Large Marine Ecosystem Models of Indicator Assessment

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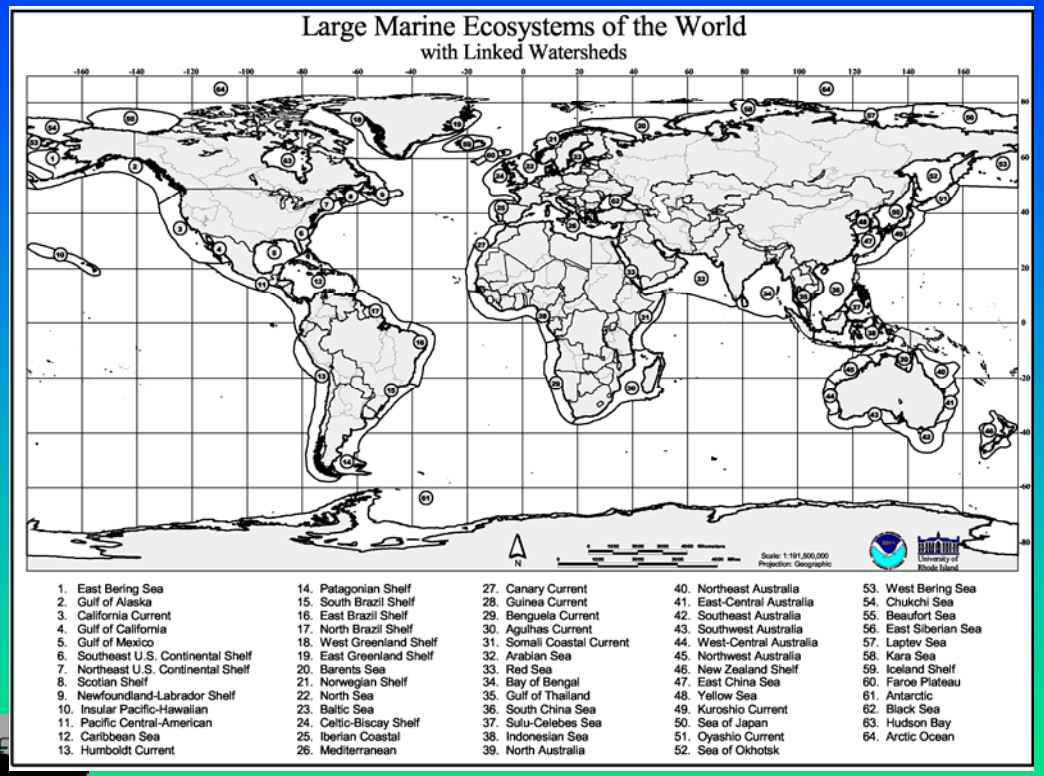
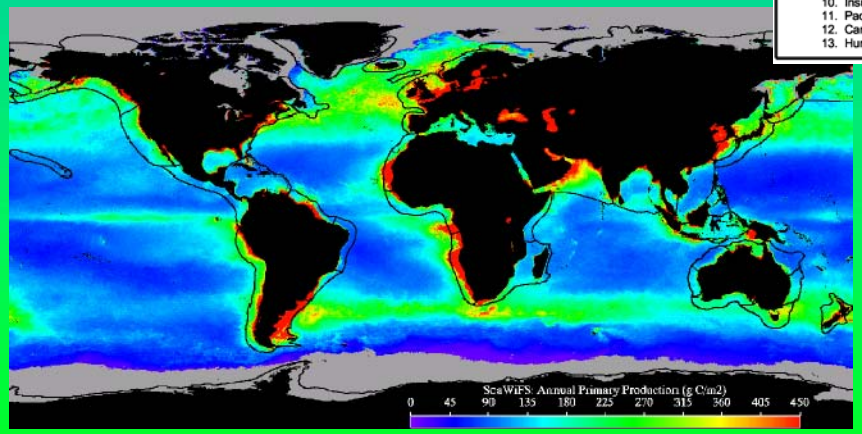
ECOLOGICAL CRITERIA USED TO DETERMINE AREAL EXTENT OF LMES:

