

Effects of Climate Warming on Biomass Yields in the World's Large Marine Ecosystems

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Large Marine Ecosystems are Naturally Formed Coastal Ocean Management Areas



UN Framework Convention on Climate Change 1992

- Climate Change has a severe and increasing effect on humanity
- UNFCCC seeks mechanisms to combat the challenge

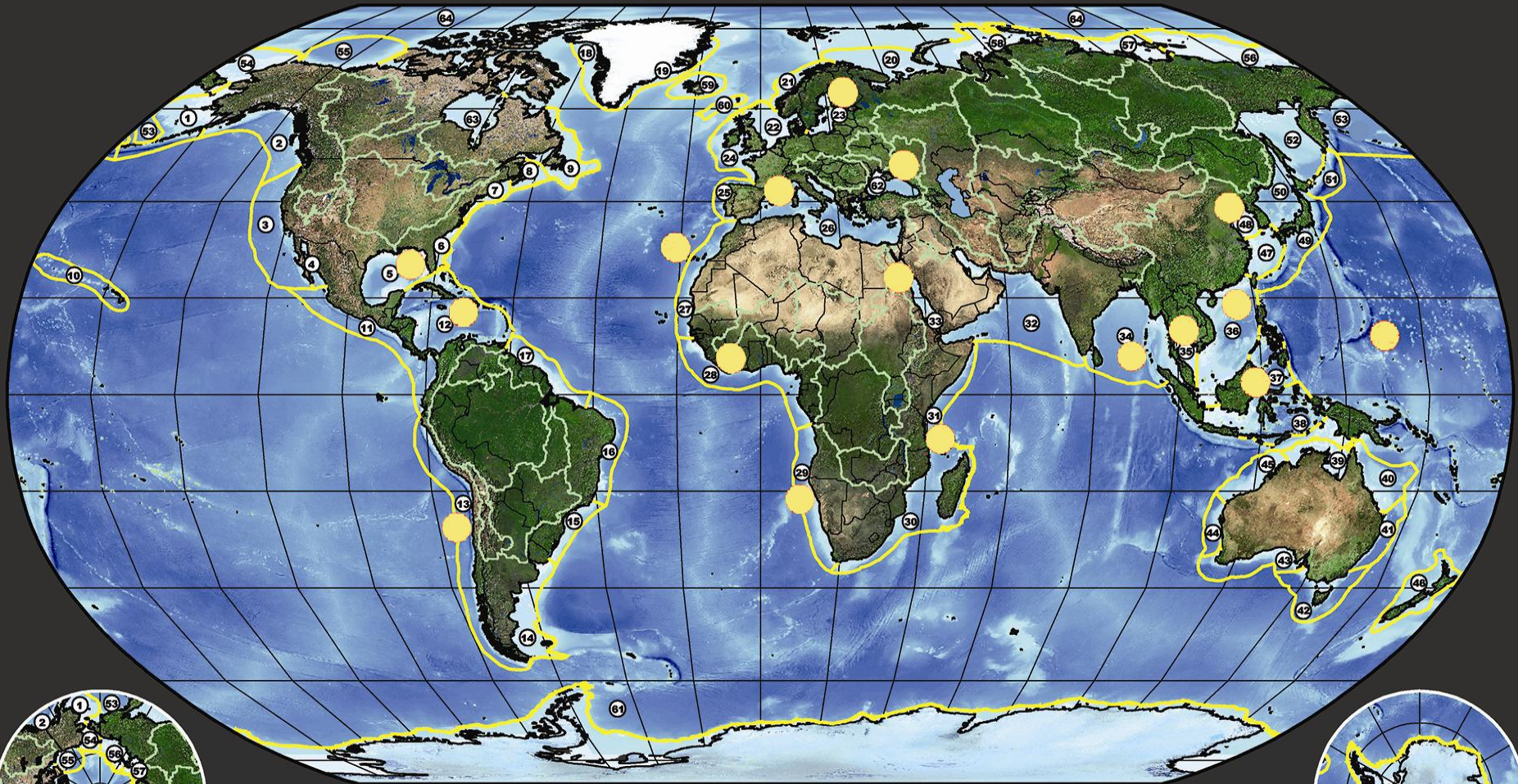
Copenhagen Accord

18 December 2009

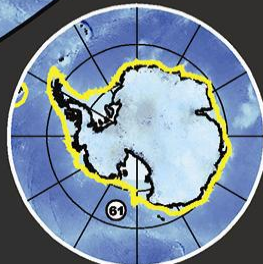
- We agree that deep cuts in greenhouse gases are required
- Enhanced actions and international cooperation on adaptations is urgently needed

