Climate Change and Small Pelagic Fish Review and Recommendations

Pierre Fréon, IRD

Dave Checkley, SIO

Francisco Werner, Rutgers

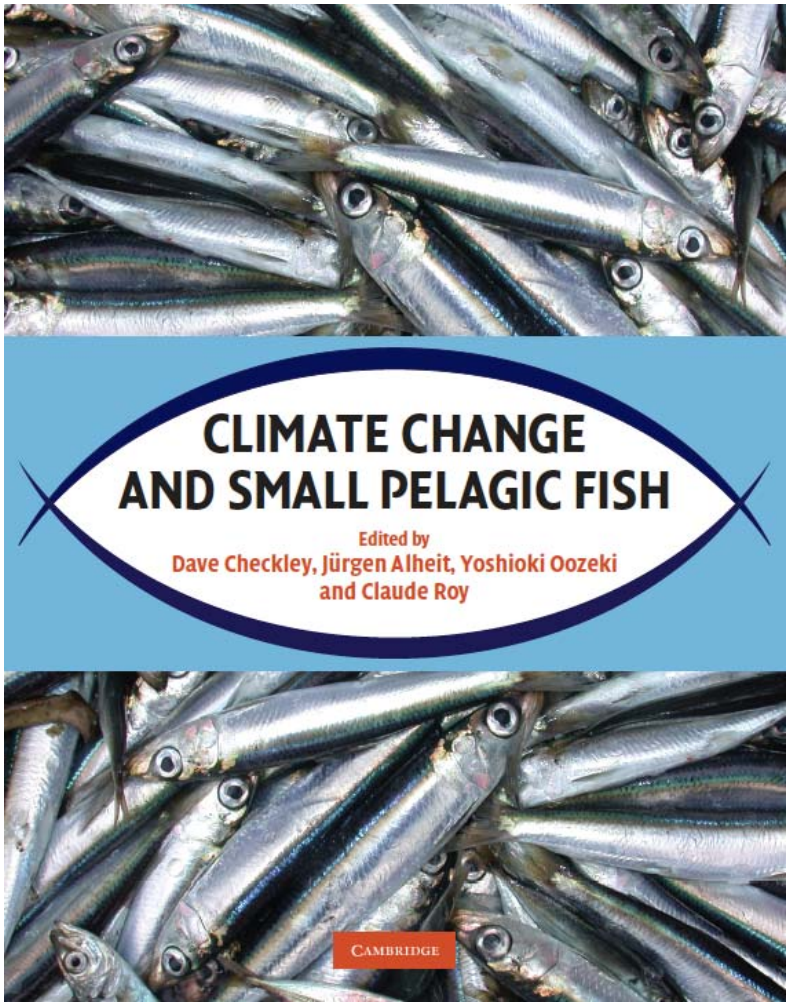
Outline

I - Introduction

II – Conjectures

III – Synthesis and recommendations

IV - SPACC II



Acknowledgements

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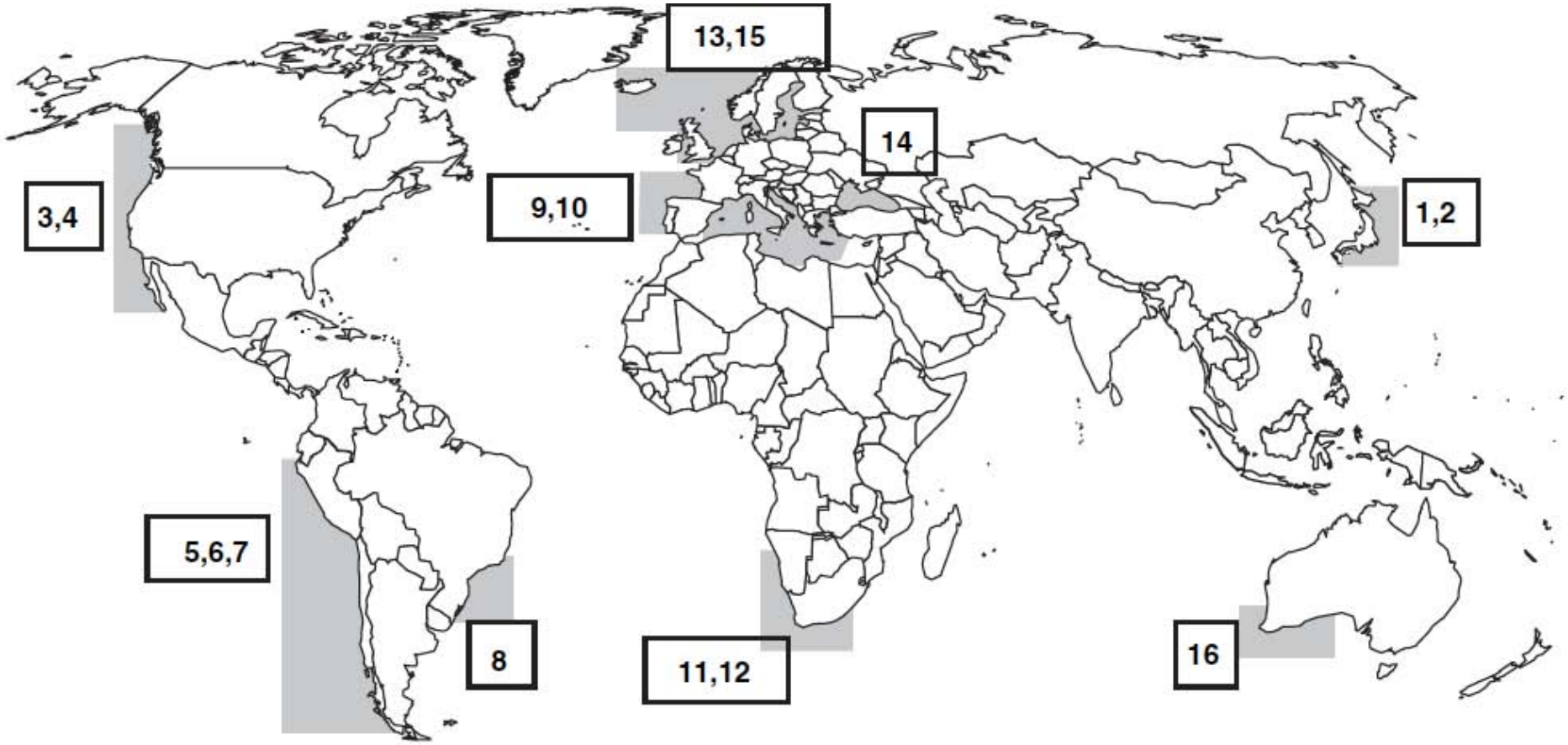
IRD
Institut de recherche pour le développement

