it follows the regions described by Ketchum (1972) except that Ketchum's boundaries for the West Indian region were less precise (e.g., southern tip of Florida and central Florida); Ketchum's boundary between the Californian and Columbian regions also is less precise.

Purpose and Uses

The NERR system was created by Section 315 of the Coastal Zone Management Act (P.L. 92-583, October 1972) to provide a system of representative estuarine ecosystem areas suitable for long-term research, education, and stewardship. The Act and accompanying Congressional reports direct the NERR system to account for regional variations/differentiation (exact wording differs between reports) of ecosystems when designating NERR sites. When establishing the guidelines to administer the NERR system, NOAA chose to achieve the mandate for regional differentiation by following the biogeographic classification developed by the Workshop on Critical Problems of the Coastal Zone (Ketchum 1972), often called the "Woods Hole Workshop." This workshop, which was held May 22 to June 3, 1972, was funded by the National Science Foundation and by the Rockefeller Foundation and cosponsored by the Institute of Ecology and Woods Hole Oceanographic Institution. The purpose of the Woods Hole Workshop was to conduct an intensive multidisciplinary examination of the coastal zone, to define the critical problems, to examine and evaluate available information, and to recommend interdisciplinary research needed to understand these complex problems. The multidisciplinary examinations included perspectives of physical, natural, and social sciences as well as governance.

One recommendation of the Woods Hole Workshop was the creation of a national system of "coastal area preserves" that would be distributed among 12 biogeographic regions (Table 1), although the workshop report actually uses the term "regional classification," not biogeographic region. Eleven of these 12 regions are used by the NERR system for its biogeographic regions, the one region listed in the workshop proceedings but not used by the NERR system falls along the eastern coast of Mexico. This classification system appears in the 1974 (see page 11 and 17) guidelines for the NERR system. Twelve NERR sites had been designated by 1982, and these sites were located in seven biogeographic regions.

NOAA staff was concerned that 11 biogeographic regions did not provide enough detail for the NERR system and considered modifications to the regions defined by the Woods Hole Workshop. This concern led to a formal review of the NEER biogeographic system by Clark (1982). Clark proposed 27 biogeographic units based on the biogeographic classifications used by the Panel on Coastal Biosphere Reserves, U.S. Man in the Biosphere Program (Ray et al. 1981), UNESCO (Ray and McCormick 1979, Udvardy 1975), United National Environment Programme (1980) and the U.S. Fish and Wildlife Service (Cowardin *et al.* 1979) (all citations based on Clark 1972). Clark strove to balance terrestrial, estuarine and nearshore characteristics. These 27 units were created to fit within the 11 biogeographic regions used by the NERR system, which facilitated their adoption by the NERR program, and were later termed "sub-regions" so they fit neatly into the NERR lexicon (Table 1). The 29 sub-regions currently used by the NERR system (15CFR921) differ from the 27 proposed by Clark (1982) in that 15CFR921 lists four sub-regions for the Great Lakes, whereas Clark only listed two. The 26 NERR sites are located within 18 of the 29 sub-regions.

While a bit tangential to the Ecosystem Delineation Working Group, it should be noted that the NERR system employs an estuarine typology system when selecting NERR sites in addition to considering biogeographic region. The purpose of considering typology is to ensure that the NERR System reflects the wide range of estuarine types within the United States. The typology

system was proposed by Clark (1982) and is part of the regulations that govern the NERR program, 15CFR921.

Criteria Used to Establish the Regions Delineated and their Boundaries
Neither Clark (1982) nor Ketchum (1972) provide a specific list of criteria used in their biogeography classification systems, although both assert that their system is a "combination of terrestrial, estuarine, and nearshore characteristics." It is worth noting, however, that both Clark and Ketchum were focused on the coastal zone characteristics, and not on ocean ecosystems criteria.

Methods Used to Validate the Delineated Regions and Zones
The Works cited above by Clark and Ketchum likely provide substantial detail on how the biogeographic regions were validated. It should be noted that both of these works, as well as the works cited within them as the source of the biogeographic regions, were assembled by teams of experts and have been peer reviewed. In addition, NOAA has incorporated the NERR biogeographic regions into federal regulations (15CFR921), which required the classification system to be reviewed from technical and governance perspectives.

Attributes and Drawbacks of the NERR Biogeographic System
The NERR system's biogeographic regions serve well as nearshore classifications of the coastal zone. These regions, however, have not been extended beyond the coastal zone and therefore do not appear, by themselves, to fully capture ocean ecosystem characteristics desired for large scale regional planning, research and ecosystem approaches to management. The original NERR System and the later modification were delineated by a panel of scientists. This panel left a paper trail of how their meeting/consensus approach operated, but documentation does not include explicit biological, physical data or other criteria. This does not mean that such criteria did not exist, but such criteria are hard to discern and a list of criteria is not readily available from the documentation literature. Without a paper trail explaining how the delineation criteria were selected and applied, it is relatively difficult to assess how the NERR biogeographic delineations apply to other uses.

C. North American Commission on Environmental Cooperation (NACEC) Marine Ecoregions

Description of the Zones Delineated
The Marine Ecoregions mapping project of the North American Commission on Environmental Cooperation (CEC) is preparing a nested series of Ecoregions and sub-ecoregions for North America (Figure 6). The project was designed to develop a consensus marine framework, for regional cooperative conservation efforts. This effort is still in progress. Peer review of these Ecoregions has been accomplished, but the changes are not finalized and the results have yet to be formally reviewed and approved by the sponsoring Nations. However, the Workgroup believed that the framework developed was relevant for discussion at the Regional Delineation Workshop.

The CEC framework is nested and includes three levels that link the global and more regional or local perspectives. At each level, there is expert knowledge about, and available data on,

particular variables which serve as a proxy to delineate ecoregions. Most variables used are oceanographic or physiographic, reflecting the range of conditions that influence species distribution, and serve as practical surrogates for biological data that are largely incomplete or inconsistent in format at the North American scale. Where available (such as at levels 1 and 3), information on faunal assemblages and community types was also used to help define the boundaries. The nested system reflects the nature of marine systems and the complex set of forces, pressures and threats that affect them, and also allows North Americans to address various geographic scales and scopes of marine conservation problems at each level simultaneously.

- **Level 1.** Level 1 captures ecosystem differences at the largest scale and is determined by more continental or ocean basin processes (sea surface temperature, major currents, water masses, ice regimes (as a reflection of temperature). There are 24 Level 1 regions in U.S. waters.

- **Level 2.** Level 2 captures the break between neritic and oceanic areas and is determined by large-scale physiography (continental shelf, slope, and abyssal plain, as well as areas of oceanic islands and major trenches, ridges and straits). This reflects the reality of depth as a major determinant of benthic marine communities.

- **Level 3.** Level 3 captures the differences within the neritic realm and is based on more locally significant variables (local characteristics of the water mass, regional landforms, as well as biological community type). Level 3 was limited to the continental shelf, since it was felt that only here was there sufficient information for finer-scale delineation. Coastal shelf and estuaries in each Level 1 ecoregion include one to nine Level 3 subdivisions.

Level 1 ecoregions define large water masses and currents, large enclosed seas, and regions of coherent sea surface temperature or ice cover, classifying biogeographic units on a continental and oceanic scale of 10^2-10^3 km. The cross-shelf domain of Level 1 extends from the continental coasts to the deep oceans. As a practical matter, the seaward boundary extends only to the jurisdictional limits of the Exclusive Economic Zone (EEZ), 200 mi offshore. However, the biogeographic provinces themselves may extend to beyond the EEZ.

While the vertical extension of the classification extend from the supra tidal zone of the nation's coasts and wetlands (the splash, spray and aerosol zone) to the benthic bottom of the marine environment, the Level 1 biogeography refers only to the sea surface. Major seas such as the Gulf of Mexico and Bering Sea, and major currents such as the Gulf Stream occupy single provinces each. The fact that the surface biogeography does not cleanly convey information on habitat associations occurring below the sea surface is an issue that remains to be resolved. Development of maps of subsurface ocean biogeography is ongoing in the CEC project and will be used in formulating future versions of this classification.

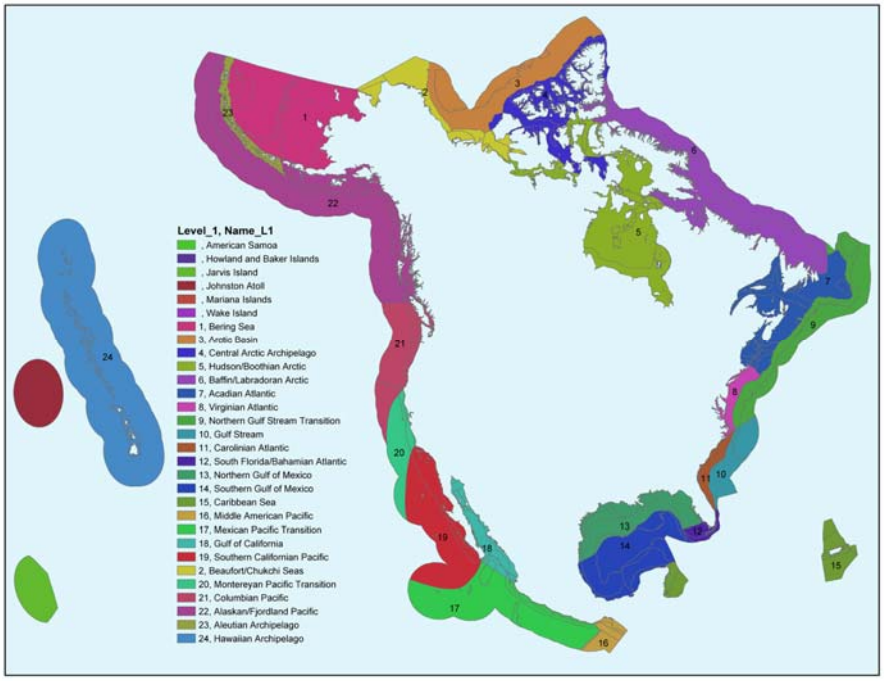

Figure 6. The Level 1 North American Ecoregion Map developed by the CEC. Note: The Level 1 Ecoregions represent 30 biogeographic regions in the United Sates, Canada and Mexico.