- Bathymetry
- Hydrography
- Productivity
- Trophodynamics

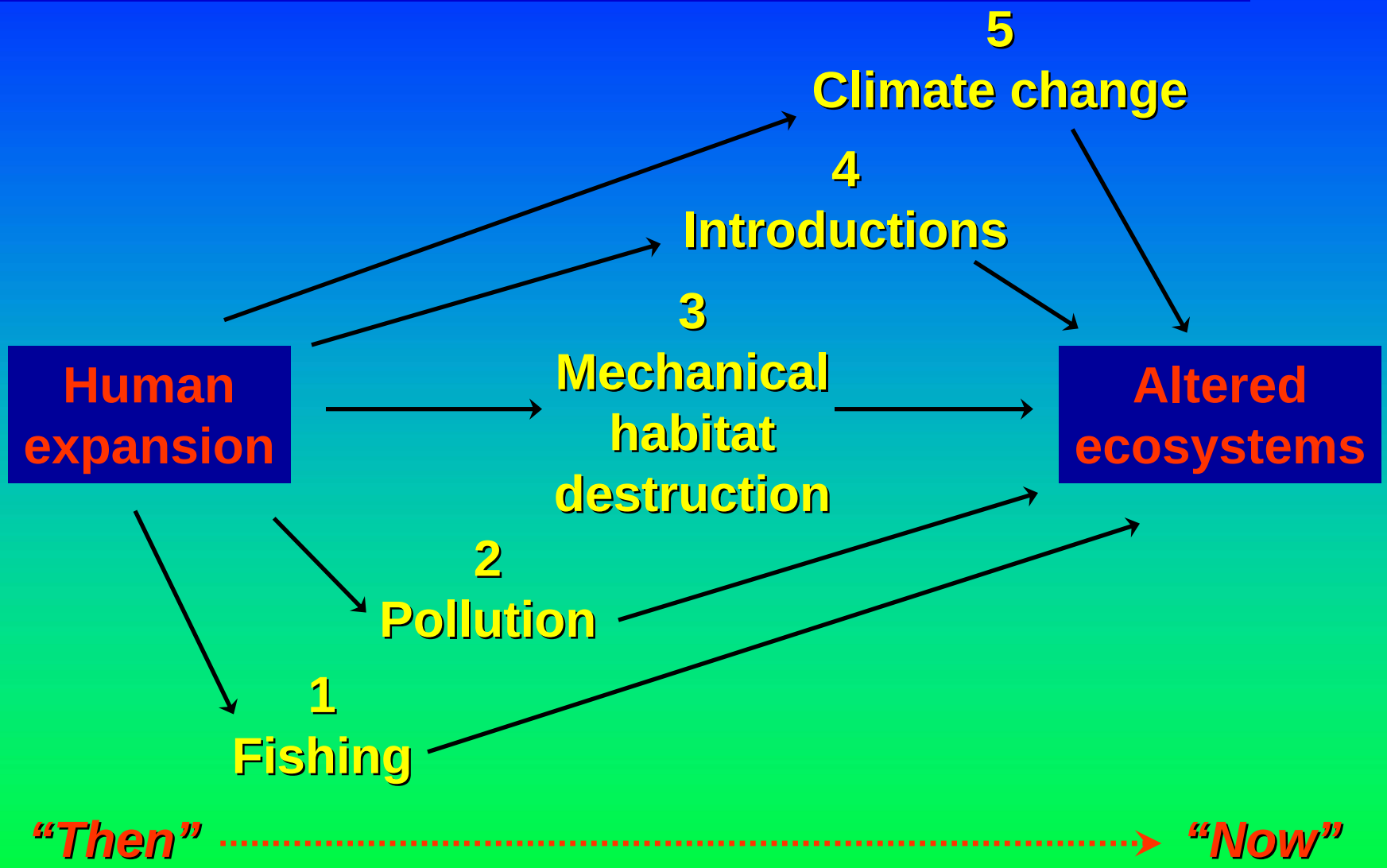
THE WORLD'S 64 LMES



95% of the World's Annual Marine Fishery Catches are Produced in 64 LMEs



PRINCIPAL CAUSES OF LME DEGRADATION



(from Jackson *et al*., *Science* vol. 293, 27 July 2001)

LMEs ARE GLOBAL CENTERS OF EFFORTS TO:

- **REDUCE** coastal pollution
- **RESTORE** damaged habitats
  (Coral reefs, mangroves, sea grasses)
- **RECOVER** depleted fishery stocks

Global Environment Facility (GEF) LME projects in support of United Nations Environment Programme (UNEP) Regional Seas Programme

- Integrate land-based sources of pollution Project activities with LME modular assessment strategy
- From $650 million to $1.8 billion
- + $200 million (Sub-Sahara World Bank Fisheries Grants and Loans)
- Total: $2 billion

INDICATORS OF CHANGING ECOSYSTEM STATES:

Productivity

Fish and Fisheries

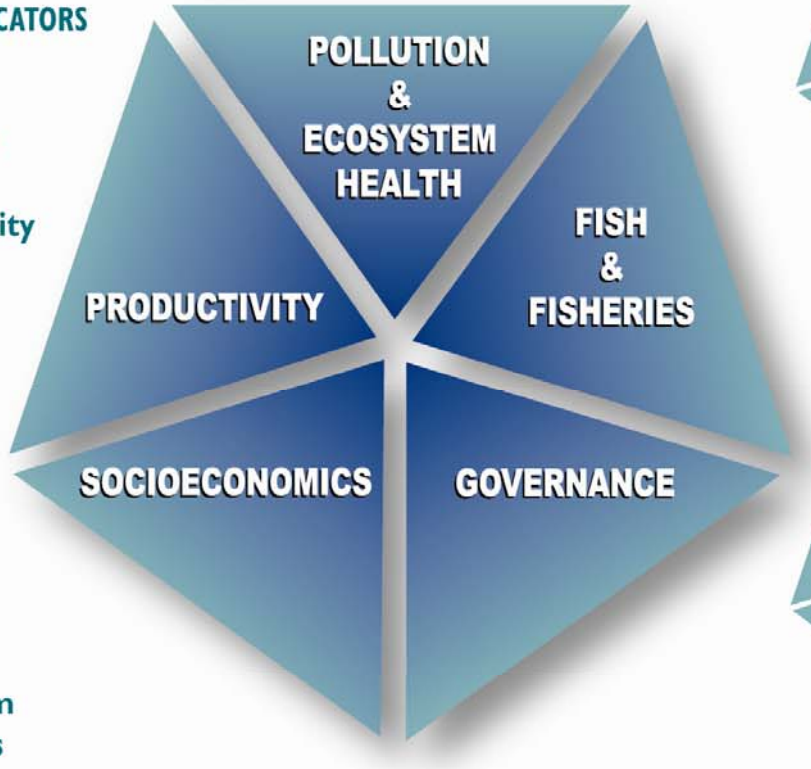
Pollution

Socioeconomic

Governance

5 MODULES WITH INDICATORS

Modular Assessments for Sustainable Development



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

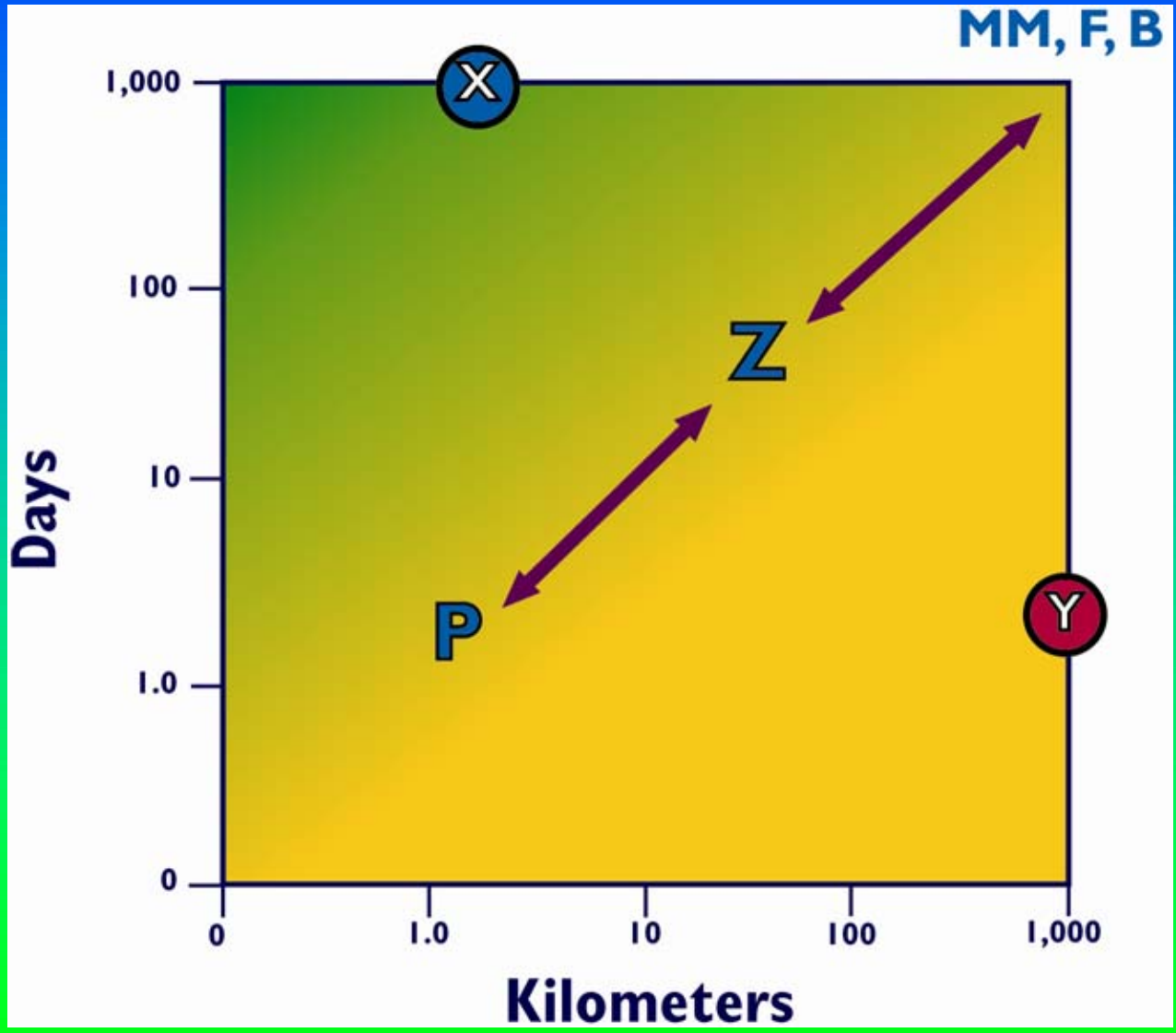
POLLUTION & ECOSYSTEM HEALTH MODULE INDICATORS
- Eutrophication
- Biotoxins
- Pathology
- Emerging disease
- Health indices
- Multiple marine ecological disturbances

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

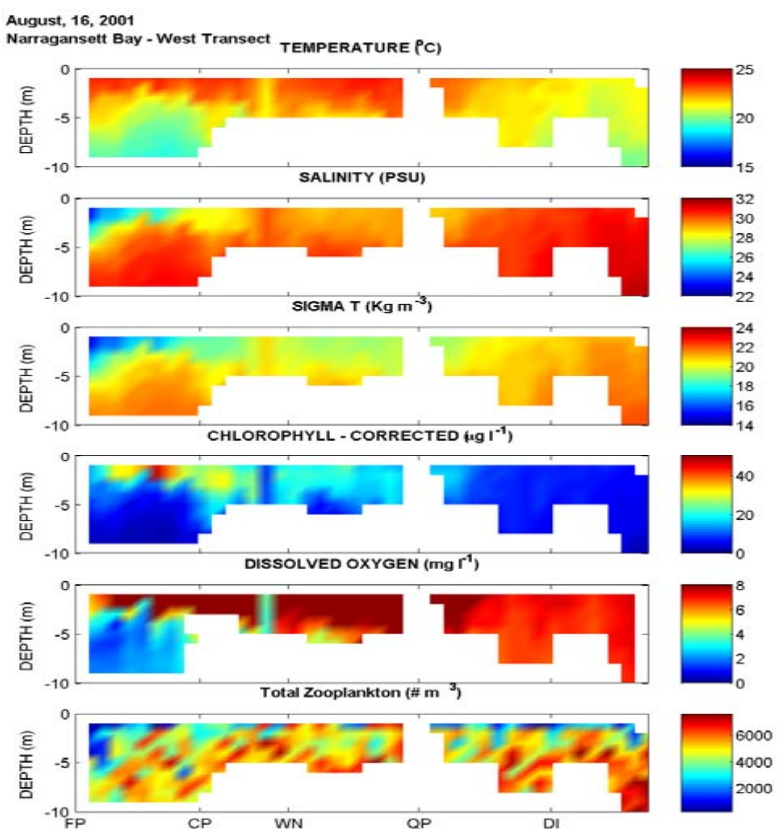
FISH & FISHERIES MODULE INDICATORS
- Biodiversity
- Finfish
- Shellfish
- Demersal species
- Pelagic species