Oceans

Part I

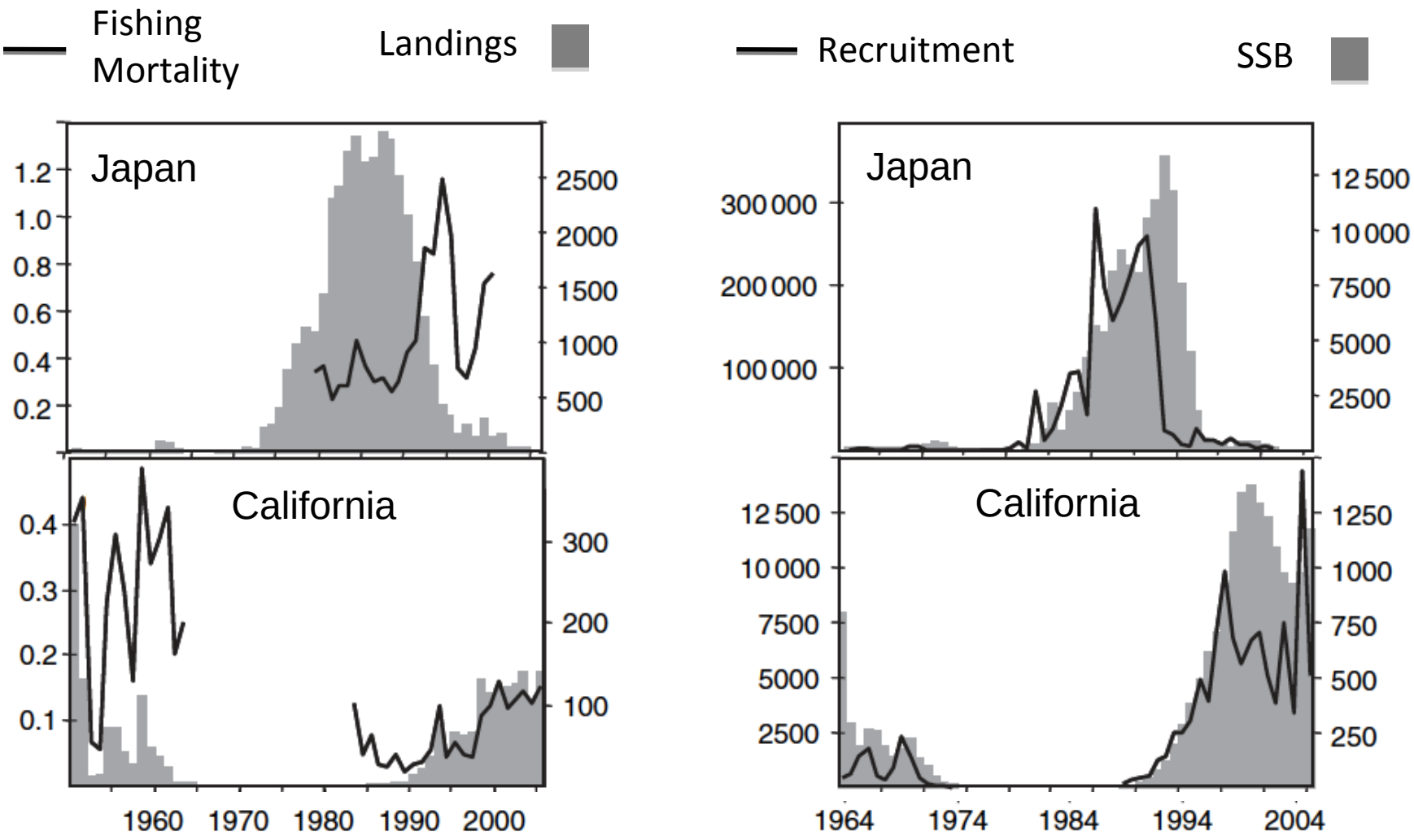
Introduction

Studied Populations of Small Pelagic Fish



(Barange *et al.* 2009)

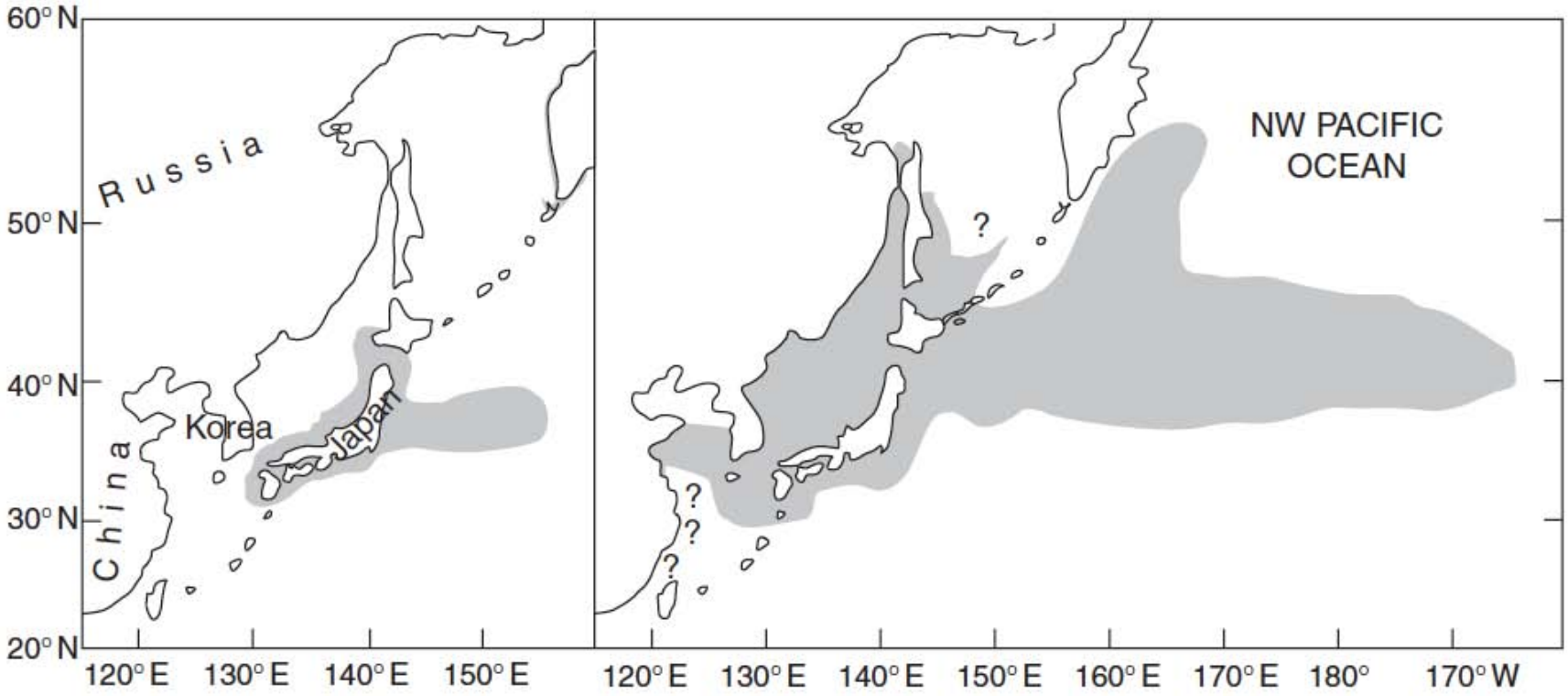
Decadal-Scale Variation: Sardine



(Barange *et al.* 2009)

