Integration of Ocean Observations into an Ecosystem Approach to Resource Management

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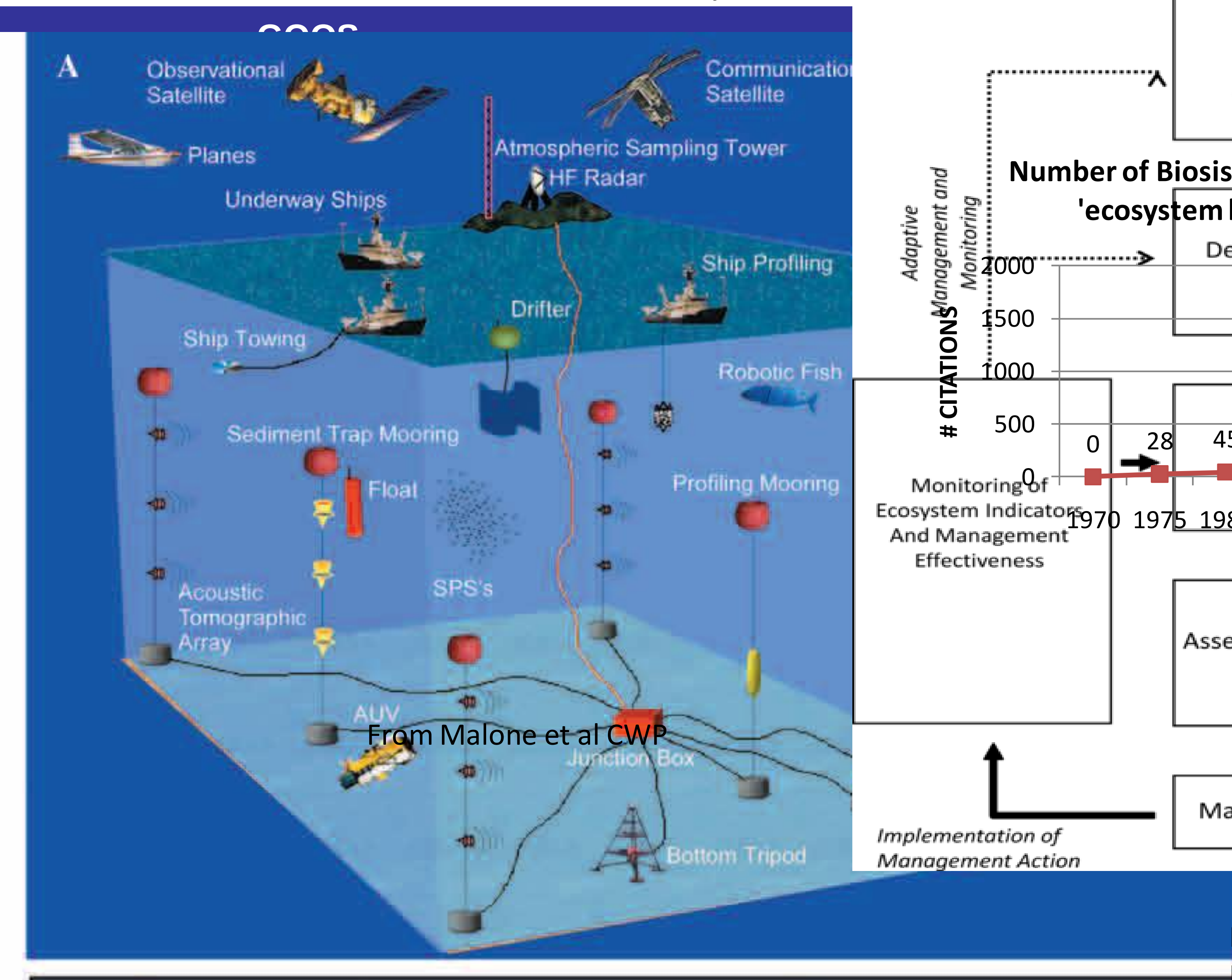
Drawing on CWPS by
M.-H. Forget : SAFARI
U. Send: OceanSITES
D.P. Costa: TOPP
N.O. Andegard: MAAS
R. O'Dor: OTN

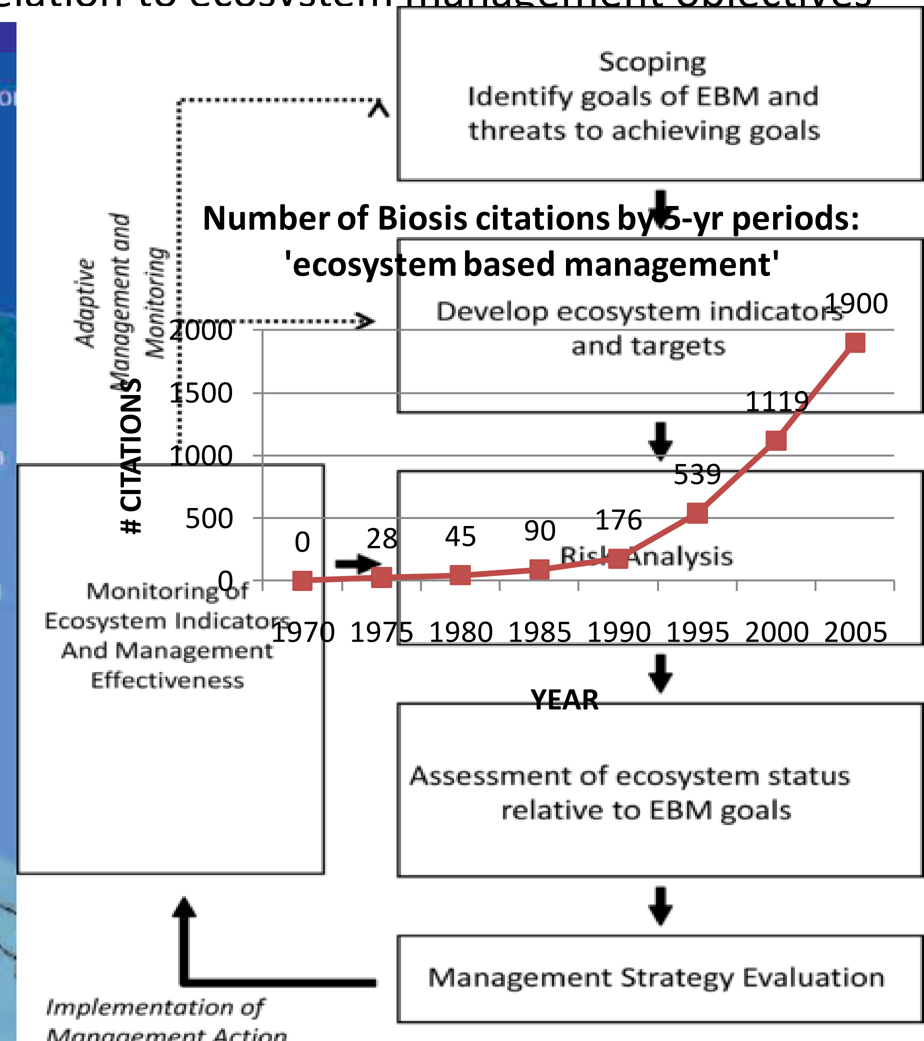
Two perspectives on ocean observations & ecosystem-based management

The observationalist

The manager: Integrated ecosystem assessment as synthesis and analysis in relation to ecosystem management objectives