Purpose and Uses

The North American Commission for Environmental Cooperation (CEC) is an international organization created by Canada, Mexico and the United States under the North American Agreement on Environmental Cooperation. The CEC was established to address regional environmental concerns, to help prevent potential trade and environmental conflicts, and to promote the effective enforcement of environmental law. The Agreement complements the environmental provisions of the North American Free Trade Agreement (NAFTA). The Conservation of Biological Diversity is one of four major areas of concentration for the CEC. The Marine Ecoregions mapping project was designed to provide a framework for marine conservation planning for two or more of the countries, using agreed-upon scales and criteria.

A consensus marine framework can be displayed on a set of ecoregional maps that the public and decision-makers can clearly understand. These maps can help to: a) support the implementation, development and coordination of national and international mandates, conventions, policies and acts, b) support conservation goals of non-government organizations, and c) provide information to the public, non-government agencies, industry and governments. They are also meant to support research and education, inventorying and monitoring and other planning efforts. Delineated ecoregions can also serve as the basis for regional and cooperative stewardship and management efforts. They can be used as reference points for periodic assessments of ecosystems and their environmental components. Finally, the definition of marine ecoregions also helps to define representative and critical areas of the marine environment through a network of marine protected areas, a cornerstone of any ecosystem-based conservation and sustainable development strategy. As a major purpose of these regions was to include

biogeographically representative communities of organisms (especially benthic communities that are likely to exhibit the highest endemism and biodiversity), the size of the regions had to be significantly smaller than that of Large Marine Ecosystems.

The first application of this framework has been in an initiative to develop a North American Marine Protected Areas Network. Coordinated by the CEC, in collaboration with the North American Marine Working Group of IUCN/World Commission on Protected Areas, it aims to enhance and strengthen the conservation of marine biodiversity in critical marine habitats throughout North America by creating functional linkages and information exchanges among existing and planned marine protected areas. The ecoregions are being used to analyze representation of different biogeographic zones within the proposed network.
NOAA is currently applying the Level 1 framework as a top level of a National Coastal/Marine Habitat Classification Standard being developed by NatureServe (Madden et al. 2004). The Classification Standard is a hierarchical approach to organizing knowledge about coastal and ocean resources of North America. The classification is a comprehensive framework that is applicable from scales of >1 m to <106 m and encompasses benthic and pelagic regimes of estuarine, nearshore marine, neritic and oceanic systems. The organizing framework provides an ecosystem-oriented, science-based method for identification, inventory, assessment, analysis and management of biodiversity and habitat resources. Plans are being developed for the classification to integrate with and provide an organizing framework for the Census of Marine Life's Ocean Biogeographic Information System.

Criteria Used to Establish the Regions Delineated and their Boundaries
The major criteria used for Level 1 ecoregions were large water masses and major currents, large enclosed seas, and regions of coherent sea surface temperature or ice cover, and established faunal biogeographic distributions. In general, decisions on the delineation of the boundaries were based on existing systems in the literature and expert opinion, rather than on a quantitative analysis of new information. Temperature and physical structures determine patterns of biological distributions and endemism at the lower levels of the classification representing the largest spatial scales of the environment. Divisions of the biogeographic ecoregions at Level 1 generally follow the work of Udvardy (1975), Cowardin (1979), Pielou (1979), Hayden et al. (1984), Longhurst (1998), with modifications.

Methods Used to Validate the Delineated Regions and Zones
The overall CEC approach and the initial maps were developed at a CEC workshop held at the NOAA Coastal Services Center in Charleston, NC. in 2002. The workshop was attended by 42 experts from the three countries. The draft Level 1 maps and descriptions were subsequently sent out to a larger group of reviewers for comment and revision. Generally there was good agreement on boundaries, however in several cases experts differed in their identification of boundaries.

Summary of Option in Meeting NOAA Purposes for Regional Management Schemes
The CEC Marine Ecoregions of North America provide a useful framework for some ecosystem-level management efforts. As shown in Table 2, the CEC Ecoregions generally nest within the Large Marine Ecosystems. The few exceptions, where boundaries or scales differ, would require

further evaluation. As with LMEs, they have a level of common currency with neighboring countries with which we share marine resources.

The CEC ecoregions are of the same scale and the coastal regions generally track the boundaries of the Biogeographic Regions used by the National Estuarine Research Reserve System. They differ in that they also include certain offshore bioregions (obviously not a concern for NERRS). They also include a more accurate biogeographic division of the Pacific Island jurisdictions.

The 24 Level 1 ecoregions in the U.S. EEZ are clearly far too many to serve as individual governance units. However, if one purpose is to accurately reflect the biological communities that are being managed, the CEC Marine Ecoregions may provide finer-scale divisions that more accurately reflect marine biodiversity. In this respect they could be used as either stand-alone units or as nested subdivisions of larger LMEs or other regional management units.

Table 2. Comparison of the CEC Ecoregions and LMEs, NERR Biogeographic Regions, and other key biogeographic classification systems.

Region Number	Ecological Region CEC	Comparable Biogeographic Division				
		LME	Hayden et al. (1984)	U.S. National Estuarine Research Reserve System Biogeographic Regions	Sullivan Sealey and Bustamante (1999).	Longhurst 1998
1	**Bering Sea**	Eastern Bering Sea LME	Arctic	Subarctic	--	Bering Sea Portion of the North Pacific Epicontinental Sea Province
2	**Beaufort/Chukchi Seas**	Beaufort LME and Chukchi LME	Arctic	--	--	Boreal Polar Province
3	**Arctic Baisin**	Arctic Ocean LME	Arctic	--	--	Boreal Polar Province
4	**Central Arctic Archipelago**	Arctic Ocean LME	Arctic	--	--	Boreal Polar Province
5	**Hudson/Boothian Arctic**	Hudson Bay LME	Arctic	--	--	Boreal Polar Province
6	**Baffin/Labrador Arctic**	Newfoundland-Labrador Shelf LME	Arctic	--	--	Boreal Polar Province
7	**Acadian Atlantic**	Scotian Shelf LME & Northeast U.S. Continental Shelf LME	Acadian	Acadian	--	Northwest Atlantic Shelves Province
8	**Virginian Atlantic**	Northeast U.S. Continental Shelf LME	Virginian/Acadian	Virginian	--	Northwest Atlantic Shelves Province
9	**Northern Gulf Stream Transition**	Northeast U.S. Continental Shelf LME	Virginian/Acadian	--	--	Gulf Stream Province
10	**Gulf Stream**	Southeast U.S. Continental Shelf LME	Carolinean	--	--	North Atlantic Subtropical Gyral Province
11	**Carolinian Atlantic**	Southeast U.S. Continental Shelf LME	Carolinean	Carolinean	--	Northwest Atlantic Shelves Province
12	**South Florida/Bahamian Atlantic**	Southeast U.S./Gulf of Mexico/Caribbean	Carolinean	West Indian	South Florida & Bahamian Biogeographic Regions	Caribbean Province

13	**Northern Gulf of Mexico**	Gulf of Mexico Ecosystem	Louisianian	Louisianian	Northern Gulf of Mexico (not described)	Caribbean Province
14	**Southern Gulf of Mexico**	Gulf of Mexico Ecosystem	Louisianian	--	Gulf of Mexico Biogeographic Region	Caribbean Province
15	**Caribbean Sea**	Caribbean LME	West Indian	West Indian	Central Caribbean Biogeographic Region	Caribbean Province
16	**Middle American Pacific**		Mexican	--	Chiapas-Nicaragua Biogeographic Region	Central American Coastal Province
17	**Mexican Pacific Transition**	California Current LME-Southern edge?	San Diegan	--	Mexican Tropical Pacific Biogeographic Region & Cliperton & Revillagigedo Islands	Central American Coastal Province
18	**Gulf of California**		Cortezian	--	Cortezian	Central American Coastal Province
19	**Sputhern Californan Pacific**	Southern Extent of the California Current LME	San Diegan Province	Californian (Southern California sub-region)	Mexican Temperate Pacific and Magdalena Transition	Southern Extent of the California Current Province
20	**Montereyan Pacific Transition**	Central Portion of the California Current LME	Oregonian Province	Californian (Central California & San Francisco Bay sub-regions)	--	Central Portion of the California Current Province
21	**Columbian Pacific**	Northern Extent of the California Current LME	Oregonian Province	Columbian	--	Northern Extent of the California Current Province
22	**Alaskan/Fjordland Pacific**	Gulf of Alaska LME & Pacific portion of Eastern Bering Sea LME	Aleutian and Sitkan Provinces & Northern extent of Oregonian Province	Fjord (Southern Alaska sub-region)	--	Alaska Downwelling Coastal Province
23	**Aleutian Archipelago**	Eastern Bering Sea LME	Aleutian Province	Fjord (Aleutian Islands sub-region)	--	Alaska Downwelling Coastal Province
24	**Hawaiian Archipelago**	Insular Pacific -Hawaii LME	--	Insular (Hawaiian Islands)	--	North Pacific Tropical Gyre Province
	Johnston Atoll		--	Insular (Hawaiian Islands)	--	
	U.S. Line Islands		--	--	--	
	U.S. Phoenix Islands		--	--	--	
	Wake Island		--	--	--	
	Mariana Islands		--	--	--	
	American Samoa		--	--	--	

D. Other Regional Science and Management Options

Most federal agencies and federal-like entities that manage natural resources have offices located regionally throughout the nation. Although these regional management units are rarely similar between agencies and are not based on ecological criteria, they provide another option for dividing the country into regions. The following are some of the jurisdictional divisions made by federal entities:

NMFS Eight Regional Fisheries Management Councils

The Magnuson Fishery Conservation and Management Act of 1976, (renamed the Magnuson-Stevens Fishery Conservation and Management Act when amended on October 11, 1996) established a U.S. exclusive economic zone which ranges between 3 and 200 miles offshore, and

created eight regional fishery councils (Figure 7) to manage the fisheries of the United States, and provide management of transboundary species.

Figure 7. Eight Regional U.S. Fishery Management Councils

Jurisdictional boundaries for the eight regional fishery councils were determined more by geopolitical concerns than by any ecological criteria. Nonetheless, the jurisdiction of some councils, correspond closely with LME boundaries. For example:

- The Gulf of Mexico Fisheries Management Council manages all fishery resources within the U.S. component of the Gulf of Mexico Large Marine Ecosystem.
- The North Pacific Fisheries Management Council manages fishery resources in the entire Eastern Bering Sea Shelf Large Marine Ecosystem and in all U.S. waters of the Gulf of Alaska Large Marine Ecosystem.
- The Western Pacific Fishery Management Council manages all fisheries resources within the Pacific Insular Large Marine Ecosystem.
- The Caribbean Fishery Management Council manages all fisheries resources with the U.S. waters of the Caribbean Sea Large Marine Ecosystem.