Range Contraction and Expansion

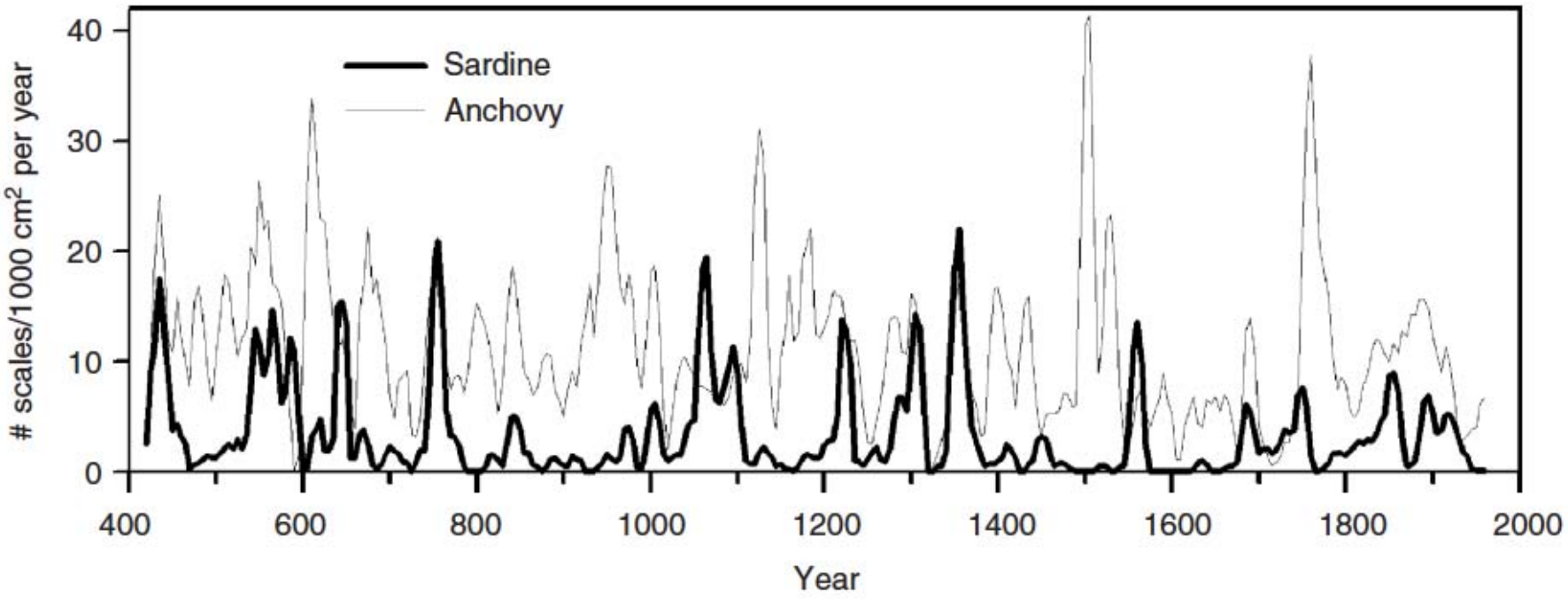
Japanese Sardine



(Alheit *et al.* 2009, after Lluch-Belda *et al.* 1989)

Santa Barbara Basin Fish Scale Deposition

Natural variability λ ~ 50-70y Asynchrony



(Field *et al.* 2009, updated from Baumgartner *et al.* 1992)

Santa Barbara Basin Fish Scale Deposition

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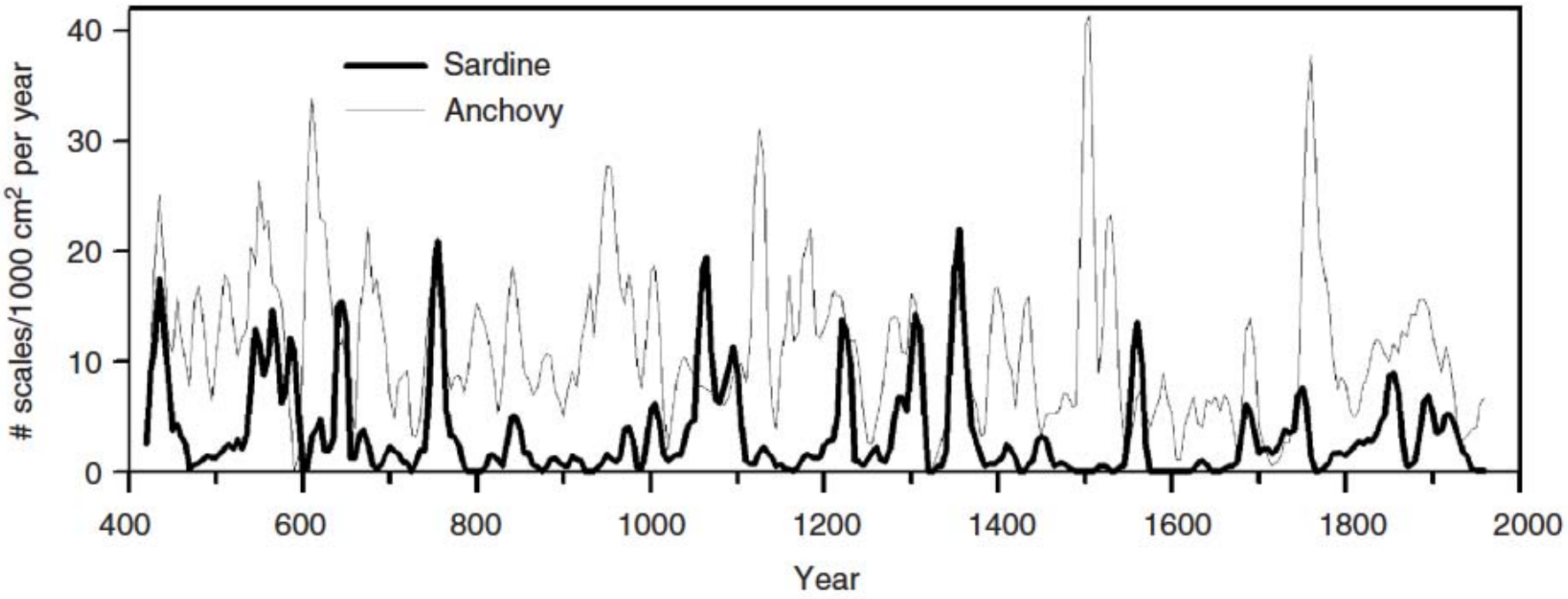


CLIMATE

(Field *et al.* 2009, updated from Baumgartner *et al.* 1992)

Part II

Conjectures on future climate effects on marine ecosystems dominated by small pelagic fish

(Chapter 14 - Fréon, Werner, and Chavez)

Can we predict the effects of climate change on upwelling ecosystems?

Why is it so challenging to make realistic forecasts of the effects of climate change?

