# Pathway To Sustainable Development of the World's Large Marine Ecosystems

**Dr. Kenneth Sherman**

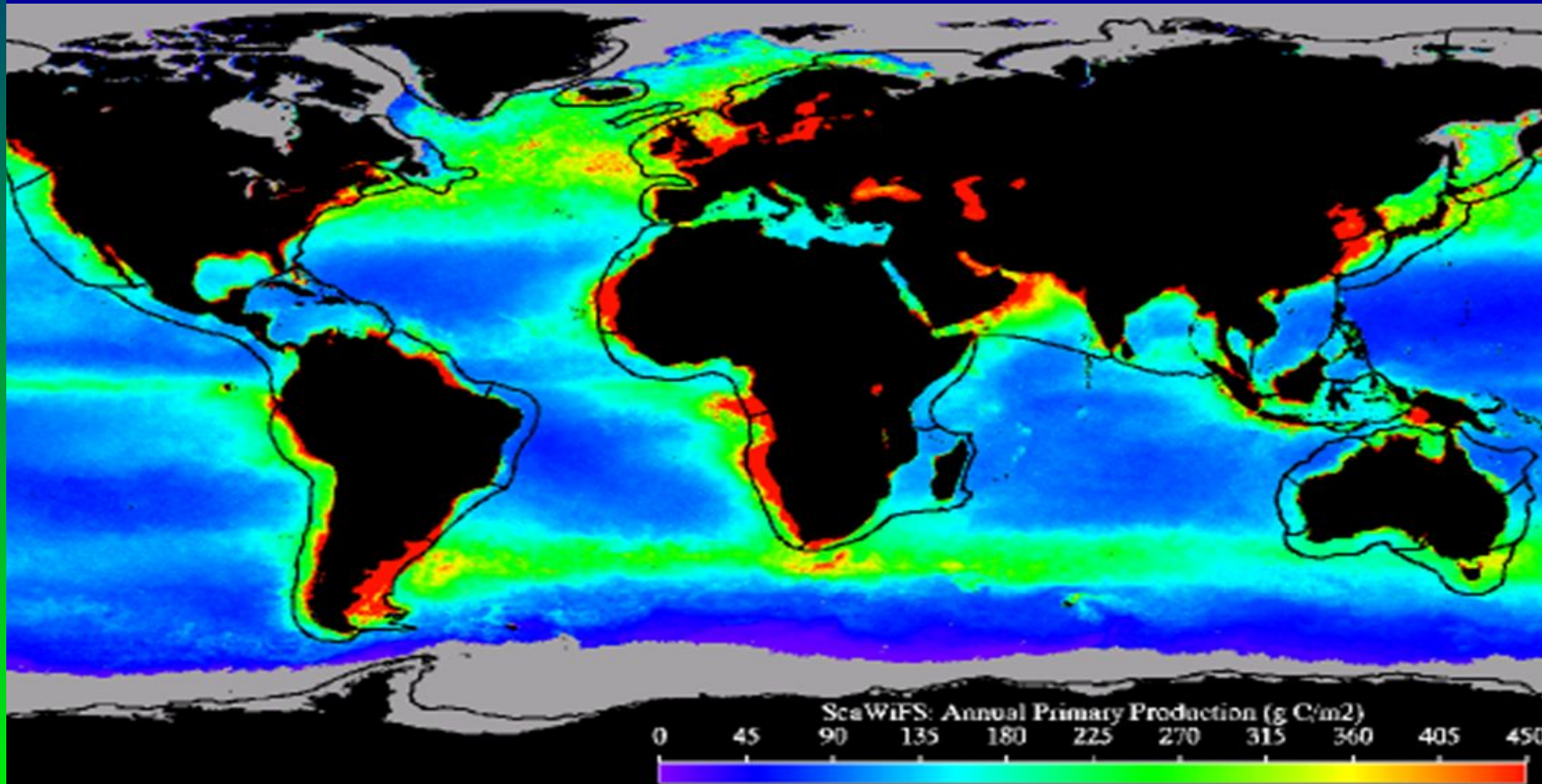**Coastal Resources