Ernst & Young
October 10, 2011

Large Marine Ecosystems of the World and Linked Watersheds

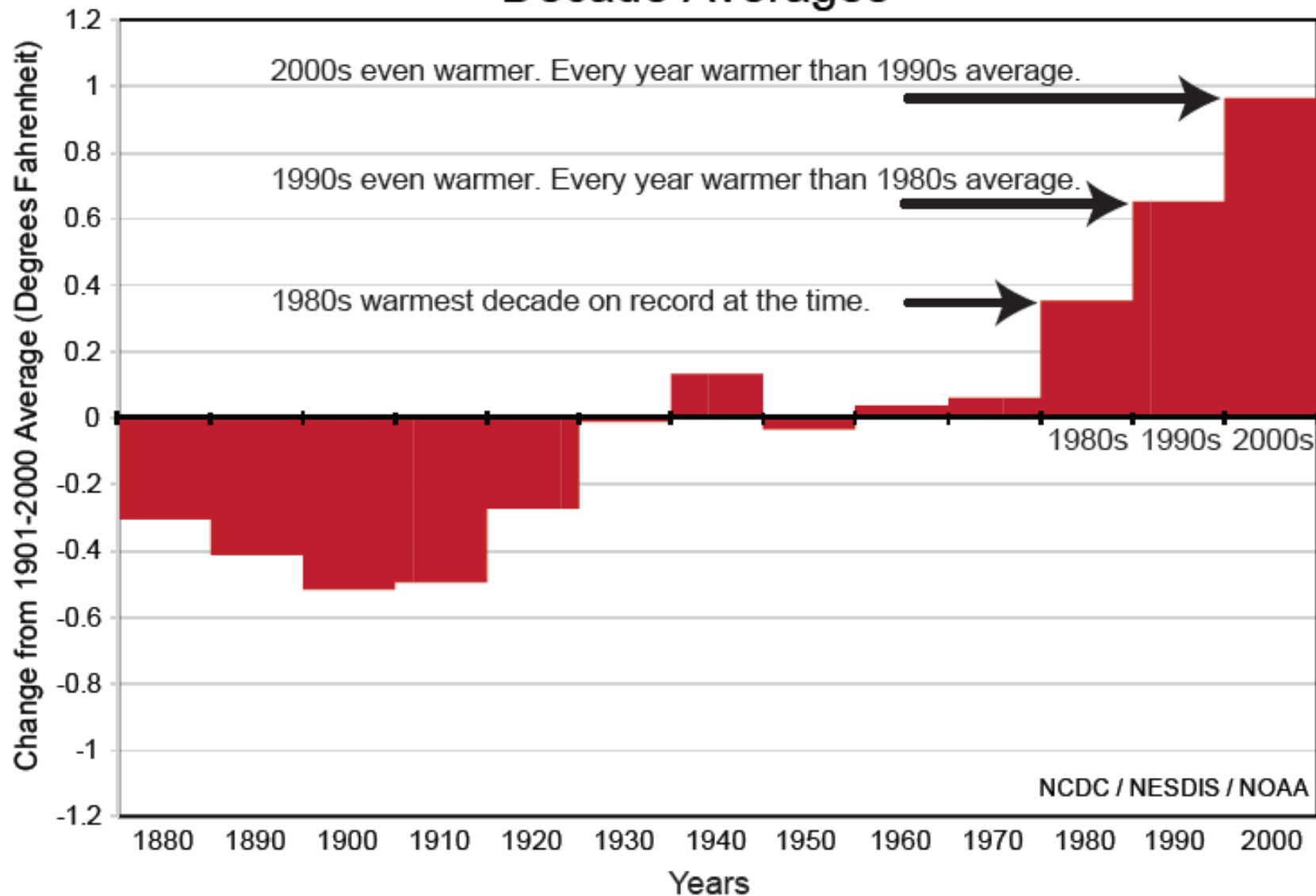


NORTH POLAR REGION



