- Critical importance of shipboard science, to be integrated with (but not replaced by) autonomous instruments

- Ecosystem models remain elementary relative to needs for the 21st century

- The 'Invisible Present': slowly acting processes, and processes with time lags, have deep impacts on natural ecosystems

NATIONAL SCIENCE FOUNDATION
LTER NETWORK
LONG TERM ECOLOGICAL RESEARCH

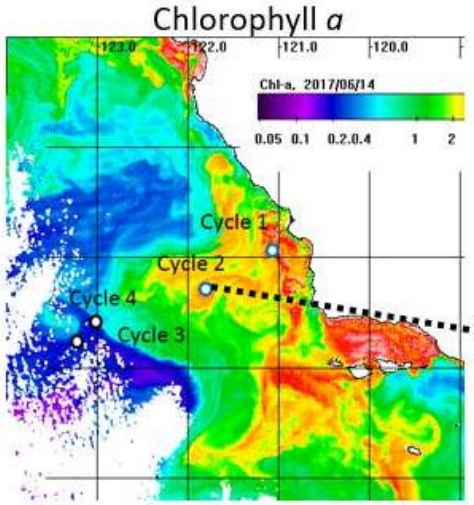
20 Nov. 2023

Mark D. Ohman

California Current Ecosystem LTER site

SCRIPPS INSTITUTION OF OCEANOGRAPHY
University of California San Diego

Integration of shipboard and autonomous instruments



Lagrangian Process Study

(free-drifting autonomous measurements combined w/ shipboard experiments)

Driftarray
(in situ growth, grazing)

Drifting sediment traps

Zooglider

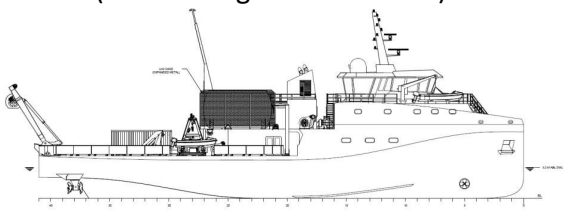
CFE
(C Flux Explorer)

CF calib
(C Flux calibration)

CFE-2

CF calibration

H_2 fuel cell-powered
(soon to begin construction)