From Malone et al CWP

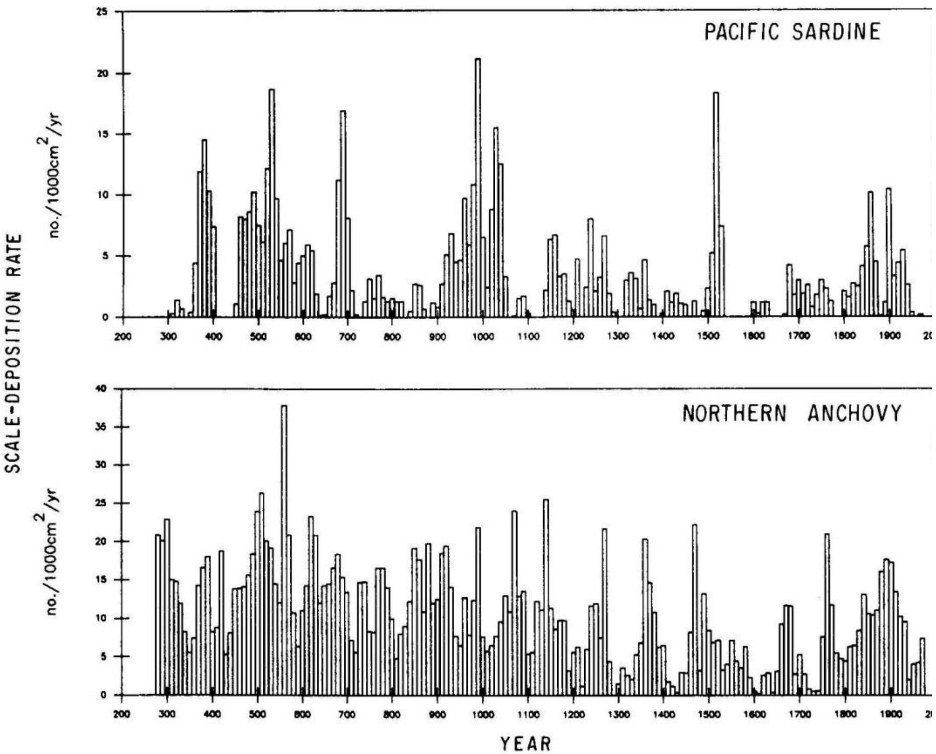


From: Levin et al (2009) PLOS Biology

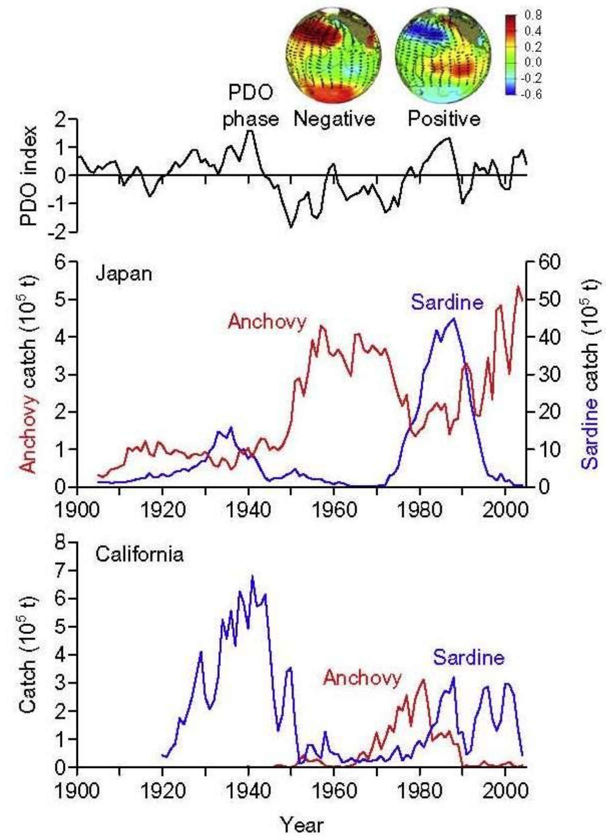
Ecosystem threats

- Anthropogenic
  - Impacts of fisheries on target species, bycatch spp, habitat, competitors and predators, community structure and ecosystem processes
  - Ecosystem impacts of other sector activities, e.g. coastal development, nutrient inputs, pollution, introduced species, etc
- Impacts of climate variability and climate change on target species, competitors & predators, community structure and ecosystem processes

Why climate?



(from Baumgartner et al. 1992 CalCOFI Repts)



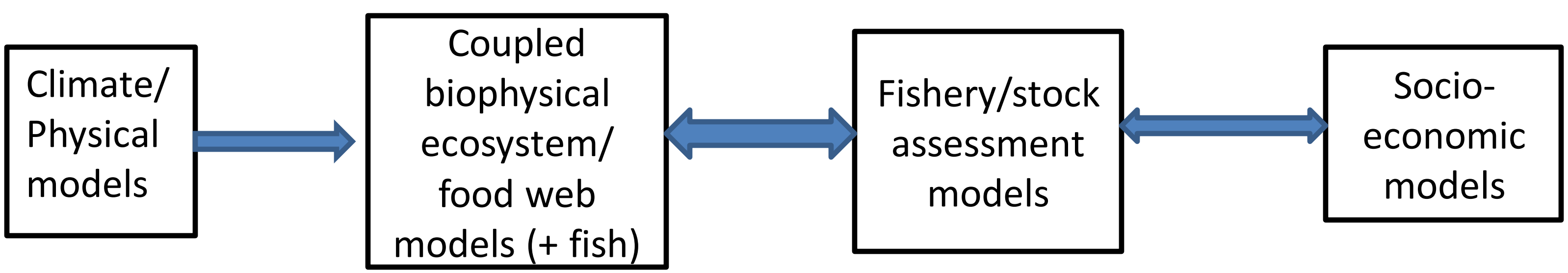
(from Takasuka et al. 2008 Prog Ocean)

Climate drives marine populations/ecosystems in upwelling systems; also driven by NAO in N Atlantic

Integrated Ecosystem Assessment

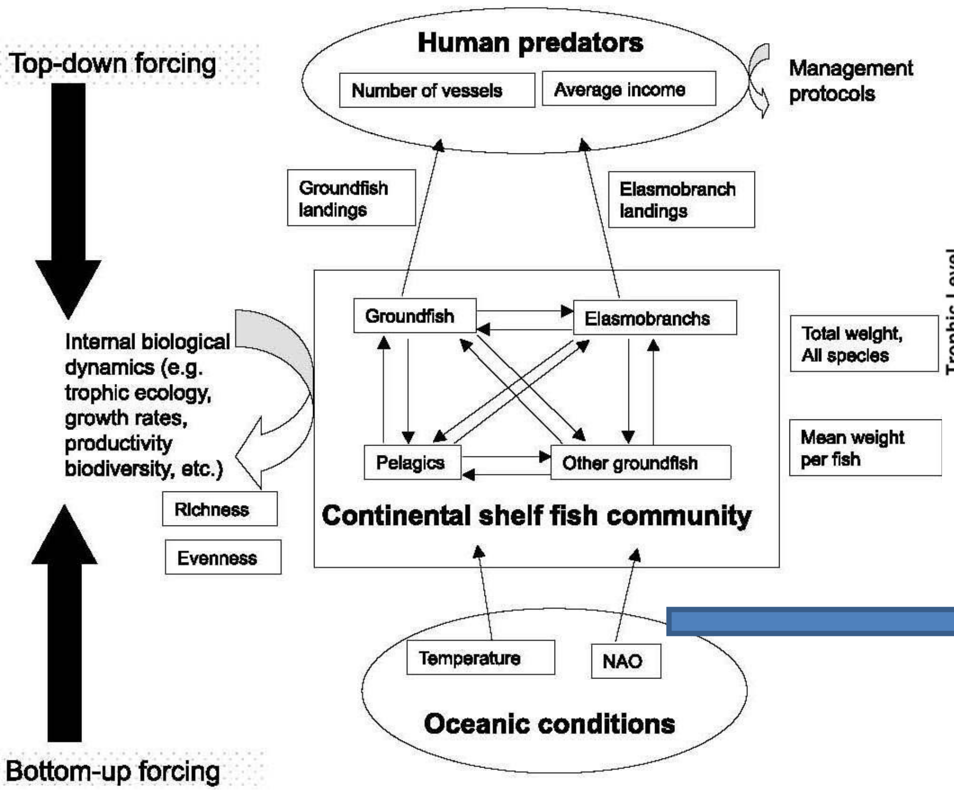
- Tracking of physical, biological, anthropogenic indicators
- Integration/iteration of modeling/observations/(process studies)