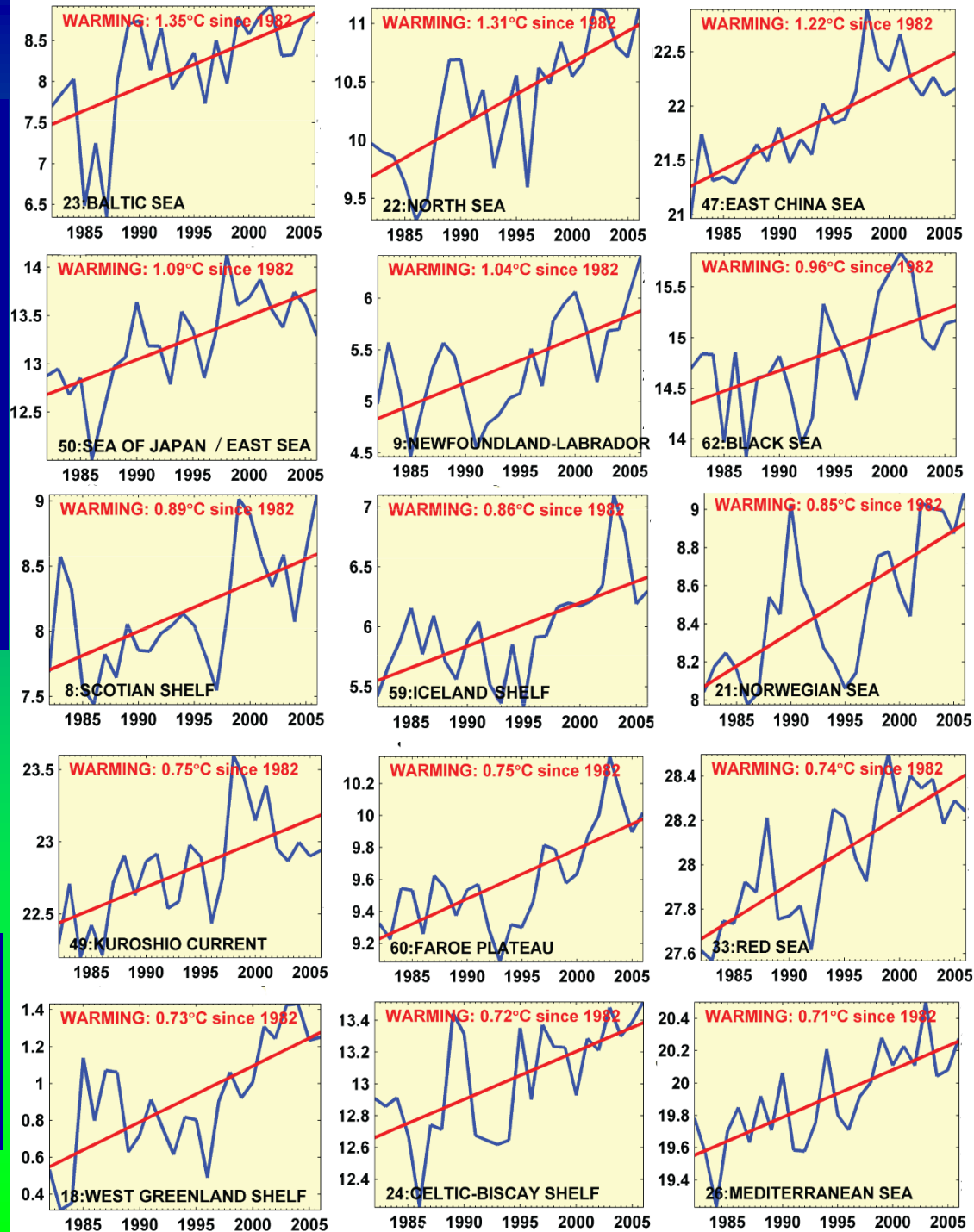
SOUTH POLAR REGION

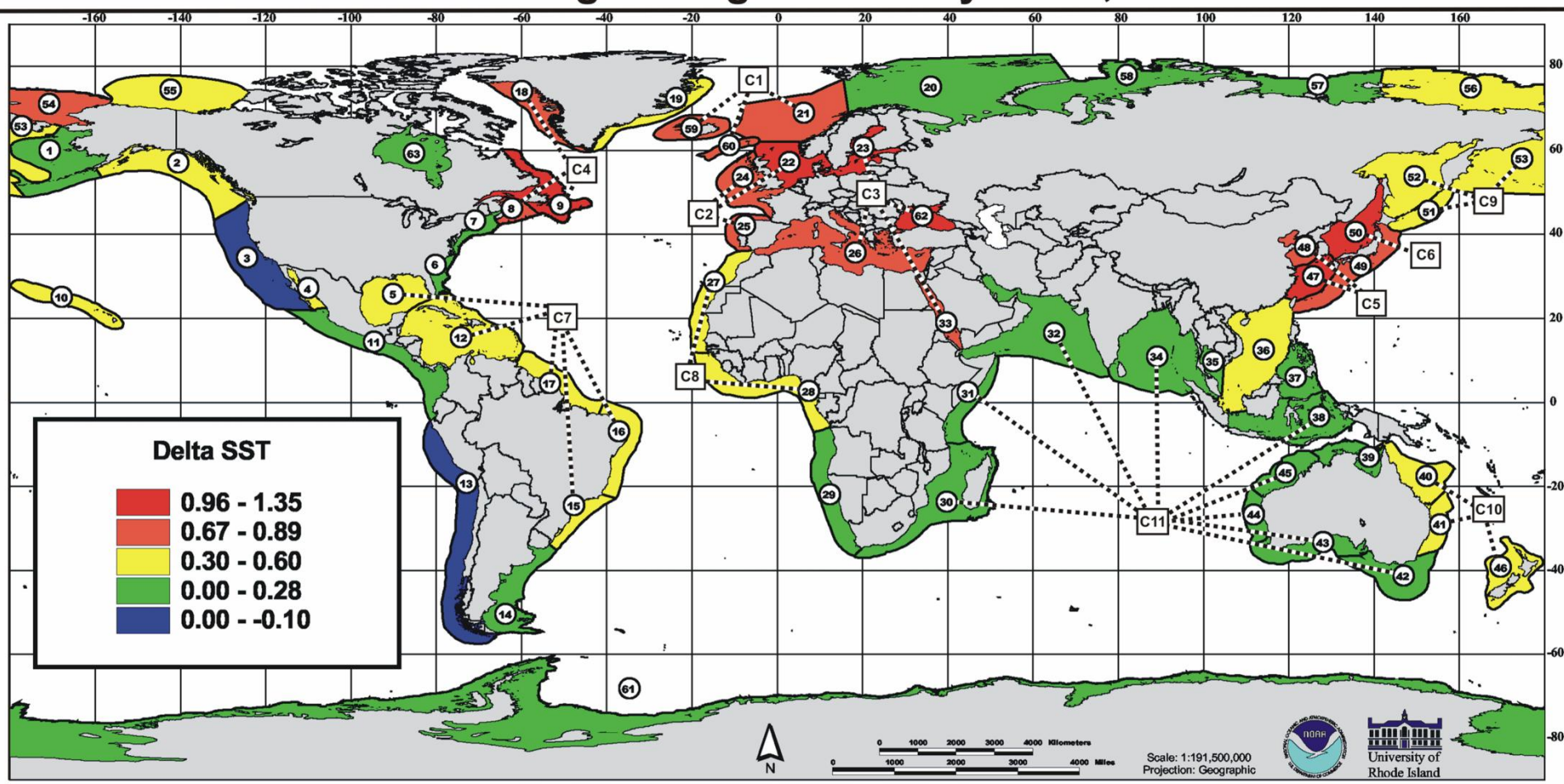
Global Temperature Change Decade Averages