The boundaries of other councils correspond less well with ecosystem boundaries. For example fishery resources within the Northeast U.S. Shelf LME, which ranges from the Gulf of Maine to Cape Hatteras, are managed by the New England Fishery Management Council and the Mid-Atlantic Fishery Management Council. Management for stocks which range the entire ecosystem requires close coordination between and by the councils.

Fishery management councils' jurisdictions also do not account for those parts of LMEs that exist in state and international waters and the waters of other countries' EEZs. For example, shrimp stocks in the Gulf of Mexico are distributed within the waters of each Gulf state as well as Mexico, requiring close cooperation with those entities for effective management of that fishery.

Integrated Ocean Observing System Regions

The following text is extracted from a draft document titled Guidance for the Establishment of Regional Associations and the National Federation of Regional Associations found on the web page of Ocean U.S. at http://www.ocean.us/.

The operational goal of the Integrated Ocean Observing System (IOOS) is the routine and timely provision of comprehensive data and information on past, present and future states of the oceans, the nation's Exclusive Economic Zone (EEZ), the Great Lakes, and the nation's estuaries. This will be achieved through the coordinated development of observing and prediction systems that efficiently link observations to the data and information needs of multiple user groups through integrated data management on global, national, regional, and local scales. User groups play critical roles in the design and evaluation of the system and must be involved in the governance of the IOOS from the beginning.

The IOOS consists of two closely related and interdependent components. The global (basin scale) component is the U.S. contribution to the global ocean-climate module of GOOS (Global Ocean Observing System). The coastal component is developing as a national "backbone" for the nation's EEZ with regional coastal ocean observing systems that include the nation's estuaries and bays as well as the open waters of the coastal ocean. Although actual boundaries are being defined by regional groups as they work to form Regional Associations, the following regions (Figure 8) are given to indicate the spatial scale on which regional observing systems are expected to develop:

- ***Alaska*** (Gulf of Alaska, Bering Sea, Chukchi Sea and Bristol Bay)
- ***Insular Pacific*** (Hawaii and the west Pacific Trust Territories)
- ***Northwest*** (Canadian border to Point Arena)
- ***Central West Coast*** (Point Arena to Point Conception)
- ***Southern California*** (Point Conception to the Mexican border)
- ***Gulf of Mexico*** (Mexican border to the Florida Keys)
- ***Southeast*** (Florida Keys to Cape Hatteras)
- ***Mid-Atlantic Bight*** (Cape Hatteras to Cape Cod)
- ***Gulf of Maine*** (Cape Cod to Canadian Border)
- ***Great Lakes***

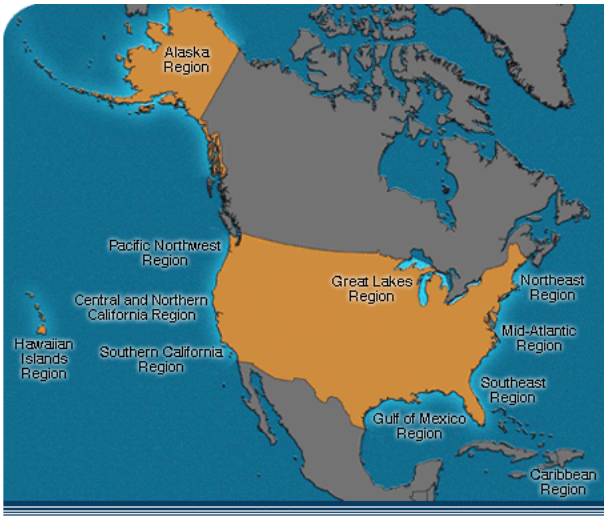

Figure 8. Possible Regional Association Observing Systems

Source: http://usnfra.org/

Note: These regions are the same as those identified in the preliminary draft of the USCOP Report, but were removed from the final report.

The proposed IOOS regions mesh well with LMEs and in some cases they mirror the LMEs exactly (i.e., Alaska, Insular Pacific, Gulf of Mexico). In other cases, one LME encompasses several IOOS regions. The Northeast Shelf LME encompasses the IOOS regions of Mid-Atlantic Bight and Gulf of Maine which indicates that the smaller IOOS regions might also provide options for nested ecosystems.

NOAA National Climatic Data Center (NCDC)

NCDC's mission is to manage the Nation's resource of global climatological in-situ and remotely sensed data and information to promote global environmental stewardship; to describe, monitor and assess the climate; and to support efforts to predict changes in the Earth's environment. This effort requires the acquisition, quality control, processing, summarization, dissemination, and preservation of a vast array of climatological data generated by the national and international meteorological services. NCDC's mission is global in nature and provides the U.S. climate representative to the World Meteorological Organization, the World Data Center System, and other international scientific programs. NCDC also operates the World Data Center for Meteorology, Asheville. NCDC provides information on three levels; region, state and sub-state. Figure 9 depicts NCDC regions, which are different from NOAA Regional Climate Centers. NCDC Climate Divisions are standardized areas within each state designating areas of similar climate regime. The number of climate divisions in a state varies from one (Rhode Island) to a maximum of ten (many states). Refer to the following website for further information on NCDC: http://www.ncdc.noaa.gov/oa/ncdc.html

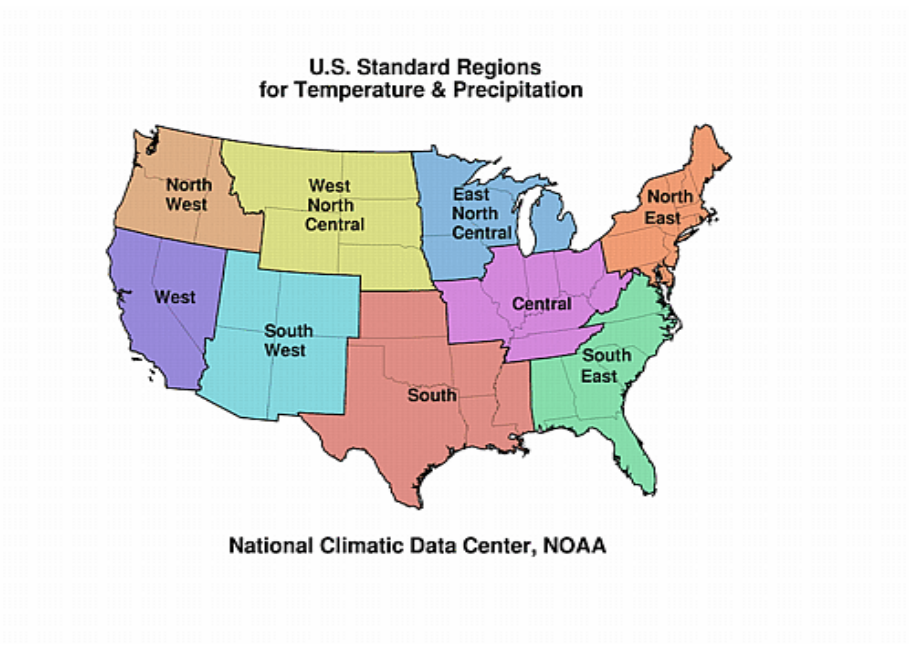

Figure 9. NCDC Regions for Temperature and Precipitation

Source: http://www.ncdc.noaa.gov/oa/ncdc

Political Boundaries of Federal Regions

The Ecosystem Delineation Workshop participants were provided with examples of regional boundaries set-up by several natural resource agencies. Since none of these delineations were solely ecological in nature, the workshop participants agreed that political boundaries of federal regions should not be considered in delineation of the largest ecosystem order. Although, the workshop participants did agree that these boundaries of federal regions might be applicable in future sub-delineation of ecosystems. A few examples of federal agency regions or divisions are listed below as a future reference when considering geo-political areas in sub-regional delineation.

National Marine Fisheries Service (NMFS)

The NMFS agency regional offices are distributed as follows (Figure 10):

- ***Alaska***
- ***Northwest*** (Oregon, Washington, Idaho and Montana)
- ***Pacific Islands*** (American Samoa, Guam, Hawaii, Northern Mariana Islands, and the U.S. Pacific island possessions i.e., Johnston Atoll, Palmyra Atoll and Kingman Reef, Jarvis Island, Howland and Baker Islands, and Wake Island)
- ***Southwest*** (California)
- ***Southeast*** (eight coastal states of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Texas, the inland states of Arkansas, Iowa, Kansas, Kentucky, Missouri, Nebraska, New Mexico, Oklahoma and Tennessee, as well as the Commonwealth of Puerto Rico and the U.S. Virgin Islands)
- ***Northeast*** (coastal states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and North Carolina; and inland states of Vermont, Minnesota, Michigan, Wisconsin, Illinois, Indiana, Ohio, and West Virginia)

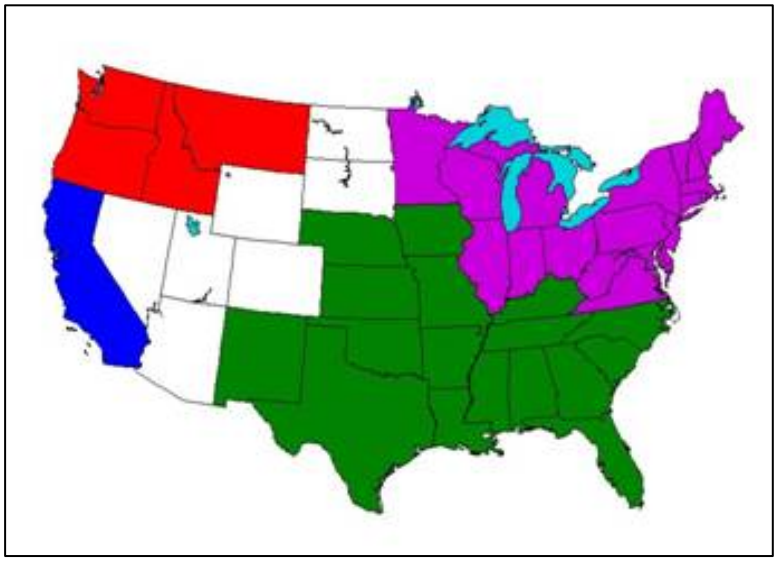

Figure 10. National Marine Fisheries Regions

The United States Fish and Wildlife Service (USFWS)

The USFWS agency regional offices are distributed as follows (Figure 11):

- ***Pacific Region*** (Region 1) includes California, Idaho, Nevada, Oregon, Washington, Hawaii and the Pacific Islands.
- ***Southwest Region*** (Region 2) includes Arizona, New Mexico, Oklahoma and Texas.
- ***Great Lakes-Big Rivers Region*** (Region 3) includes Illinois, Indiana, Iowa, Michigan, Missouri, Minnesota, Ohio and Wisconsin.
- ***Southeast Region*** (Region 4) includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Puerto Rico/Virgin Islands, South Carolina and Tennessee.
- ***Northeast Region*** (Region 5) includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia and West Virginia.
- ***Mountain-Prairie Region*** (Region 6) includes Colorado, Kansas, Montana, North Dakota, Nebraska, South Dakota, Utah and Wyoming.
- ***Alaska Region*** (Region 7) consists of the state of Alaska.