Center/Graduate School of Oceanography/University of Rhode Island**
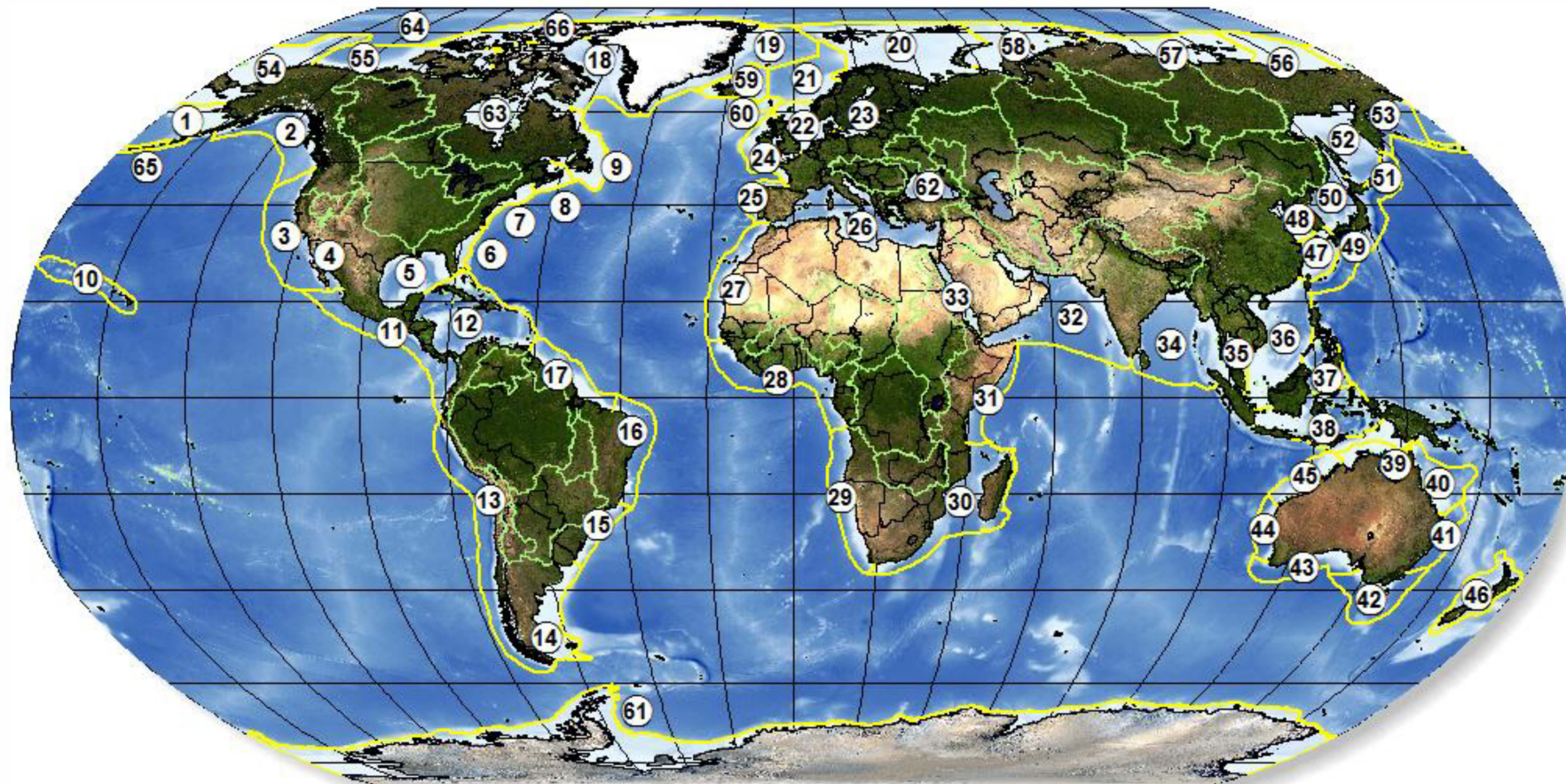
**HIGHLY PRODUCTIVE LMEs**
**80% of the World's Marine Fisheries