Accelerated Warming of the World's LMEs in 61 of 63 LME Assessments

The 15 fastest warming LMEs around the globe





Warming Clusters of LMEs in Relation to SSTs (Sea Surface Temperatures), 1982-2006:

FAST WARMING:

C1 Northern European Cluster; C2 Southern European; C3 Semi-Enclosed European Seas; C4 of the NW Atlantic; C5 Fast Warming East Asian LMEs; C6 Kuroshio Current and Sea of Japan/East Sea LMEs.

MODERATE WARMING:

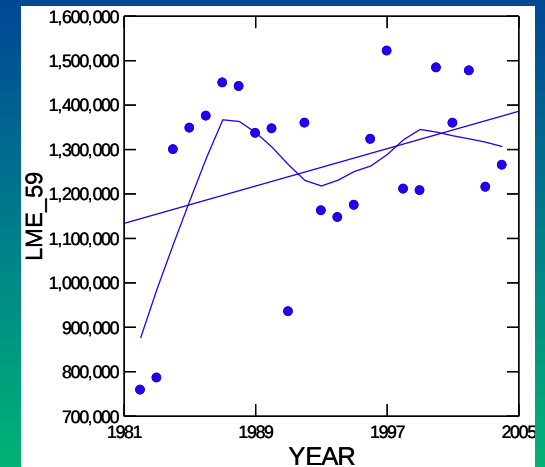
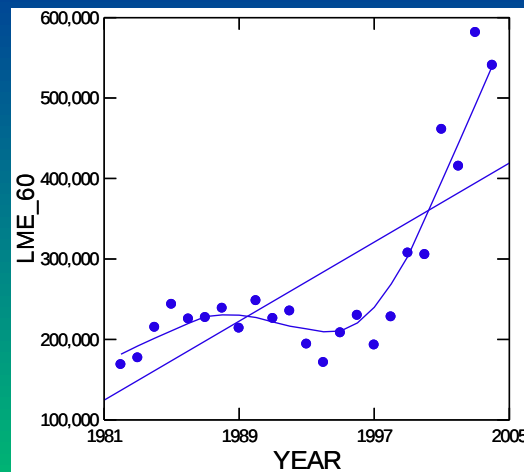
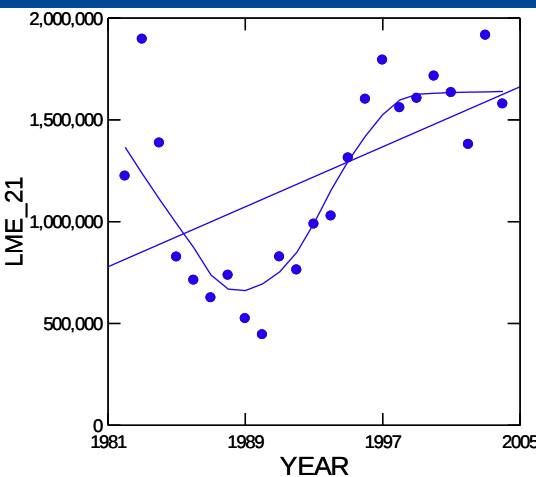
C7 Western Atlantic LMEs; C8 Eastern Atlantic LMEs; C9 NW Pacific LMEs; C10 SW Pacific LMEs. Several Non-Clustered, Moderate Warming LMEs: NE Australia, Insular Pacific Hawaiian, Gulf of Alaska, Gulf of California; South China Sea, East Greenland Shelf;

SLOW WARMING:

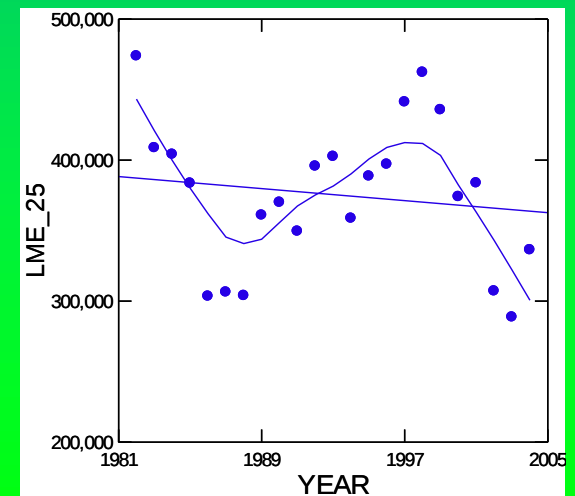
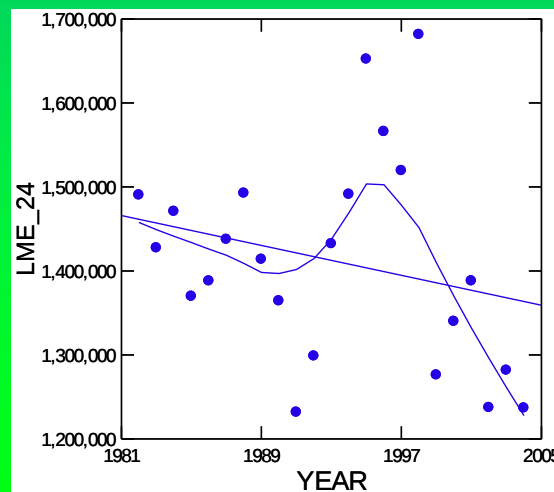
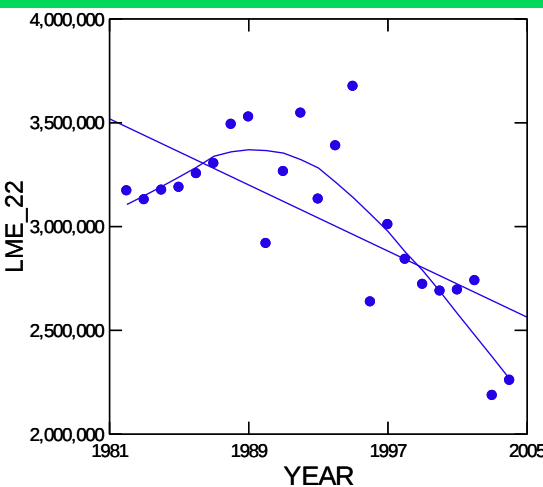
C11 Indian Ocean and Adjacent Waters.

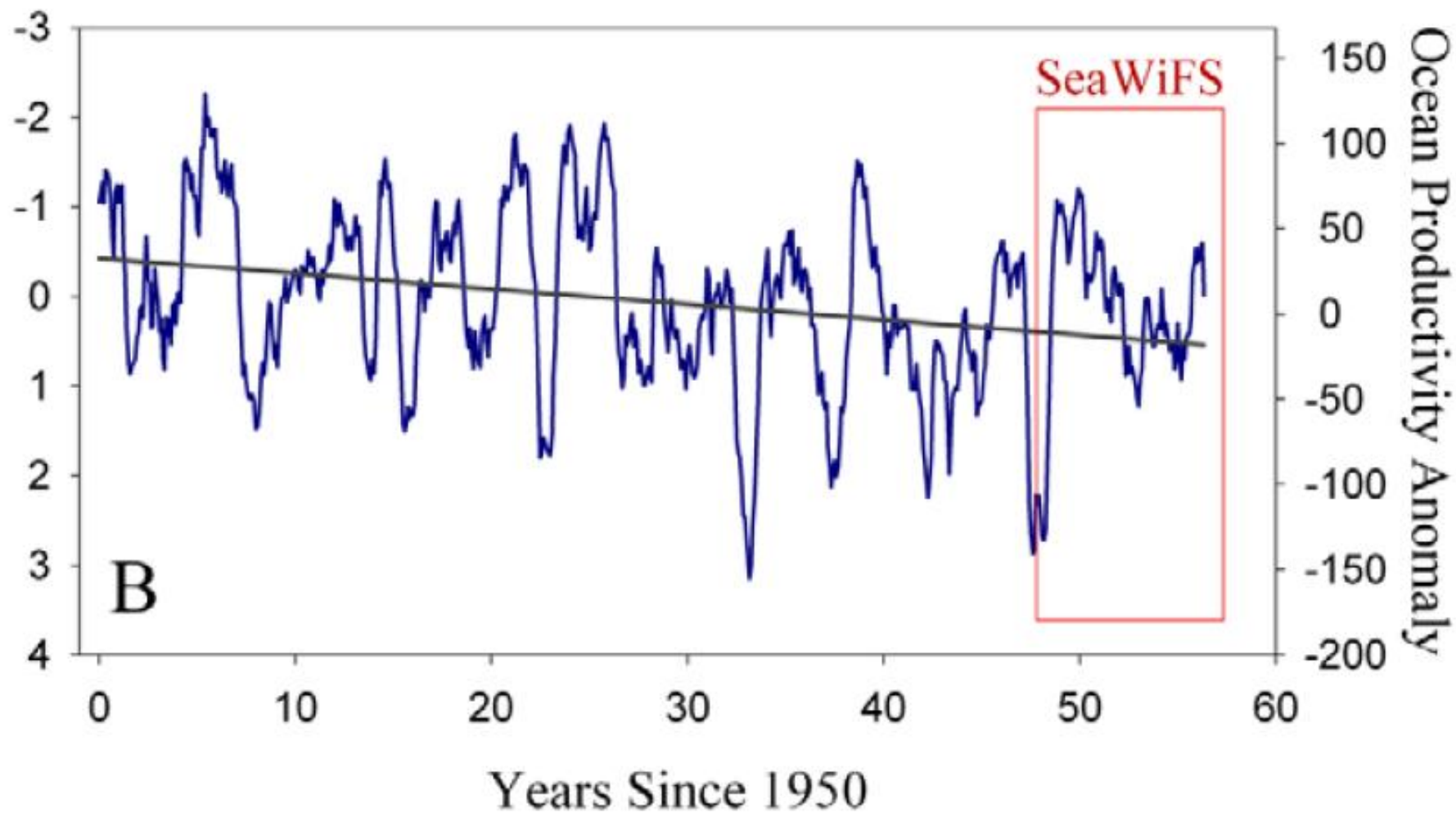
Non-clustered, Slow Warming LMEs include the U.S. Northeast Shelf, the U.S. Southeast Shelf, the Barents Sea, East Bering Sea; Patagonian Shelf, Benguela Current and Pacific Central American Coastal LMEs.