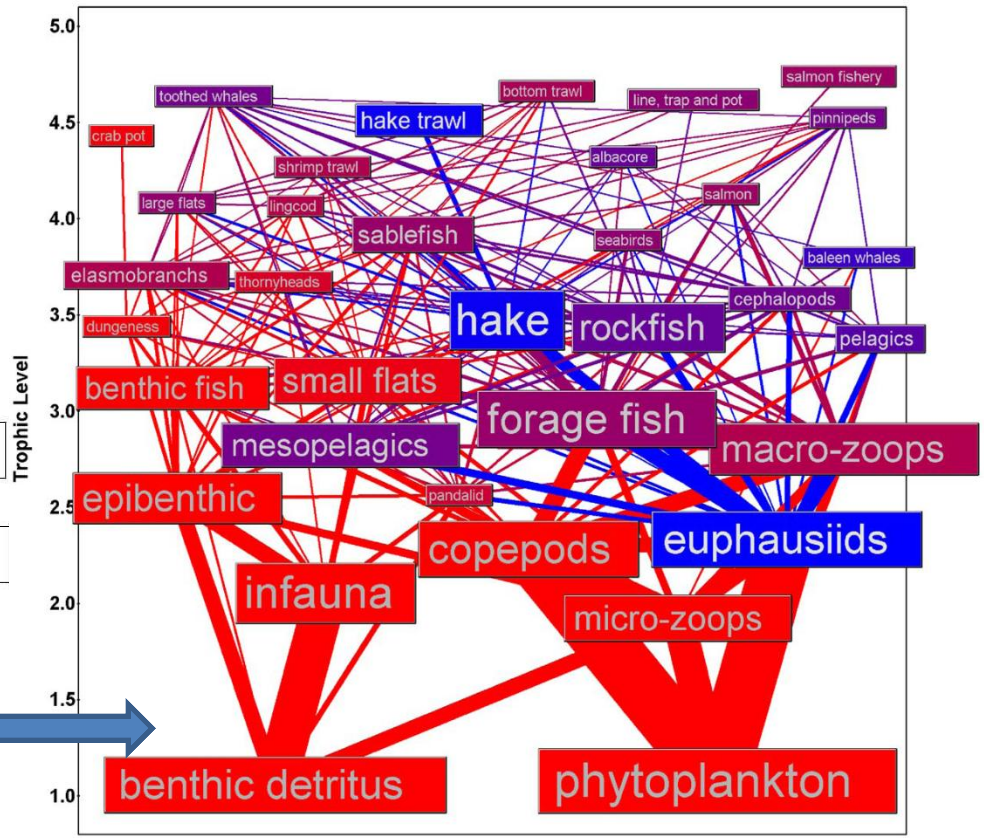
But what kinds of models & observations?



(Adapted from Schwing et al. 2009)

Integrated Ecosystem Assessment:





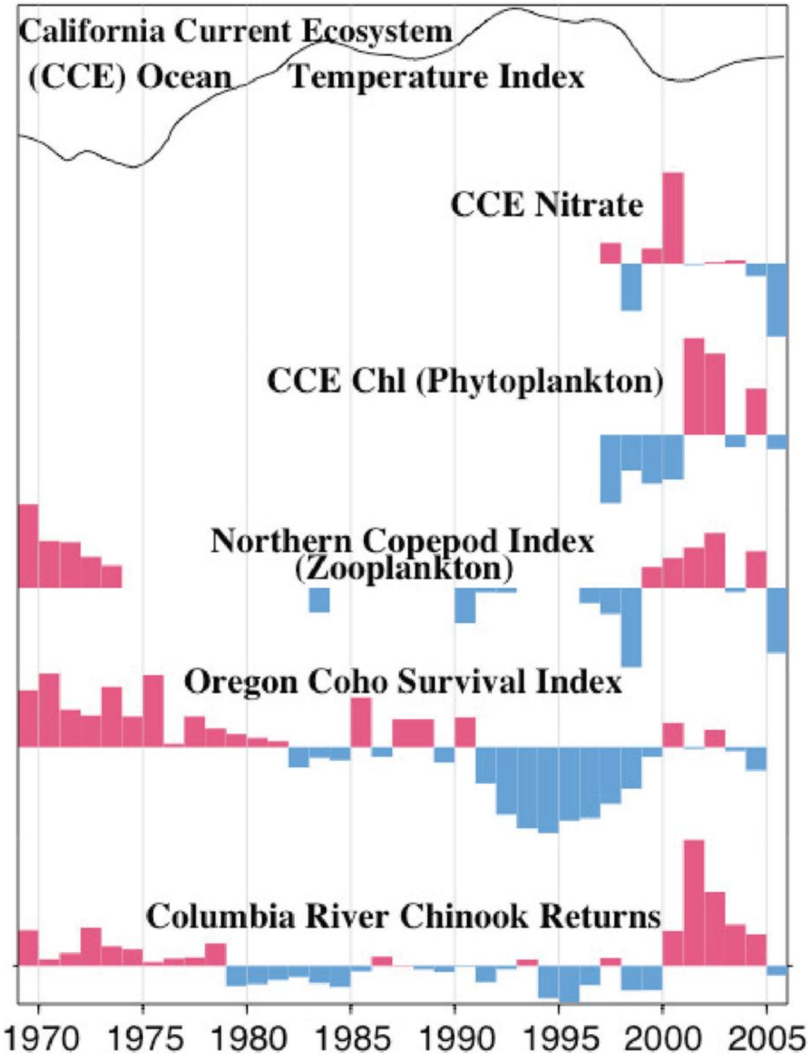
(from Field & Francis 2006 Mar Policy)

(from Link et al. 2002 CJFAS)

Key model limitations: 1) Do not incorporate behavior of mid- & higher trophic levels; 2) models incorporate food web interactions but do not model recruitment

Data requirements

- Physical/chemical/lower trophic level (phyto-, zooplankton)
  - Remote sensing: SST, SSH, ocean color
  - OceanSITES: depth profile moorings/stations: T, S, chl (O_2, nutrients, pH)
  - Gliders, ARGO: T, S, chl (particles (LOPC))
  - Ship-based (e.g. CalCOFI): T, S, chl, nutrients, O_2, phyto pigments, zooplankton, ichthyoplankton
  - CPR surveys: zooplankton species (one depth)
  - The weak link – zooplankton – but often a critical one between climate and fisheries



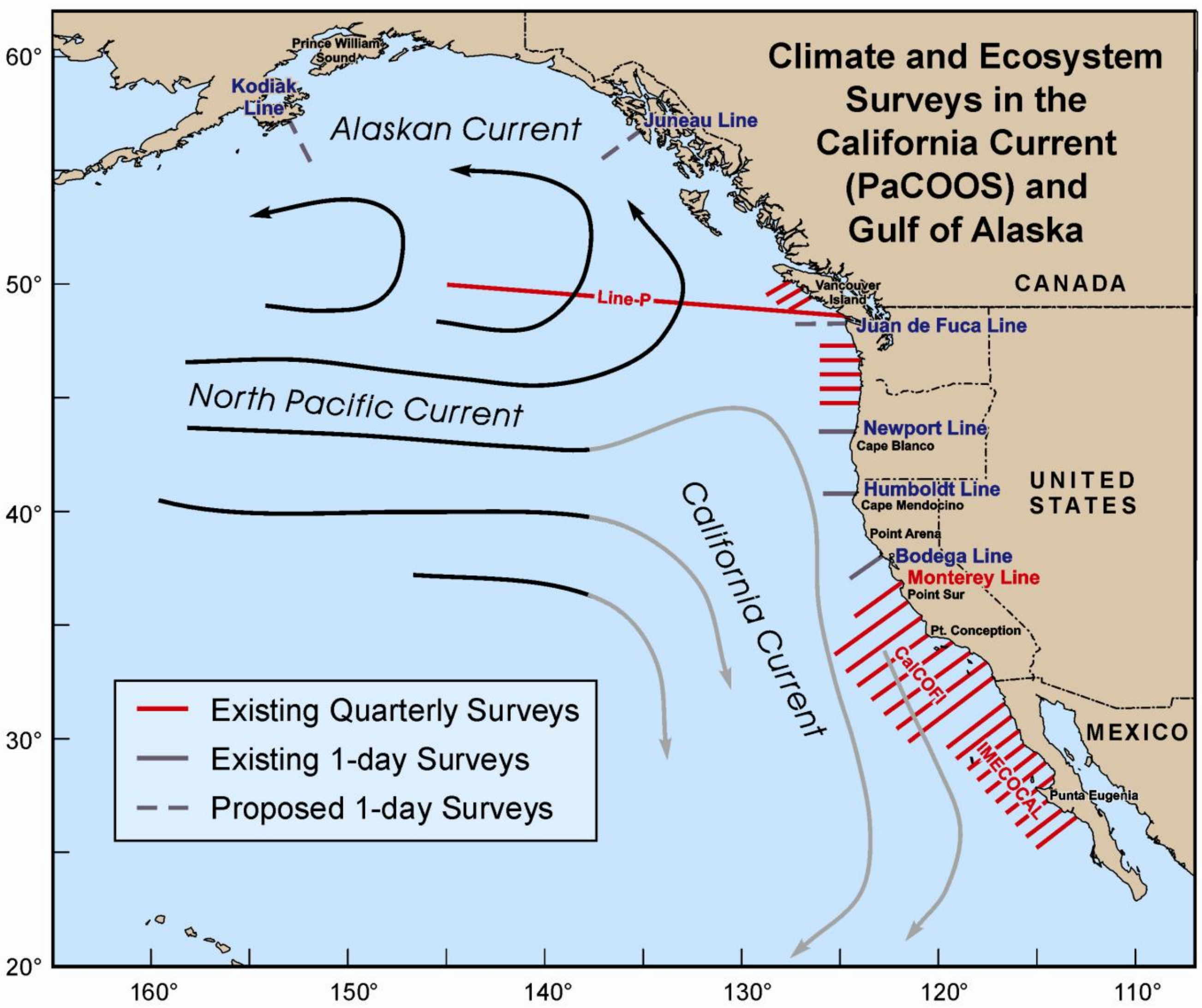
Data requirements (cont)

- Fishery: landings by species, recruitment, size/maturity at age, size/age structure
  - Collected by fishery agencies
- Mid- & higher trophic levels
  - Sources: acoustic/trawl, egg surveys, seabird & mammal observations/surveys
  - MAAS: Mid-trophic Automatic Acoustic Sampler: proposed basin-scale multi-frequency acoustic sampling of macrozooplankton - micronekton
  - Behavior (distribution) critical: TOPP (Tagging of Pacific/Pelagic Predators), POST (Pacific Ocean Shelf Tracking), OTN (Ocean Tracking Networks), acoustics combined with fine-scale hydrography (e.g. Moving Vessel Profiler). Extends complexity of models.