GOVERNANCE MODULE INDICATORS
- Stakeholder participation
- Adaptive management

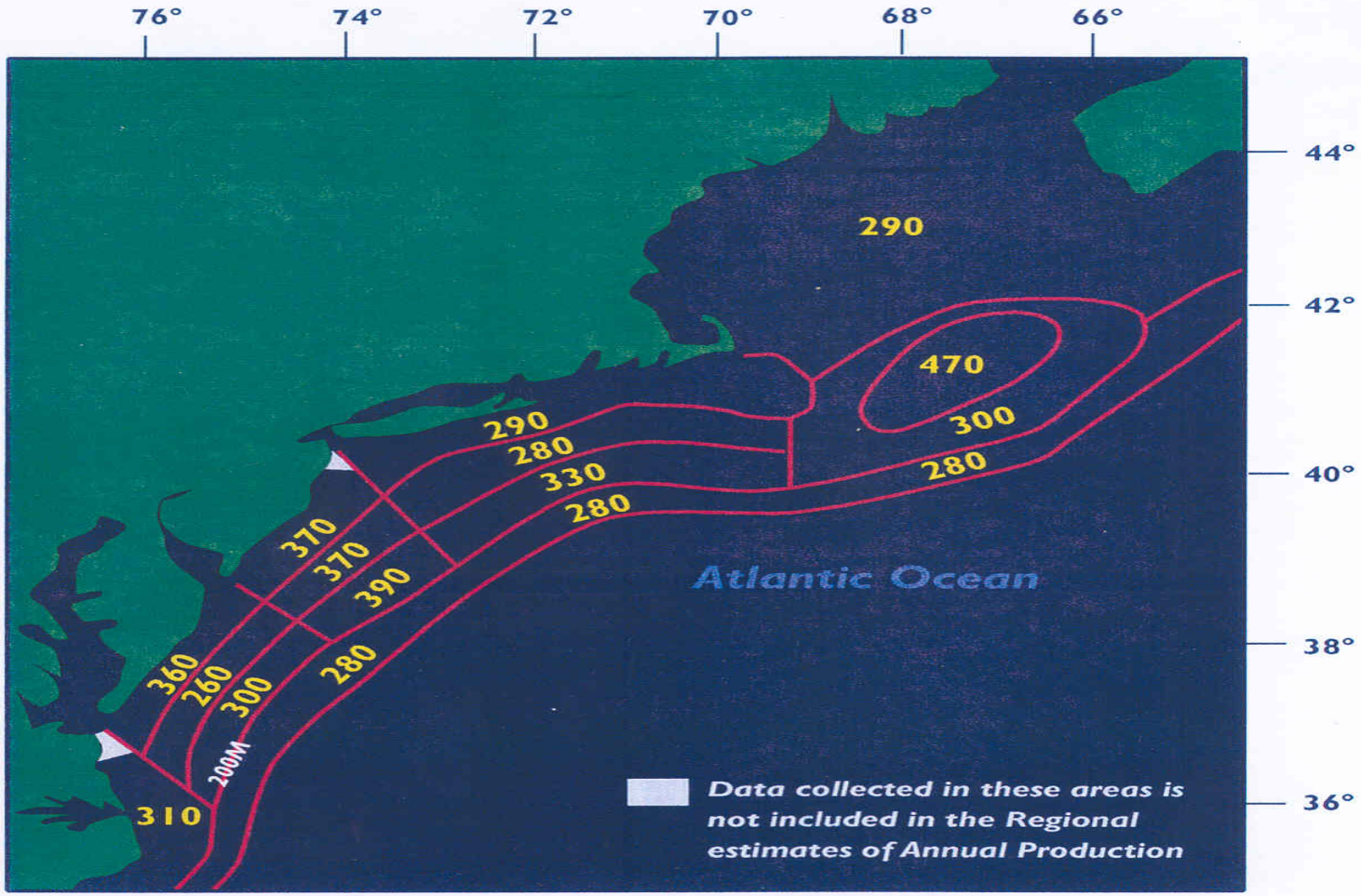
TEMPORAL AND SPATIAL SCALE RELATIONS FOR THE PELAGIC FOOD WEB



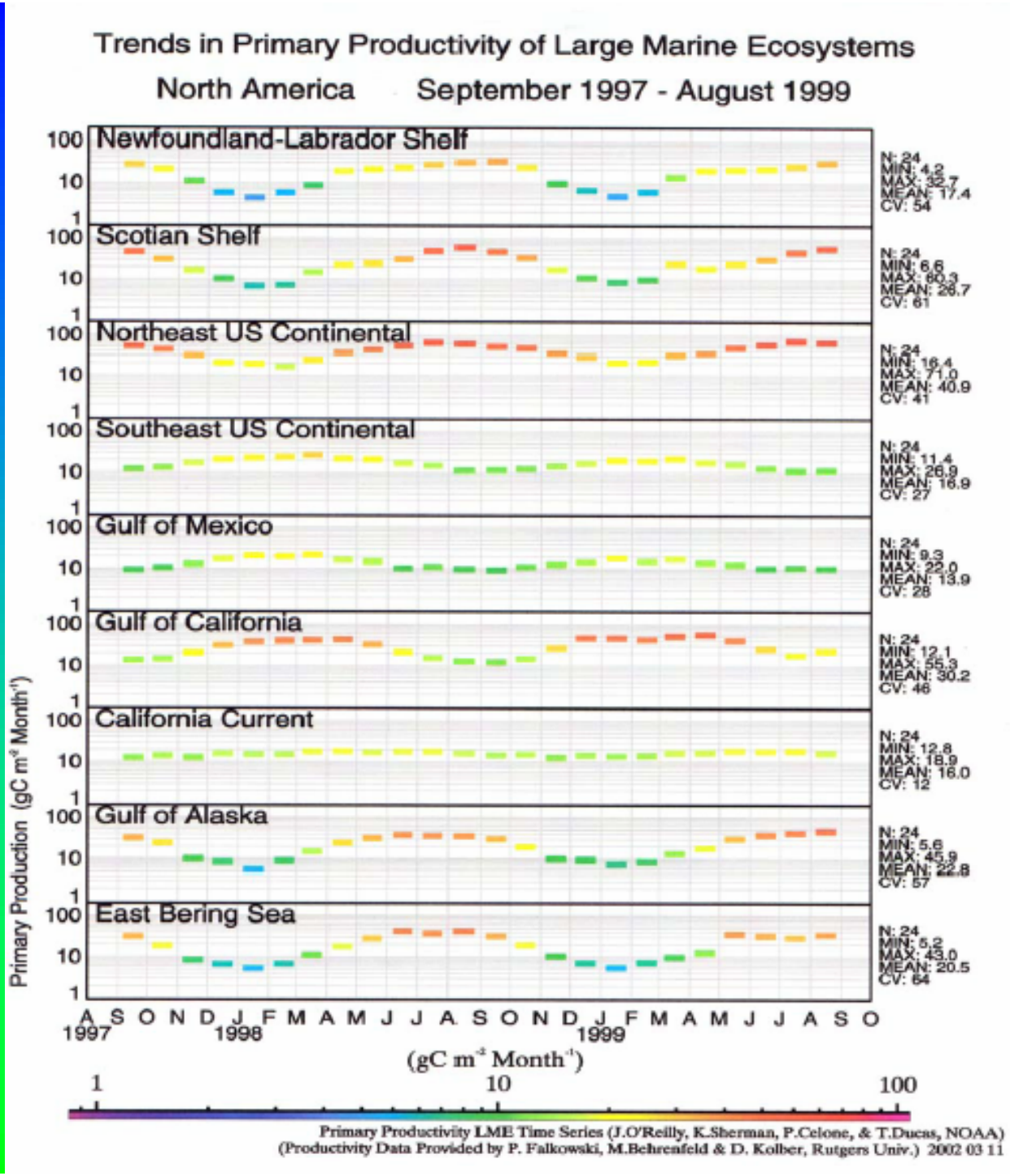
PRODUCTIVITY INDICATORS



An undulating oceanographic recorder, towed behind a ship, is used to collect ecological parameters needed to assess the state of the marine ecosystem.