Fisheries biomass yield trends (metric tons) in fast warming cluster 1: Norwegian Sea (LME 21), Faroe Plateau (LME 60), and Iceland Shelf (LME 59).



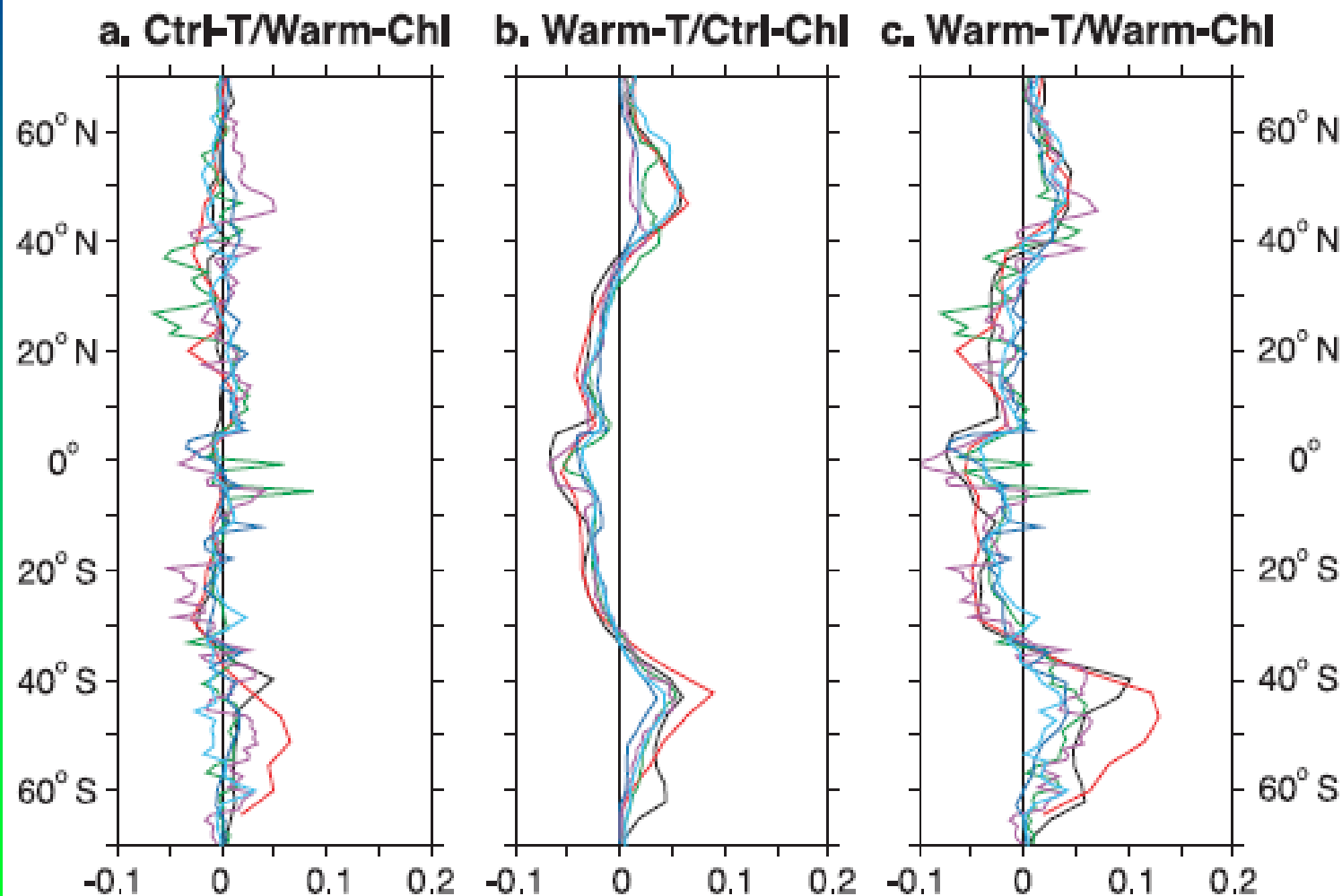
Fisheries biomass yield trends (metric tons) in fast warming cluster 2: North Sea (LME 22), Celtic Biscay (LME 24) and Iberian Coastal (LME 25)