Data management & communication

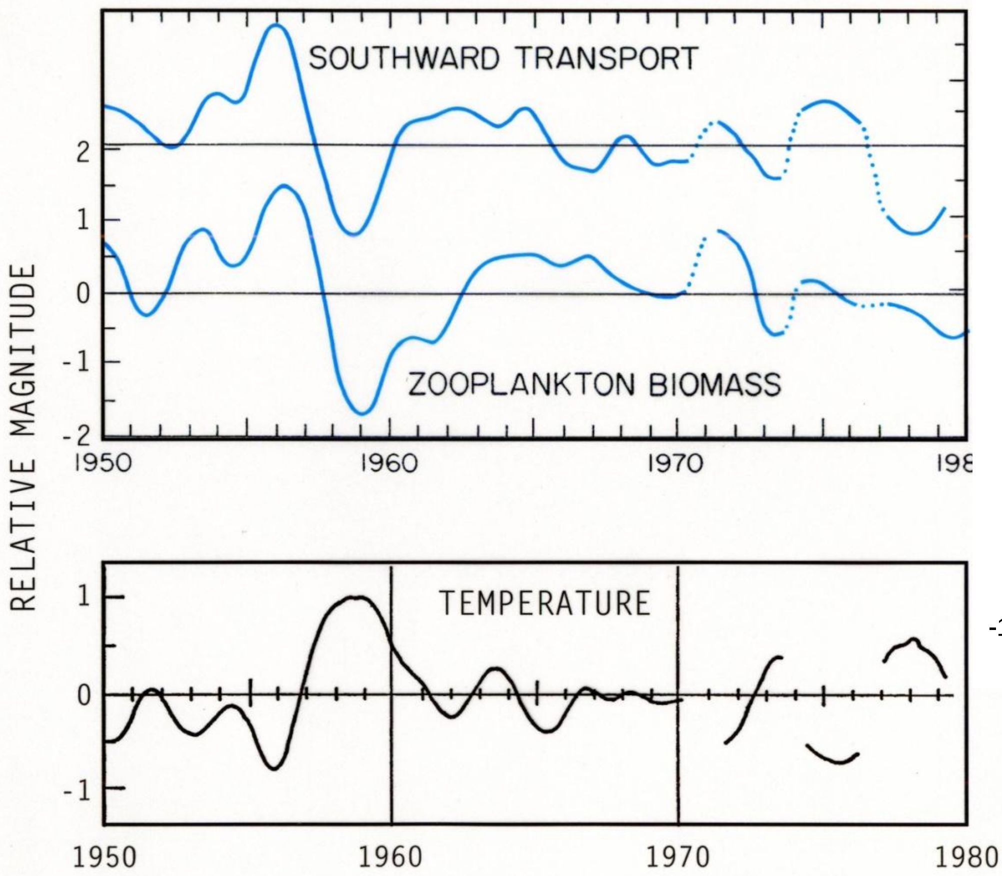
- Disparate data types: physical properties at discrete locations, depths, remotely-sensed, continuous sections (acoustics, MVP, gliders/AUVs)
- Disparate agencies (academic, govt, etc), researchers, nations….. All with different formats (and agendas!)

Observing systems in the California Current



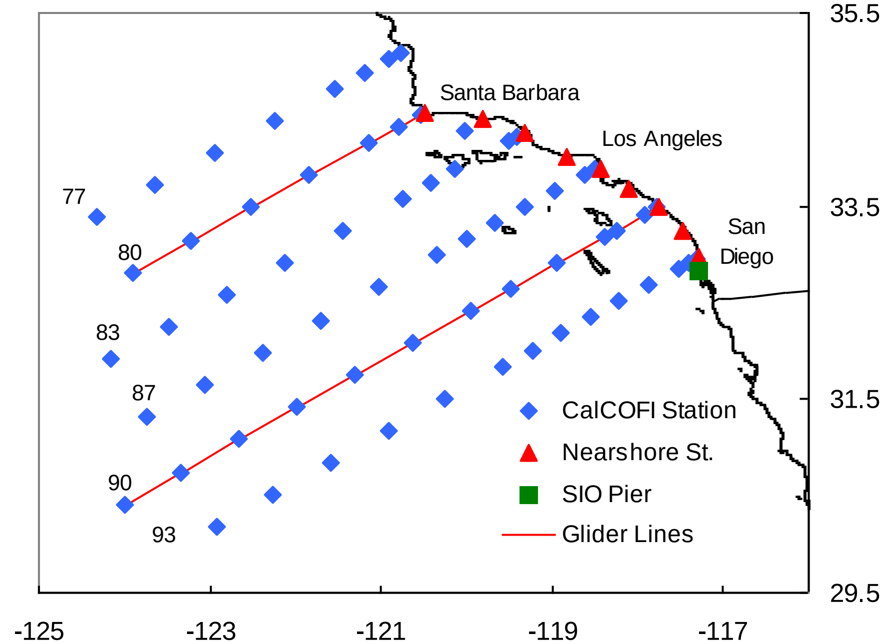
The surveys extend over 3 nations: Canada, the USA and Mexico, various government agencies and research institutions.
Varied survey designs and methods.
Challenge: how to integrate to prepare Integrated Ecosystem Assessments as the basis for ecosystem-based management?

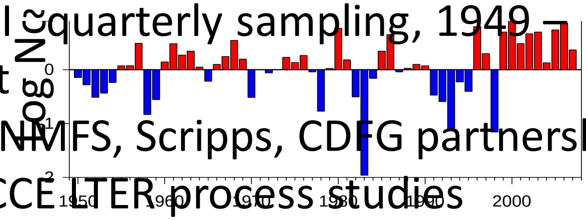
Ocean observations & climate impacts in the California Current



Chelton, Bernal & McGowan (1982)

PDO index





CalCOFI – quarterly sampling, 1949 – present

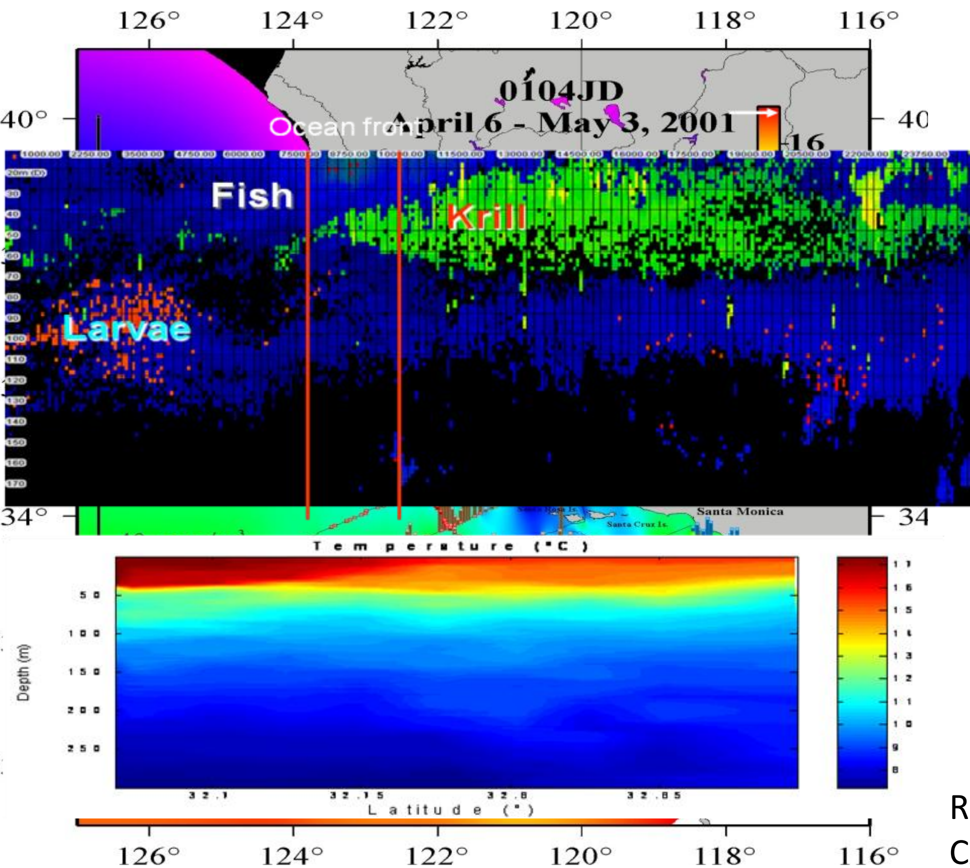
NOAA/NMFS, Scripps, CDFG partnership

2004: CCE LTER process studies

Standard hydrography, ichthyoplankton, zooplankton, seabird & mammal obs

Brinton and Townsend (2003)

