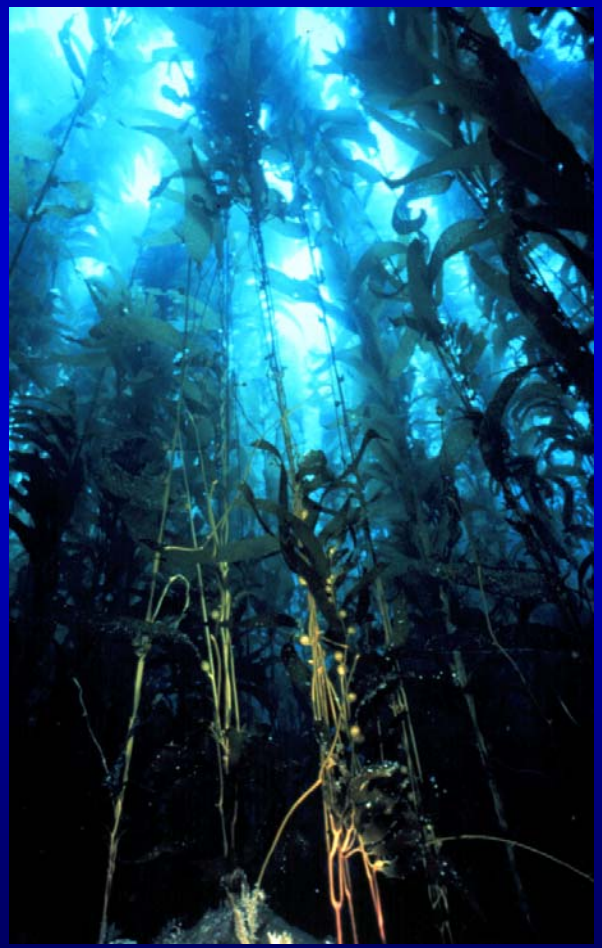
Social - Ecological Interactions in Coastal Marine Ecosystems