From Behrenfeld et al. 2007

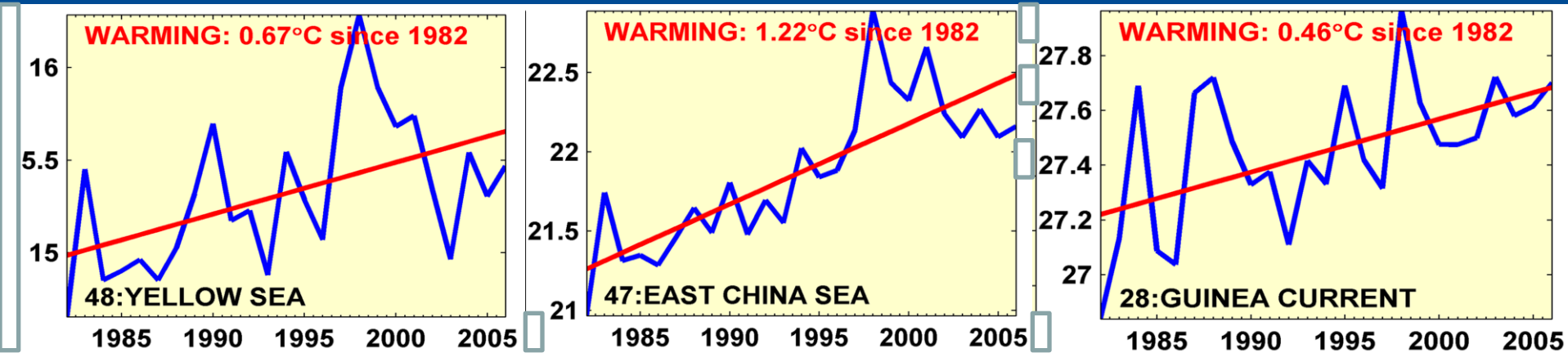
Estimated 2040 – 2060 primary production change ($\text{Pg-C deg}^{-1} \text{ yr}^{-1}$)



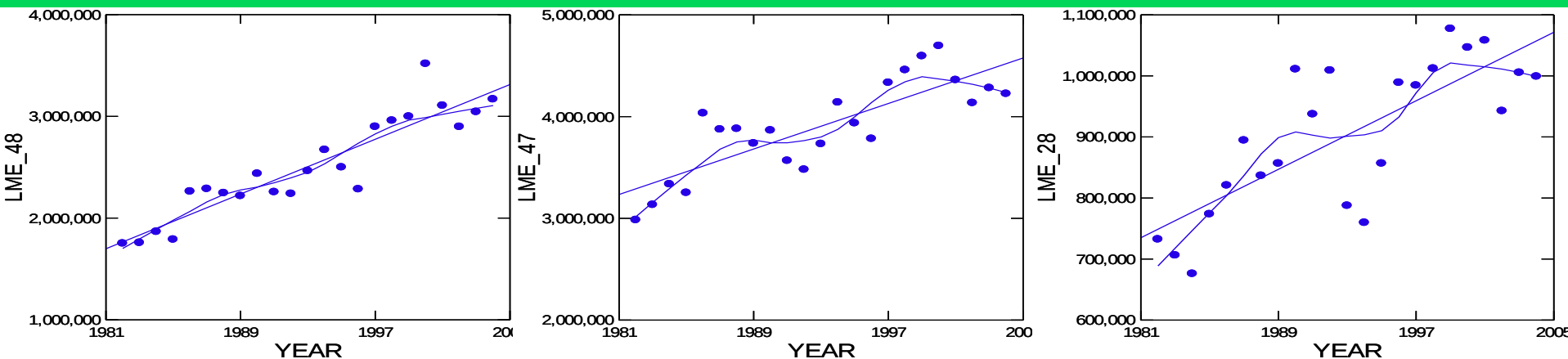
— CSIRO
— GFDL
— Hadley
— IPSL
— MPI
— NCAR