EBM in the southern California Current



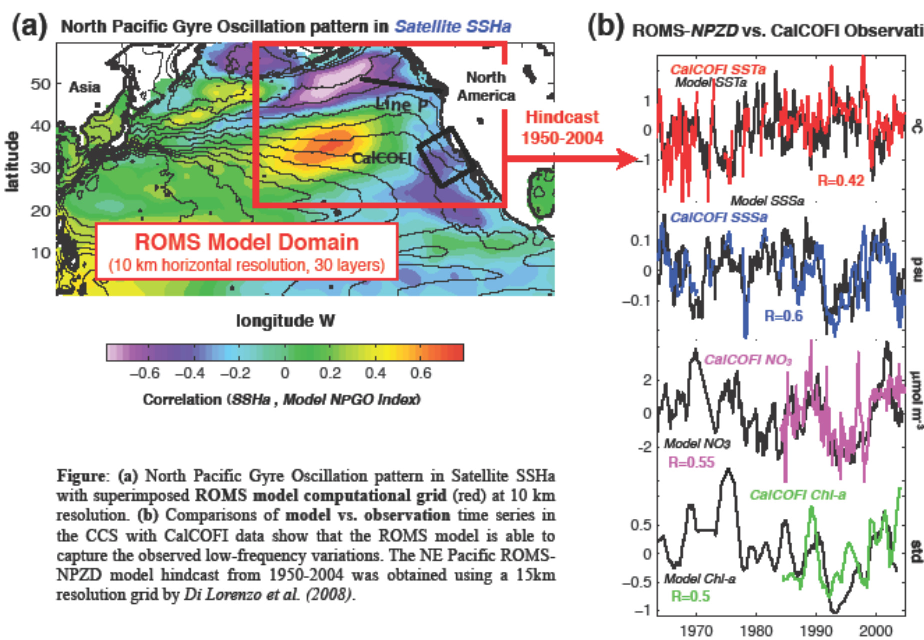
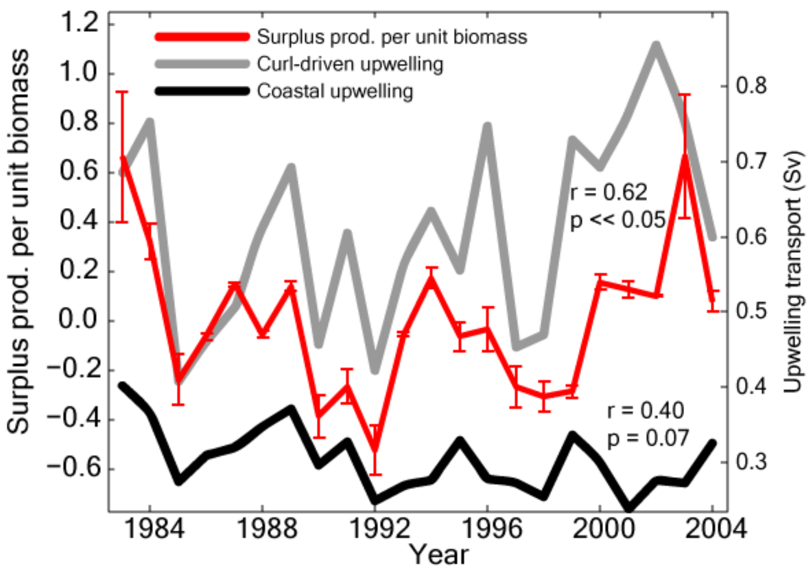


Figure: **(a)** North Pacific Gyre Oscillation pattern in Satellite SSHa with superimposed **ROMS model computational grid** (red) at 10 km resolution. **(b)** Comparisons of **model vs. observation** time series in the CCS with CalCOFI data show that the ROMS model is able to capture the observed low-frequency variations. The NE Pacific ROMS-NPZD model hindcast from 1950-2004 was obtained using a 15km resolution grid by *Di Lorenzo et al. (2008)*.

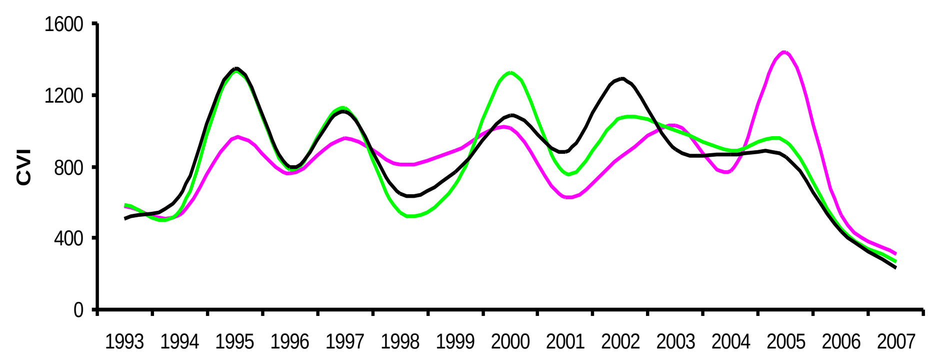
ROMS model: climate links with nutrients, lower trophic levels
CAMEO: mid-trophic level model under dev’t
NMFS & Scripps: multi-frequency acoustic study under dev’t
NSF-funded sardine recruitment proposal
NMFS, Scripps: IEA under dev’t

Climate and fisheries in the California Current

Role of offshore upwelling on sardine production
(Rykaczewski and Checkley 2009)



Trophic models with environmental indicators improve salmon forecasts
(Wells et al 2008)



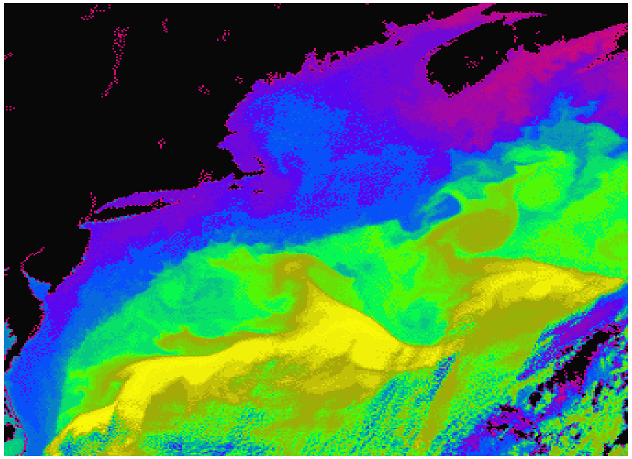
Central Valley chinook

Model (with Environmental Indicators, R^2 = 0.92)

Model (based on Jacks - early returns, R^2 = 0.66)