Figure 11. U.S. Fish and Wildlife Service Regions
Source: http://firefws.gov/job vacancies/Employment.htm

Environmental Protection Agency

The Environmental Protection Agency regional offices are distributed as follows (Figure 12):

- Region 1 includes New Hampshire, Vermont, Maine, Massachusetts, Rhode Island, and Connecticut.
- Region 2 includes New York, New Jersey, Puerto Rico and Virgin Islands.
- Region 3 includes Pennsylvania, West Virginia, Virginia, Delaware, Maryland and District of Columbia.
- Region 4 includes Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina and Tennessee.
- Region 5 includes Minnesota, Wisconson, Illinois, Michigan, Ohio and Indiana.
- Region 6 includes New Mexico, Texas, Oklahoma, Arkansas and Louisiana.
- Region 7 includes Nebraska, Iowa, Missouri and Kansas.
- Region 8 includes Montana, North Dakota, South Dakota, Wyoming, Colorado and Utah.
- Region 9 includes California, Nevada, Arizona, Hawaii, Guam, Trust Territories, American Samoa and Northern Mariana Islands.
- Region 10 includes Washington, Oregon, Idaho and Alaska.

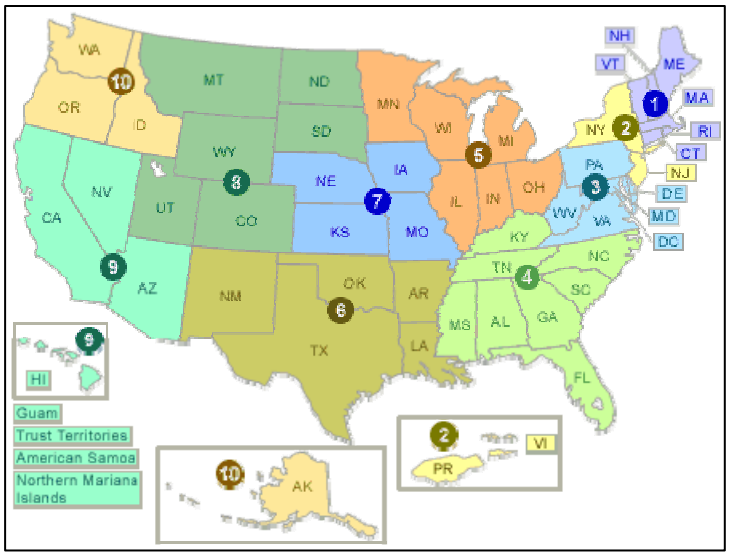

Figure 12. Environmental Protection Agency Regions

US Army Corps of Engineers Regions

U.S. Corps of Engineers divisions are not distributed along state lines as in the other federal examples presented. However, the divisions are organized in a fairly similar geographic manner with the exception of the Mississippi Valley Division which transects the U.S. vertically (Figure 13).

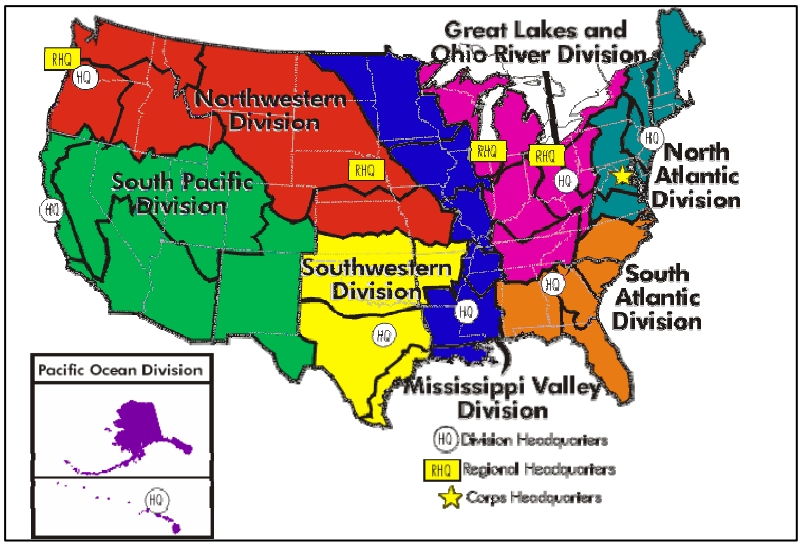

Figure 13. U.S. Army Corps of Engineers Regions

Source: http://www.usace.army.mil/mildivdistmap.html

Marine Protected Areas

Marine Protected Area region recommendations were not discussed at the workshop, but were included since they could potentially be relevant for sub-delineation (Figure 14).

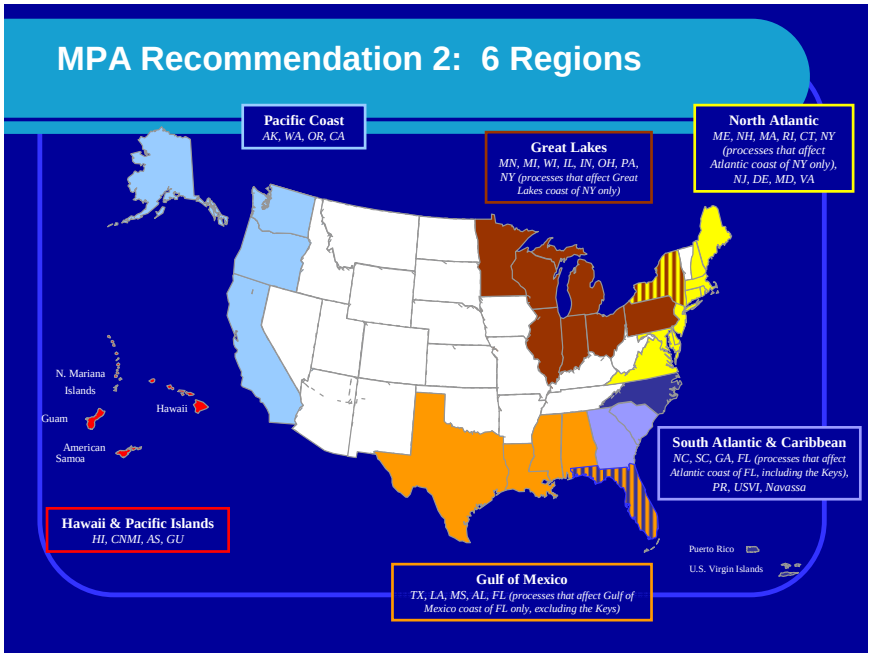

Figure 14. Marine Protected Area Recommendation

Source: NOAA Marine Protected Areas Center

Private Sector Models

The Nature Conservancy (TNC)
The Marine Initiative is the TNC's effort in integrating terrestrial, fresh water and marine aspects in ecoregional planning and builds "models to delineate marine ecosystems in locations where habitat data are sparse" with the goal of enhancing conservation. The Marine Initiative includes a comprehensive ecoregional planning process for nearshore conservation, including: 1) identifying targets, 2) establishing goals, 3) analyzing threats, and 4) setting priorities.

TNC's first Marine Ecoregional Plan is located in the Northern Gulf of Mexico extending from Anclote Key, Florida to the Laguna Madre de Tamaulipas, Mexico. This ecoregion is divided into three subregions: western (south from Galveston Bay, Texas), central (Galveston Bay to Mobile Bay, Alabama), and eastern (northwest Florida coast). Other TNC marine ecoregions with plans include the Willamette Valley/Puget Trough/Georgia Basin (Pacific Northwest), Southern California, and Mid-South Atlantic. Central and South Florida and Northern California are in progress. The Nature Conservancy's website regarding ecoregional planning is located at http://nature.org/initiatives/marine/work/.