Dan Reed
Santa Barbara Coastal LTER



LTER Coastal Marine Ecosystems


California Current Ecosystem


Palmer Station


Santa Barbara Coastal


Virginia Coast Reserve

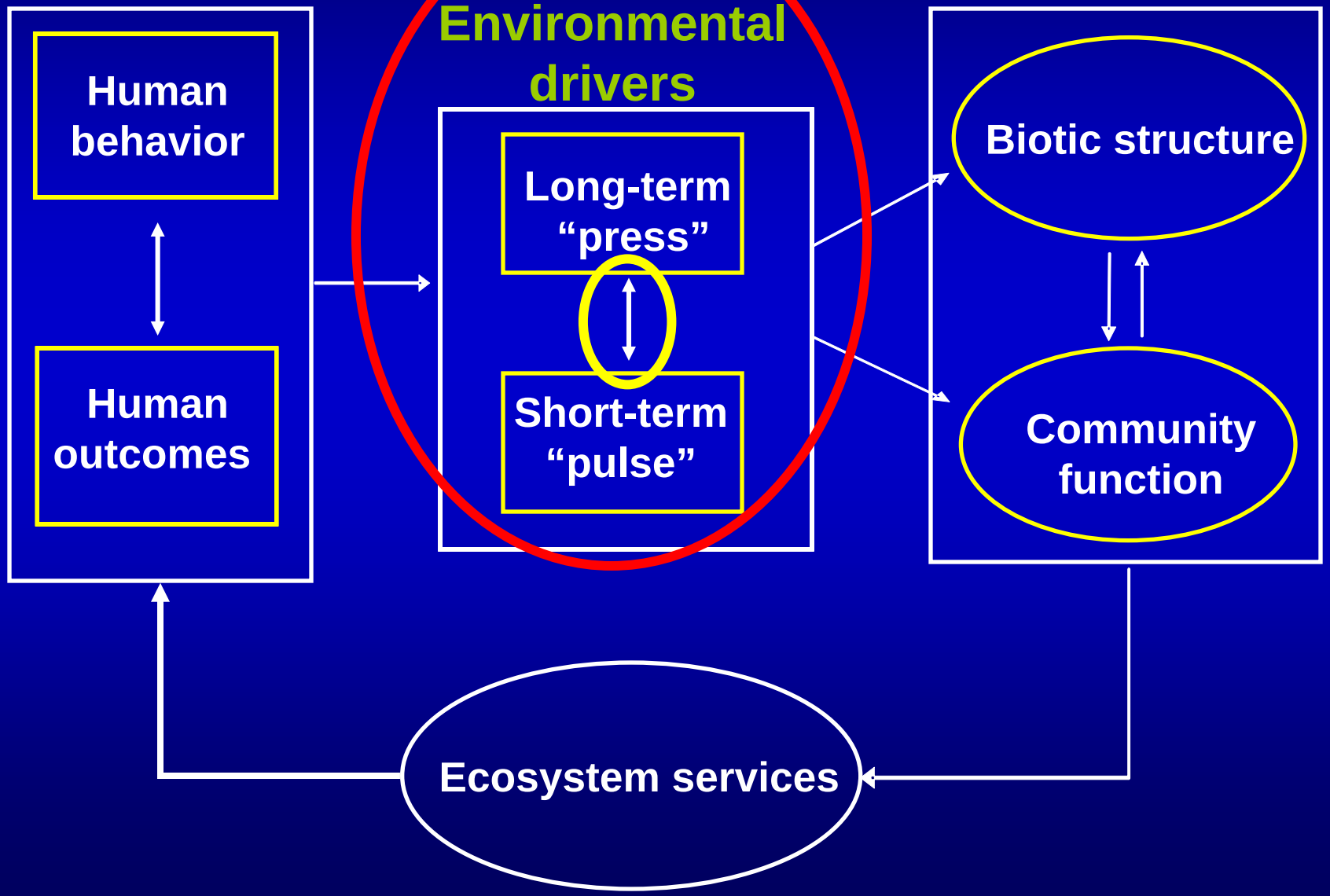

Georgia Coastal Ecosystem


Moorea Coral Reef


Florida Coastal Everglades


Plum Island Ecosystem

CONCEPTUAL FRAMEWORK



Environmental Drivers of Coastal Marine Ecosystems

Climate

temperature

wave disturbance

nutrients

acidification

sea level

Land use

runoff

pollution

sedimentation

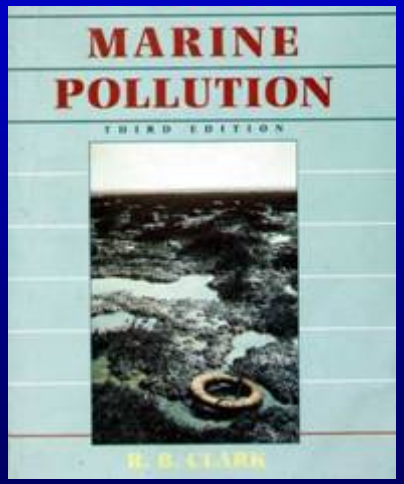
eutrophication

Extraction

recreational fishing

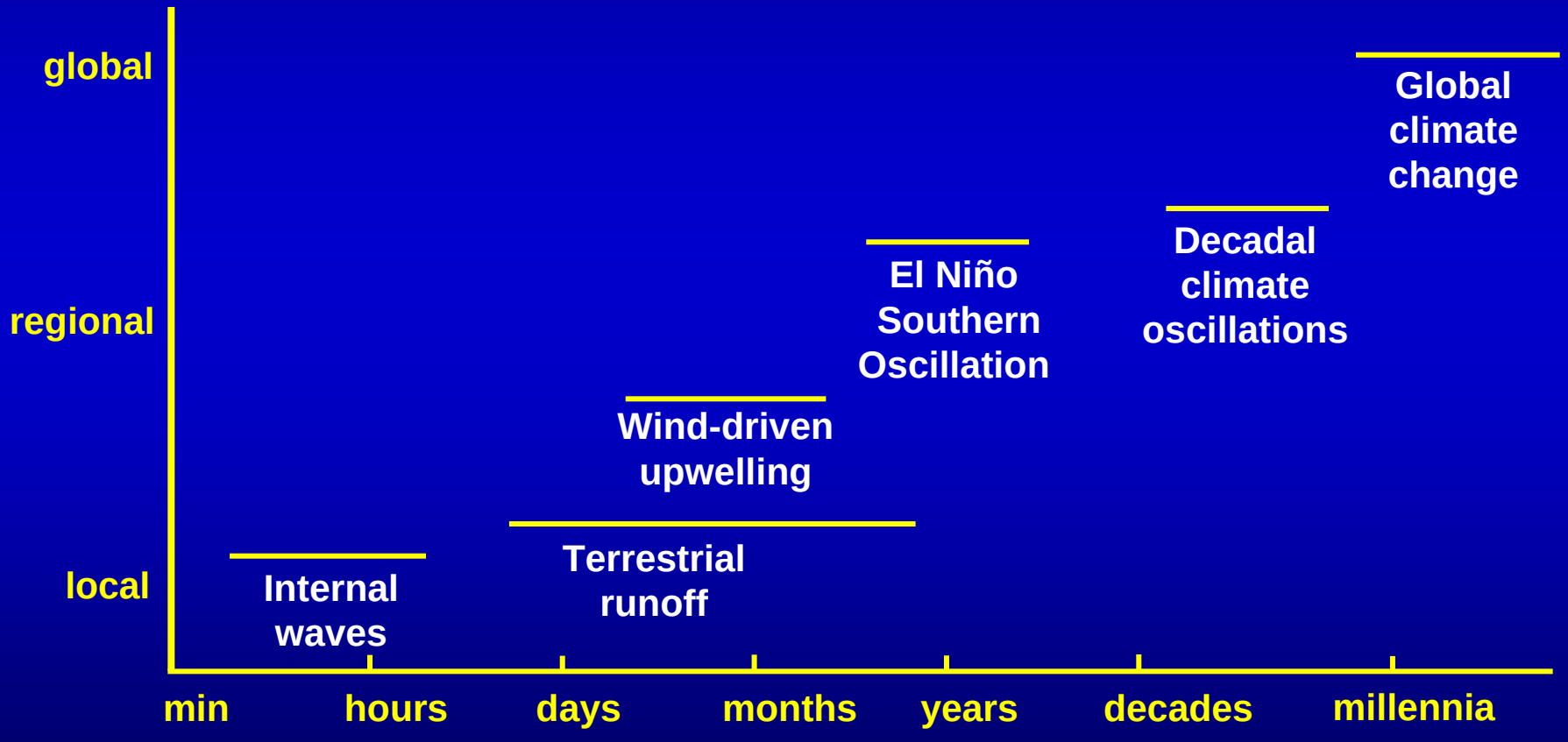
commercial fishing

Non-renewable resources



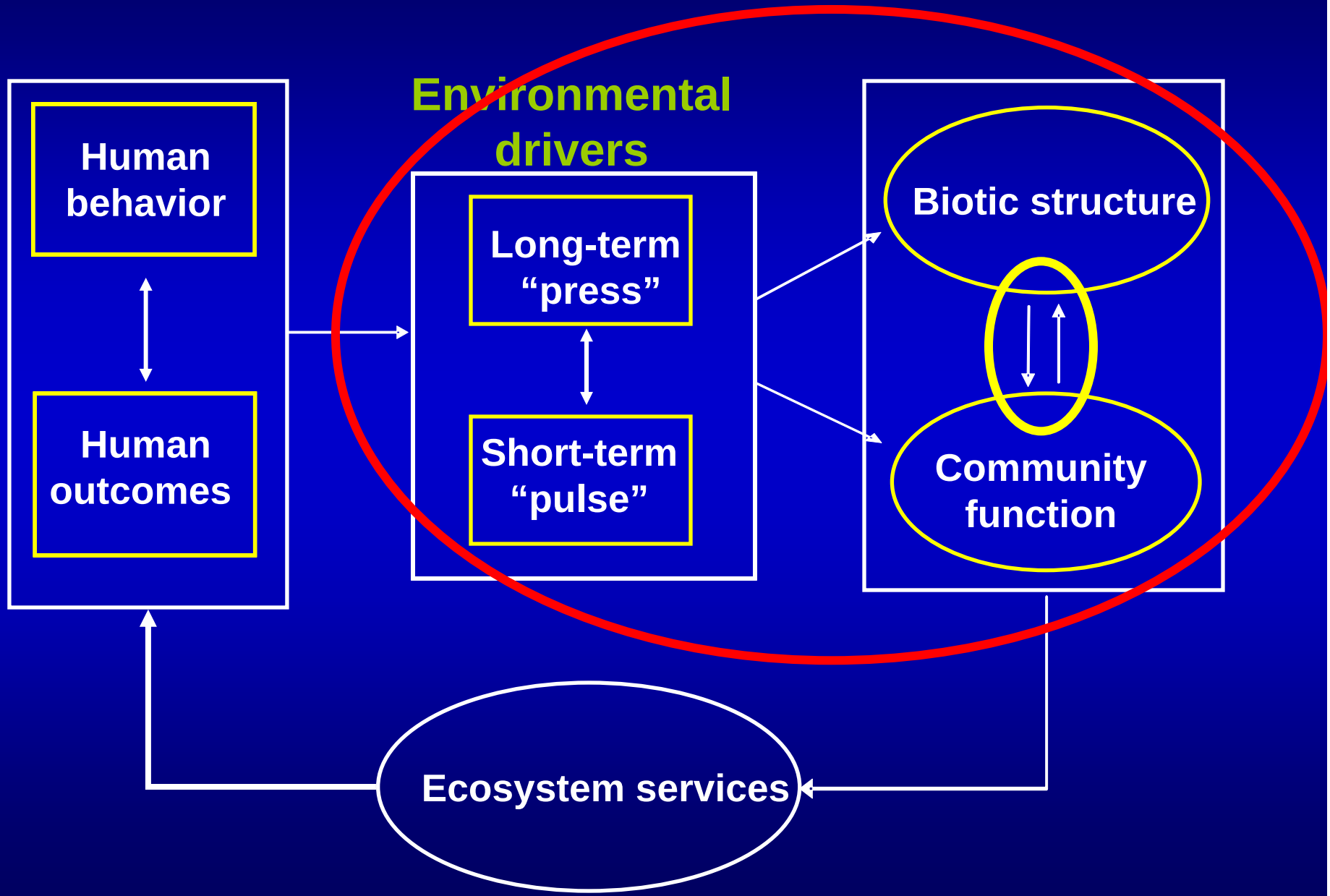
Pulse & Press Drivers

- a continuum, not a dichotomy
- drivers interact in space and time



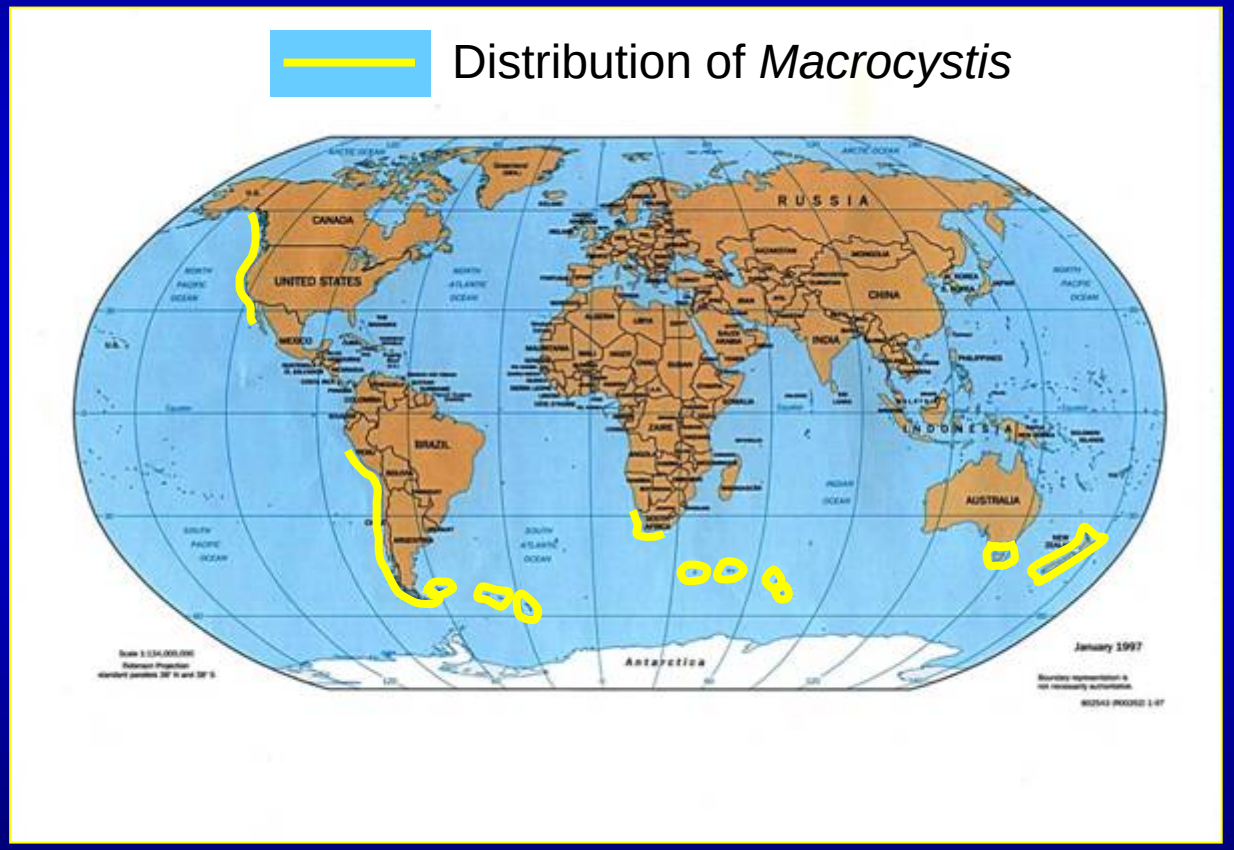
Drivers affecting nutrient delivery to coastal marine ecosystems