Catches**
**are produced in LMEs.**
**LMEs contribute $27.7 trillion annually in ecosystem**
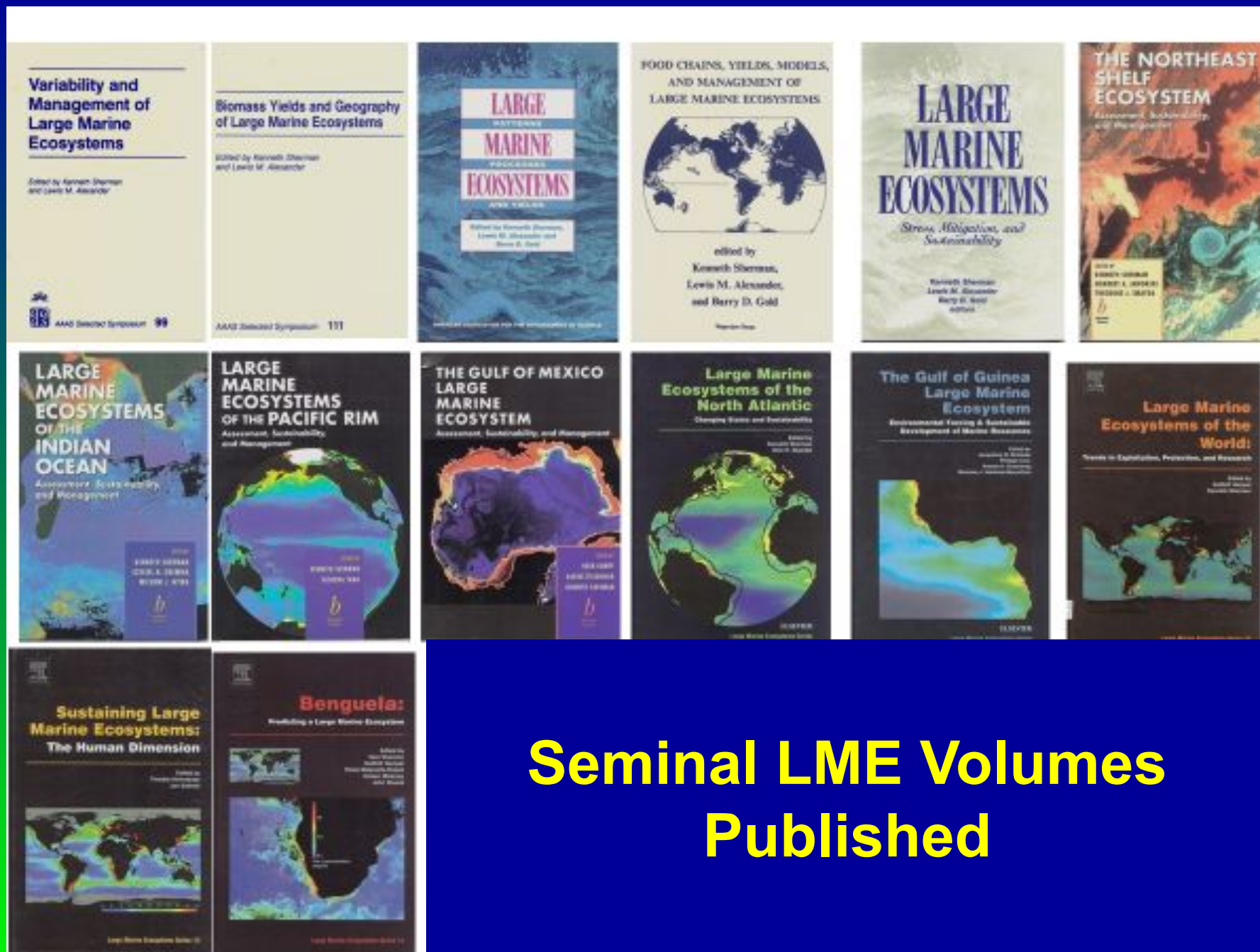**services to the global economy**