Northeast Fisheries Science Center Ecosystem Observation Program

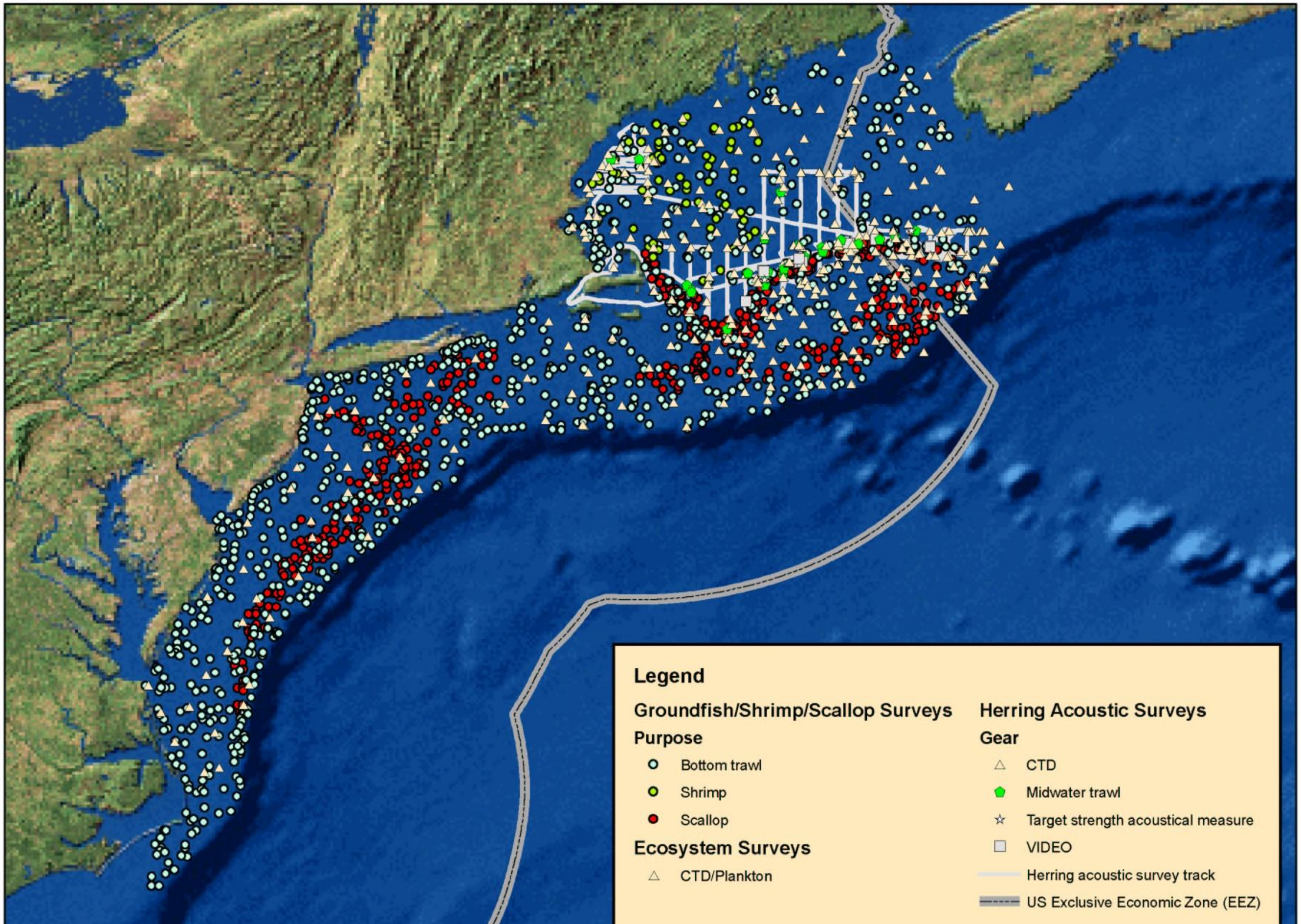
- Satellite Oceanography
- Oceanographic Moorings and Buoys
- Standardized Surveys
  - Bottom Trawl Surveys
  - Plankton Surveys
  - Shellfish Surveys
  - Protected Resource Surveys
- Fishery Monitoring



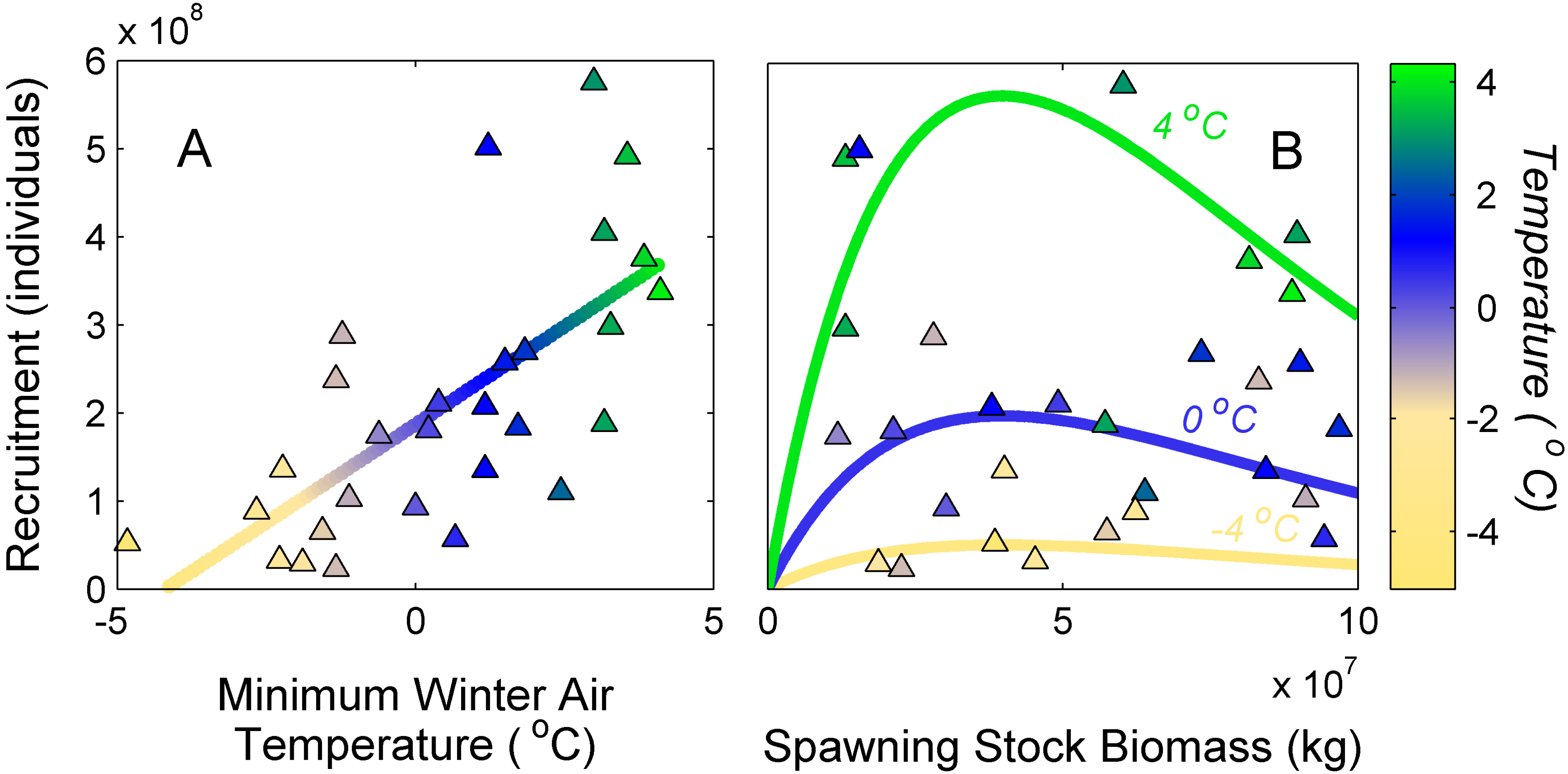
- Ships of Opportunity – CPR Program
- Fishery Observer Program
- Cooperative Industry Research

Sampling Locations for Selected NEFSC at-Sea Ecosystem Observation Program Elements