CONCEPTUAL FRAMEWORK



Giant Kelp Forests

Macrocystis pyrifera

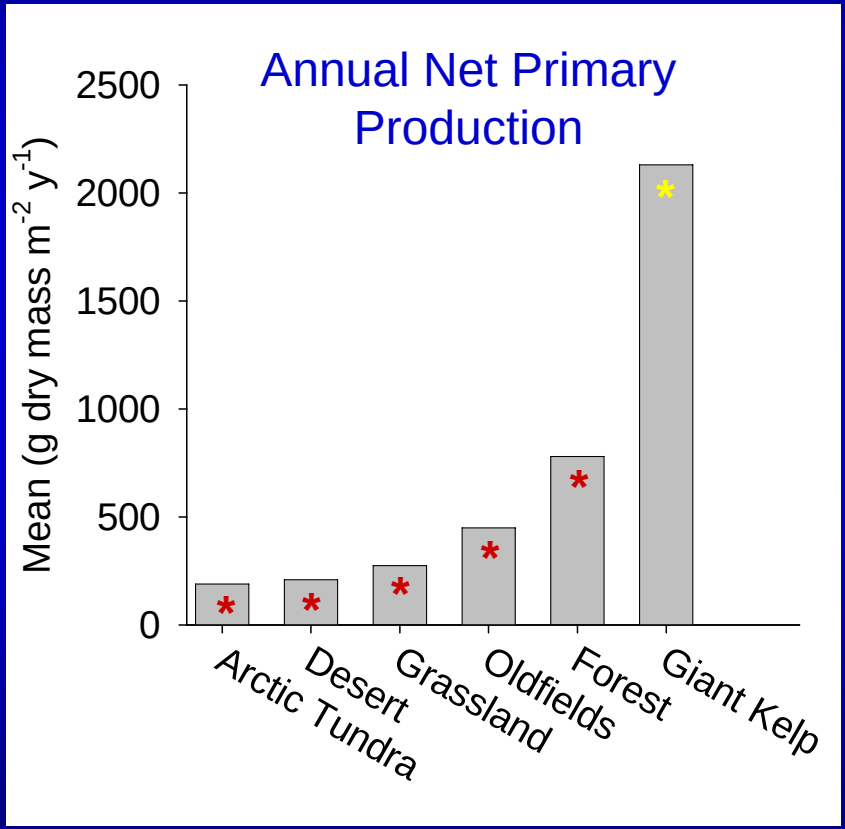


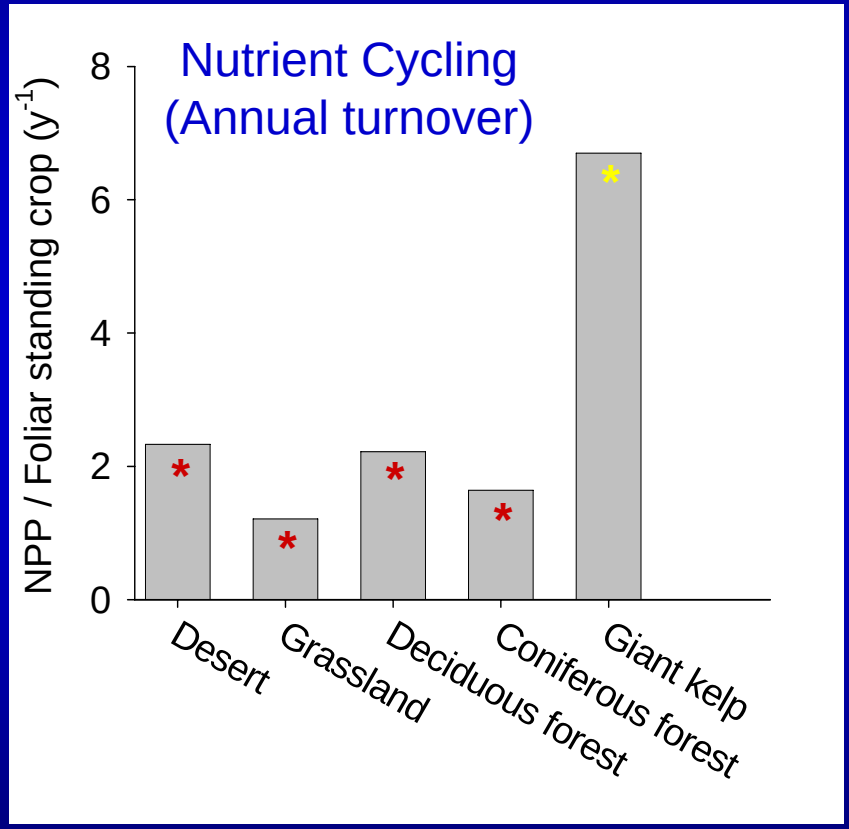
Giant Kelp is a Foundation Species

The number of living creatures of all Orders whose existence intimately depends on the kelp is wonderful. *Darwin 1860*

Yet if in any country a forest was destroyed, I do not believe nearly so many species of animals would perish as would here from the destruction of the kelp. *Darwin 1860*

Giant Kelp Forests Have High Functional Value





* from Knapp and Smith 2001, Science 291:481-484

* from SBC LTER

* from Webb et al. 1983, Ecology 64:134-151

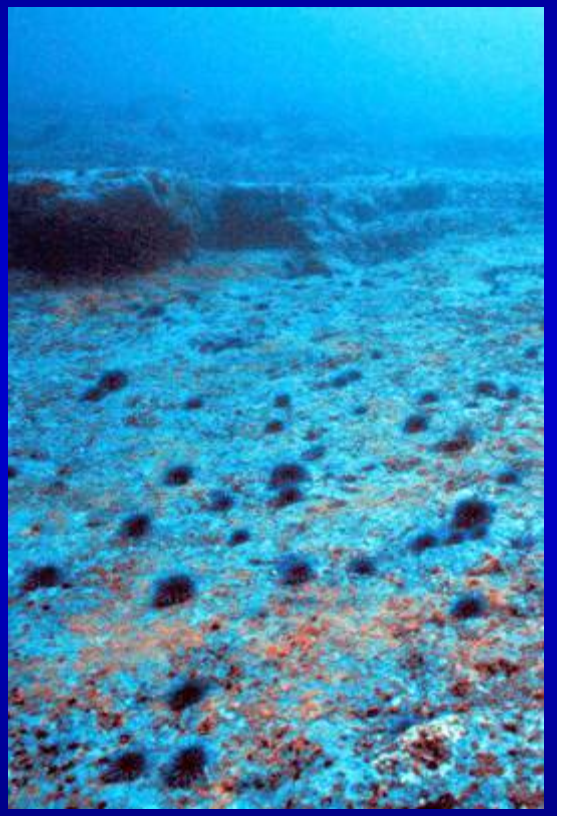
* from SBC LTER

Environmental Drivers Cause Changes in the Abundance of Giant Kelp, which Cause Shifts in Community Structure

Forested
Complex structure

Predator decline
Herbivore increase
Large waves (that remove kelp)
Warm, nutrient-poor conditions

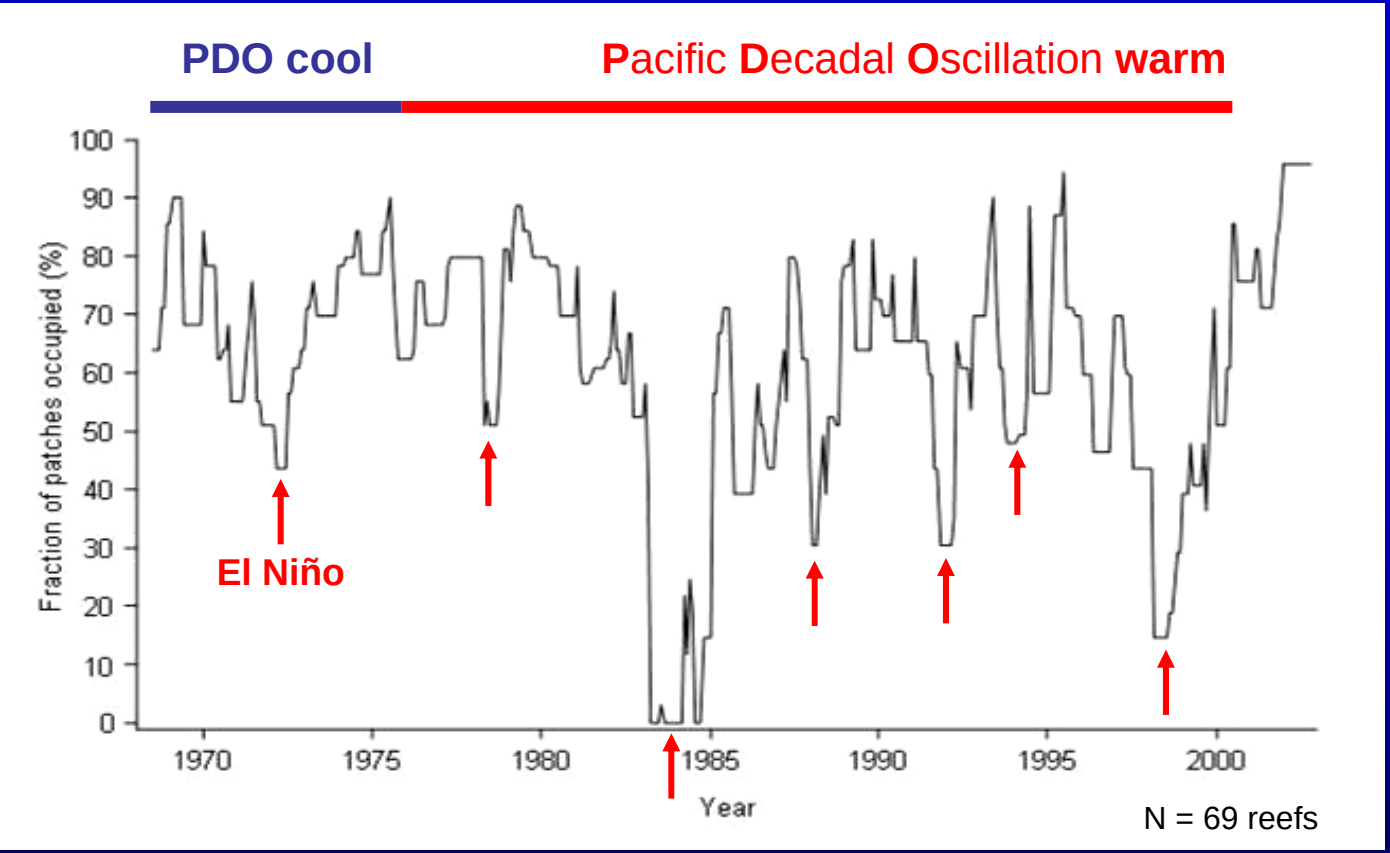
Predator increase
Herbivore decline
Large waves (that remove grazers)
Cool, nutrient-rich conditions