J. Sarmiento in Behrenfeld et al. 2007

Sea Surface Temperature Trends



Fisheries Biomass Yields

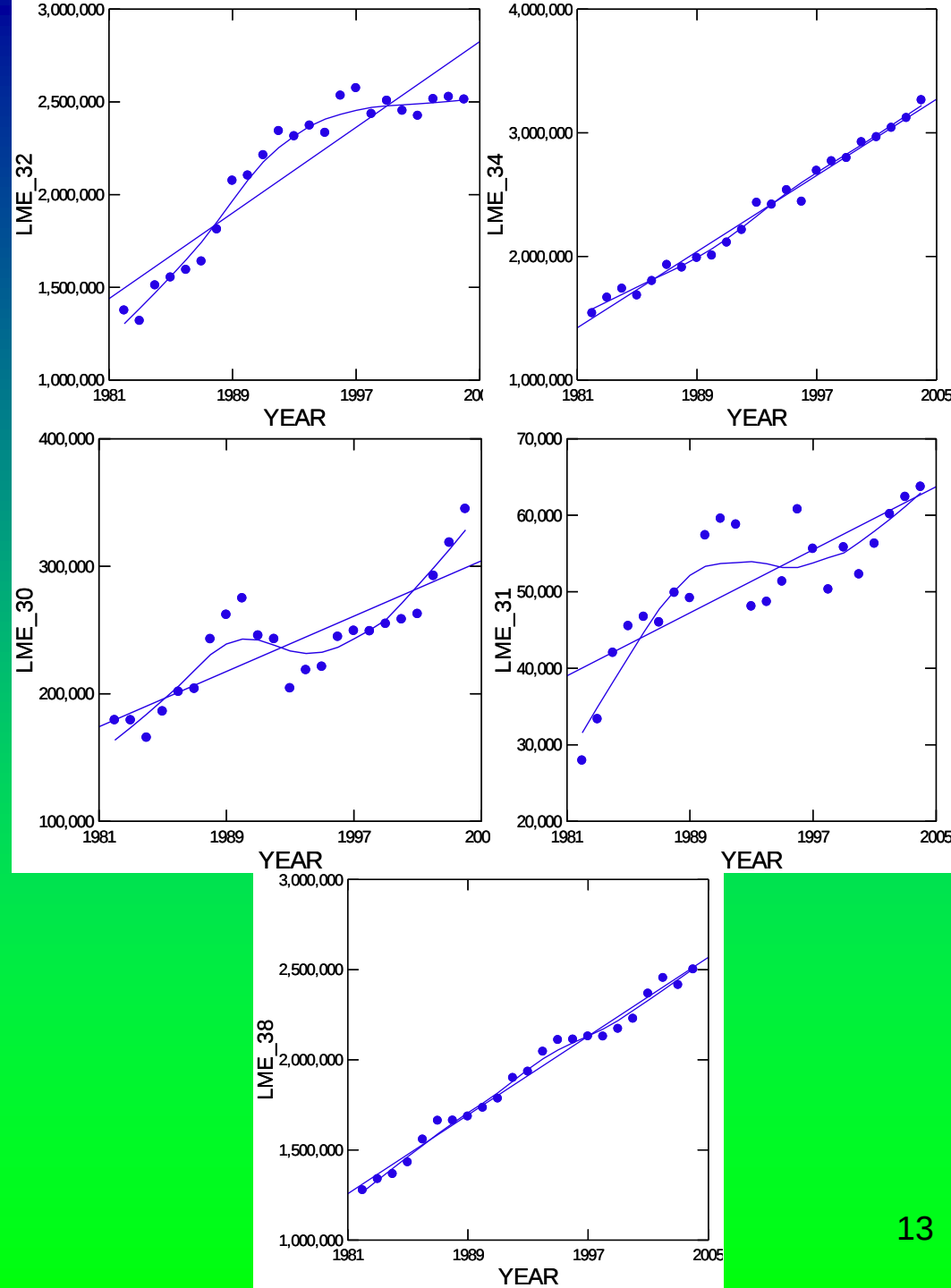


Cap and Sustain

Comparative dynamics of fisheries biomass yield in the slow warming Indian Ocean and adjacent LMEs:

Arabian Sea (LME32),
Bay of Bengal (LME 34),
Agulhas Current (LME 30),
Somali Current (LME 31), and
Indonesian Sea (LME 38).

Linear regression shown as
blue trend line, adjacent
averaging smoothing is shown
as curved trend line.



DEVELOPING COUNTRIES AT WORK TO OPERATIONALIZE THE GLOBAL SCALE APPLICATIONS OF THE LME APPROACH:

- Implementing the 5 Module approach**
- 17 international GEF-funded LME projects in Africa, Asia, Latin America and eastern Europe**
- Level of funding: \$3.1 billion**
- Partnership of 5 UN agencies**
- NOAA provides scientific and technical support**
- Hands on participation of 2,500 LME experts and practitioners**



“Integrated research, monitoring, training, and outreach programs at the large-marine-ecosystem scale are urgently needed in every large marine ecosystem.”

J. Lubchenco foreword, “Lessons from the Ice Bear”
p.xiii in Ecosystem-based Management for the Oceans,
K. McLeod and H. Leslie, eds. 2009, Island Press.

Durban Nov.-Dec. 2011



The Sustainable Development of Large Marine Ecosystems