Prediction of climate change is the first order difficulty

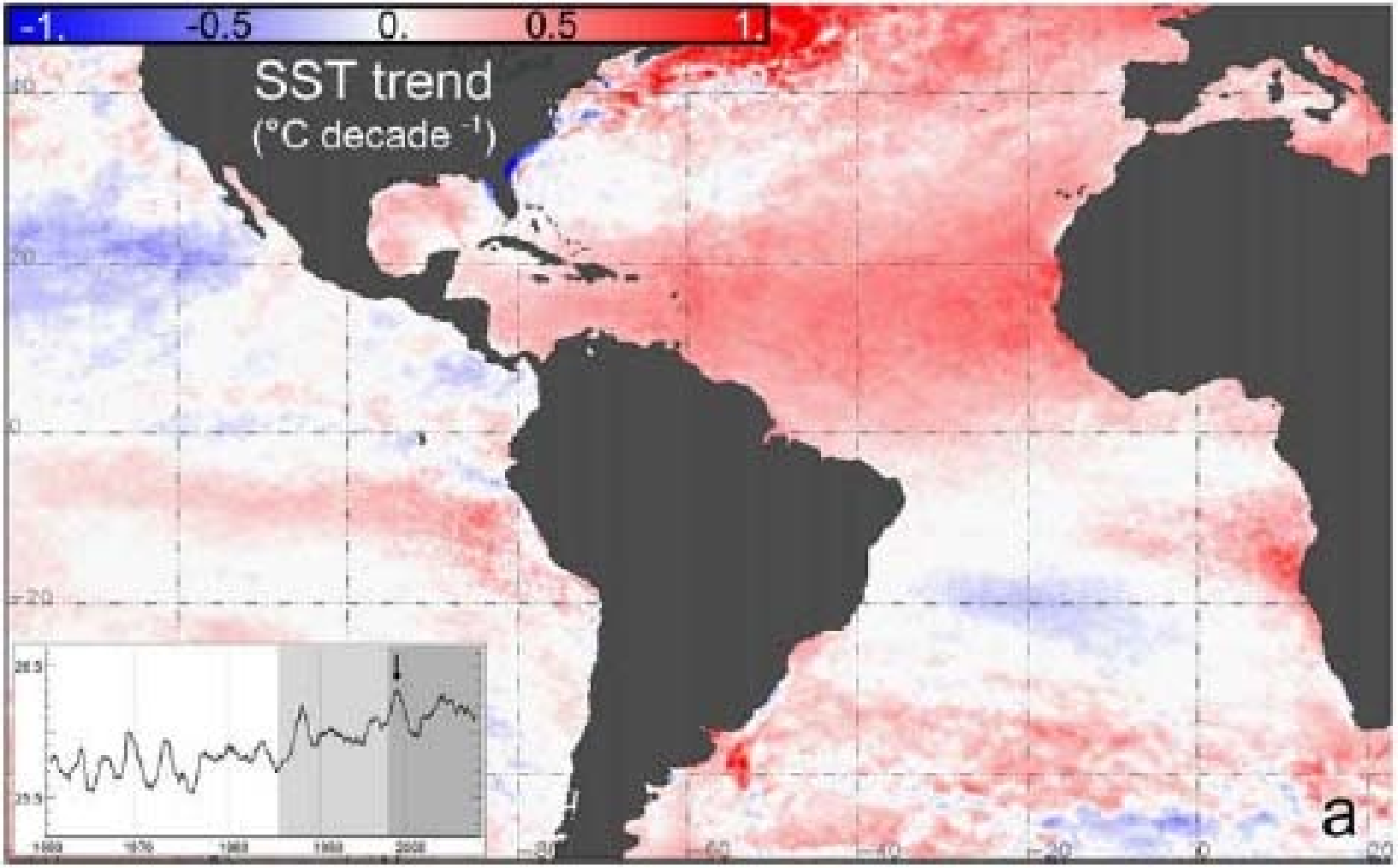
Exacerbated by the confounding of anthropogenic and natural forcing factors, including those driven by socio-economic aspects

Ecological responses to CC depend on:

- Direct and indirect effects
- Lagged or unlagged effects
- Feedbacks
- Threshold effects
- Non-linear responses
- Spatial heterogeneity in the changes
- Interactions between different temporal scales (natural and social)
- Ecosystem effects

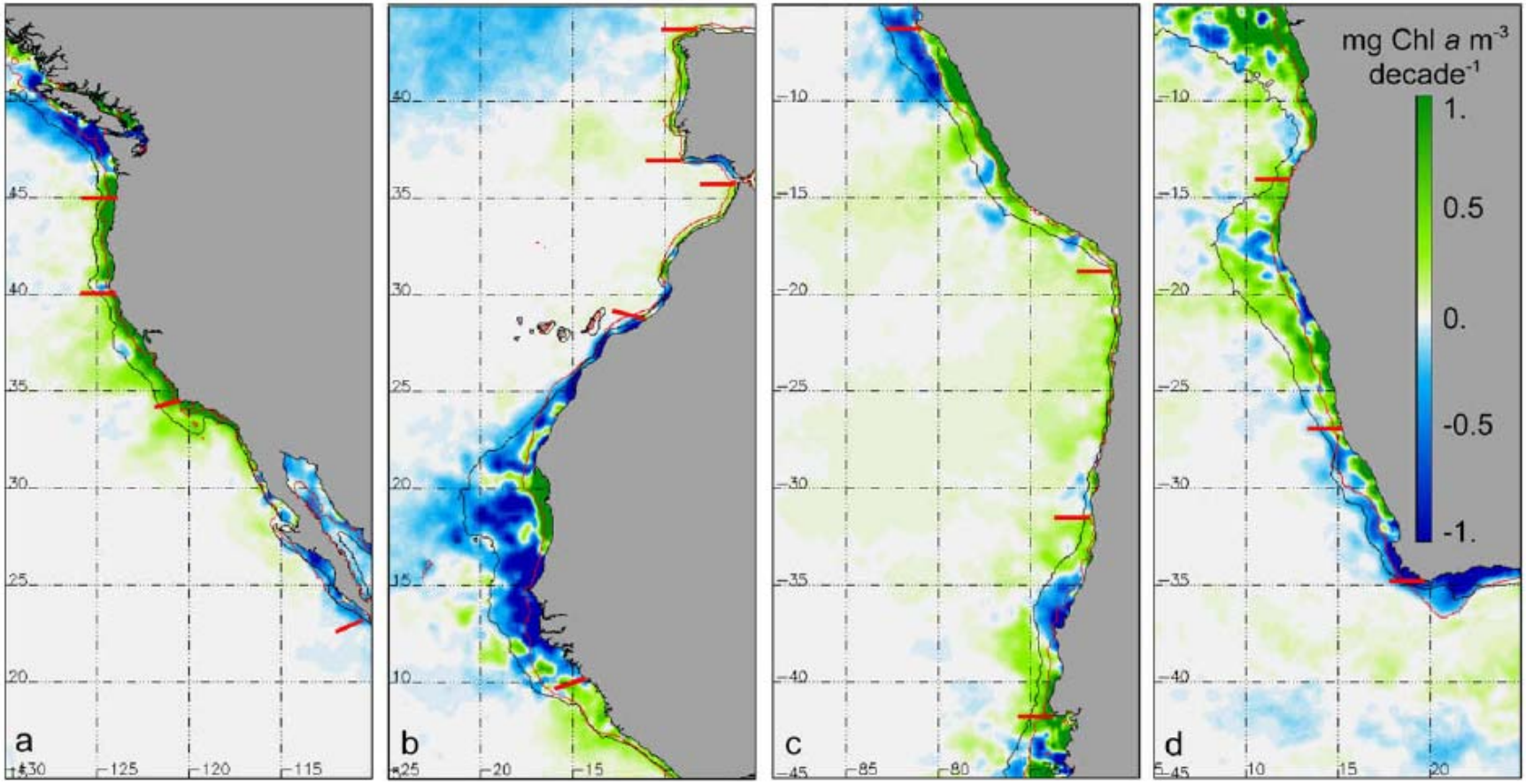
We are extrapolating outside the range of present observations, and perhaps the past half-million years in terms of types, scales and rates of change that the Earth System is undergoing

Trends in SST 1960-2007



(Demarcq 2009)