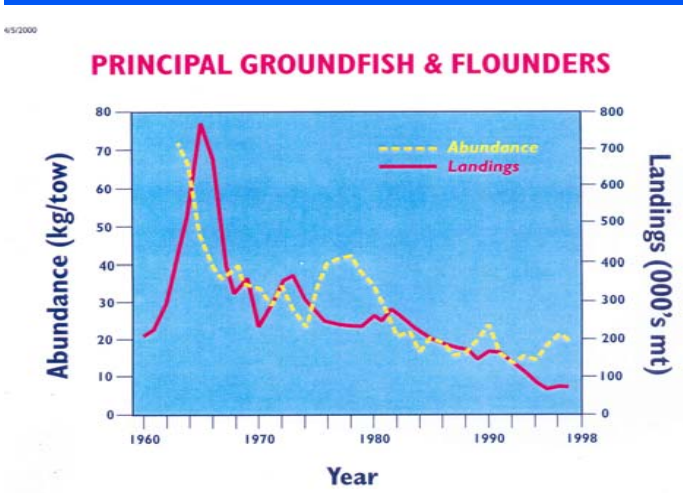
Estimates of annual phytoplankton primary production by region (particulate + dissolved organic carbon); gC m^{-2} y^{-1}

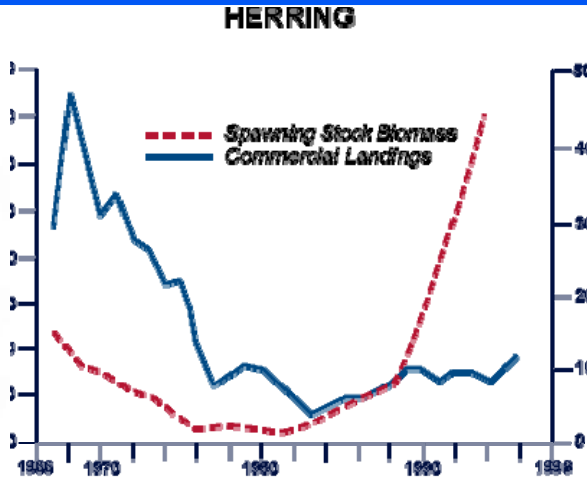

Trends in Primary Productivity of Large Marine Ecosystems
North America
September 1997 - August 1999
Newfoundland-Labrador Shelf
N: 24
MIN: 4.2
MAX: 32.7
MEAN: 17.4
CV: 54
Scotian Shelf
N: 24
MIN: 6.6
MAX: 60.3
MEAN: 26.7
CV: 61
Northeast US Continental
N: 24
MIN: 16.4
MAX: 71.0
MEAN: 40.9
CV: 41
Southeast US Continental
N: 24
MIN: 11.4
MAX: 26.9
MEAN: 16.9
CV: 27
Gulf of Mexico
N: 24
MIN: 9.3
MAX: 22.0
MEAN: 13.9
CV: 28
Gulf of California
N: 24
MIN: 12.1
MAX: 55.3
MEAN: 30.2
CV: 46
California Current
N: 24
MIN: 12.8
MAX: 18.9
MEAN: 16.0
CV: 12
Gulf of Alaska
N: 24
MIN: 5.6
MAX: 45.9
MEAN: 22.8
CV: 57
East Bering Sea
N: 24
MIN: 5.2
MAX: 43.0
MEAN: 20.5
CV: 64
100
10
1
Primary Production (gC m-2 Month-1)
A S O N D J F M A M J J A S O N D J F M A M J J A S O
1997
1998
1999
(gC m-2 Month-1)
1
10
100
Primary Productivity LME Time Series (J.O'Reilly, K.Sherman, P.Celone, & T.Ducas, NOAA)
(Productivity Data Provided by P. Falkowski, M.Behrenfeld & D. Kolber, Rutgers Univ.) 2002 03 11