3

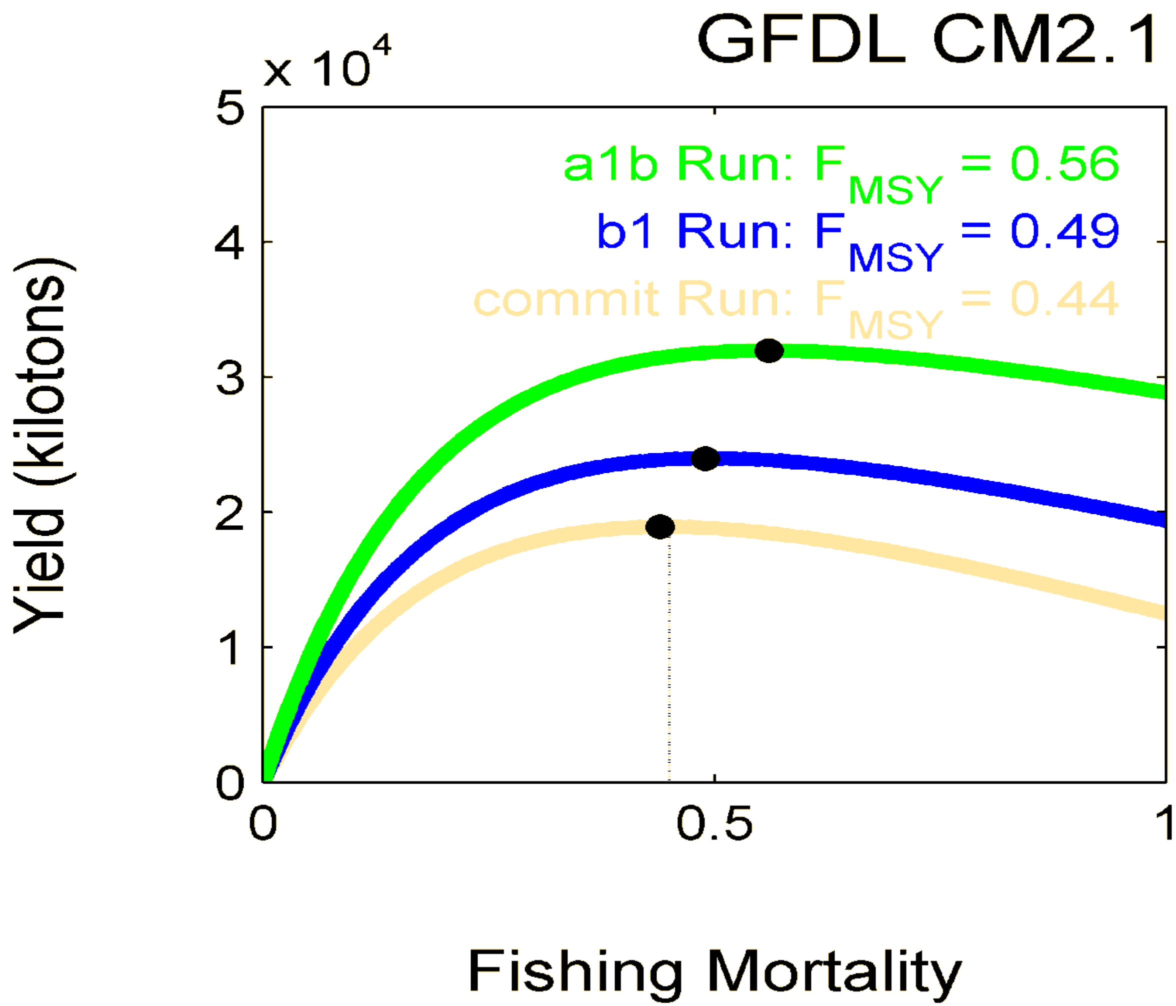


Atlantic Croaker Temperature Effects on Recruitment



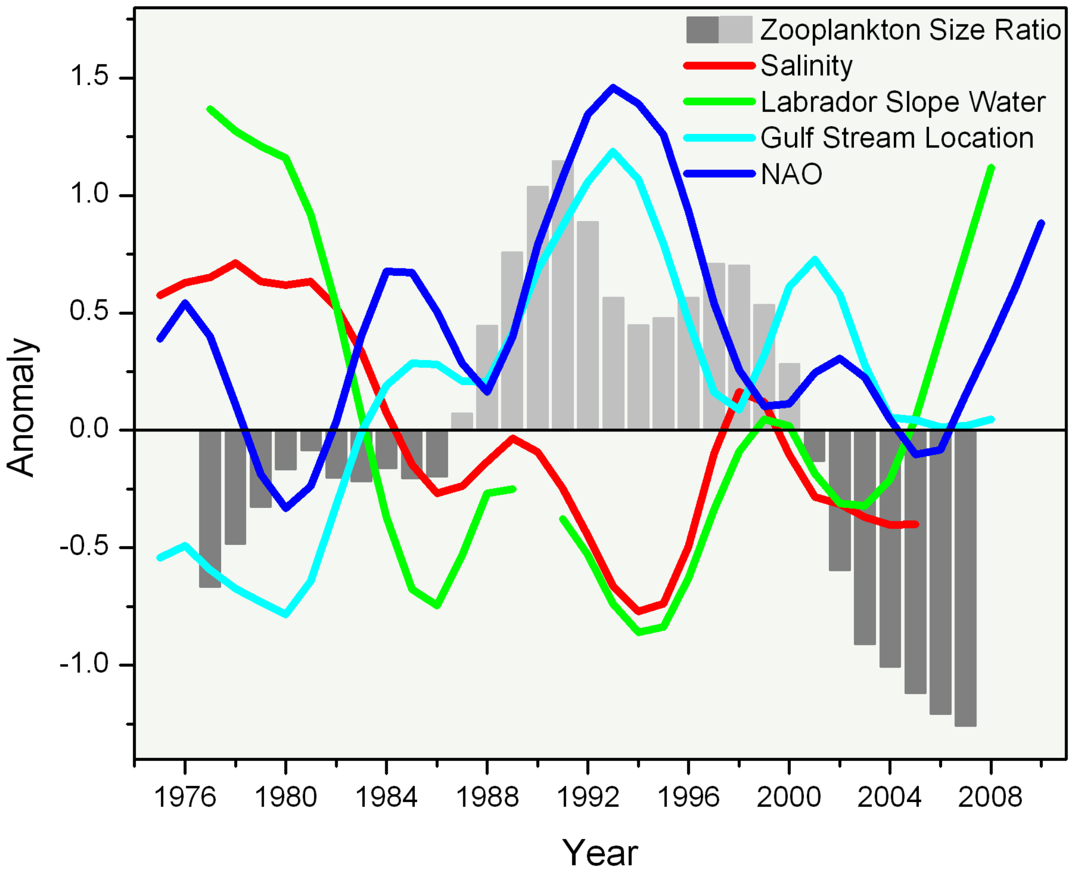
J. Hare et al. Ecological Applications, in press

Projected Croaker Yield under Three Climate Change Scenarios



J. Hare et al. Ecological Applications, in press

Zooplankton Community Composition and Environmental Drivers



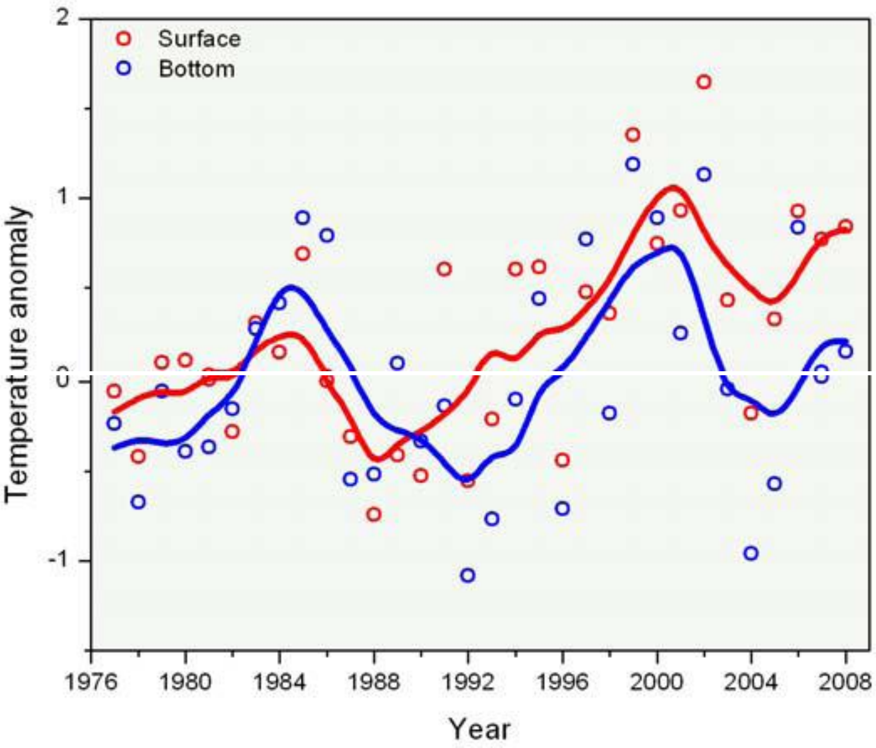
Zooplankton Community Composition: Ratio of Small to Large-Bodied Copepods