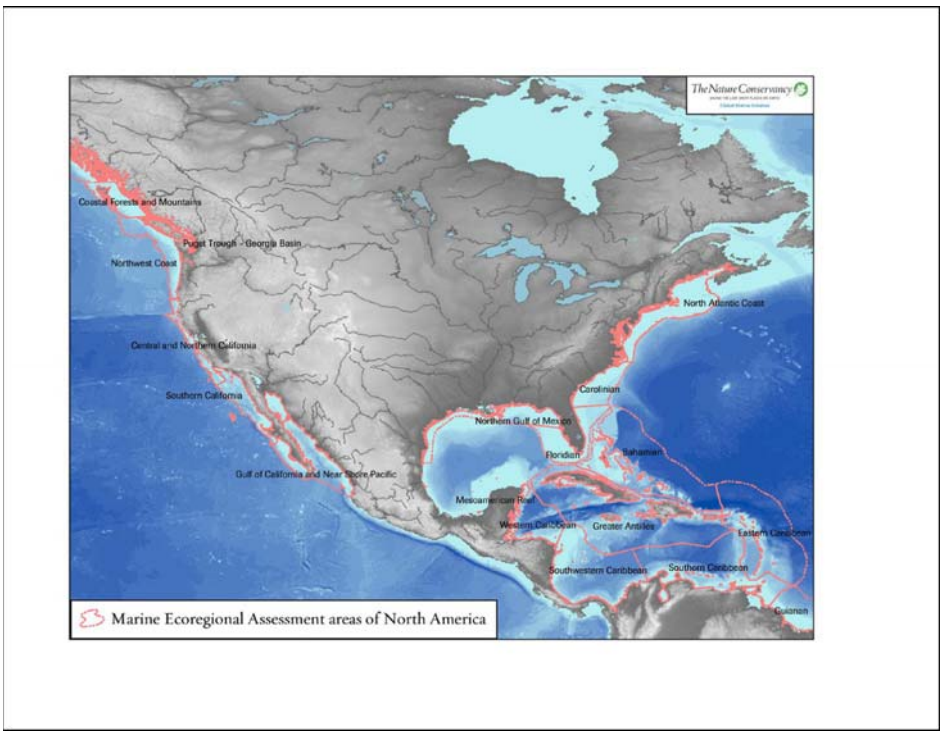

Figure 15. The Nature Conservancy Marine Ecoregions of North America

Source: http://nature.org/initiatives

III. Analysis of Important Criteria to Consider in Delineation of Ecosystems

As noted above, the delineation of regional ecosystems works best when the number of biological populations, distinct oceanographic processes, and human activities that occupy two or more defined ecosystems is minimized. In practice, there will never be a perfect set of delineations so the boundaries represent a compromise among the various established criteria. Apart from the expediency of political institutions and governance, there are four criteria based on the physical and biological characteristics of ecosystems that are useful in defining areas that function in more-or-less independent ways. The physical criteria that provide the oceanographic setting for marine ecosystems are *bathymetry* and *hydrography*. These two factors determine water mass characteristics and bottom habitats that structure benthic communities. There is a clear relationship between regional oceanography and plankton communities, and, as well, between benthic communities and characteristics such as water depth, temperature and bottom type composition. Useful ecosystem definitions can be developed on these two criteria alone because of their importance in structuring pelagic and demersal communities of organisms. Adding biological characteristics provides a basis for considering the interactions among species and trophic levels.

There are a number of biological attributes that are appropriate for consideration when delineating regional ecosystems. These include patterns of biogeography (e.g., species richness, endemism), *productivity*, and *trophic interactions*. Regional oceanographic processes are closely aligned with patterns of biogeography and structure patterns of productivity. Likewise, breaks in productivity (e.g., primary productivity, growth rates of species, recruitment retention areas) can be strongly determined by regional oceanographic processes such as fronts, banks, and current systems. All four of these criteria, then, are important in considering alternative definitions of ecosystems for the purposes of management.

Non-scientific factors could also be considered, but the workshop participants agreed that at the largest order of ecosystem delineation it did not make sense to include political considerations in ecosystem boundary setting criteria. Political criteria can easily be included when large marine and fresh water ecosystems are broken down into sub-regions that are a more manageable size. As an example, the Northeast U.S. Large Marine Ecosystem contains the states Maine through North Carolina. The number of states in this example combined with the Federal Agencies which have regional coastal and marine jurisdiction may be considered too large for effective planning and implementation of ecosystem approaches. In this regard, the concept of scaling can be introduced to manage regional ecosystems, so that agencies having jurisdictional responsibilities within a LME can function at different scales or hierarchies. Management would occur at a national scale (i.e. a LME), at a regional scale (i.e. jurisdictional area of responsibility of a fishery management council), and at the local scale (i.e. managing marine protected areas such as coral reefs, sanctuaries, or closed fishing areas).

Note an example of LME scaling: In the Northeast U.S. LME there are several subareas that could be considered for management purposes such as the Regional Fisheries Management Councils that are established for jurisdictional responsibility of transboundary fish stocks, or Marine Protected Areas that have been designated for rebuilding and recovering depleted living marine resources.

IV. Inland Boundaries

Introduction

As described in the *Purpose for Delineating Coastal and Marine Ecosystems* section of this report, coastal watersheds and their uses and inland habitats of marine species play a critically important role in the distribution and condition of regional ecosystems. Yet these factors are frequently overlooked as an essential element of ecosystem approaches to managing coastal and marine resources. NOAA intends to define inland boundaries of regional ecosystems to ensure that its marine programs and activities closely relate to its coastal programs and activities as well those activities of NOAA partners. NOAA does not intend to take away jurisdiction of any state or federal agency that deals with inland activities, but rather intends to work more closely with those governments for a more effective and comprehensive resource management system.

To support NOAA's Ecosystem Goal fully, the inland boundaries of ecosystems identified in this effort must at least include the inland-most areas for which NOAA has management responsibility, such as the freshwater habitat of salmon and other diadromous fish. By including such areas within an ecosystem framework and organizing information within this framework, NOAA can make informed management decisions wherever conservation and management are required. The following discussion of inland boundary issues will describe the various alternative approaches that were presented at the workshop. Each approach described below will include a recommended approach for defining inland boundaries, discuss several scenarios that will require adjustments to some inland boundaries, and briefly mention implementation considerations.

Possible Inland Boundary Alternatives

NOAA's Coastal Assessment Framework (CAF)
The Coastal Assessment Framework (CAF) provides a consistently derived, watershed-based digital spatial framework for managers and analysts to organize and present information on the nation's coastal, near-ocean, and Great Lakes' resources. It encompasses nearly 83 percent of the land area within the contiguous United States and includes the drainage basins of nearly all of the nation's rivers. The CAF includes coastal and estuarine drainage areas along the nation's coasts and fluvial drainage areas upstream—a design that has facilitated identification of coastal counties (673 total), creating a bridge between geographic and political boundary-based coastal data analyses. Spatial units in the CAF were derived from the following building blocks: a set of approximately 700 U.S. Geological Survey hydrologic cataloging units, a shoreline for the oceanic coasts, a shoreline for the Great Lakes, and a set of lines representing the United States' open-ocean boundary (12 nautical miles from the coast). For more information about the CAF visit http://spo.nos.noaa.gov/projects/caf/caf.html.

USGS's National Water Quality Assessment (NAWQA) Study Units
Since 1991, USGS scientists with the NAWQA program have been collecting and analyzing data in more than 50 major river basins and aquifers across the nation (NAWQA framework), with the goal of developing long-term consistent and comparable information on streams, ground water, and aquatic ecosystems to support sound management and policy decisions. A NAWQA

study unit boundary frequently crosses state boundaries and usually encompasses more than 10,000 square kilometers (about 3,900 square miles). Geographic areas were selected to represent a variety of important hydrologic and ecological resources; critical sources of contaminants, including agricultural, urban, and natural sources; and a high percentage of population served by municipal water supply and irrigated agriculture. For more information about the NAWQA Program visit http://water.usgs.gov/nawqa/about.html .

EPA's Level III Ecoregions

Level III Ecoregions were derived from Omernik (1987) and from refinements of Omernik's framework. Designed to serve as a spatial framework for environmental resource management, Ecoregions (84 for contiguous U.S.) denote areas within which ecosystems—and the type, quality, and quantity of environmental resources—are generally similar. Ecosystem classification criteria include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The most immediate needs of the Ecoregions project are to develop regional biological criteria and water quality standards and to set management goals for nonpoint source pollution. For more information about EPA's Ecoregions visit http://www.epa.gov/wed/pages/ecoregions/level_iii.html.

USGS's Hydrologic Units (HUCs)

USGS's hydrologic framework divides the U.S. into successively smaller hydrologic units, classified as follows: regions (21), sub-regions (222), accounting units (352), and cataloging units (2,150). The hydrologic units are arranged within each other, from the smallest (cataloging units) to the largest (regions). A cataloging unit is a geographic area representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature, while a region contains either the drainage area of a major river (e.g., Missouri region) or the combined drainage areas of a series of rivers (e.g., Texas-Gulf region, which includes a number of rivers draining into the Gulf of Mexico). Hydrologic unit boundaries are available in digital format at scales of 1:2,000,000 and 1:250,000. For more information about USGS's Hydrologic Units visit http://water.usgs.gov/GIS/huc.html.

NOAA's National Basin Delineation (NBD) Project

NOAA's National Severe Storms Laboratory (NSSL) has delineated basins from 1-arc-second (~30-meter) digital elevation data for use in the Flash Flood Monitoring and Prediction Program to assist in flash flood warning decisions. Basin delineation was based on USGS's National Elevation Dataset (NED), the product of merging the highest-resolution, best quality elevation data available across the United States into a seamless raster format. Basins in the NBD project aggregate to USGS cataloging units and were defined and assigned unique identification numbers using the Pfafstetter system of basin delineation and codification. This system defines basins according to the natural topographic control of drainage and the topology of the river network. The Pfafstetter codification scheme makes efficient use of digits such that basins smaller than 4,000 square kilometers can be uniquely identified using five-digit identification numbers. For more information about NOAA's NBD Project visit http://www.nssl.noaa.gov/western/basins/.

Recommended Initial Inland Boundary Alternative

The Regional Ecosystem Delineation Workgroup recommends that Inland Boundaries for coastal/marine ecosystems include the Coastal Drainage Area or the Estuarine Drainage Area, as appropriate, based on NOAA's Coastal Assessment Framework (CAF), adjusted for the inland extent of the range of diadromous fish for which NOAA has direct responsibilities. When looking at the factors affecting a coastal ecosystem, the entire Fluvial Drainage Area should be considered as an important Area of Influence over the coastal/ marine ecosystem, but should not be included as part of the ecosystem.

Initiating management activities requires collecting and organizing information about the resources present and their use in coastal areas (small-scale action). Moreover, information must be gathered to evaluate long-term coastal management strategies (large-scale action). The National Research Council has stated that "because aquatic ecosystems are interconnected and interactive, the watershed" (National Research Council, 1992). NOAA's Coastal Assessment Framework (CAF) provides such a watershed-based spatial framework, with a nested hierarchy of spatial units for the small- and large-scale coastal resource data analyses needed to effectively manage our nation's diverse coastal areas.

The CAF is composed of 124 Estuarine and Sub-estuarine Drainage Areas (EDAs), 43 Fluvial Drainage Areas (FDAs), 285 Coastal Drainage Areas (CDAs), and 15 Fluvial components of Coastal Drainage Areas (FCDAs). Effective management efforts should be conducted on a large enough scale to include all significant components.

An **Estuarine Drainage Area (EDA)** is that component of an estuary's entire watershed that empties directly into the estuary and is affected by tides. EDAs may be composed of a portion of a single USGS hydrologic unit, an entire hydrologic unit, more than one hydrologic unit, or several complete hydrologic units and portions or several adjacent hydrologic units. An EDA includes all or part of the USGS cataloging unit containing the most upstream extent of tidal influence (head-of-tide).