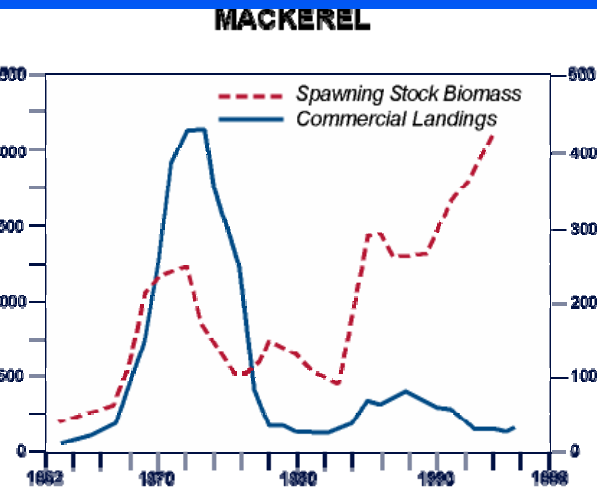
FISH AND FISHERIES INDICATORS

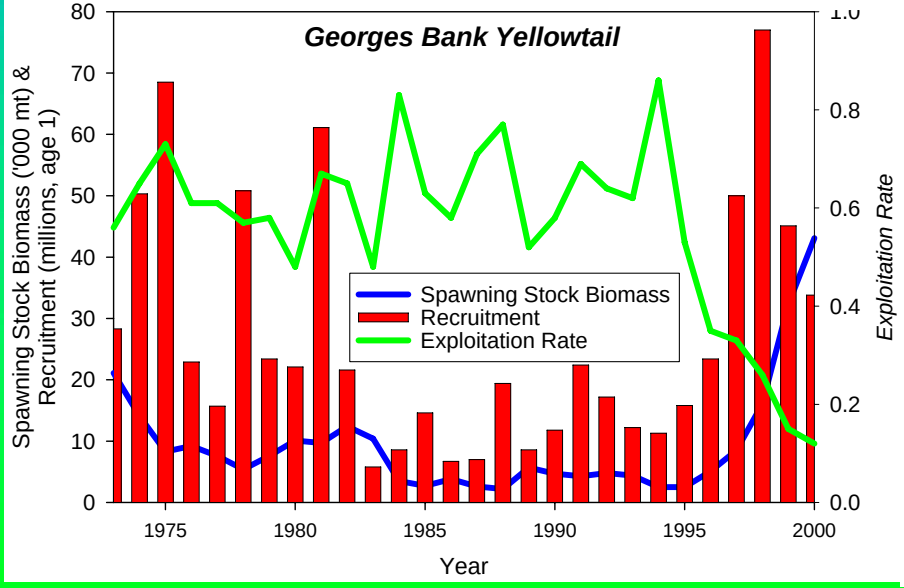
- Demersal species surveys
- Pelagic species surveys
- Ichthyoplankton surveys
- Invertebrate surveys (clams, scallops, shrimp, lobster, squid)
- Essential fish habitat
- Marine protected areas

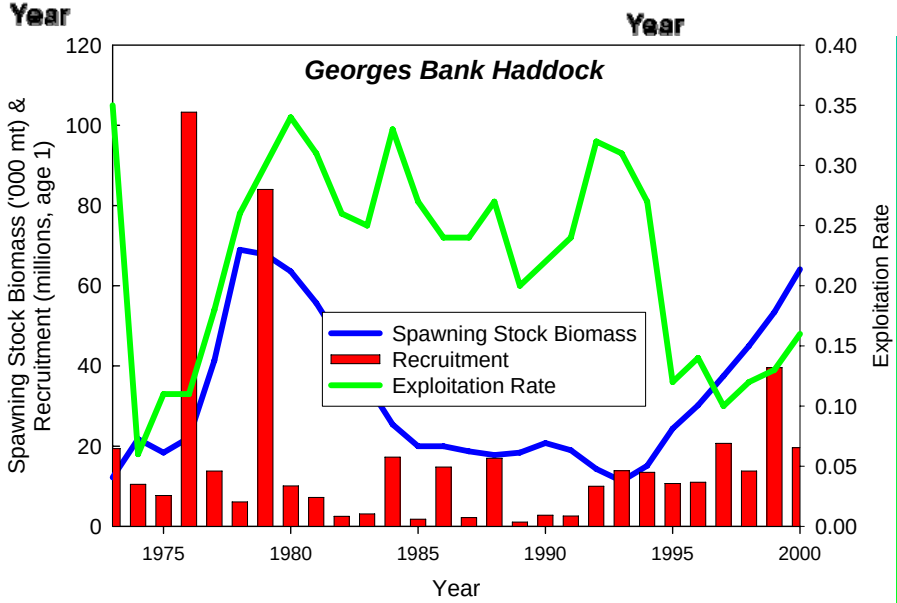
FISH AND FISHERIES INDICATORS



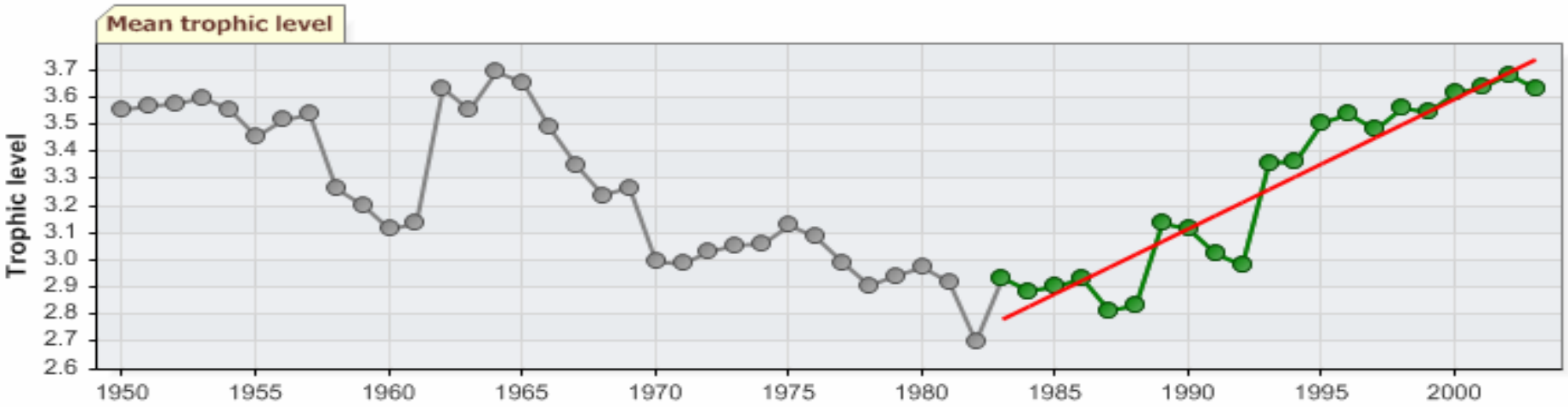








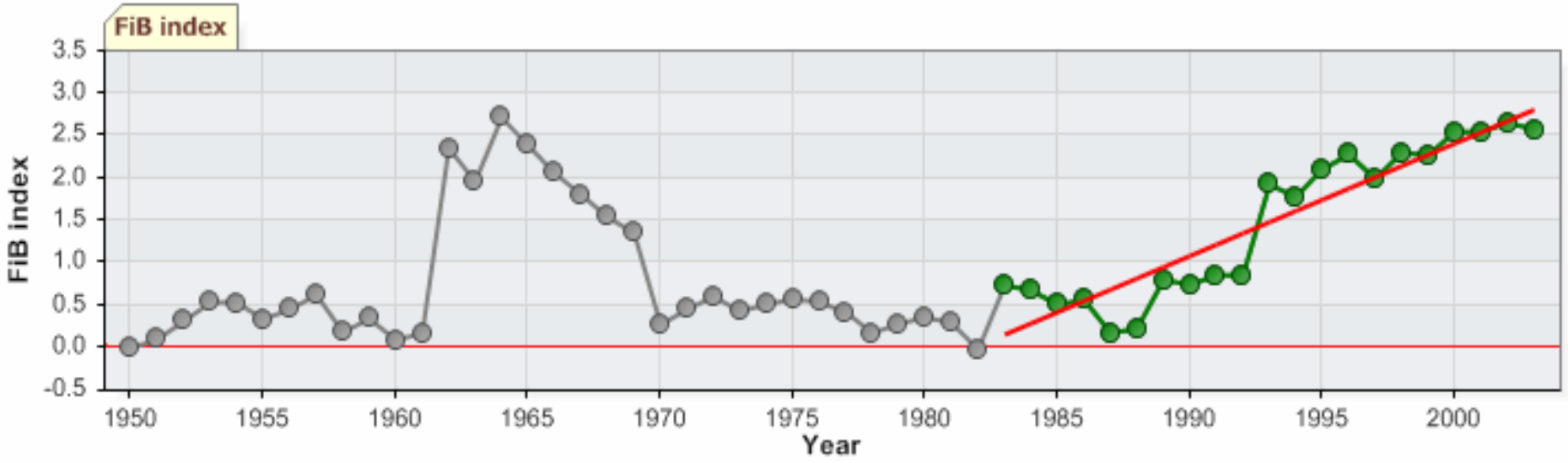
Trophic Index with Regression-Southeast Australia Shelf LME