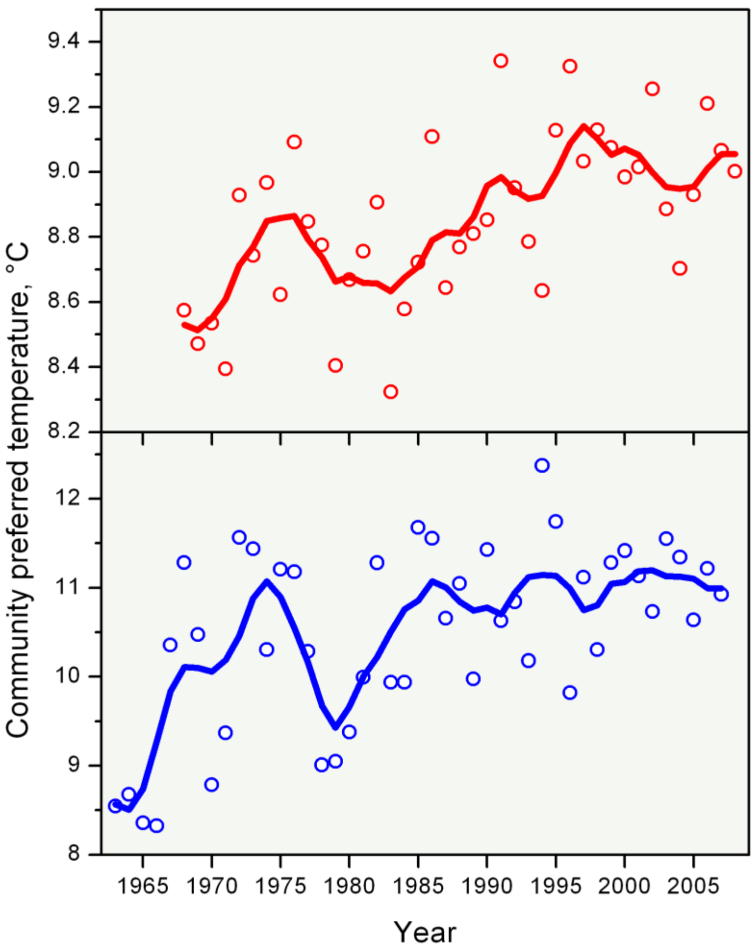
EAP. 2009. Ecosystem Status Report. NEFSC Lab. Ref. Doc. 09-11

Trends in Fish Community Preferred Temperature: Northeast U.S. Continental Shelf

NEFSC Bottom Trawl Surveys in spring (Upper) and autumn (Lower).

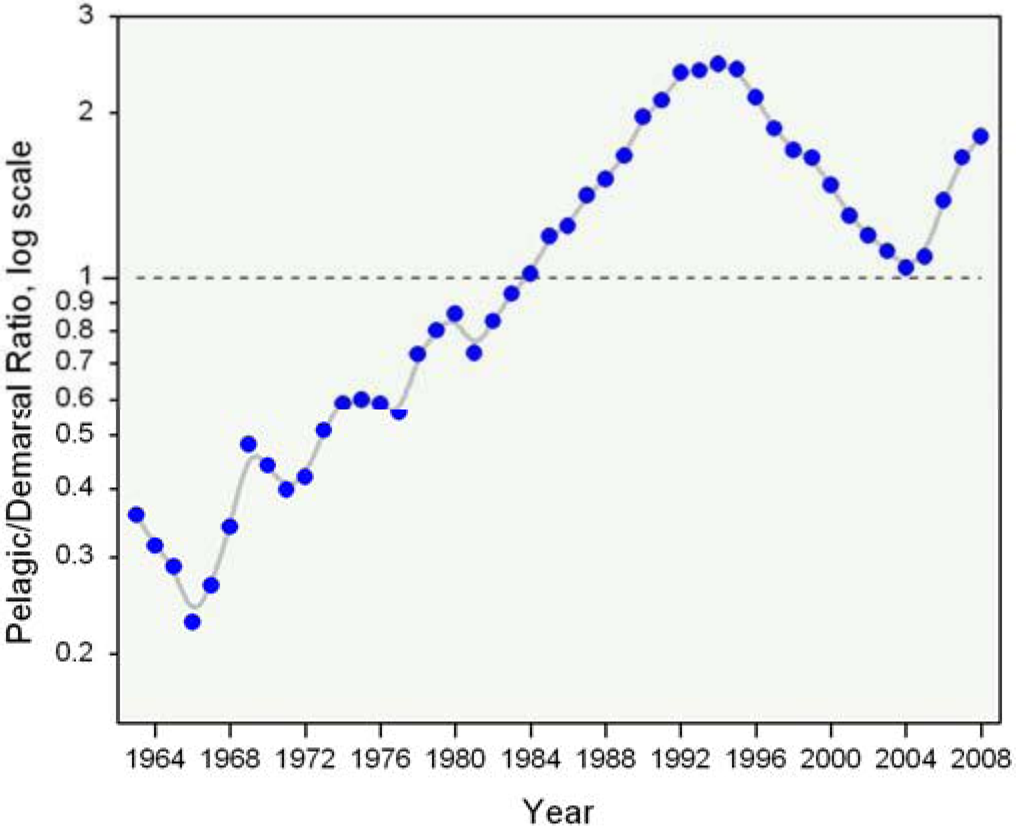
Temperature trends





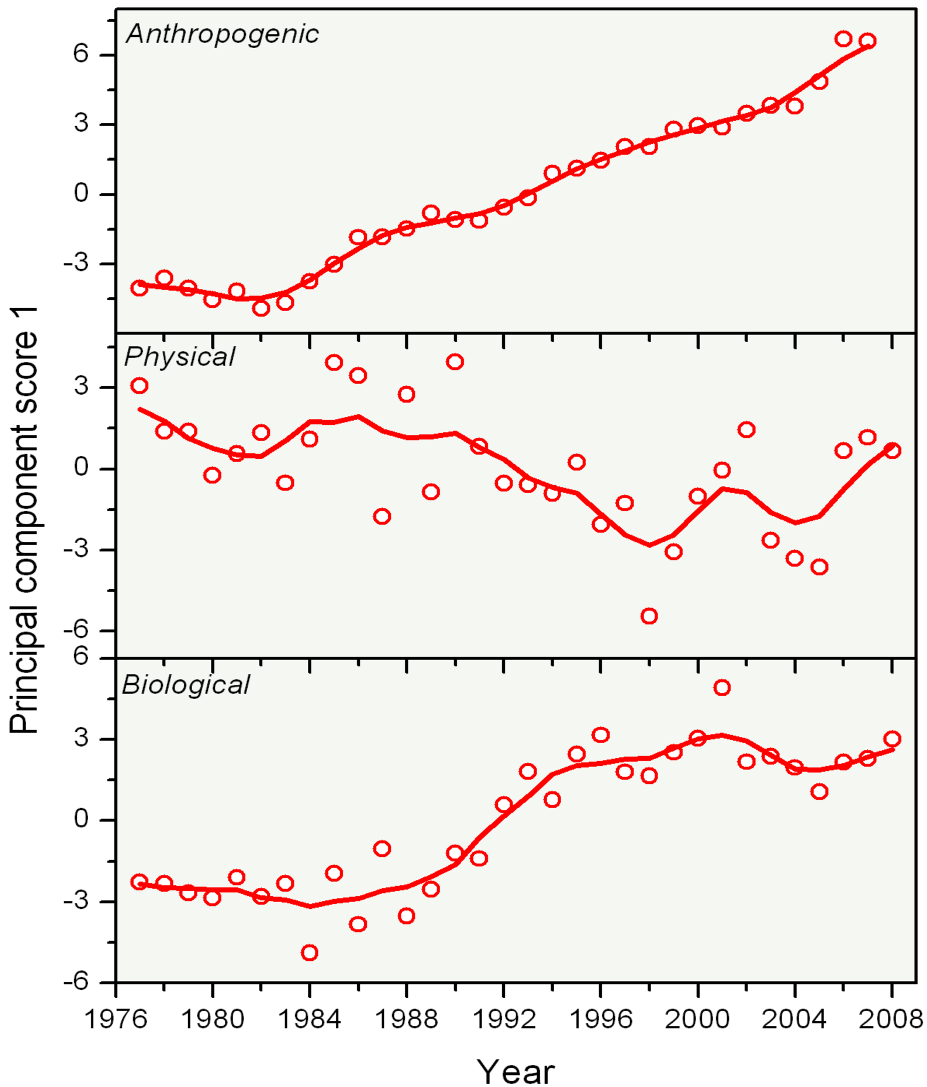
EAP. 2009. Ecosystem Status Report. NEFSC Lab. Ref. Doc. 09-11

Impacts of fishing on fish community structure



Mean trophic level of landings for the Northeast continental shelf LME.

Time Trends in Anthropogenic, Physical and Biotic Indicator Variables Northeast U.S. Shelf



EAP. 2009. Ecosystem Status Report. NEFSC Lab. Ref. Doc. 09-11

Conclusions

- EBM has progressed conceptually and operationally over the past 5 – 10 years
- Challenges remain

Models:

– Incorporate behavior of mid- to higher tropic levels in models
– Model the recruitment process (the link between physics and fish)

Data:

– Economically observe physics, chemistry, lower to higher trophic levels, combined with fishery data: eliminate ‘the missing middle’
– Process studies to resolve recruitment dynamics, links from physics to fish

Data management & communication:

- Integrate across varied data types, observers & users

Interdisciplinary team:

Observationalists, modelers, data managers, fishery scientists & managers (process studies)