SeaWiFS: Annual Primary Production (g C/m2)

0   45   90   135   180   225   270   315   360   405   450

# Large Marine Ecosystems of the World and Linked Watersheds



1. East Bering Sea
2. Gulf of Alaska
3. California Current
4. Gulf of California
5. Gulf of Mexico
6. Southeast U.S. Continental Shelf
7. Northeast U.S. Continental Shelf
8. Scotian Shelf
9. Newfoundland-Labrador Shelf
10. Insular Pacific-Hawaiian
11. Pacific Central-American
12. Caribbean Sea
13. Humboldt Current
14. Patagonian Shelf

15. South Brazil Shelf
16. East Brazil Shelf
17. North Brazil Shelf
18. Canadian Eastern Arctic - West Greenland
19. Greenland Sea
20. Barents Sea
21. Norwegian Sea
22. North Sea
23. Baltic Sea
24. Celtic-Biscay Shelf
25. Iberian Coastal
26. Mediterranean
27. Canary Current

28. Guinea Current
29. Benguela Current
30. Agulhas Current
31. Somali Coastal Current
32. Arabian Sea
33. Red Sea
34. Bay of Bengal
35. Gulf of Thailand
36. South China Sea
37. Sulu-Celebes Sea
38. Indonesian Sea
39. North Australian Shelf
40. Northeast Australian Shelf
41. East-Central Australian Shelf

42. Southeast Australian Shelf
43. Southwest Australian Shelf
44. West-Central Australian Shelf
45. Northwest Australian Shelf
46. New Zealand Shelf
47. East China Sea
48. Yellow Sea
49. Kuroshio Current
50. Sea of Japan/East Sea
51. Oyashio Current
52. Sea of Okhotsk
53. West Bering Sea
54. Northern Bering-Chukchi Seas

55. Beaufort Sea
56. East Siberian Sea
57. Laptev Sea
58. Kara Sea
59. Iceland Shelf and Sea
60. Faroe Plateau
61. Antarctic
62. Black Sea
63. Hudson Bay Complex
64. Central Arctic Ocean
65. Aleutian Islands
66. Canadian High Arctic-North Greenland

**Seminal LME Volumes Published**

4

# LMEs and UN Movement towards Sustainable Ocean Development

## LME Volumes

450 Authors

American Association for the Advancement of Science, 4 vols. 1986-1993

Blackwell Science, 4 vols. 1996-1999

Elsevier Science, 5 vols. 2002-2006

390 Marine Journal Articles. 1996-2016

## United Nations

UNCED 1992

WSSD 2002  EBM support

2012 Rio +20  EBM support

2015 SDG 14  EBM support


14 LIFE BELOW WATER


United Nations


1992 UNCED Logo


RIO+20
United Nations Conference on Sustainable Development

# 5 MODULES WITH INDICATORS



**Modular Assessments for Sustainable Development**

**PRODUCTIVITY MODULE INDICATORS**
Photosynthetic activity
Zooplankton biodiversity
Oceanographic variability
Zooplankton biomass
Ichthyoplankton biodiversity

**POLLUTION & ECOSYSTEM HEALTH MODULE INDICATORS**
Eutrophication
Biotoxins
Pathology
Emerging disease
Health indices
Multiple marine ecological disturbances

**SOCIOECONOMIC MODULE INDICATORS**
Integrated assessments
Human forcing
Sustainability of long-term socioeconomic benefits