Every EDA has both a land and a water component, with the land component composed of a mainland component and, for certain EDAs, an island component. Overall size and characteristics of these EDAs vary greatly. For example, the Chesapeake Bay EDA including its subEDAs along the Mid-Atlantic coast covers 38,200 square miles, while several EDAs or subEDAs along the Pacific coast cover 100 square miles or less.

A **Coastal Drainage Area (CDA)** is generally defined as that component of an entire watershed that meets the following three criteria: 1) it is not part of any EDA or a corresponding FDA; 2) it drains directly into an ocean, an estuary, or the Great Lakes; and 3) it is composed only of the downstream-most HUC in which the head-of-tide is found.

A **Fluvial Drainage Area (FDA)** is that component of an estuary's entire watershed upstream of the EDA boundary. Less than half the EDAs (43) have corresponding FDAs. FDAs have land components only. The huge 1,131,700 square mile Mississippi River FDA dwarfs all others, and makes up over half of the total drainage area covered by the entire CAF.

The **Fluvial component of a Coastal Drainage Area (FCDA)** is that component of a coastal watershed that lies "upstream" of the CDA boundary. Like FDAs, FCDAs only have a land component.

Within and outside NOAA, the Coastal Assessment Framework (CAF) is the cornerstone of a series of past and ongoing efforts to develop a national estuarine assessment capability, and many coastal resource databases are spatially attributed to the CAF. To name a few:

- NOAA's National Coastal Assessment and Data Synthesis (CA&DS) provides a systematic framework that integrates data such as eutrophication conditions, pollutant sources and loadings, population, shellfish harvest areas, salinity and circulating freshwater inflow, sediment contamination, and others that are consistently formatted using a hierarchical set of spatial units defined by the CAF.
- NOAA's population estimates for U.S. watersheds are based on the CAF.
- NOAA's Estuarine Living Marine Resources (ELMR) Database is organized by the CAF.
- EPA's Estuarine Pollution Susceptibility Index uses the CAF as the spatial framework to classify the susceptibility of coastal watersheds to pollution.

Additional benefits unique to the CAF include: a means to estimate the upstream extent of tidal influence (head-of-tide), and watershed boundaries clipped to NOAA's Medium Resolution Digital Vector Shoreline (average mapping scale is 1:70,000).

Inland Extent of Diadromous Fish

NOAA has direct responsibilities for diadromous (i.e. anadromous fish like salmon and catadromous fish like the American eel) fish and their supporting habitats under Endangered Species Act (ESA), Magnuson-Stevens Act (MSA), Fish and Wildlife Coordination Act (FWCA), Federal Power Act, and National Environmental Policy Act (NEPA). These resources migrate inland in some cases beyond the Estuarine Drainage Areas discussed above or between Estuarine and Fluvial Drainage Areas (Figure 16). Where specific scientific information exists, the inland range of these fish should be incorporated into the initial boundary delineations of coastal and marine ecosystems. Alternatives of the inland extent include:

- The current inland range of diadromous fish over which NOAA has some direct responsibility.
- The scientifically documented historical range of diadromous fish.
- The current inland range of diadromous fish extended to the 2nd dam or other blockage where it has been determined to be practicable and feasible to gain fish passage to the 1st dam or blockage.

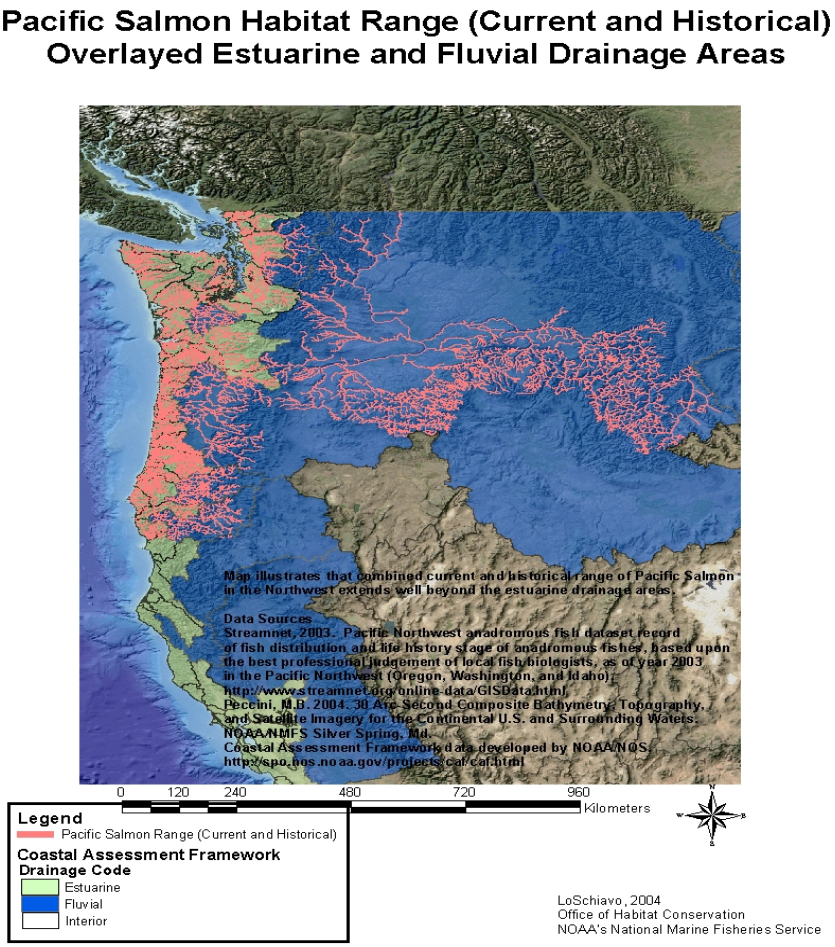

Figure 16. Scientifically documented historical range of diadromous fish.

Source: NOAA, Office of Habitat Conservation

Analysis of these alternatives:
With respect to diadromous fish, the current extent of migration often goes beyond the CDA and possibly the EDA boundaries up to in-stream barriers such as dams, culverts, or impoundments (Figure 17). Scientific information is more readily available on the current ranges of diadromous fish than on historic ranges. However, the historic ranges of several diadromous fish species are known to go beyond the EDA boundaries and in-stream barriers. It is important to recognize the differences between current and historic diadromous fish habitat due to in-stream barriers. For example, historical accounts document shad and striped bass spawning migration in Roanoke River tributaries as far upstream as 590 km; current primary spawning habitat is confined to a relatively small remnant reach of fall line rock rapids complex (15-18 km) (NOAA Fisheries' Modified Fishway Prescription for FERC Project No. 2009, Roanoke Rapids and Gaston).

The extent of historical inland migration of a diadromous species listed under Endangered Species Act may be designated as Critical Habitat, or as Essential Fish Habitat under the Magnuson-Stevens Fishery Conservation and Management Act. For example, Pacific salmon EFH and critical habitat extend into Idaho. Federal actions with downstream effects above these

historical ranges may also require consultation under ESA or EFH. Limiting ecosystem boundaries to the terminal or second in-stream barrier would not accurately reflect the habitat needed for diadromous species to thrive and contribute to overall ecosystem productivity. NOAA's ecosystem boundaries are further blurred when accounting for diadromous fish species that move between south-Atlantic bays and estuaries to north/mid-Atlantic bays and estuaries (i.e., striped bass).

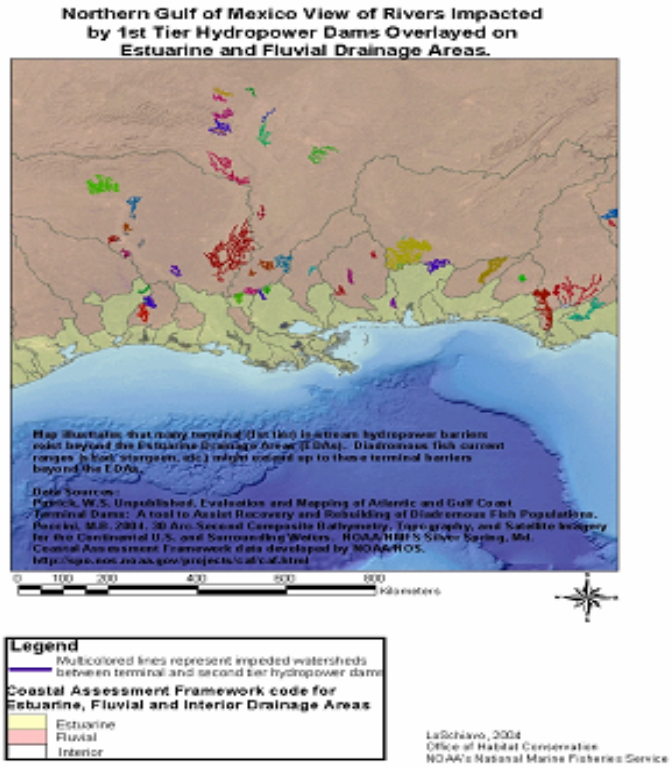

Figure 17. 1st Tier Hydropower Dams overlaid on Estuarine and Fluvial Drainage Areas.

Source: NOAA, Office of Habitat Conservation

Other Future Considerations for Inland Boundary Adjustment

Although the CAF and diadromous fish ranges provide a consistent spatial framework for delineating the inland boundaries of coastal ecosystems, selection over time of an inland boundary also depends on its intended purpose. It may be necessary to adjust inland ecosystem boundaries based on scientific or legal criteria. For example, coastal and estuarine waters of the Gulf of Mexico are Essential Fish Habitat for fishery species such as penaeid shrimp, but these areas are ecologically linked to watersheds far inland. Nutrient inflow (nitrogen) from the Mississippi River, together with hydrologic and climatic factors, is largely responsible for the recurring hypoxia in the northern Gulf of Mexico off the coast of Louisiana (CENR 2000). The primary sources of these nutrients are farmlands in Midwestern states. From a practical point of view, it may make sense to designate the Estuarine Drainage Area (modified by the inland extent of important diadromous species) as an inland boundary when considering the habitat of an individual species. The entire Fluvial Drainage Area must be considered an important Area of Influence when looking at the factors affecting a coastal and marine ecosystem.