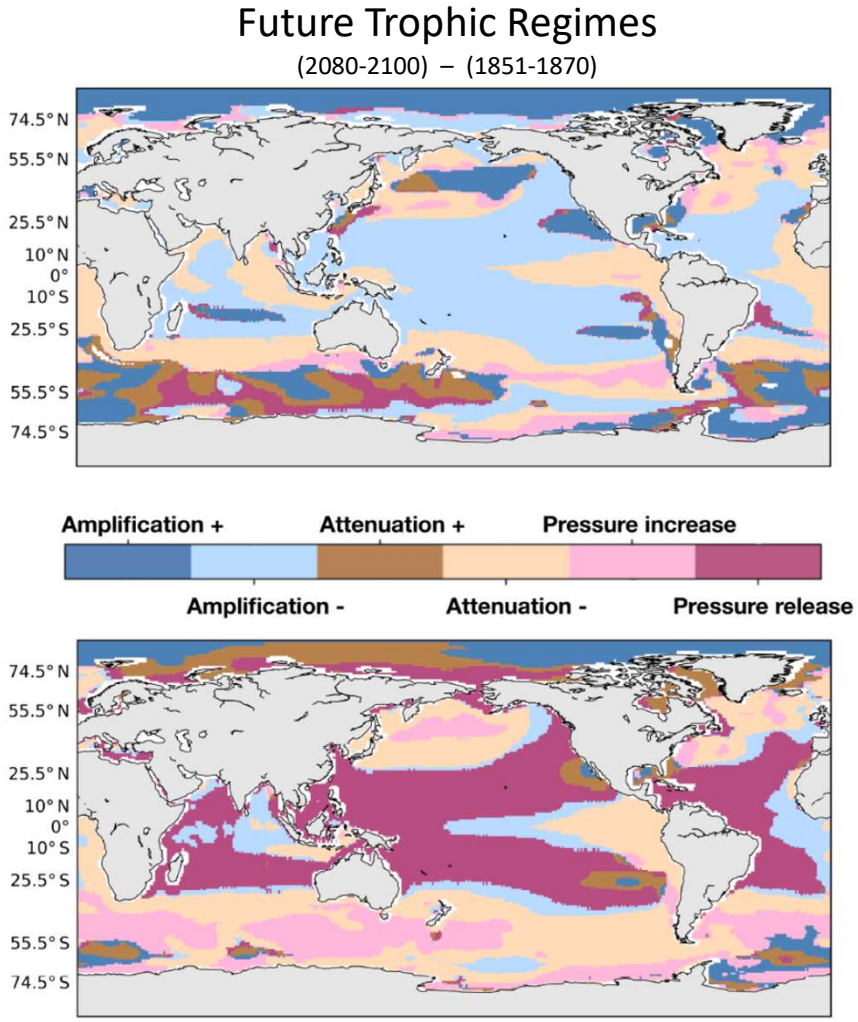


SCRIPPS INSTITUTION OF OCEANOGRAPHY

R/V *Roger Revelle*
+ 7 autonomous vehicles

OBSERVE EXPERIMENT MODEL
CCE LTER

Ecosystem models remain elementary relative to needs for the 21st century



2 Δ model formulations for
Coupling to Higher Trophic Levels

1-way

2-way

Dupont et al. (2023) *Global Change Biol.*

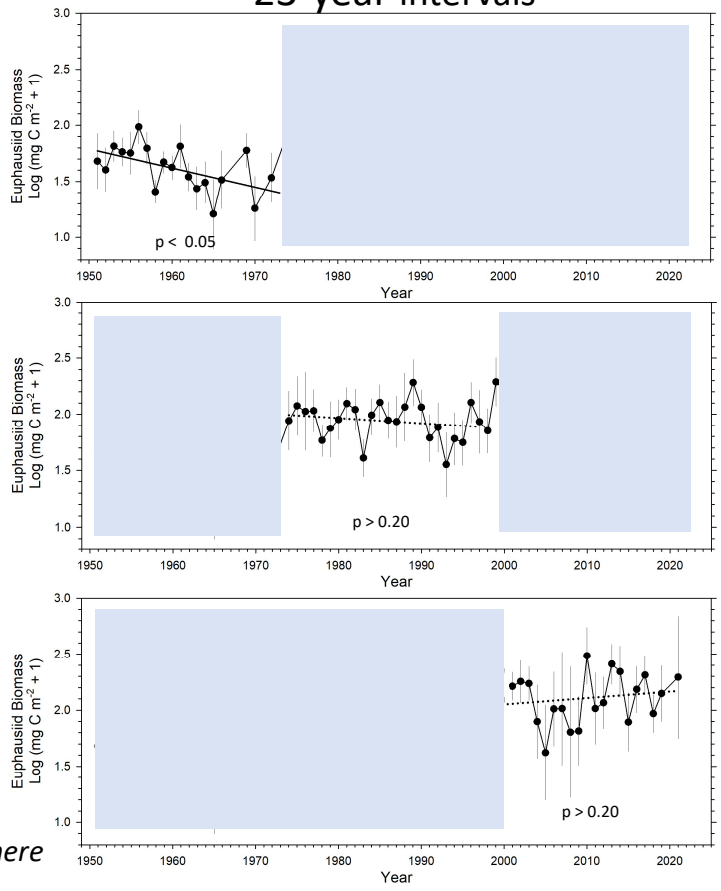
The "Invisible Present"

J. Magnuson (1990) *BioScience*

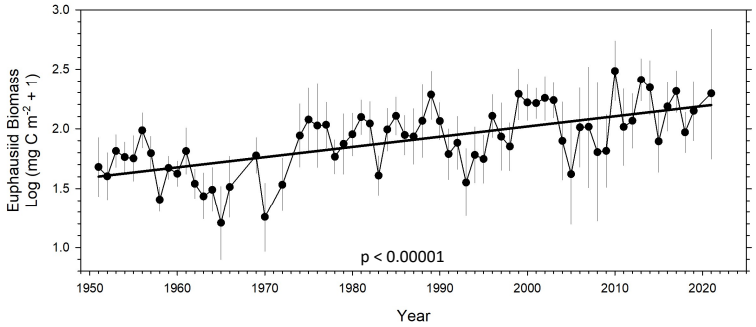
Secular Trend in Euphausiid Biomass ?

CalCOFI/CCE-LTER Region

23-year intervals



70-year interval



Importance of:

- *slowly acting processes*
- *time lags*

Long-term trends are resolvable only over multiple decades, because of intrinsic natural variability on interannual and decadal scales

Rastetter, Ohman, et al. (2021) *Ecosphere*