**FISH & FISHERIES MODULE INDICATORS**
Biodiversity
Finfish
Shellfish
Demersal species
Pelagic species

**GOVERNANCE MODULE INDICATORS**
Stakeholder participation
Adaptive management

POLLUTION & ECOSYSTEM HEALTH

FISH & FISHERIES

PRODUCTIVITY

SOCIOECONOMICS

GOVERNANCE

**110 Participating Countries**
**22 LMEs with GEF Supported EBM**
**Projects since 1994**
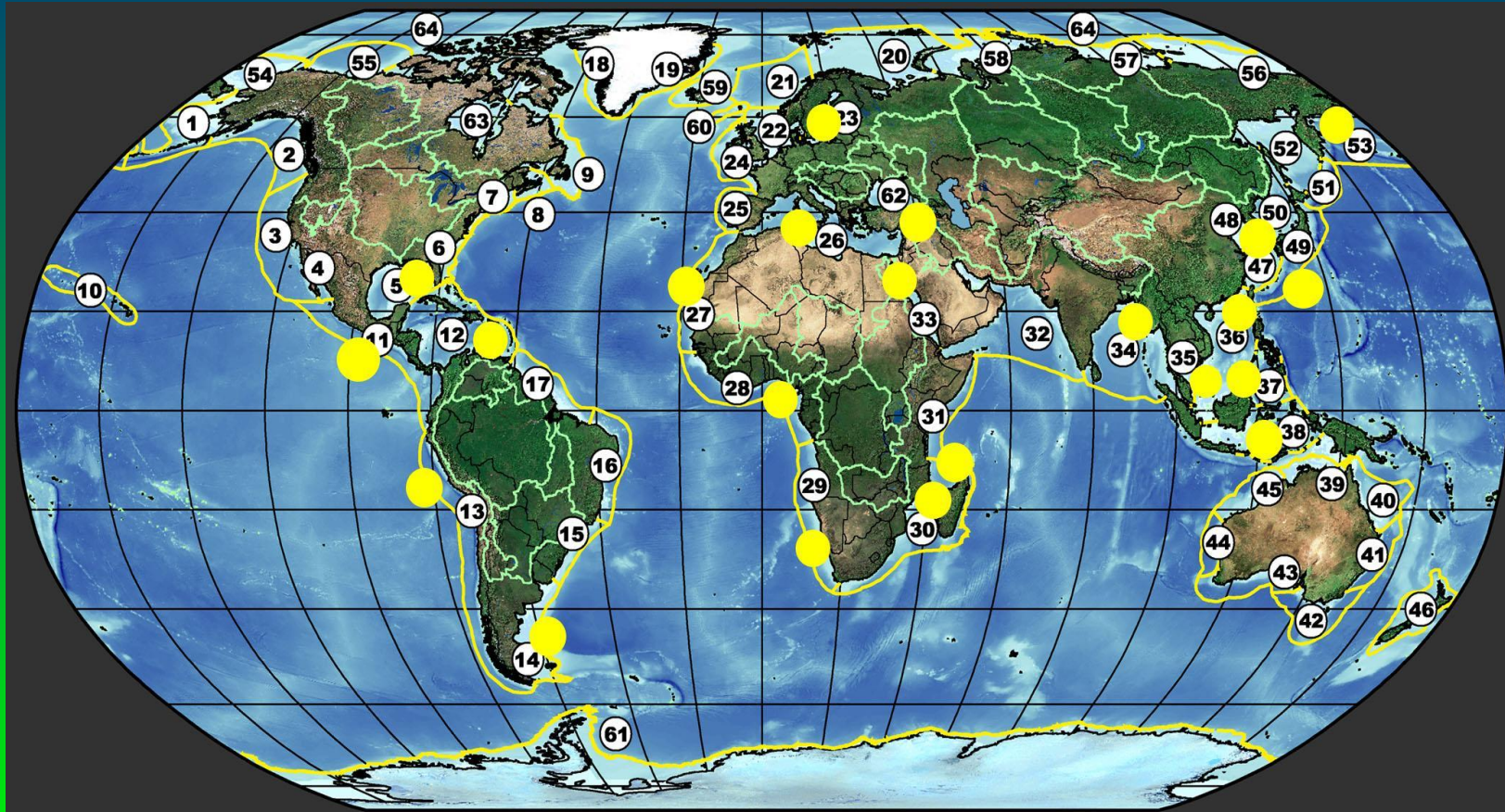
# Engaging with partners

- **5 UN Agencies**
  - UNDP
  - UNEP
  - UNIDO
  - FAO
  - IOC UNESCO
- **2 NGOs**
  - IUCN
  - WWF
- **2 Global Financial Institutions**
  - Global Environment Facility
  - World Bank
- **4 OECD Countries-U.S, Norway, Sweden, Germany**