While hypoxia in the Gulf of Mexico provides an example of the influence of inland watersheds on coastal species, diadromous fish demonstrate how inland watersheds are affected by marine species. For example, when sockeye salmon return from the Pacific Ocean to the Stanley Basin Lakes of Idaho, their carcasses provide a significant source of nutrients. Thus, marine-derived nutrients are translocated upstream by migratory fish, at the same time that terrestrial nutrients are moved seaward by stream flow. With respect to diadromous fish, the current extent of migration (to headwater streams or in-stream barriers) and the immediate drainage areas associated with this migration may function as an inland boundary, rather than the entire fluvial watershed. Laws administered by NOAA may require the adjustment of inland boundaries to satisfy a statutory requirement for diadromous fish and their supporting habitats under the Endangered Species Act, Magnuson-Stevens Act, Fish and Wildlife Coordination Act, Federal Power Act, or NEPA. For example, the extent of historic inland migration of a diadromous species listed under the Endangered Species Act may be designated as Critical Habitat, or as Essential Fish Habitat under the Magnuson-Stevens Fishery Conservation and Management Act.

The geographic focus for "management" is some defined area, such as a bay, estuary or regional coastal and marine ecosystem, and the land areas draining into the bay, estuary or regional ecosystem (e.g., Puget Sound, Long Island Sound, Mobile Bay, and Gulf of Mexico LME). It may be a combination of a drainage area and boundaries of local governments of general jurisdiction, as it is the case for the water management districts in Florida. However, it is critical to understand that many of the problems in coastal areas stem from activities upstream and upwind from the coastal area, from the headwaters, and beyond, to the Estuarine Drainage Area. In addition, some or many of the demands imposed on the uses of the resources of a given coastal area originate from outside the watershed, outside the given state, and/or outside the country. For example at least 90% of two of the ten critical pollutants of concern with respect to Lake Superior originate from outside the basin. With respect to Chesapeake Bay, on the order of 25-30% of the nitrogen input to the Bay originates from outside the basin. Typically the institutional arrangement designated or established for management of the coastal area has no jurisdiction beyond the limited boundaries specified. Thus, decisions with respect to Inland Boundary definitions and coastal management might involve tradeoffs among desired outputs. The relative importance of the various uses and users is also likely to change over time.

Implementation

The Coastal Assessment Framework (CAF) has undergone few changes since it was created in the mid-1990s. Advances in Geographic Information Systems (GIS) technology and environmental characterization techniques could be employed to refine the CAF and improve its future applications. For example, CAF watershed boundaries could be revisited with more recent 30-m Digital Elevation Model (DEM) data from NSSL's National Basin Delineation Project. Another possibility might be to incorporate 12- and 14-digit hydrologic unit data developed by USDA's National Resources Conservation Service (NRCS). Maximum benefit from such efforts would likely require: partnerships with NSSL and NRCS and other partner agencies to ensure framework accuracy and quality, and a mechanism to collect and incorporate expert feedback (e.g., workshop). Funding and resources also would need to be identified and secured to adequately address the update of the framework.

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VI. Workshop Summary

Overview and Call to Action – Dr. Paul Sandifer and Dr. Douglas DeMaster

National Oceanic and Atmospheric Administration (NOAA) is guided by four missions detailed in the agency's Strategic Plan. The first NOAA mission deals with improving the health of ecosystems and encouraging a well informed public to act as stewards. In September 2004, the U.S. Commission on Ocean Policy (USCOP) released its final report which clearly instructs all federal agencies to move towards ecosystem-based management. NOAA's Strategic Plan and the USCOP Final Report are a call to action for new ecosystem approaches to management for coastal and marine ecosystems. As a first step down a long road of partnership and collaboration, NOAA's Ecosystem Goal held a multi-stakeholder workshop to discuss the major boundaries of marine and aquatic ecosystems of the U.S.

The purpose of the workshop was to solicit guidance from within NOAA, other federal agencies, and other regional and state organizations as to how to delineate regional ecosystems within the U.S. This step is critical as NOAA has defined an ecosystem approach to management as being a geographically specific approach. A Working Group (WG) was established within NOAA to organize the workshop. The primary objectives were to (1) discuss the delineation of large ecosystems on the basis of natural science (not political boundaries), (2) discuss how those large ecosystems might be broken down into sub-areas based on natural science criteria, and (3) discuss inland extent of regional ecosystems.

55 individuals participated in the workshop. These participants represented federal agencies/institutions (Forest Service, Army Corps of Engineers, Natural Resource Conservation Service, Fish and Wildlife Service, Geological Service, Environmental Protection Agency, Department of State, Minerals Management Service, Oceanographer of the Navy, Department of the Interior, and NOAA), academic institutions (University of New Hampshire and University of South Florida), fishery management councils (South Atlantic, Caribbean, and Western Pacific), an interstate fishery commission (Atlantic States Marine Fisheries Commission), state agencies (Alaska, Hawaii, Mississippi, Minnesota, and South Carolina), non-governmental organizations (The Nature Conservancy and The Heinz Center), and staff of the U.S. Commission on Ocean Policy (USCOP). Additionally, the interests of all coastal states were represented at the workshop by the Coastal States Organization.

USCOP Recommendations Regarding Ecosystem Based Management

Dr. Paul Sandifer, U.S. Ocean Commissioner, opened the workshop with a presentation on the USCOP recommendations regarding ecosystem-based management. He noted that U.S. ocean and coastal resources should be managed to reflect the relationships among all ecosystem components, including human and nonhuman species, and the environments in which they live. Applying this principle of ecosystem-based management will require defining relevant geographic management areas based on ecosystem, rather than political, boundaries. This will also require looking at all the links among living and nonliving resources, rather than considering single issues in isolation, and considering human activities, their benefits, and their potential impacts within the context of the broader biological and physical environment. The focus should be on the multiple activities occurring within specific areas that are defined by ecosystem, rather than political, boundaries. Because of the connection between land-based activities and ocean conditions, the USCOP suggested that an appropriate geographic boundary for ecosystem-based management of ocean areas might combine all or part of a large marine ecosystem with the watersheds that drain into it. Sandifer also briefly presented three specific USCOP recommendations relevant to this topic, as follows:

Rec. 5-1. The National Ocean Council should work with the Congress, the President's Council of Advisors on Ocean Policy, and state, territorial, tribal, and local leaders, including representatives from the private sector, non-governmental organizations, and academia, to develop a flexible and voluntary process for the creation of regional ocean councils. States, working with relevant stakeholders, should use this process to establish regional ocean councils, with support from the National Ocean Council.

Rec. 5-2. The President, through an executive order, should direct all federal agencies with ocean- and coastal-related functions to immediately improve their regional coordination and increase their outreach efforts to regional stakeholders.

Rec. 5-3. The President should form a task force of federal resource management agencies to develop a proposal for adoption and implementation of common federal regional boundaries. This task force should solicit input from state, territorial, tribal, and local representatives.

Objectives of NOAA's Ecosystem Goal

Dr. Douglas DeMaster, acting NOAA Ecosystem Goal Lead, summarized the primary objectives of the Ecosystem Goal as follows: one of NOAA's four primary goals is to "Protect, Restore, and Manage the Use of Coastal and Ocean Resources through an Ecosystem Approach to Management". The definition of an ecosystem is "a geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics" (NOAA Strategic Plan, 2004). An ecosystem approach to management is one that is "geographically specified, adaptive, takes account of ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse societal objectives." Implementation will need to be "incremental and collaborative" (NOAA Strategic Plan, 2004).

Because it is the intention of NOAA to manage geographically specified ecosystems, the delineation of ecosystems at least within the EEZ is necessary. This action is consistent with the preliminary and final recommendations reported by the USCOP. The primary strategy for achieving this goal is to: (1) begin a national process to delineate ecosystems through collaboration with federal, state and other partners (2) convene regional stakeholder workshops to further delineate regional ecosystems into subecoregions, to define coastal and inland boundaries that would be useful to regional stakeholders and to begin to identify key ecological, social and economic regional ecosystem indicators, and joint efforts to observe and monitor these ecosystem indicators; and (3) develop in each region, necessary steps and plans to advance ecosystem approaches to managing coastal and marine resources efforts by October 2005.

Presentation on Large Marine Ecosystems

Dr. Kenneth Sherman, NOAA's Narragansett Laboratory Director, presented marine ecosystem delineation using the "large marine ecosystem" (LME) approach. Over 20 years of work has been put into the ecosystem approach to management by Sherman and colleagues. In 1992, the UNCED Declaration recommended that nations integrate management and sustainable development of coastal areas and the marine environment. In the 2002 World Conference in Johannesburg, actual sustainability targets were agreed to by over 100 countries. A set of four ecological criteria – bathymetry, hydrography, productivity and trophodynamics – led to the designation of the world's 64 LMEs. These LMEs encompass most of the world's marine areas of high productivity, including coastal waters annually producing 95% of the world's marine fish catches.

Because coastal ecosystems are seriously degraded, funding from the World Bank and the Global Environment Facility has been available for projects linking environmental protection to resource development and sustainability. Financial resources on the order of $2.1 billion in 1994-98, $2.7 billion in 1999-2002, and $3 billion in 2002-05 have been made available. NOAA is working on the issue of international waters with UN partners. LMEs are focal areas of efforts to reduce pollution, restore damaged habitats, and recover depleted resources.

Beginning with the Northeast U. S Continental Shelf LME, five modular assessment and objectives have been developed by NOAA (Sherman et. al. 2002) for productivity (zooplankton to upper trophics), fish and fisheries, pollution and ecosystem health, socioeconomic considerations and governance. Sherman noted that the intent of delineating an ecosystem is not to change the governance or jurisdiction, but to allow for the ecological characterization of a coherent ecosystem by all parties through an established collaborative process by LME stakeholders.

Summary of Marine/Ocean Boundaries Alternatives

Dr. Pace Wilber, NOAA's Coastal Services Center, outlined several of the existing scientific and political delineation systems for ocean and coastal systems. The following options were presented to the workshop participants for their consideration: boundaries associated with Large Marine Ecosystems (LMEs) (as used by NOAA, IUCN, IOC); biogeographic regions of the National Estuarine Research Reserve System (NERRS); North American Marine Ecoregions of the North American Commission on Environmental Cooperation (CEC); boundaries established by The Nature Conservancy's (TNC) Marine Initiative Program; boundaries established by the eight regional fishery management councils; regional ocean information program areas suggested in the Preliminary Report of the USCOP; proposed regions of the Integrated Ocean Observing System; boundaries established by NOAA's National Climatic Data Center; and political boundaries used by federal agencies (e.g., NMFS, USFWS, EPA).