Deforested
Simple structure

Environmental Drivers Cause Changes in Kelp Forest Structure

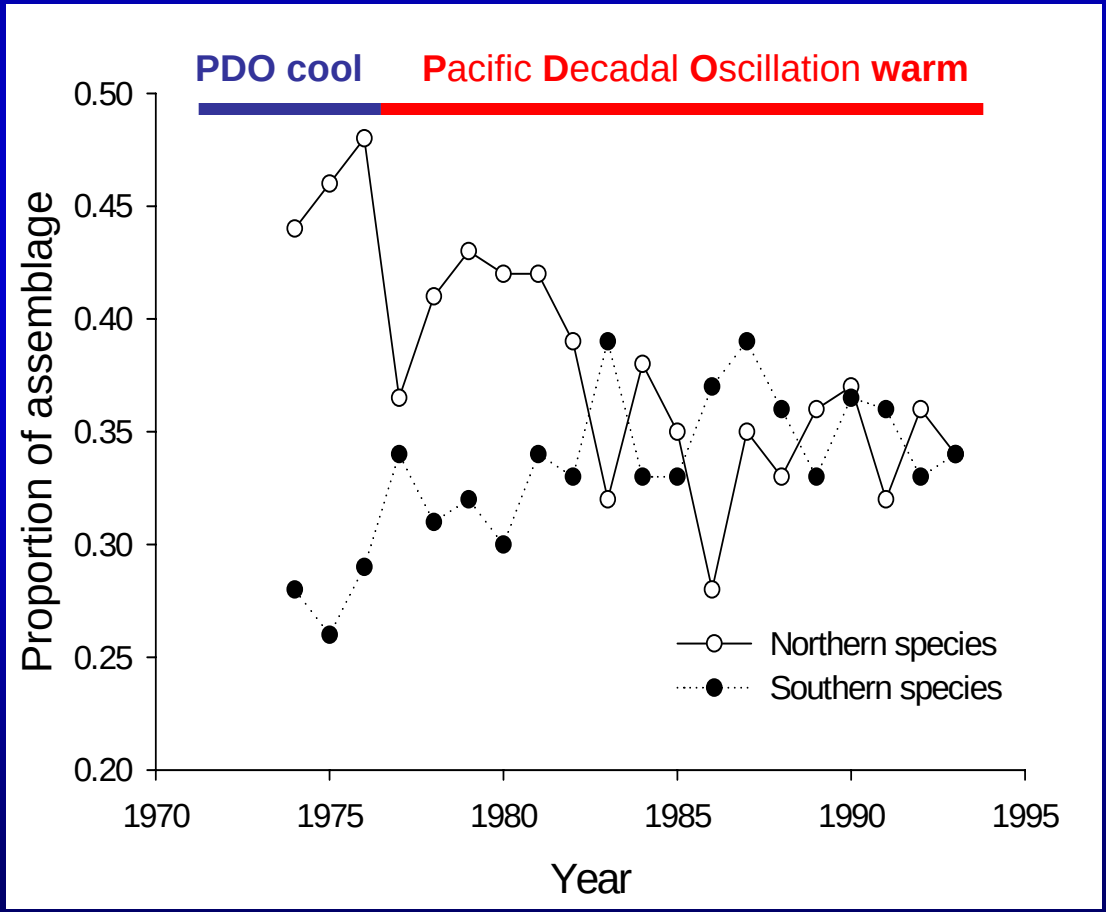
Occupancy of giant kelp on reefs in southern California



Reed et al. 2006. Marine Metapopulations. Academic Press

Environmental Drivers Cause Changes in Kelp Forest Structure

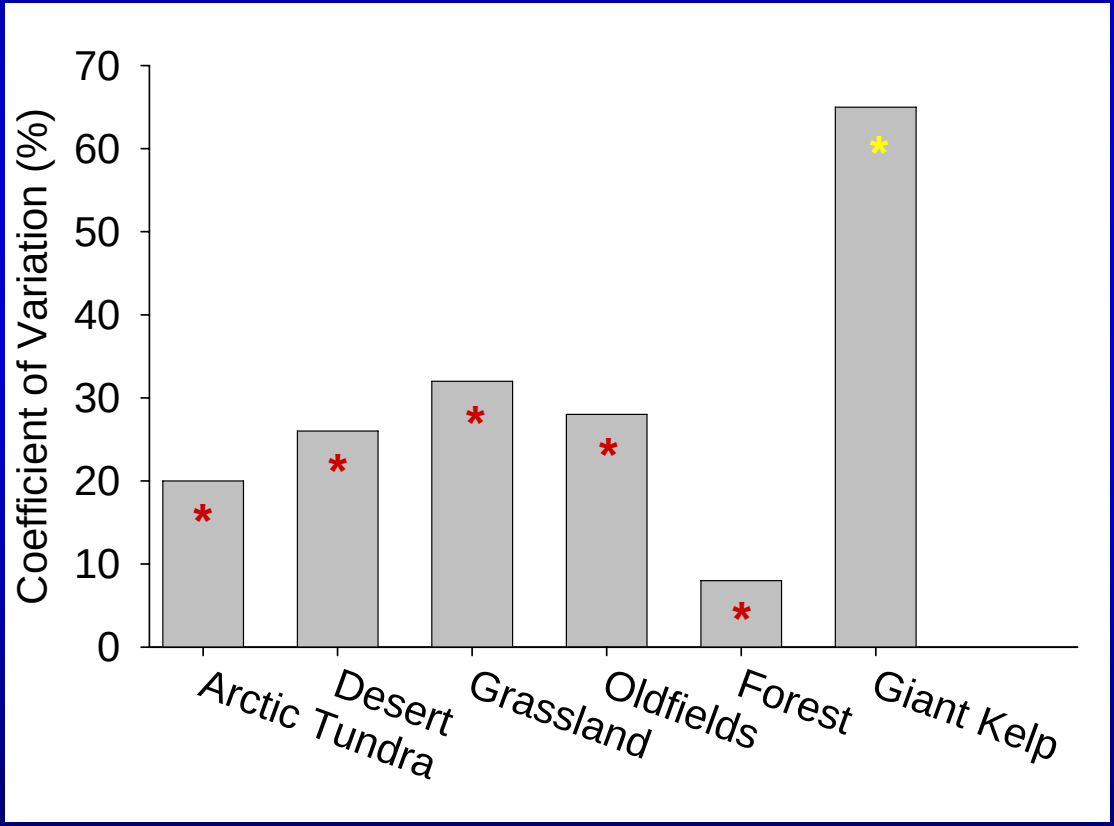
Species composition of kelp forest fish assemblage



Holbrook et al. 1997. Ecol Appl. 7:1299-1310

Environmental Drivers Affect Kelp Forest Function

Interannual variability in net primary production

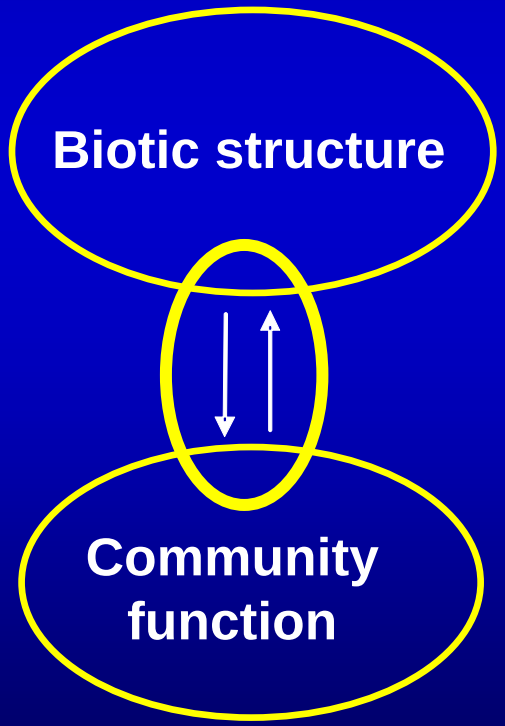


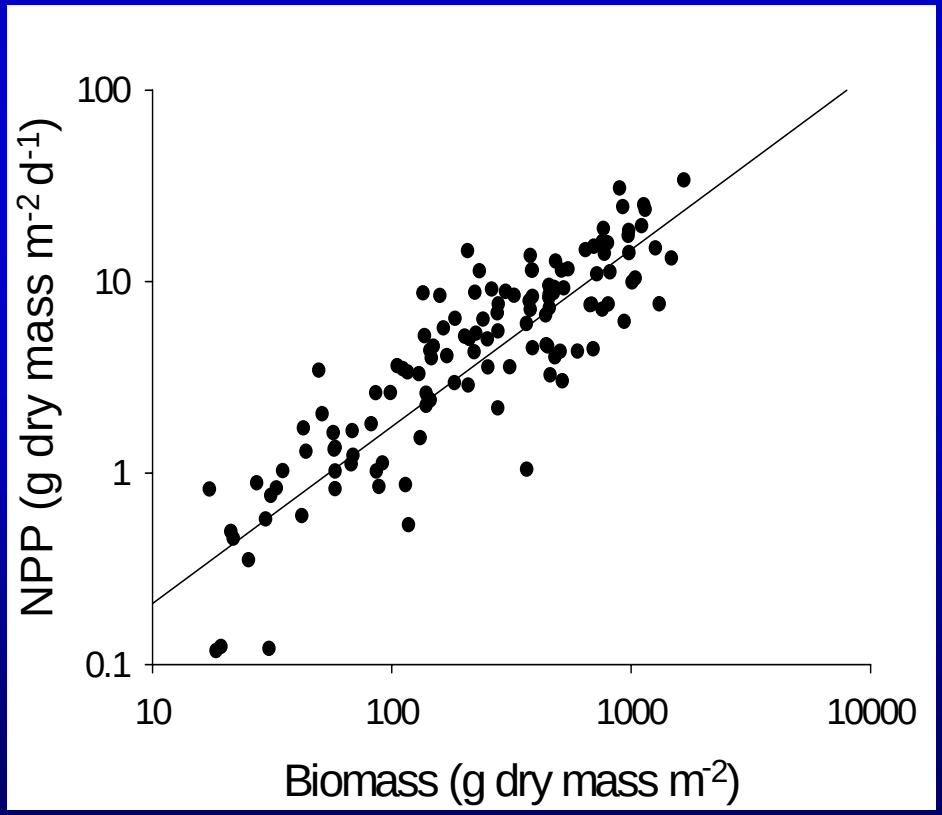
* from Knapp and Smith 2001, Science 291:481-484