# Invited N.K Panikkar Lecture for 2023 IOC-UNESCO Assembly
# June 23rd, 2023
# IOC-UNESCO, Paris

**Dr. Kenneth Sherman**

**Coastal Resources Center/Graduate School of Oceanography/University of Rhode Island**



# Pathway To Sustainable Development of the World's Large Marine Ecosystems

# U.N Honors Rhode Island Oceanographer

Dr Kenneth Sherman, adjunct Professor of Oceanography, Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island, received the N.K. Panikkar Memorial Medal, following his invited lecture on Large Marine Ecosystems delivered to the 32nd Annual Ocean Assembly of the United Nations Educational, Scientific, and Cultural Organization, on 23 June. His lecture was entitled, "Pathway to Sustaining the World's Large Marine Ecosystems". The lecture describes the approach to the assessment and management of coastal ocean marine resources within the spatial domains of the world's Large Marine Ecosystems, or LMEs, located along the margins of the continents. Each year the LMEs produce 80% of the world's marine fisheries catch and contribute an estimated 27.7$ trillion in ecosystem-services annually to the global economy.

The LME concept was developed by Dr. Sherman in collaboration with his former colleague, now deceased, Professor Lewis Alexander of the University of Rhode Island in the mid-1980s. During the past 39 years, the LME approach has successfully applied a 5-module series of natural science and social science indicators of changing conditions of LME 1. Productivity 2. Fish and Fisheries 3. Pollution and Ecosystem Health 4. Socio-economics and 5. Governance.

Dr. Sherman was awarded the medal in recognition of the contributions he made in leading a global effort for the implementation of LME assessment and management programs underway in 125 economically developing countries in Africa, Asia, Latin America, and eastern Europe. Since 1995, an international financial institution, the Global Environment Facility

(GEF), has provided $6.01 billion in catalytic financial assistance to support LME programs in developing countries for reducing human and natural stressors on sustainable development of marine resources.

Scientific and technical assistance is being provided to these LME programs by 5 United Nations agencies, United Nations Development Program UNDP,  United Nations Environment Program UNEP, United Nations Industrial Development Organization UNIDO, United Nations Food and Agriculture Organization UNFAO, and the Intergovernmental Oceanographic Commission of the United Nations Education Scientific and Cultural Organization IOC-UNESCO, and 4 countries with advanced economies including, the United States (NOAA-Fisheries), Norway (NORAD), Sweden (SIDA), and Germany (ZMT).

The lecture was transmitted from Rhode Island to the U.N Ocean Assembly, via video, followed by a question and answer session with the Assembly participants', conducted via zoom. The United States Representative to the Assembly, Nicole Leboeuf, assistant administrator of NOAA, received the medal on behalf of Dr. Sherman.

# Pathway To Sustainable Development of the World's Ocean's

Thank you, Executive Secretary Ryabinin, for your kind and generous introduction.

Distinguished members of the 2023 IOC-UNESCO Assembly, I am pleased to join you via video as the presenter of the N.K. Panikkar Memorial Lecture. I am honored and humbled to also be the recipient of the 2023 Panikkar Medal. The title of my lecture is, Pathway to Sustainable Development of the World's Large Marine Ecosystems'',

I have had a full and eventful 60-year career with the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA) as an ocean researcher, beginning in 1960. Throughout my career, I was a proponent of fulfilling the need for strengthening links between social scientists and natural scientists supporting mitigation actions for reducing human and natural stressors on coastal ocean resources.

It has been said that a pathway to success in business is to define a need and fill it. The same can be said for scientific advances.

In the case of the need for strengthening the linkages between social and natural marine sciences, the Large Marine

Ecosystem (LME) approach has proven most useful as an ecologically defined, large area of ocean space designated for sustainable development of ocean resources. The LMEs are located along the margins of the continents. Their boundaries have been defined on the basis of ecological criteria, including bathymetry, hydrography, productivity ($gCm^{2-y}$), and trophic interactions. The LMEs annually produce 80% of the world's marine fisheries catch and contribute an estimated $27.7 trillion in ecological services annually to the global economy.