Sum of the product of species fractional trophic level and catch divided by the sum of the catch, where fractional trophic level is determined by the prey in the diet of a species

$$TL_y = \sum_i \left(TL_i \cdot Y_{iy}\right) / \sum_i Y_{iy}$$

Fishing in Balance (FiB) Index – Southeast Australia Shelf LME



FIB maintains a value of zero when a change in TL is matched by an appropriate change in catch, but will decrease indicates an unsustainable food web and increase an expanding fishery

$$FiB_y = \log\left\{\left[Y_y \cdot (1/TE)^{TL_y}\right] / \left[Y_0 \cdot (1/TE)^{TL_0}\right]\right\}$$

POLLUTION AND ECOSYSTEM HEALTH INDICATORS

Indicators:

- ***Water Clarity***
- ***Dissolved Oxygen***
- ***Coastal Wetland Loss***
- ***Eutrophic Condition***
- ***Sediment Contamination***
- ***Benthic Index***
- ***Fish Tissue Contaminants***
- ***Multiple Marine Ecological Disturbances***

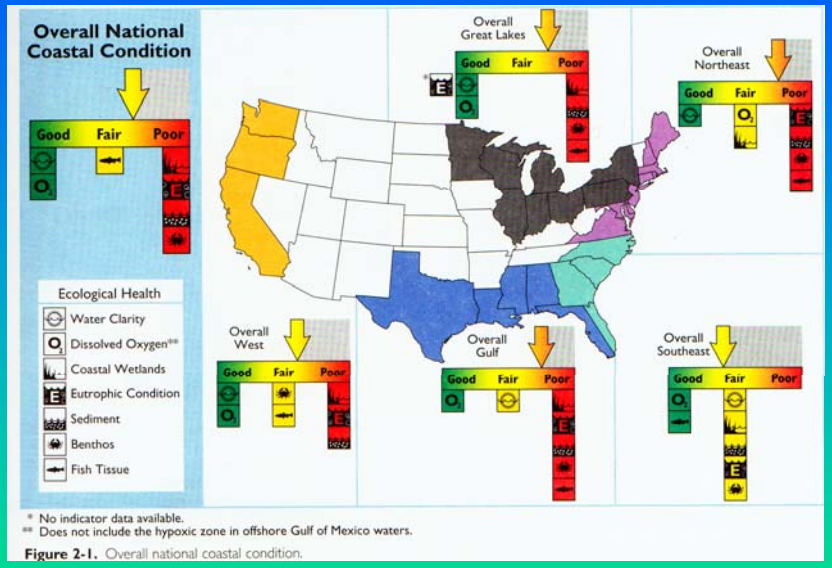
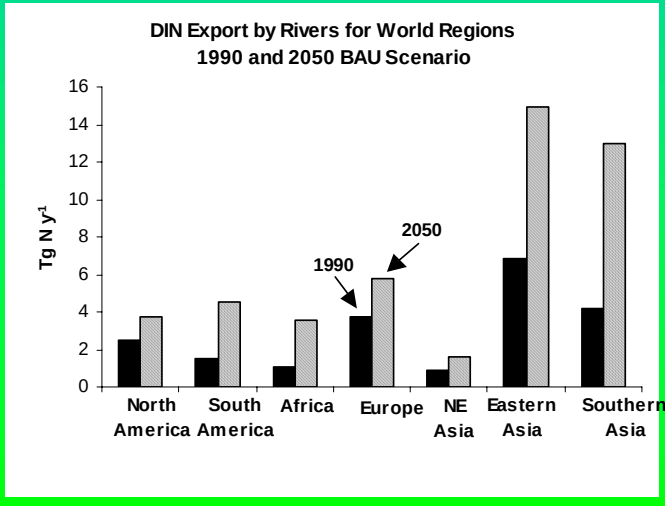
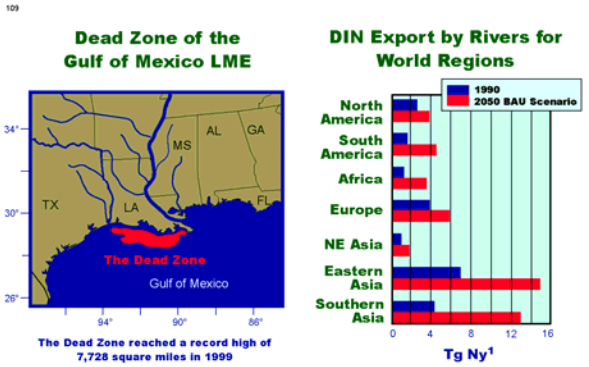