Wilber used real-time Geographic Information System (GIS) software and fixed maps to illustrate the various small-scale delineation options currently being used by agencies and organizations. The discussion of nested sub-regions centered on criteria that would be important to consider, e.g., how to gain stakeholder buy-in, identifying sub-regional issues/priorities, commonalities among current sub-regional divisions, and collecting and building data and maps that can be fit to any scale (spatially explicit data). Fuzzy sub-area boundaries or sub-areas defined by the spatial extent of the problem/issue may be the best way to address region-specific concerns. Wilber displayed each area of the country and led a discussion of the proposed delineation schemes' pros and cons in each region, and workshop participants noted regional variations which would influence sub-regional boundaries.

Discussion of Alternative Approaches for Delineating Regional Ecosystem and Sub-Regions

Workshop participants generally supported the use of LMEs to delineate ecosystems in the U.S. EEZ, as well as the criteria used to define boundaries for LMEs (i.e., bathymetry, hydrography, productivity and trophodynamics), although concerns were raised that fisheries issues should not be the only factor used to delineate ecoregions. Sherman led a discussion regarding the measurement of productivity for that LME criterion, and informed the workshop that primary productivity was the main component. The following LMEs were suggested as the preliminary ecosystems that could be used by NOAA in managing living marine and Great Lakes resources with an ecosystem approach to management: Beaufort Sea and Chukchi Seas in the Arctic area,

East Bering Sea, Gulf of Alaska, California Current, Insular Pacific Islands, Gulf of Mexico, Caribbean, Southeast (Atlantic) Shelf, Northeast (Atlantic) Shelf, and Great Lakes. Many participants strongly urged NOAA to address those cases in which the above delineation does not incorporate all of the EEZ. Most participants also strongly urged that these LMEs have nested sub-regions based upon regional specific criteria or needs.

Participants strongly supported the need to delineate sub-regions within each of the LMEs; however no single approach was overwhelmingly supported. Several approaches were noted among the workshop participants during discussion of LME application to specific regions. For example, the Insular Pacific Hawaiian Islands LME as described in scientific literature does not include Guam, American Samoa, Commonwealth of the Northern Marianas Islands (CNMI), Johnston Island, Wake Island, Fiji, Tahiti, and other islands. The Pacific Island region may consist of several ecosystems that are managed as a "regional complex" of ecosystems. Similarly, the state of Alaska has four LMEs off of its coasts: Beaufort Sea, Chukchi Sea, East Bering Sea, and Gulf of Alaska. Alaska would likely be formed into a regional complex of several LMEs for management purposes, but assessment of observations and other data would occur by ecosystem. Several regional ecosystems – Gulf of Alaska, California Current, Gulf of Mexico, Caribbean - would require international cooperation in order to achieve an ecosystem approach to management.

There was general support for sub-regions to be delineated using approaches such as those reported by NERRS, NACEC or TNC, and also support for the boundaries to remain flexible so that specific issues can be addressed effectively. Sub-region delineation should take regional specific criteria into account, such as biogeography, state and other jurisdictional boundaries and authorities. There was agreement that sub-region delineation should primarily be the responsibility of the stakeholders in each region, and that this should be one of the priority tasks assigned to regional stakeholders.

Dr. John Sibert, Pelagic Fisheries Research Program – University of Hawaii, gave a presentation on the Western Pacific Perspective on Marine Ecosystems. Sibert described the areas included in the U.S. EEZ in the Pacific Ocean, which are spread over expansive distances. He also outlined the Fishery Management Plans prepared by the Western Pacific Fishery Management Council, oceanographic phenomena such as currents, transition zones and seasonal differences in temperature, as well as alternate classification schemes for regional management in the Pacific.

Inland Boundaries

Mr. Dan Farrow, NOS Special Projects Division Chief, presented options for inland boundaries to be considered and discussed: (1) Coastal Assessment Framework (CAF), (2) coastal component of Coastal Assessment Framework (i.e., Estuarine and Coastal Drainage Areas), (3) inland extent of diadromous fish, (4) head of tide (or first obstruction preventing fish passage upstream), and (5) coastal component of Coastal Assessment Framework and watersheds containing inland extent of diadromous fish (i.e., a combination of options 2 and 3).

The Coastal Assessment Framework (CAF) consists of watershed units called Estuarine Drainage Areas, Fluvial Drainage Areas, Coastal Drainage Areas, and Fluvial components of Coastal Drainage Areas. An Estuarine Drainage Area (EDA) is that component of an estuary's entire watershed that empties directly into the estuary and is affected by tides. Every EDA has both a land and a water component. A Coastal Drainage Area (CDA) is as that component of an entire watershed that meets the following three criteria: 1) it is not part of any EDA or a corresponding FDA; 2) it drains directly into an ocean, an estuary, or the Great Lakes; and 3) it is composed only of the downstream-most Hydrologic Unit Codes in which the head-of-tide is found. A Fluvial Drainage Area (FDA) is that component of an estuary's entire watershed upstream of the EDA boundary. It was noted that less than half the EDAs have corresponding FDAs. FDAs have land components only. The Fluvial component of a Coastal Drainage Area (FCDA) is that component of a coastal watershed that lies "upstream" of the CDA boundary. Like FDAs, FCDAs only have a land component. The CAF is already worked out, is comprehensive, and is useful to many users. However, the framework needs updating and would be expensive.

Ms. Katherine Lins, U.S. Geological Service, presented the Watershed Boundary Dataset (WBD), a standard set of hydrologic unit datasets held by NRCS. The selection and delineation of hydrologic boundaries are determined solely upon science-based hydrologic principles for surface water flow, not favoring any political boundary. Watershed Boundaries provide an important dataset interoperable with other geospatial data necessary for a watershed approach to managing land. Currently a multi-agency effort is underway to further divide sub-basins into watersheds and sub-watersheds, including in coastal areas.

Ms. Debra Hernandez, Chair, Coastal States Organization and Director, Program and Policy Development for the South Carolina Office of Ocean and Coastal Resource Management, presented the state perspective and needs with regard to a regional ecosystem approach to management. The lessons learned from dealing with coastal non-point source pollution are that federal agencies must truly partner with the states. Hernandez noted that states are likely to cooperate with Federal agencies in the development and delineation of regional ecosystems and ecosystem approaches, if the needs and priorities of the states are fully considered in the effort. The purposes of the eco-region delineations and approaches need to be clearly communicated and demonstrably useful to states. For regional ecosystem approaches to management, the state participation will likely be initiated when the discussion on information use begins.

Summary of Inland Boundary Discussion

Some participants strongly supported the need to incorporate inputs to coastal marine ecosystems and the Great Lakes ecosystem from entire watersheds (Option 1). They noted that a management strategy that did not include all possible sources of pollutants and nutrients would fail to adequately protect, restore, and manage the coastal marine and Great Lakes ecosystems. Other participants strongly supported a multiple option approach, where the focus would primarily be on the coastal component of the watershed plus the actual inland extent of diadromous fish habitat (Option 5). It was generally agreed that the inland extent of diadromous fish habitat could also be left to the discretion of the region. There was general agreement that

Option 5 would provide adequate observation and assessment of areas which have an influence on marine ecosystems.

Workshop participants recognized that a long term goal of incorporating inputs from the entire watershed was desirable. However, such an approach would likely be very difficult to implement in the near future. Some concerns were expressed, particularly by state representatives that the purposes for inland ecosystem boundary delineations needed to be very clearly and carefully defined, with specific consideration given to the practical values they could bring to states.

Workshop participants also supported the concept of incorporating influences and inputs from regional weather patterns (referred to as "airsheds"). This issue, associated with short and long range atmospheric transport of pollutants across or between ecoregions, was raised several times by workshop participants. Participants strongly supported the incorporation of atmospheric transport issues into the regional ecosystem management framework.

Summary of Workshop and Next Steps

Workshop participants generally agreed with the use of LMEs as a starting point for the delineation of marine and coastal ecosystems, although the exact boundaries should remain fuzzy in order to be responsive to regional issues. The coastal watershed approach augmented by diadromous fish habitat (and potential future inclusion of fluvial drainage areas to deal with non-point source pollution) was generally acceptable to workshop participants as the preferred starting point for the inland aspect of coastal ecosystem delineation; however, no specific consensus was reached.

A number of follow-up actions were identified by or suggested to workshop participants. These included:

(1) Finalize the Technical Report and develop a Summary Report of the workshop. Participants were asked to provide comments on the technical report to the Working Group by September 10th. A detailed summary of the workshop will be prepared by NOAA and submitted to the workshop attendees for review (with a two-week comment period) and finalized by December. A final report, including the detailed summary, will be published as a NOAA Report by the end of the year and circulated to all participants, as well as being made available on the website of the Ecosystem Goal Team.

(2) Develop a process in the context of the response to the Final Report of the U.S. Commission on Ocean Policy to solicit support/input among appropriate Federal, Regional, State, and local agencies regarding whether the augmented LME approach suggested by this Workshop is an appropriate tactic for the Administration to implement the Commission's recommendations for an ecosystem approach to managing coastal, ocean and Great Lakes resources.

(3) Identify a NOAA employee who will be assigned to each of the ten Regional Ecosystems identified to provide liaison with other Federal, regional, State, and local stakeholders, ensure

ongoing communication and collaboration as the process of ecosystem delineation continues, and facilitate regional stakeholder workshops.

(4) Agree on the critical need to convene by 2005 regional workshops of key stakeholders to identify regional priorities and important ecological, social and economic indicators of ecosystem status. In addition, regional workshop participants might identify potential pilot programs that could serve, if successful, as model programs for other regions.

(5) Provide leaders of the Integrated Ocean Observing System Program with detailed information regarding each of the proposed Regional Ecosystems and related coastal areas, emphasizing a prioritized list of monitoring needs.

(6) Identify and define areas of geographic importance for those segments of the marine environment that occur outside of a Regional Ecosystem, but inside the U.S. EEZ. Define, by region, the inland extent of diadromous fish habitat.

(7) Develop in each region, necessary steps and plans to advance ecosystem approaches to managing coastal and marine resources efforts.