The LME approach to the assessment and management of coastal ocean goods and services was conceived in 1983 by myself and my colleague Professor Lewis Alexander of the University of Rhode Island (URI). At the time, as a natural scientist for NMFS-NOAA, I was leading a large-scale assessment of the interactions among plankton, fisheries, and oceanography for the entire U.S. northeast continental shelf. Professor Alexander, as a social scientist, was serving as Director of the Marine Affairs Graduate Program and Director of The Law of the Sea Institute at URI. He also had recently returned to URI from a two-year appointment as the U.S. Department of State Geographer.

From a preliminary analysis of the plankton, fisheries, oceanographic data for the northeast shelf, I concluded that the entire spatial domain of the shelf from the Gulf of Maine, south to Cape Hatteras, and from the mouths of the estuaries to the edge of the shelf, was functioning as a Large Marine Ecosystem or LME. I discussed the prospect of other large coastal areas around the globe as potential LMEs designated for the assessment and management of LME goods and services.

From a social scientist's perspective, Professor Alexander agreed that such an approach would be timely and legal under the terms of the Convention of Law of the Sea. It became clear from our discussion that a network of global LMEs could serve to strengthen the linkages between social science and natural science methodologies in support of ecosystem-based management of coastal ocean goods and services.

Following our discussions at the inception of the LME approach, we decided to extend the dialogue on the LME concept with other scientists participating in research and assessment activities in support of reducing stressors caused by rapid expansion of marine economies, including fisheries energy, transportation, recreation, and mining in the 1960s and 1970s, resulting in increasing overfishing, pollution, nutrient over-enrichment, introduction of non-indigenous species, acidification, biodiversity loss, and habitat degradation.

Given the high level of interest expressed by our colleagues in LMEs, we convened a symposium to introduce the concept of LMEs to the scientific community at-large at the Annual Meeting of the American Association for the Advancement of Science in 1984. The Symposium was well attended by natural scientists and social scientists with specialties in fisheries, pollution, economics, law, marine policy, and marine resources management. Following the Symposium, we were invited by the AAAS to edit the Symposium results for publication in the AAAS Selected Symposium Series. We accepted, and under the title, "Variability and Management of Large Marine Ecosystems," the volume was published by AAAS in 1986.

Following publication of the volume, interest in the LME approach increased significantly, prompting us to convene LME symposia during annual meetings of the AAAS in Boston, Chicago, and Seattle and workshops and conferences on LMEs in South Africa, Namibia, People's Republic of China, Indonesia, and Mexico.

Between 1986 and 2016, a total of 18 peer-reviewed volumes of LME assessment and management results were published by AAAS (4 vols), Westview Press (1 vol), Blackwell Science (4 vols), Elsevier Science (5 Vols), UNDP (2 vols), IUCN (2 vols), and 300 journal articles. An annotated bibliography of these publications was published and is available on the NOAA website.

To further encourage collaboration in LME assessment and management practices between natural scientists and social scientists, we adopted a five-module series of indicators for monitoring and assessing changes in LME conditions, including productivity (gCm$^{2-y}$), fish and fisheries, pollution and ecosystem health, socioeconomics, and governance.

In 1993, I was contacted by the Global Environment Facility (GEF), requesting scientific and technical assistance in expanding a ports development project in the Republic of Korea into a full-scale Large Marine Ecosystem program for monitoring and assessing the goods and services of the Yellow Sea Large Marine Ecosystem to be carried forward by the Republic of Korea and The People's Republic of China. Following this query, I was contacted by the United Nations Development Program (UNDP), seeking scientific and technical assistance for expanding a pollution control project in the Gulf of Guinea into an LME pilot program to be conducted by six countries - Nigeria, Ghana, Ivory

Coast, Cameroon, Benin, and Togo. This pilot was later expanded to a 16-country GEF-supported LME program over the entire spatial dimension of the Guinea Current Large Marine Ecosystem, from Guinea Bissau in the northwest to Angola in the southwest.

Authorization was given by NOAA headquarters to provide the requested assistance contingent on approval by the appropriate NMFS Science Centers, including the Director of the Southeast Fisheries Science Center for the Gulf of Guinea program and the Director of the Alaska Fisheries Science Center in the case of the Yellow Sea LME program.

In 1995, the GEF included in its Operational Plan, Large Marine Ecosystems as one of the five international water bodies, including rivers, lakes, groundwater, open ocean, and LMEs, suitable for GEF financial assistance to economically developing countries undertaking environmental improvement programs.