* from SBC LTER

Kelp Forest Community Structure and Function Are Tightly Coupled

Kelp net primary production is dependent on kelp standing crop

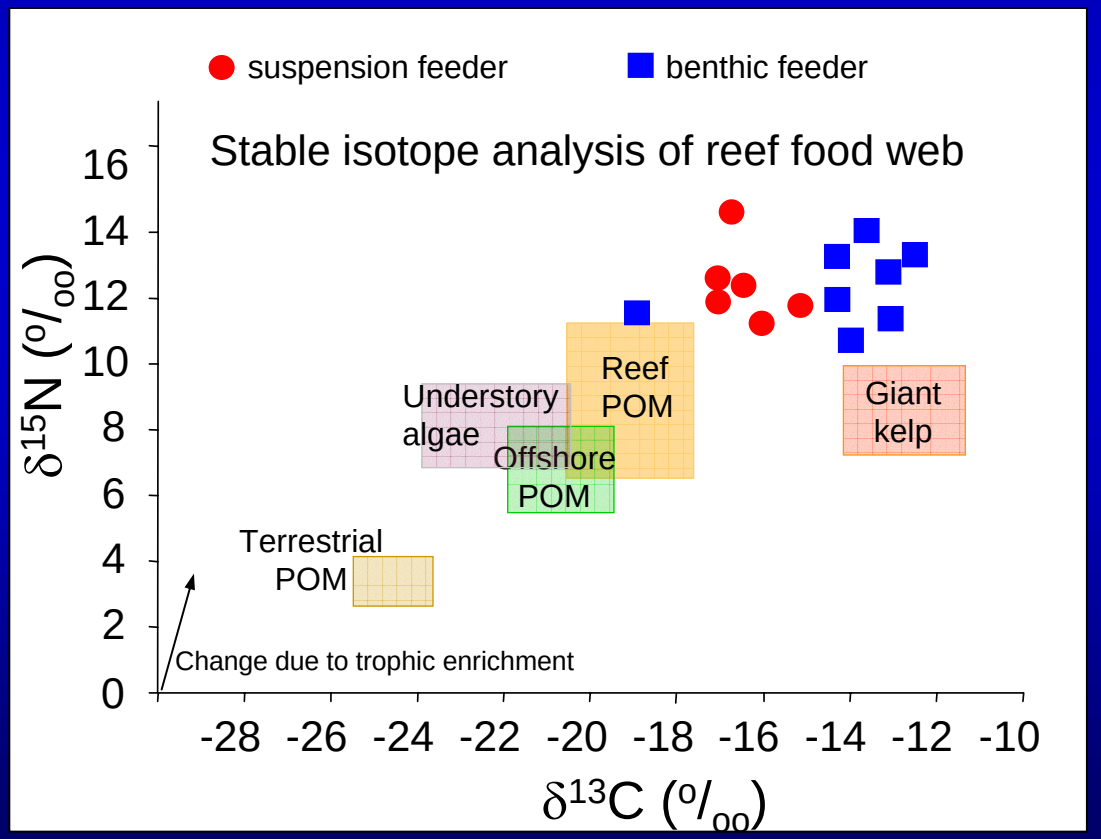




Data from SBC LTER

Kelp Forest Community Structure and Function Are Tightly Coupled

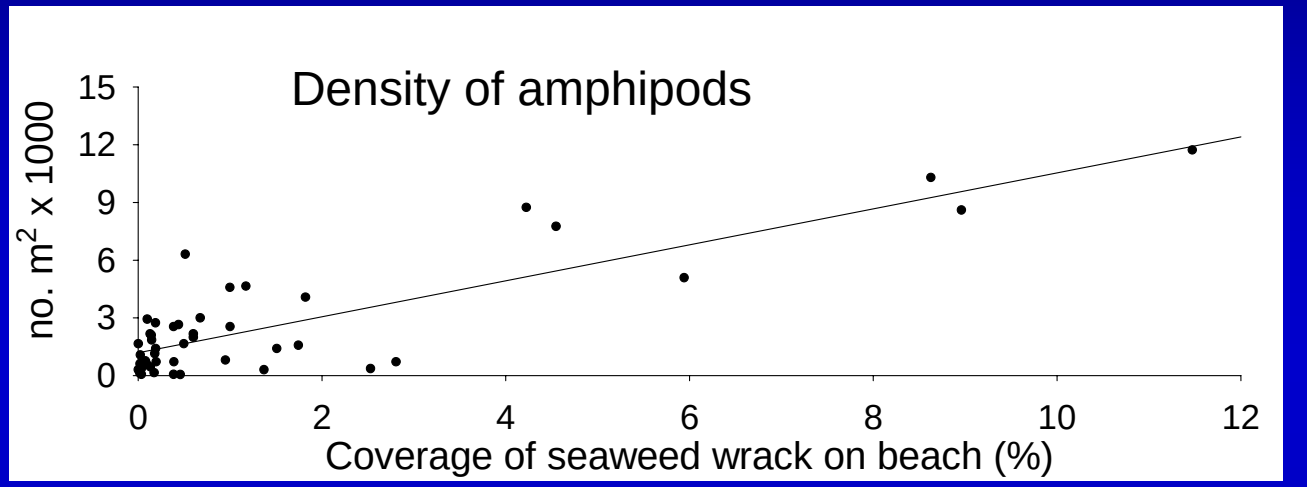
Giant kelp is a major source of dietary carbon for a diverse food web

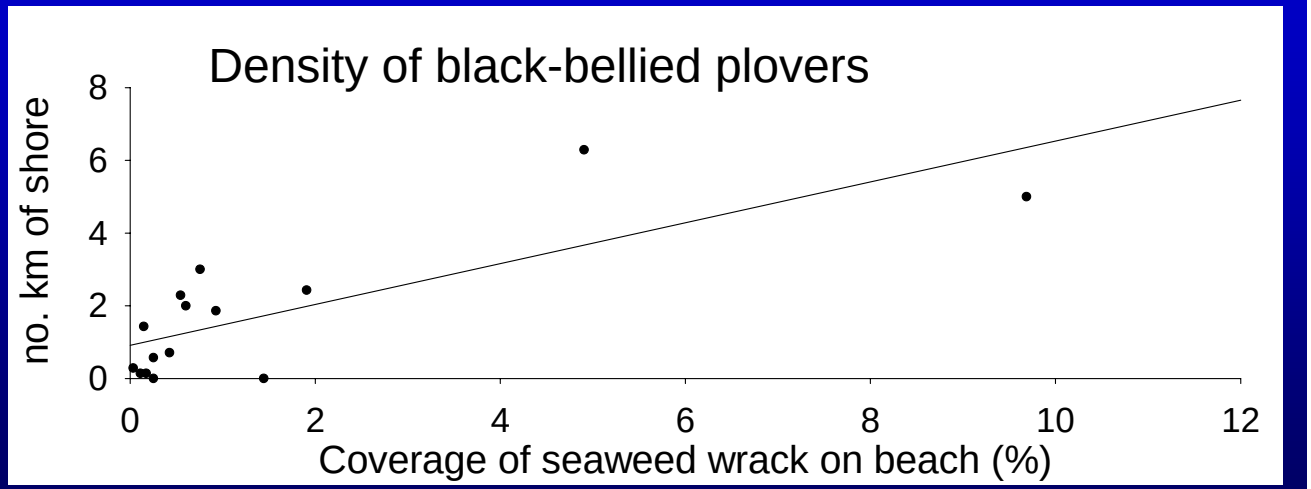


Data are annual means of samples collected during 2001-2005. SBC LTER

Kelp Forest Community Structure and Function Are Tightly Coupled

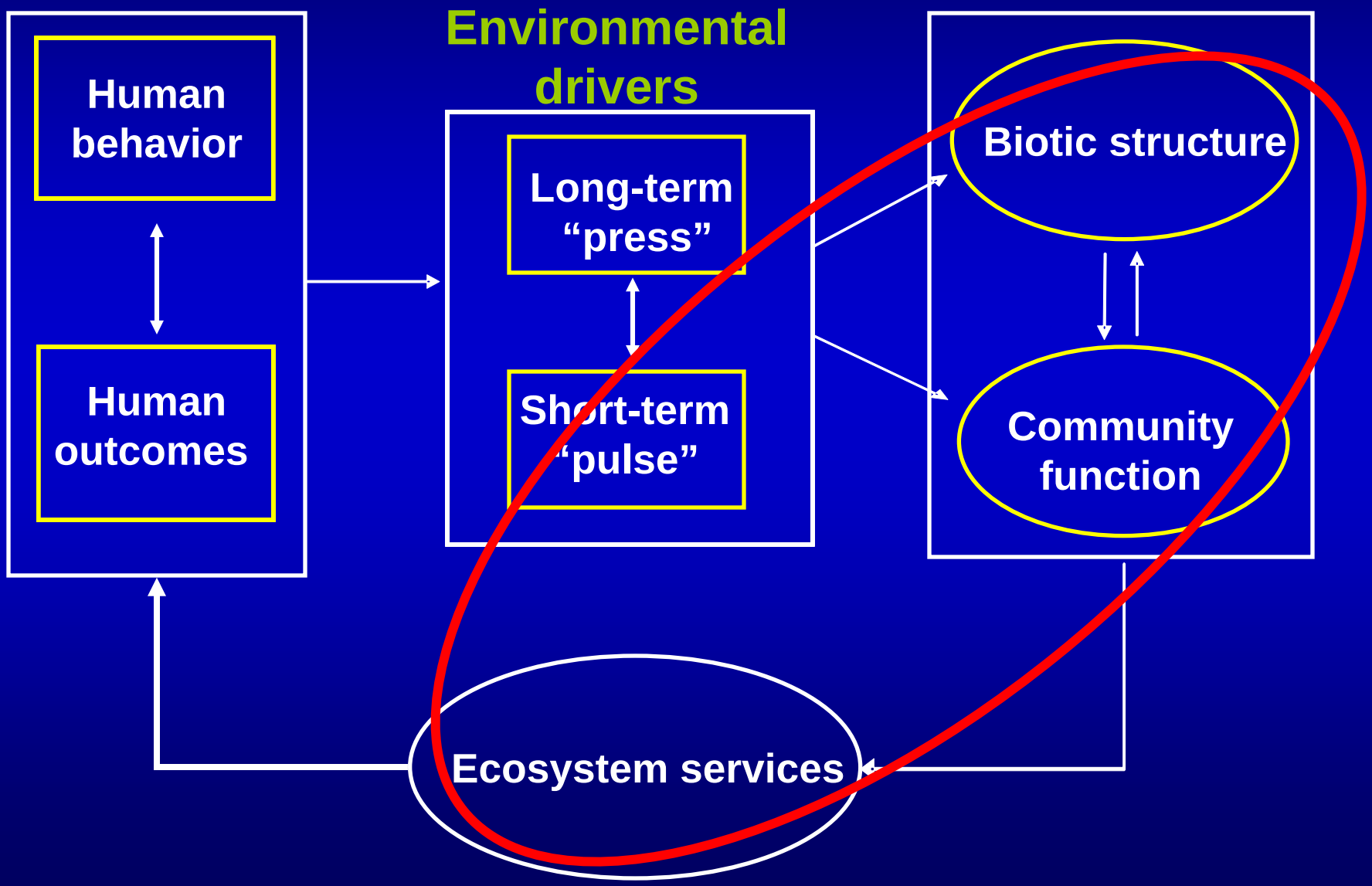
Giant kelp subsidizes the foodwebs of adjacent ecosystems