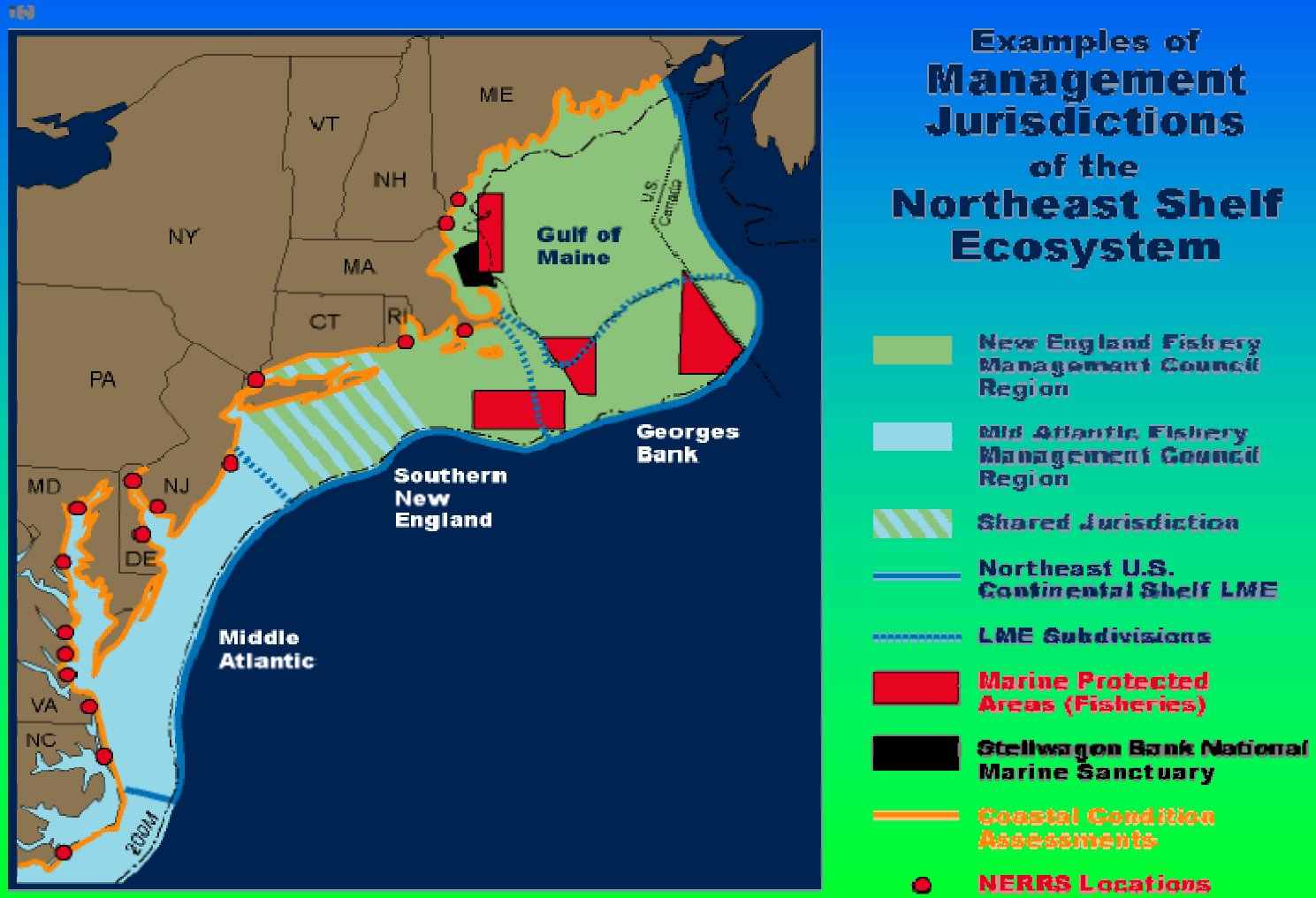
Figure 2-1. Overall national coastal condition.





SOCIOECONOMICS AND GOVERNANCE

NORTHEAST SHELF MANAGEMENT JURISDICTIONS



ECOSYSTEM MANAGEMENT: A PARADIGM SHIFT

FROM	TO
Individual species	**Ecosystems**
Small spatial scale	**Multiple scales**
Short-term perspective	**Long-term perspective**
Humans: independent of ecosystems	**Humans: integral part of ecosystems**
Management divorced from research	**Adaptive management**
Managing commodities	**Sustaining production potential for goods and services**

NOTE: Some of the substantive changes between traditional resource management and ecosystem management.

PLANNING ACTIONS

1. Transboundary Diagnostic Analysis (TDA) – provides consensus priorities from analysis and ranking of water-related resources issues, their environmental and socioeconomic impacts, immediate and root causes and possible remedies

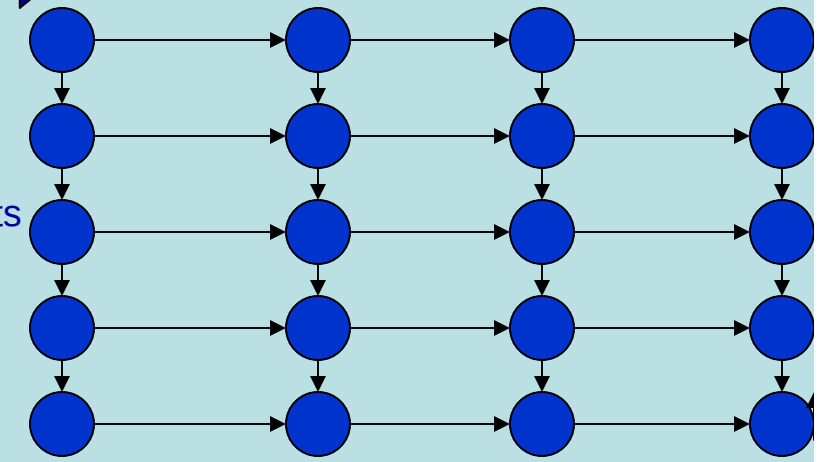
2. Strategic Action Program (SAP) – provides national and regional commitments to policy, legal and institutional reforms, and investments to remedy root causes of priority transboundary issues identified in TDA

IMPLEMENTATION ACTIONS

3. Ecosystem-based assessment and management strategy for TDA and SAP

- 3.1 Productivity indicators and assessments
- 3.2 Fish and fisheries indicators and assessments
- 3.3 Pollution and ecosystem health indicators and assessments
- 3.4 Socioeconomic indicators and assessments
- 3.5 Governance indicators and assessments

Ecosystem-Based Assessment and Adaptive Management



Year 1	Year 2	Year 3	Year 4	Years 5-10
	Assessments & Management Actions	Assessments & Management Actions	Assessments & Management Actions	Toward Self-financing Assessments and adaptive management