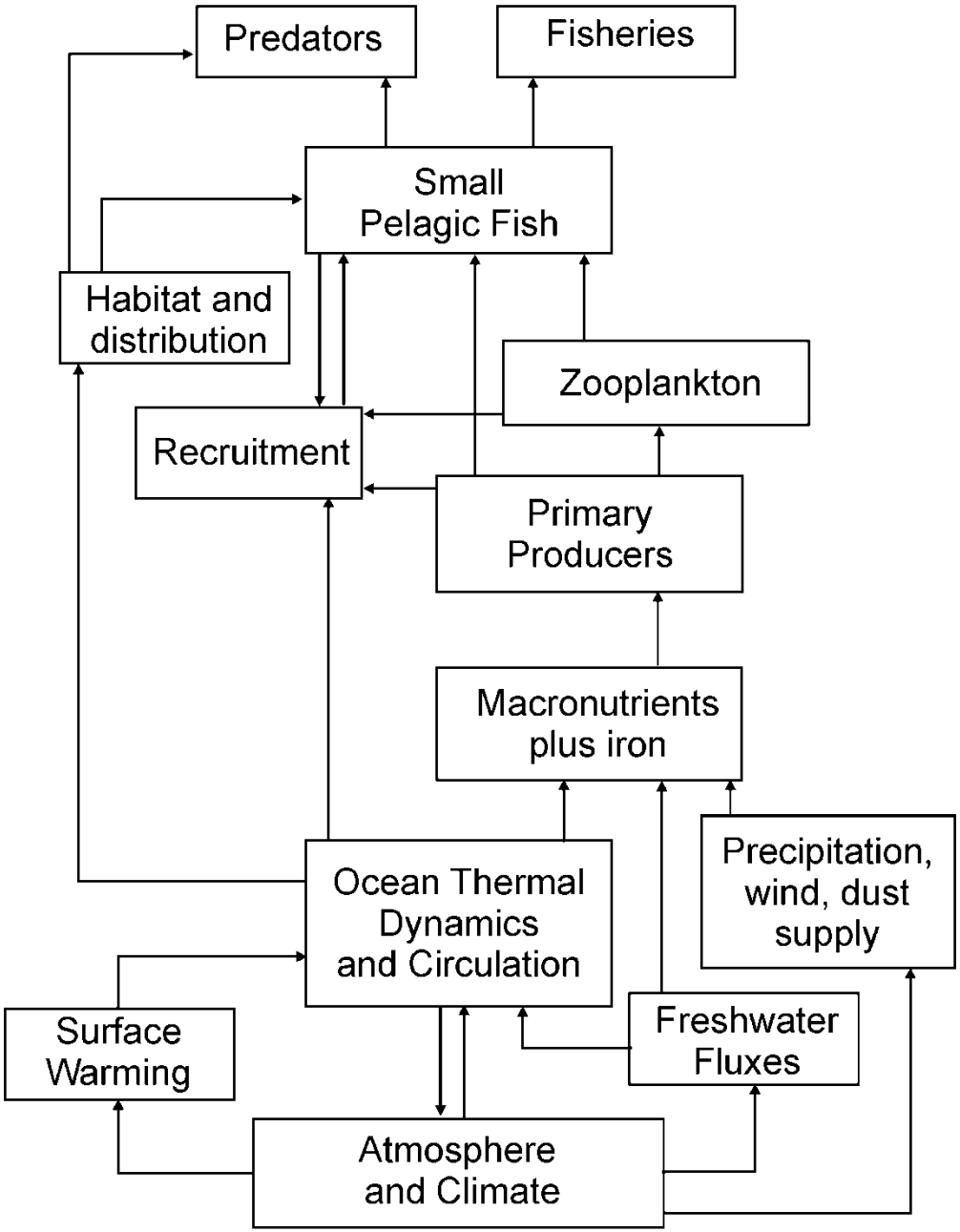
Trends in Chl *a* 1960-2007



(Demarcq 2009)

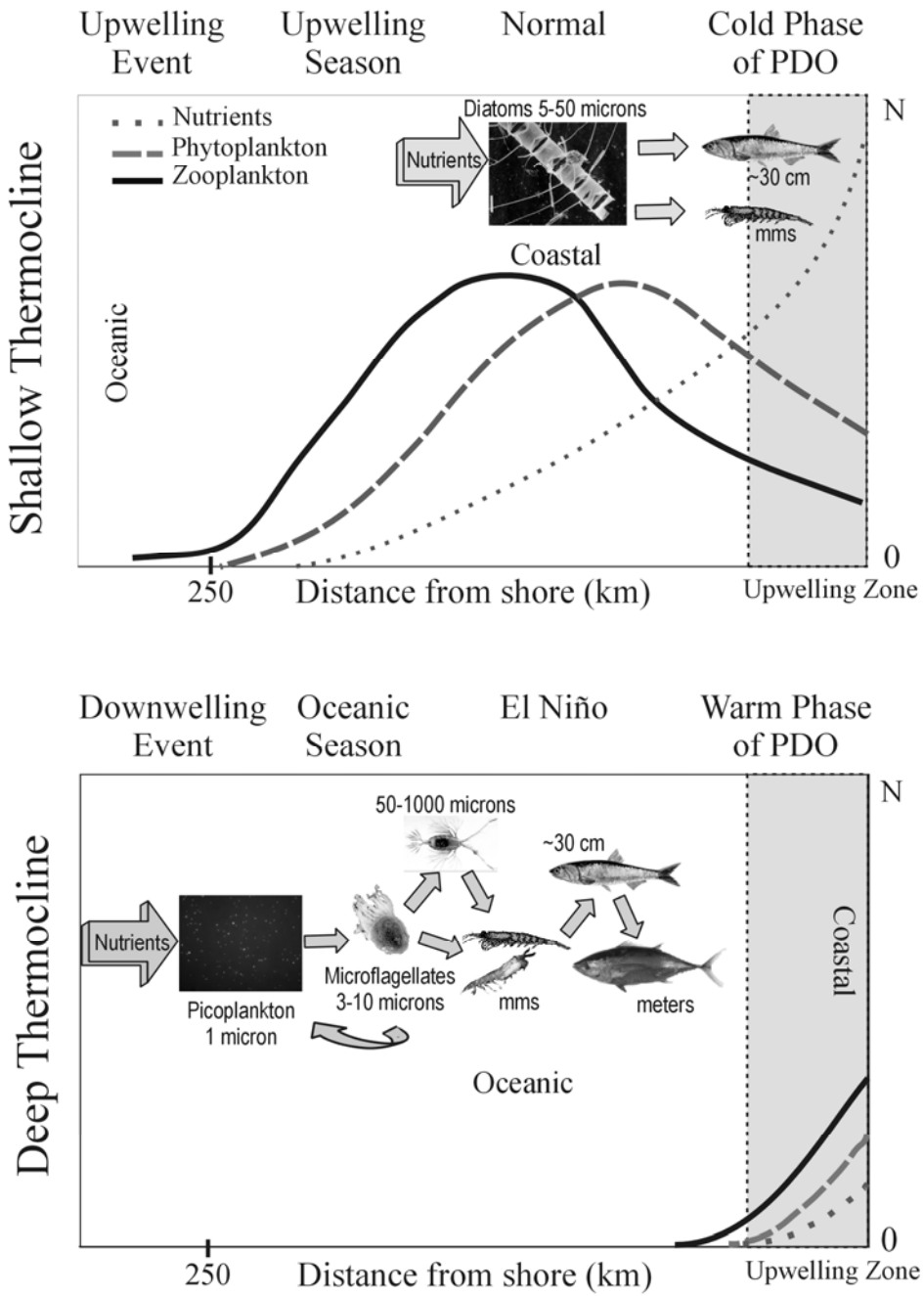
Scheme of climate change influence on an upwelling ecosystem

(only the main processes)