Dugan et al. 2003 Estuarine Coastal Shelf Science 58:133-158

CONCEPTUAL FRAMEWORK



Ecosystem Services Provided by Giant Kelp Forests

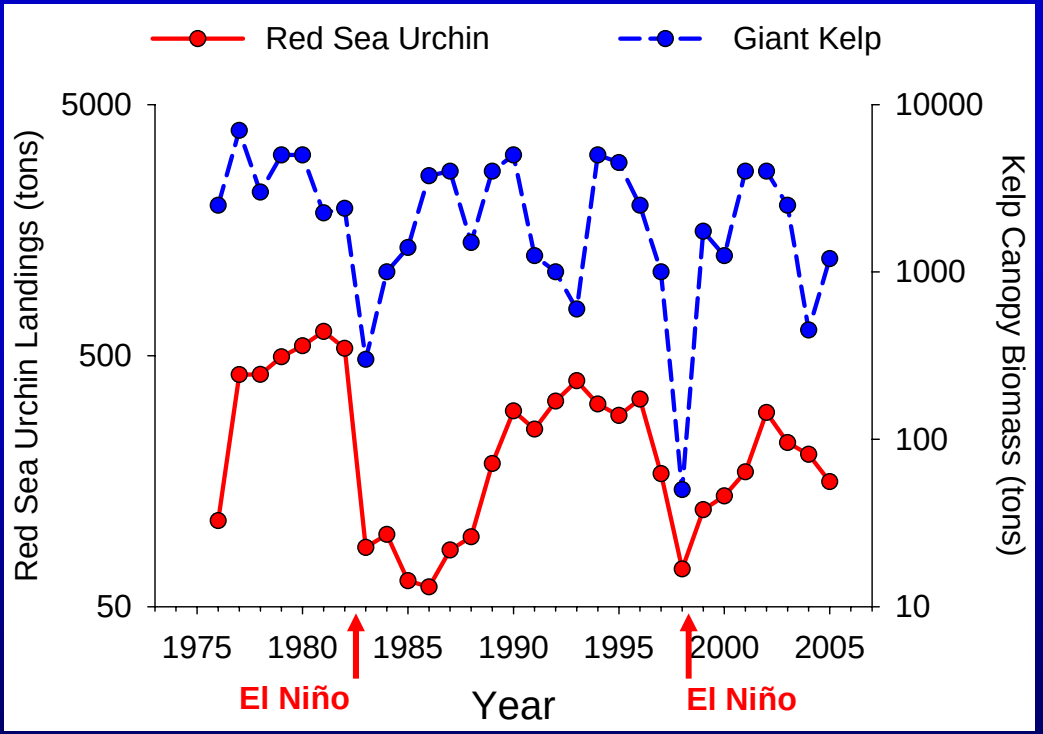
Provisioning Services
- Fisheries
- Aquaculture
- Pharmaceuticals
- Bio Fuel

Cultural Services
- Education
- Recreation
- Aesthetics
- Tourism

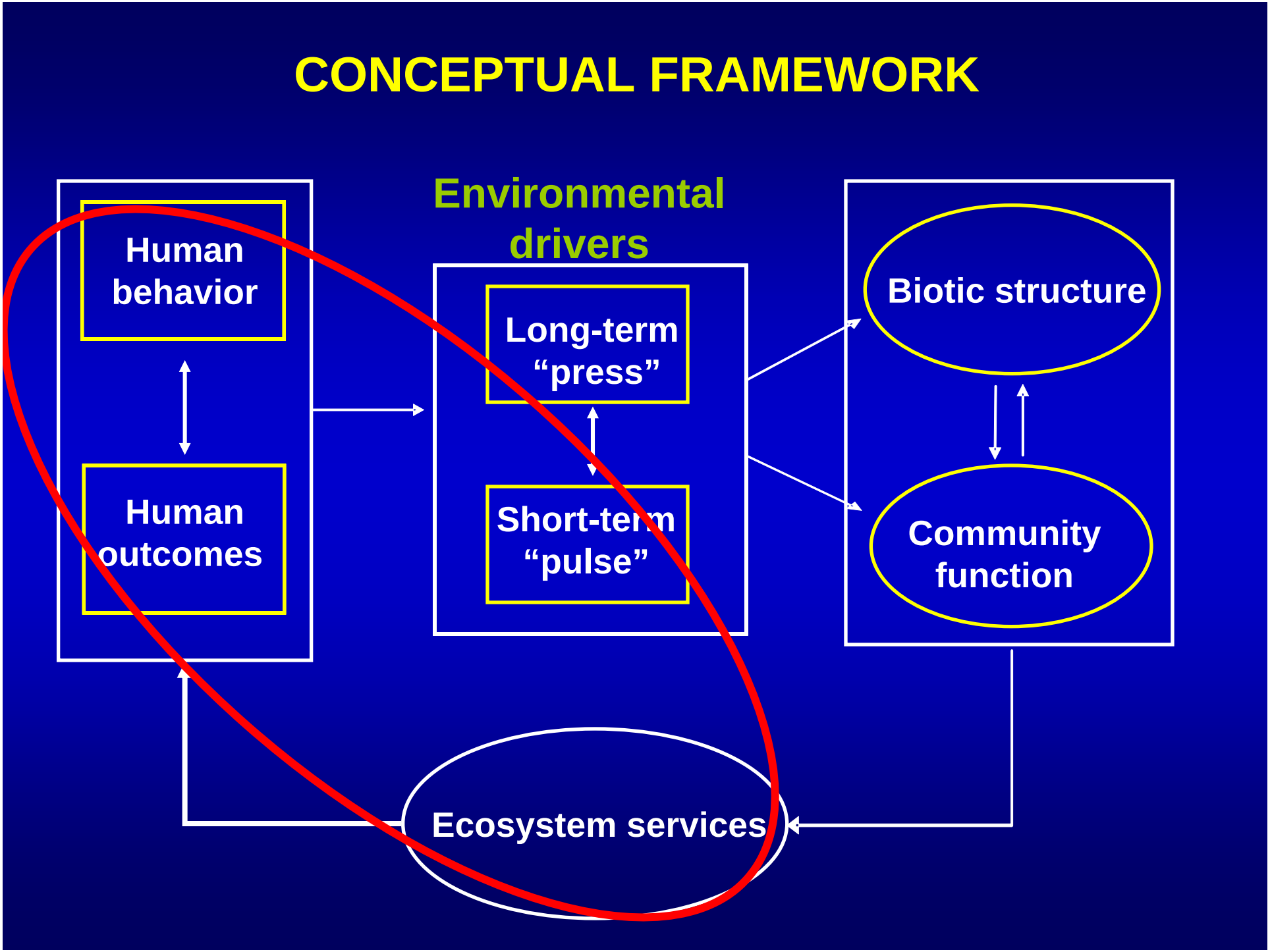
Regulating Services
- Biodiversity conservation
- Water quality
- Modify sea surface state

Changes in Biotic Structure Affect Ecosystem Services

Red sea urchin roe fishery (data from Pt. Loma)