Inclusion of the LMEs in the GEF's Operational Plan widened the pathway to sustainable development of the world's LMEs.

By 2019, a total of 110 countries were participating in 22 GEF-supported LME programs in Asia, Africa, Latin America, and Eastern Europe, with $6.01 billion in catalytic financial support from the GEF.

I observed two breakthrough innovations by the GEF as key to advancing towards sustainable development of LMEs. The first innovation provides for up to 12 months of financial support for countries applying for LME program assistance to submit a

Transboundary Diagnostic Analysis (TDA) for prioritizing through consensus a list of actions for reducing stress and promoting development of LME goods and services. The TDA document is prepared by a cadre of scientists, technicians, and resource managers representing each of the participating countries, providing a bottom-up approach to program planning.

The second GEF innovation requires the preparation by participating countries a 4-year Strategic Action Program (SAP) for operationalizing the priority actions in the TDA.
Preparation of the SAP is also accomplished with the participation of scientists, technicians, and managers engaged in marine resources assessment and management from each of the participating countries, thereby continuing the bottom-up approach to program development. For approvals by the GEF of the TDA and SAP, participating countries are encouraged to seek approval from the ministries, represented by the priority issues (e.g., fisheries, pollution, energy, transportation, and mining) identified in the TDA, providing a top-down and bottom-up country-driven program proposal process.

The successful planning and implementation of GEF-supported LME programs has been made possible through strong collaboration amongst a number of cooperating organizations providing scientific and technical assistance to participating economically developing countries.

Five United Nations agencies serve as either GEF program executing or implementing agencies: U.N Development Program (UNDP), U.N Environment Program (UNEP), U.N Industrial Development Organization (UNIDO), U.N Food and Agricultural Organization (UNFAO), and the Intergovernmental

Oceanographic Commission of UNESCO. Financial assistance is provided by both the GEF and The World Bank. Considerable outreach activity is supplemented by two Non-Governmental Organizations (NGOs), The International Union for the Conservation of Nature (IUCN) and The World Wildlife Fund (WWF). Four countries with advanced economies are also providing scientific and technical assistance to LME programs, including, The United States (NOAA-NMFS), Norway (NORAD), Sweden (SIDA), and Germany (ZMT).

The LME approach aligns very well with the merging United Nations ocean policy as adopted by the General Assembly in 2015 for supporting the goal for achieving sustainable development practices for the oceans by 2030 and as stated in the U.N declaration for 2021-2030, as The Decade of Ocean Science for Sustainable Development. In addition, the U.N. support for an ecosystem approach to achieve sustainable development of the oceans is underscored by the recommendations of the U.N UNCED+20 conference convened in Rio De Janeiro in 2012.

NOAA recognized the importance of the LME approach by designating it as one of the ten most important scientific breakthroughs in its 200-year history since being established as the coast survey by President Thomas Jefferson in 1808, as described on NOAA's website commemorating its 200-year Anniversary Celebration in 2008.

In keeping with the theme of ocean science capacity building, education, and training, as represented by the Panikkar medal, the LME approach has provided opportunities for advancing professionally for thousands of scientists,

technicians, and resource managers from developing countries around the globe. In this regard, I should like to note that the Coursera Platform has made available, free of charge, a self-learning six-week course titled "Large Marine Ecosystem's Assessment and Management," the LME "learners," successfully completing the Course can receive certification of course completion from the University of Cape Town.

In 2021, the Scientific Committee for Protection of the Environment (SCOPE) published a 694-page ebook on LME assessment and management best practices titled "Ocean Sustainability Assessing and Managing the World's Large Marine Ecosystems." It is available, free of charge, on request from the IW:LEARN website.

In conclusion, I am privileged to have had the opportunity to observe at first hand the huge intellect and energies of hundreds of individuals around the world that have focused their talents to improving our human condition. To meet with them personally in their home countries in Africa, Asia, Latin America, and Eastern Europe leads me to recognize the collective power for overcoming environmental challenges. It has been and continues to be that this energy exerted by individual human activity is for the benefit of us all.