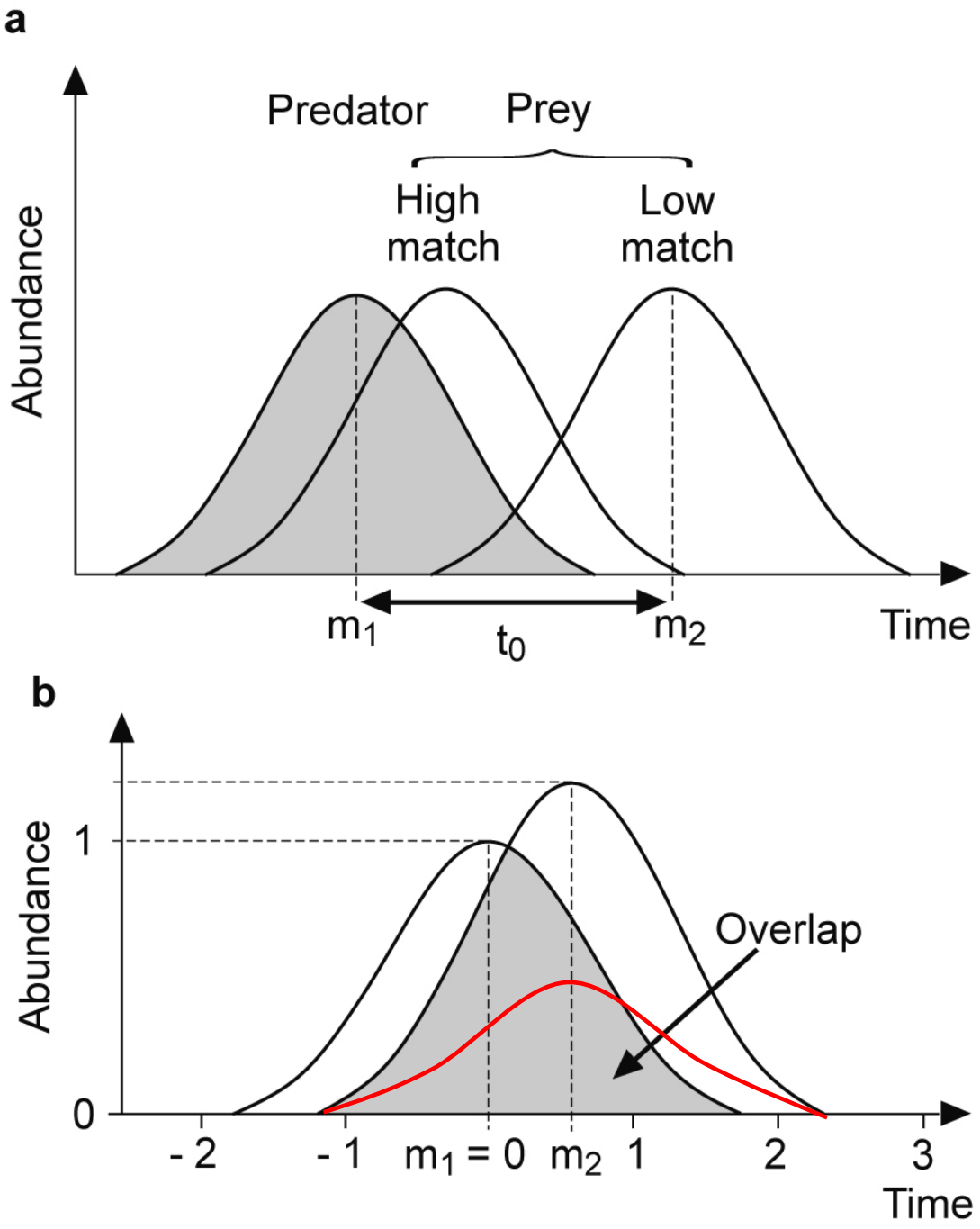
(Fréon *et al.* 2009)

Anchovy, Sardine, and the PDO



(Modified from Chavez *et al.*, 2002)