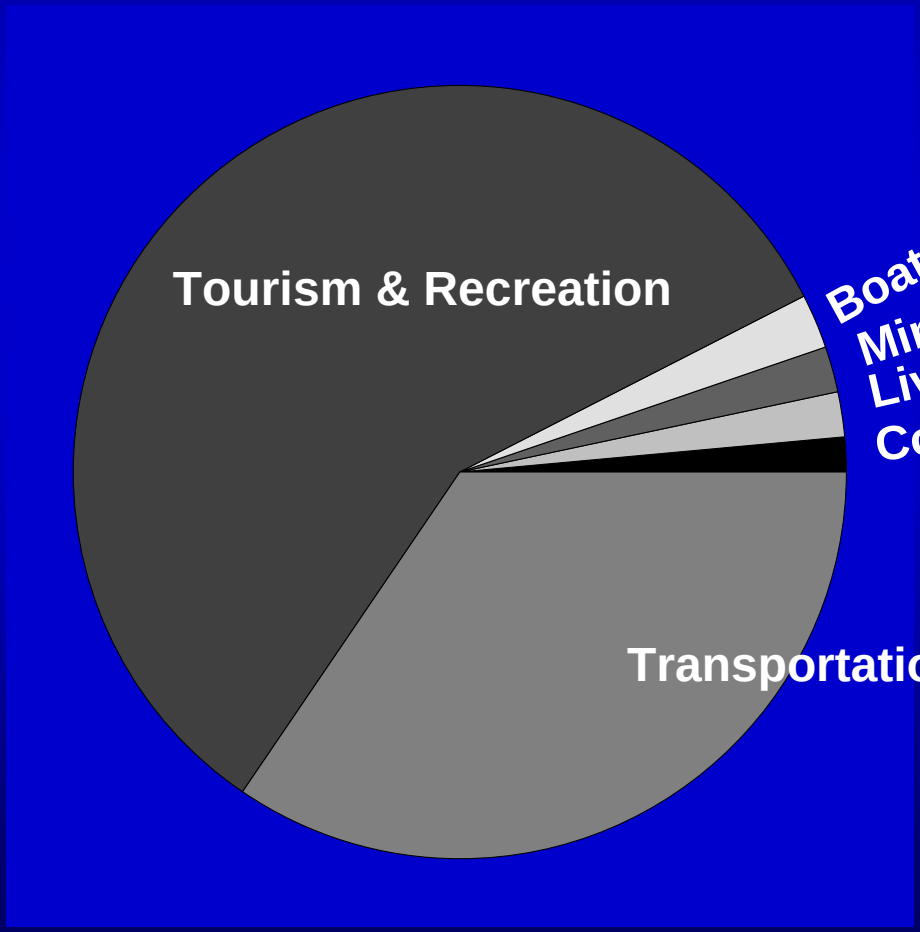


CONCEPTUAL FRAMEWORK



California's Ocean Economy

Direct Market Value = $21.4 Billion



Competing Ecosystem Services

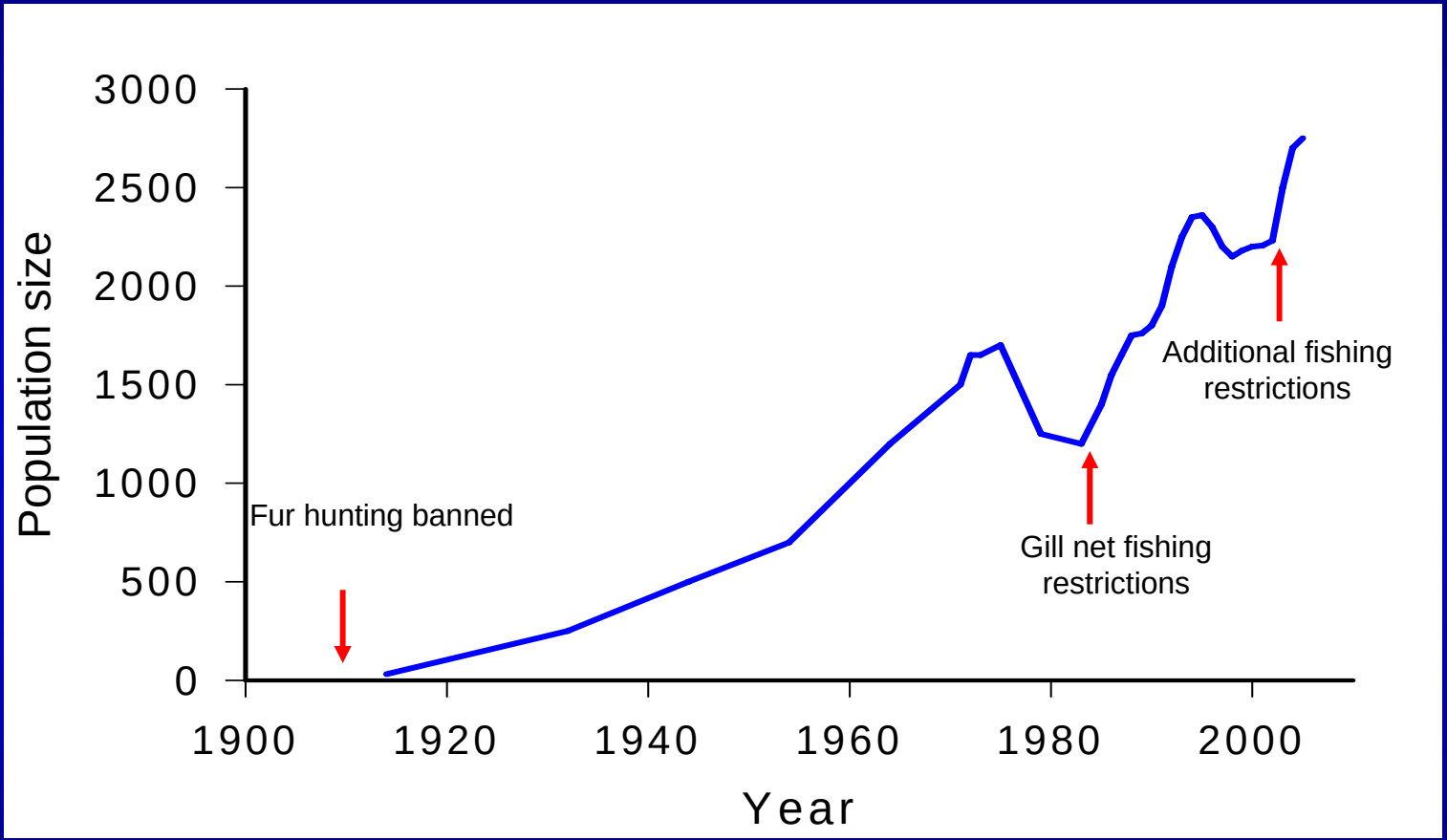
Southern sea otter “Keystone species”

Cultural Services
- Tourism
- Education
- Aesthetics

Regulating Services
- Water quality
- Conservation

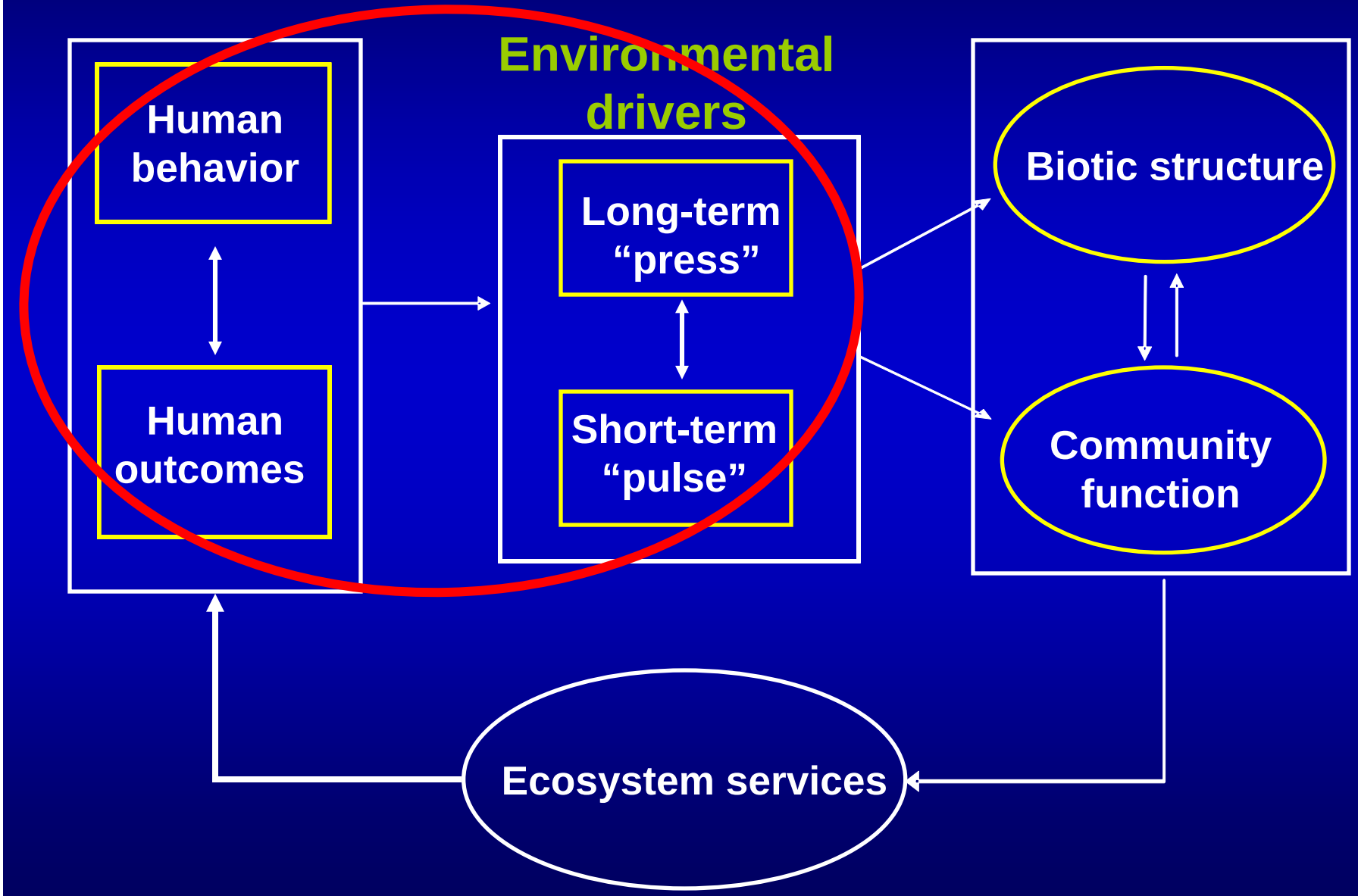
Provisioning Services
- Fisheries
- Oil and gas development

California Sea Otter Population



- **Hunted to near extinction for their fur in the 1800's**
- **Recovery linked to regulatory changes**

CONCEPTUAL FRAMEWORK



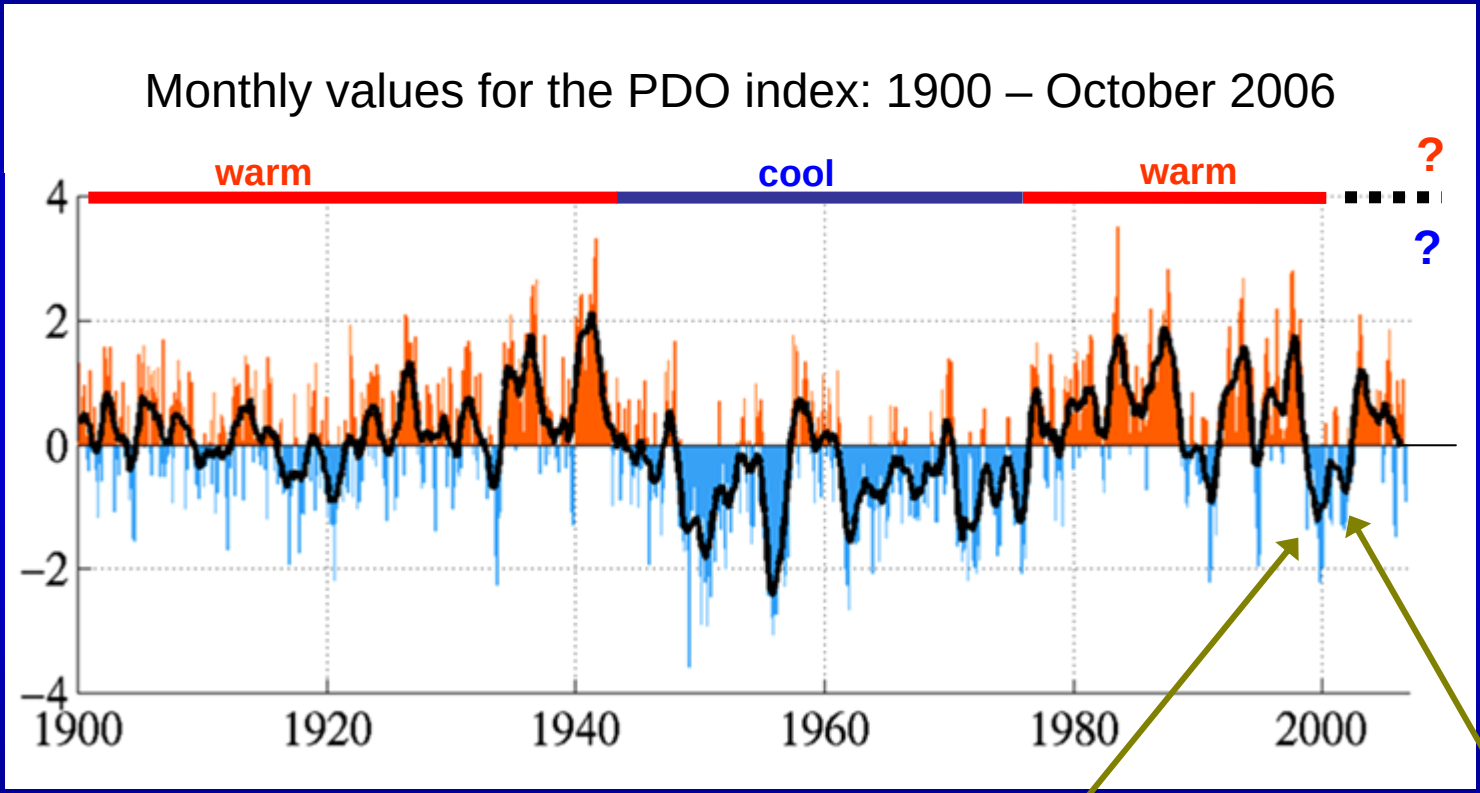
Competing Ecosystem Services Lead to Controversial Legislation

Defines the "coastal zone" and establishes land use control for the zone

Establishes a new isolated population of sea otters at an offshore island and restricts the expansion of sea otters along the mainland

Requires the state Department of Fish and Game to design and manage an improved network of marine protected areas

Changes in Policy Coincide with Changes in Environmental Drivers

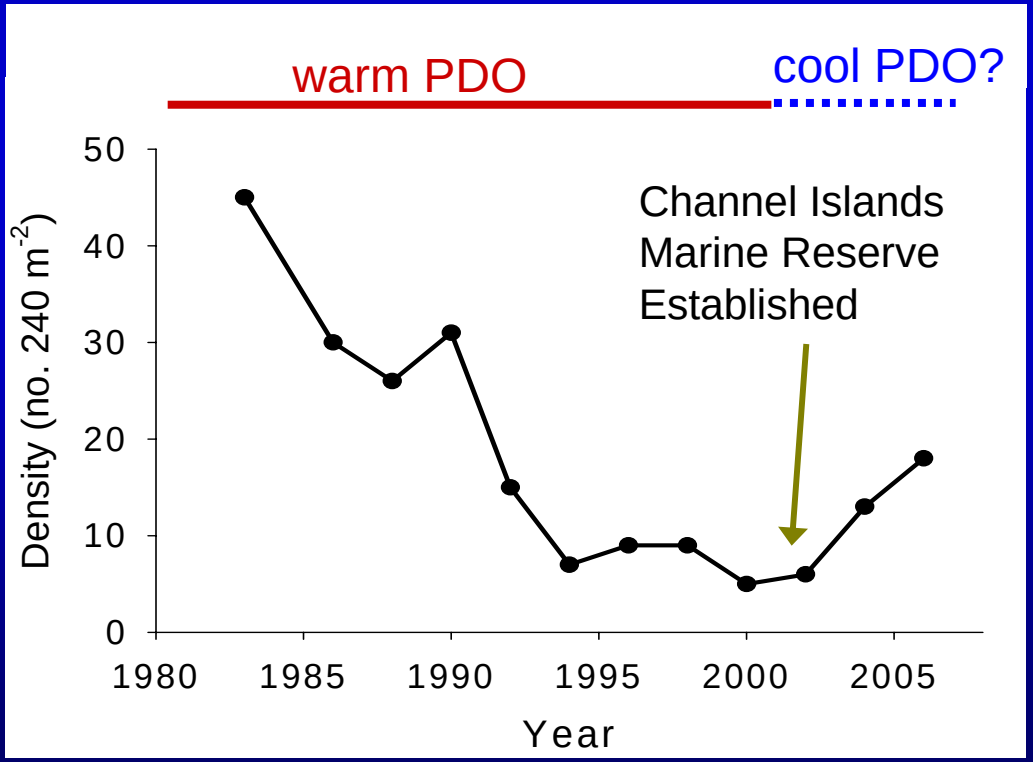


Marine Life Protection Act enacted

Santa Barbara Channel Islands Marine Reserve Established

Changes in Policy Coincide with Changes in Environmental Drivers

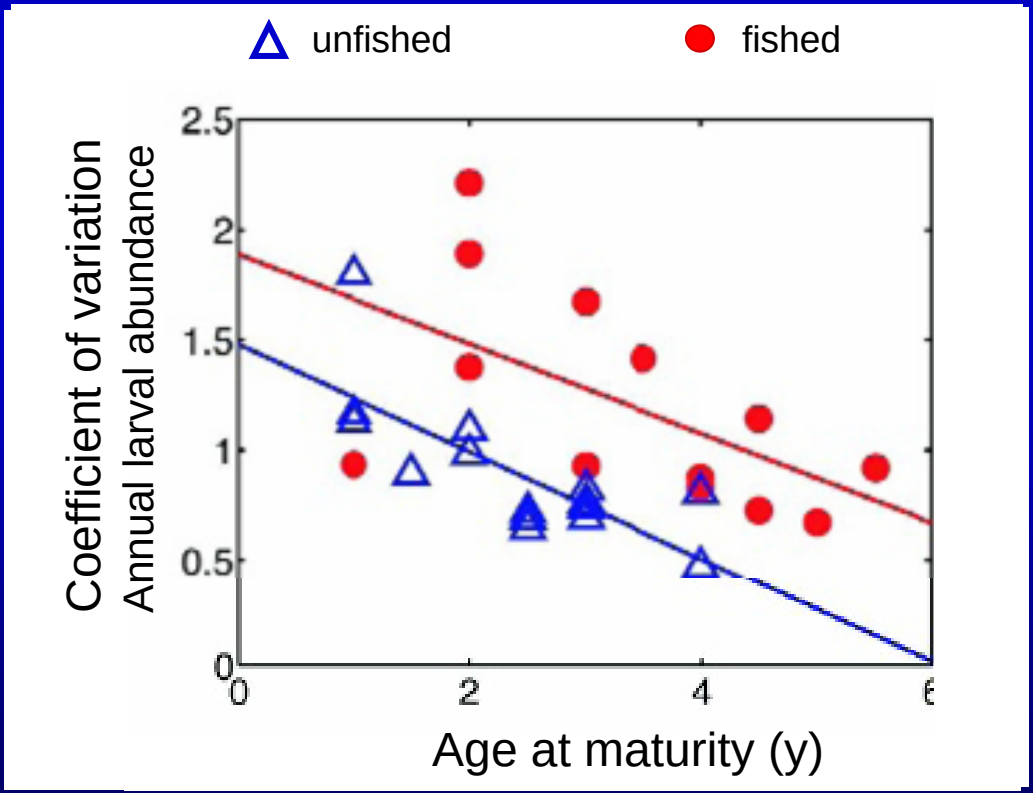
Density of black surfperch at Santa Cruz Island



Data from SBC LTER

Distinguishing Between the Effects of Natural vs. Anthropogenic Drivers

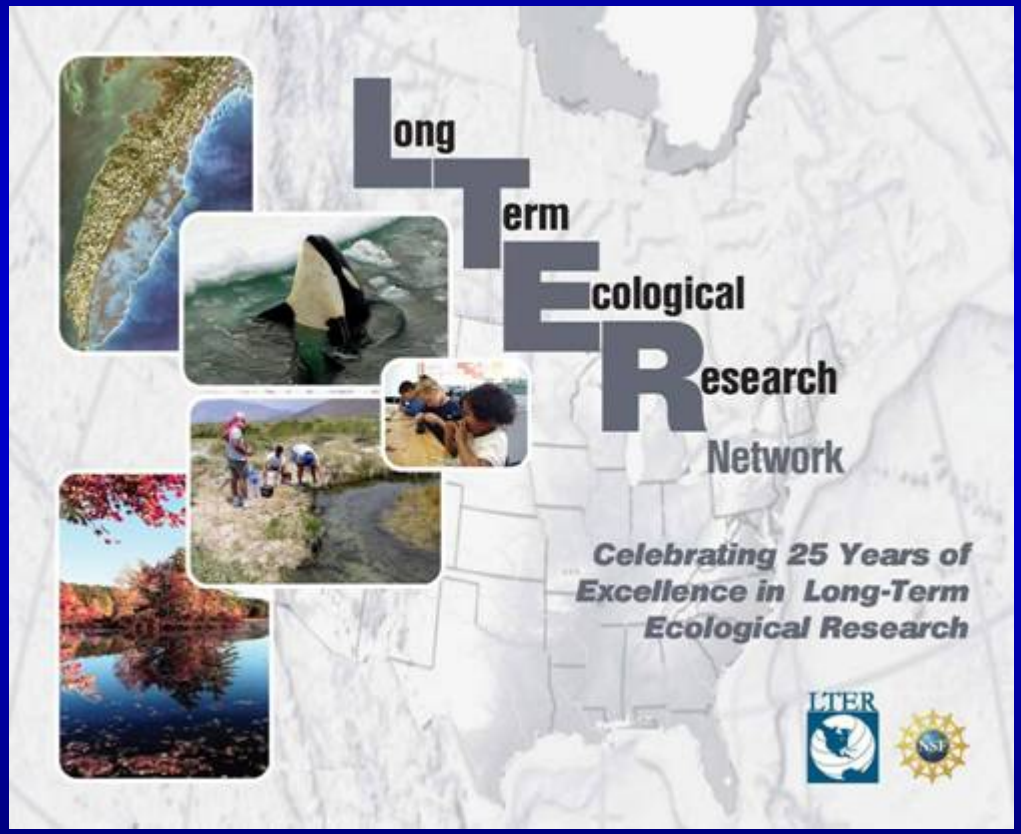
Fished species fluctuate more than unfished species



- 50 year data set used to distinguish between human & natural drivers
- Information on magnitude and sources of variability needed for effective management

Hsieh et al. 2006. Nature 453:859-862 CCE LTER

Role of LTER in Society and the Environment



- Long-term data are needed to understand patterns and causes of changing ecosystems
- Such knowledge is essential for evaluating the effectiveness of policies enacted to alter human behaviors that influence the structure and function of ecosystems and the services that they provide