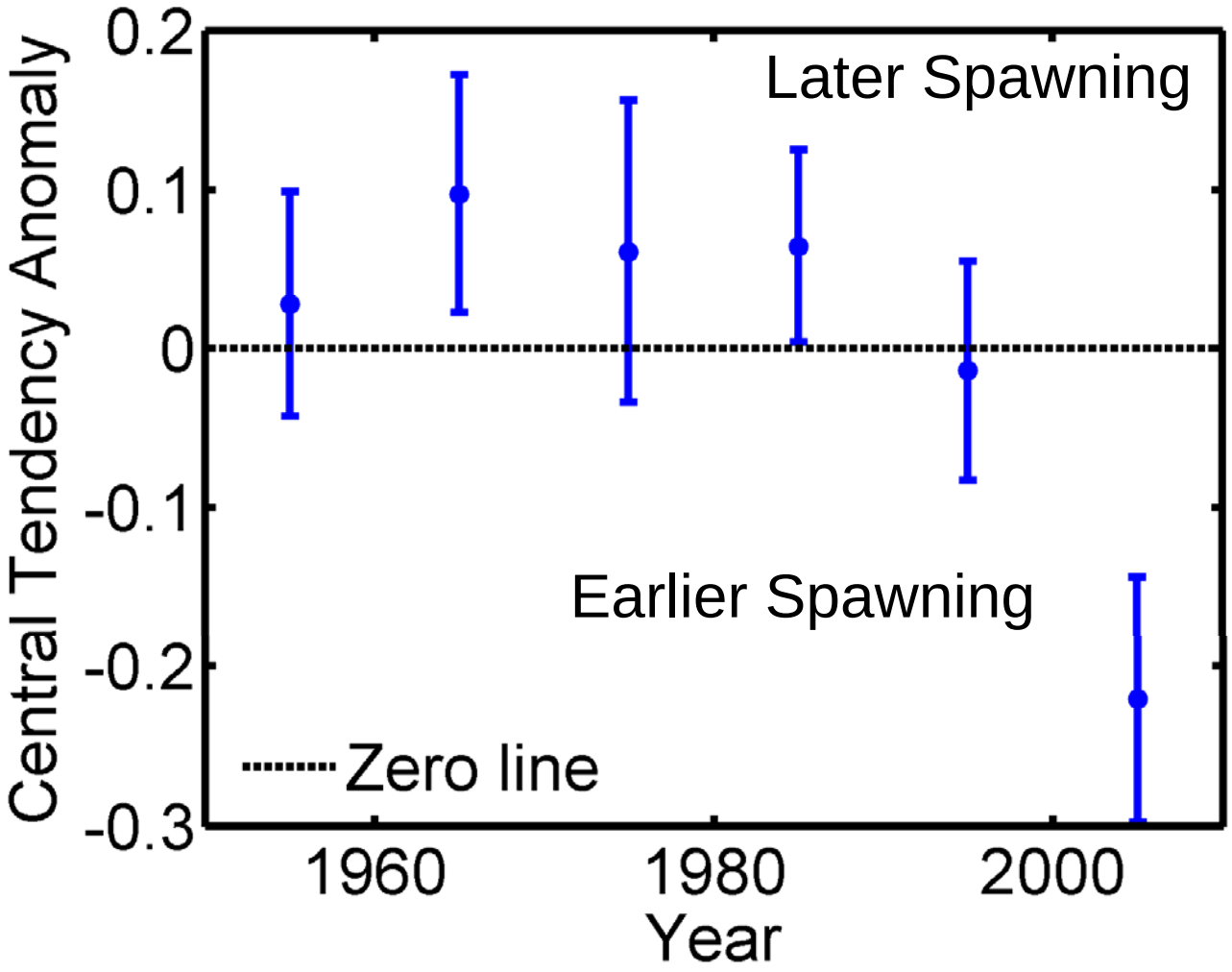
Phenology



Durant *et al*., 2005

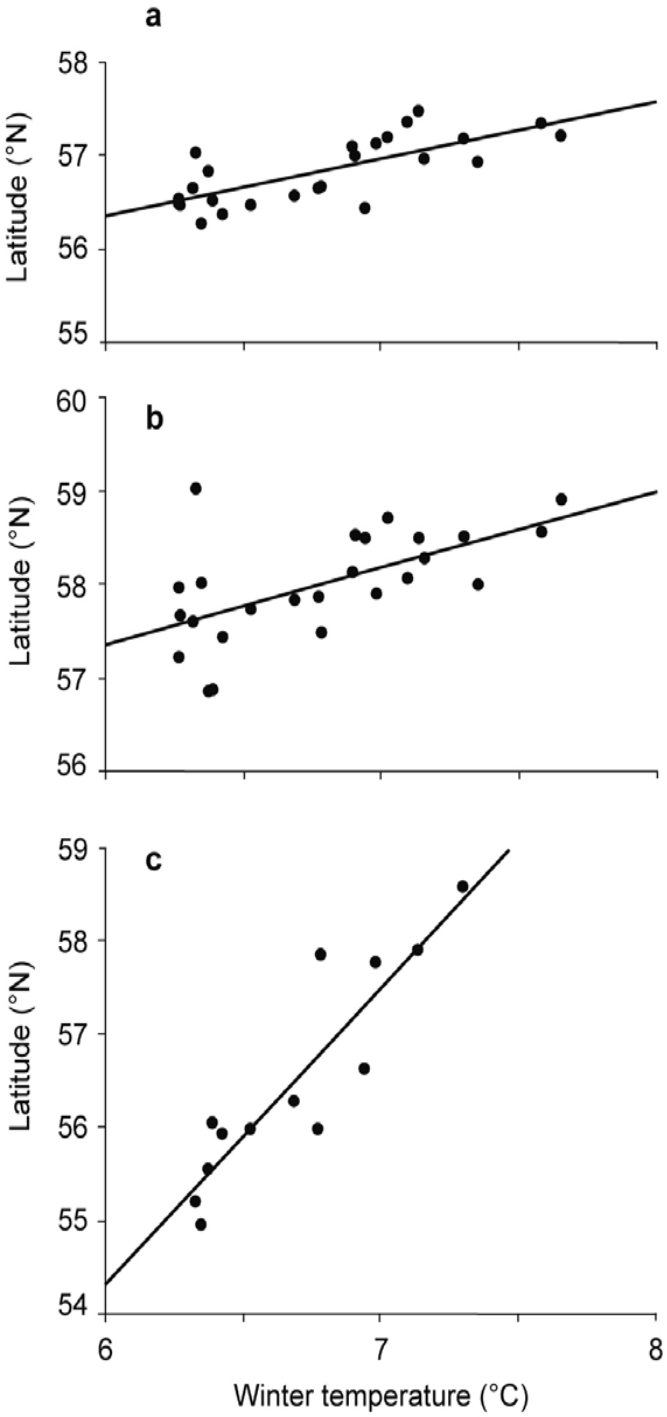
(Asch **B1-6216 Tuesday 10:30**)

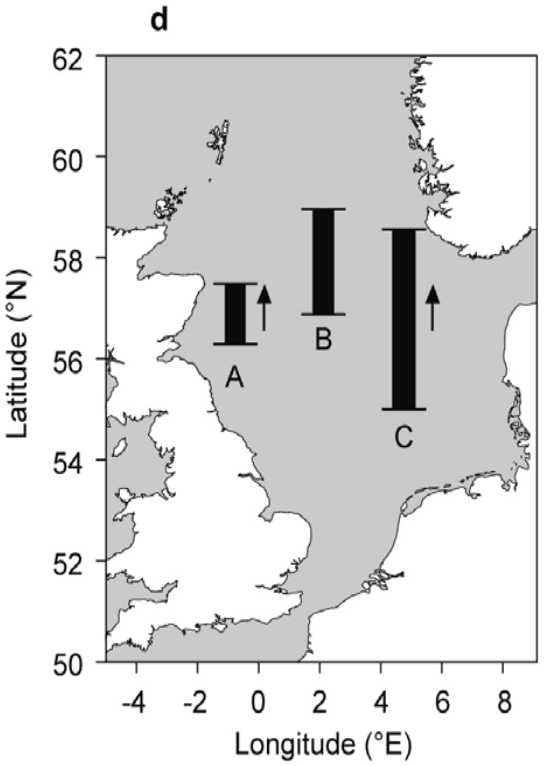
Phenology: CalCOFI Fish Larvae (43 spp)



Latitudinal Shifts

Movements of species distributions in relation to winter temperature between 1962-2001

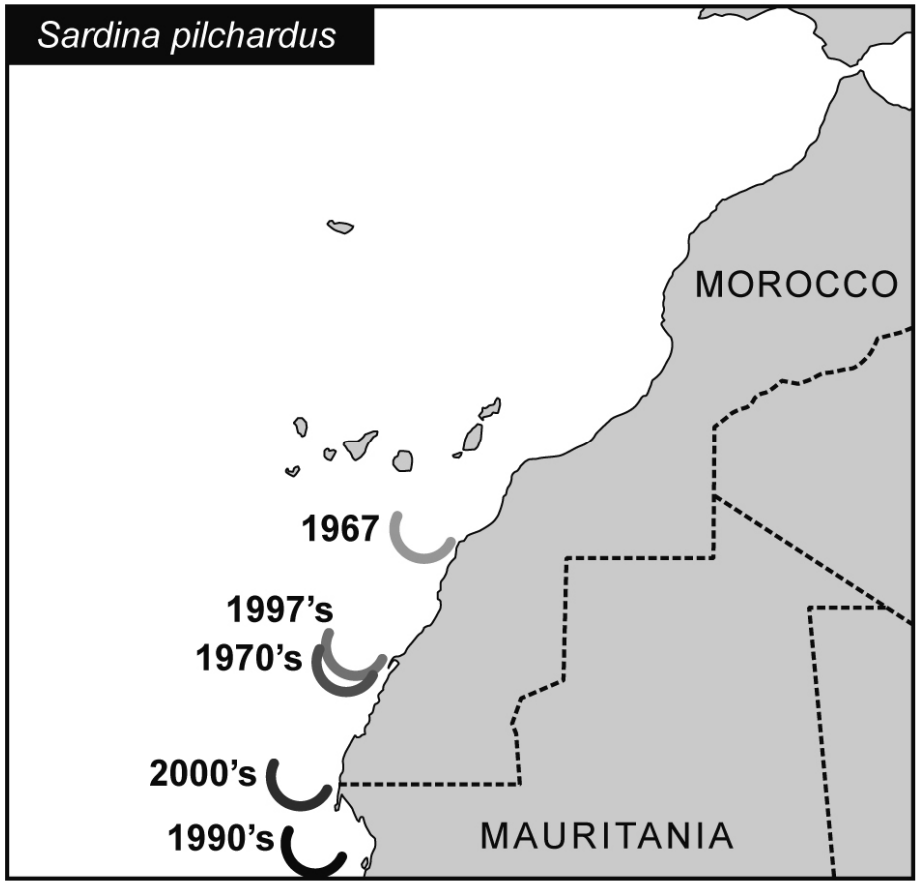


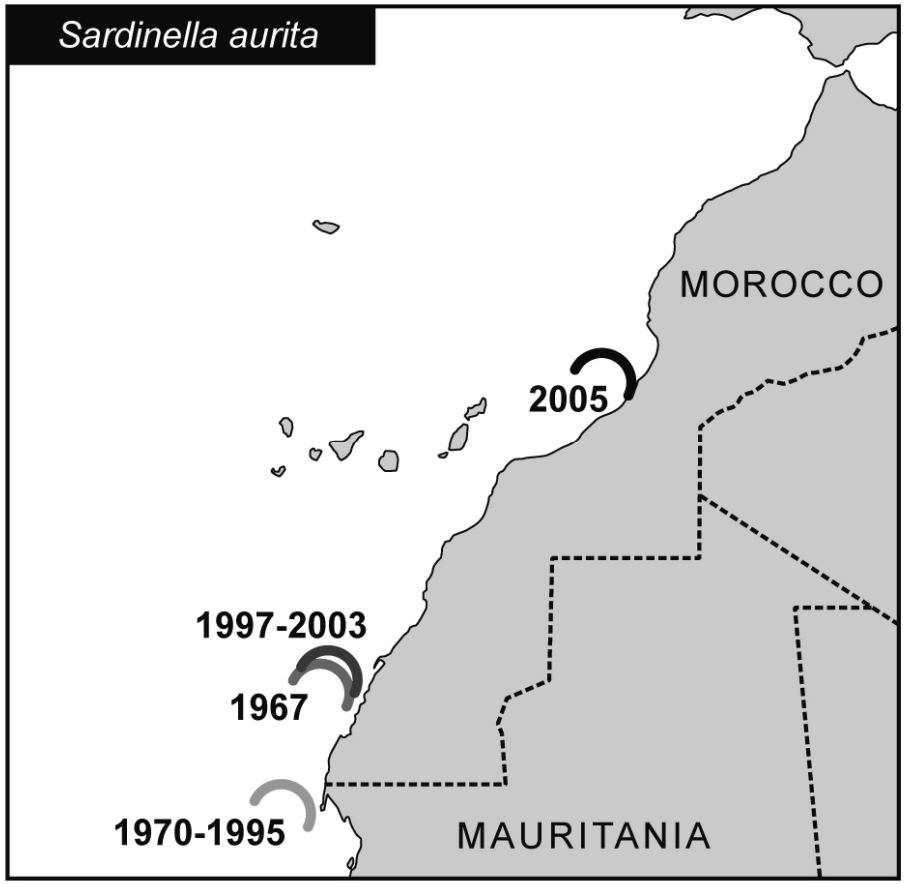


(A) cod,
(B) anglerfish,
(C) snake blenny

(Perry *et al.* 2005)

Latitudinal Shifts as Yet Unexplained





(S. Kifani, INRH, Morocco, pers. comm.)

Conjectures

- Physics
  - Changing wind fields
  - Changes in stratification
- Productivity
  - Bottom-up processes
  - Ecosystem processes
- Acidification
- Fish production

(Rykaczewski **B1-6363 Tuesday 16:45**)

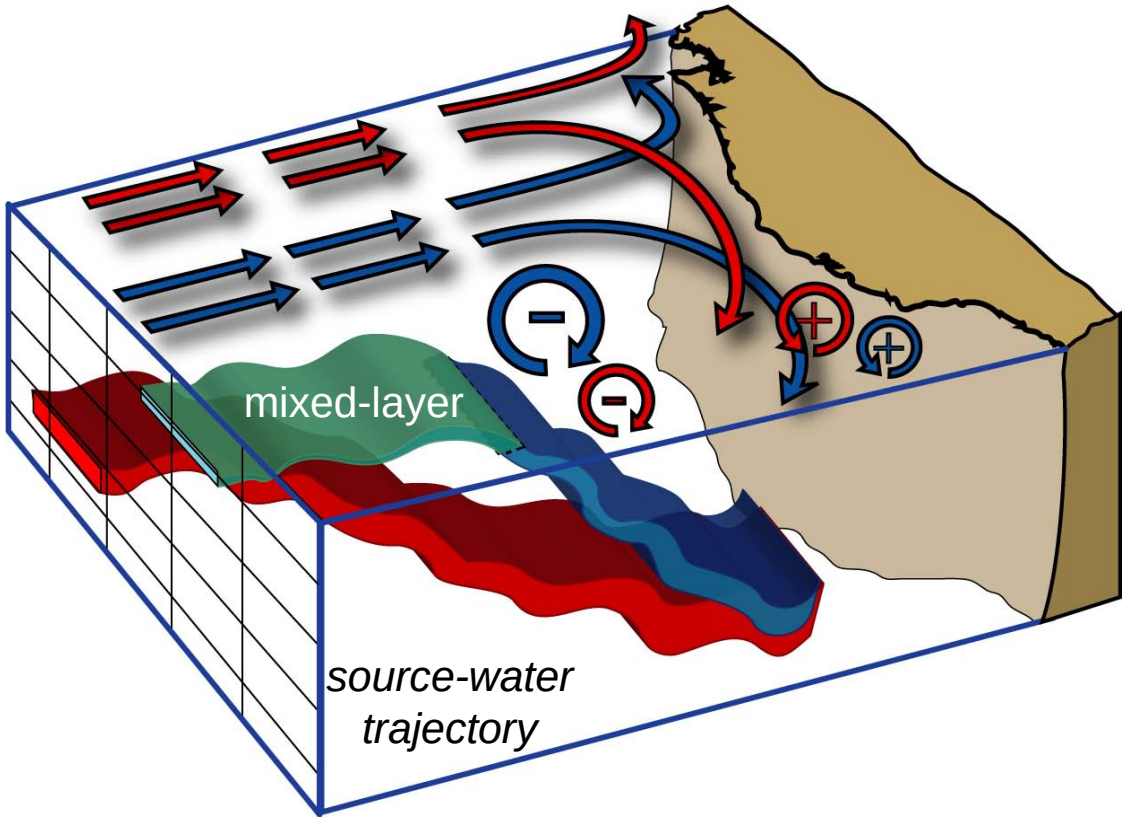
Ventilation of CCE source waters

Conceptual diagram: pre-industrial 2081-2100

poleward shift in westerlies

decreased downwelling over subtropical gyre

shallower surface mixed layer



Atmospheric and hydrographic changes have an ecological impact: increased nutrient supply to the CCE with increased North Pacific stratification on centennial scales.

Part III

Synthesis and Recommendations

(Chapter 15 – Checkley, Bakun, Barange, Castro, Guevarra, Herrick, MacCall, Ommer, Oozeki, Roy, Shannon, and van der Lingen)

Major Points

Demand will increase

Supply will either remain ~ same and fluctuate, or change with climate change

Value to ecosystem (forage, consumers) increasingly considered in decisions making

Scientific uncertainty and inadequate governance

Anchovy and sardine can vary independently, consistent with bottom-up (climate) forcing

Hysteresis: Peruvian anchoveta, Northern Benguela

Limits to prediction (*e.g.*, Hsieh *et al*. 2005)

Major Points (continued)

Herrick *et al.* 2009

$CV_{\text{global SPF landings}} = 0.36$

$CV_{\text{global anchovy landings}} = 0.65$

$CV_{\text{global sardine, sardinella, and pilchard landings}} = 0.77$

Hence, properties of groups of species may be more predictable than properties of species, let alone populations

Prediction

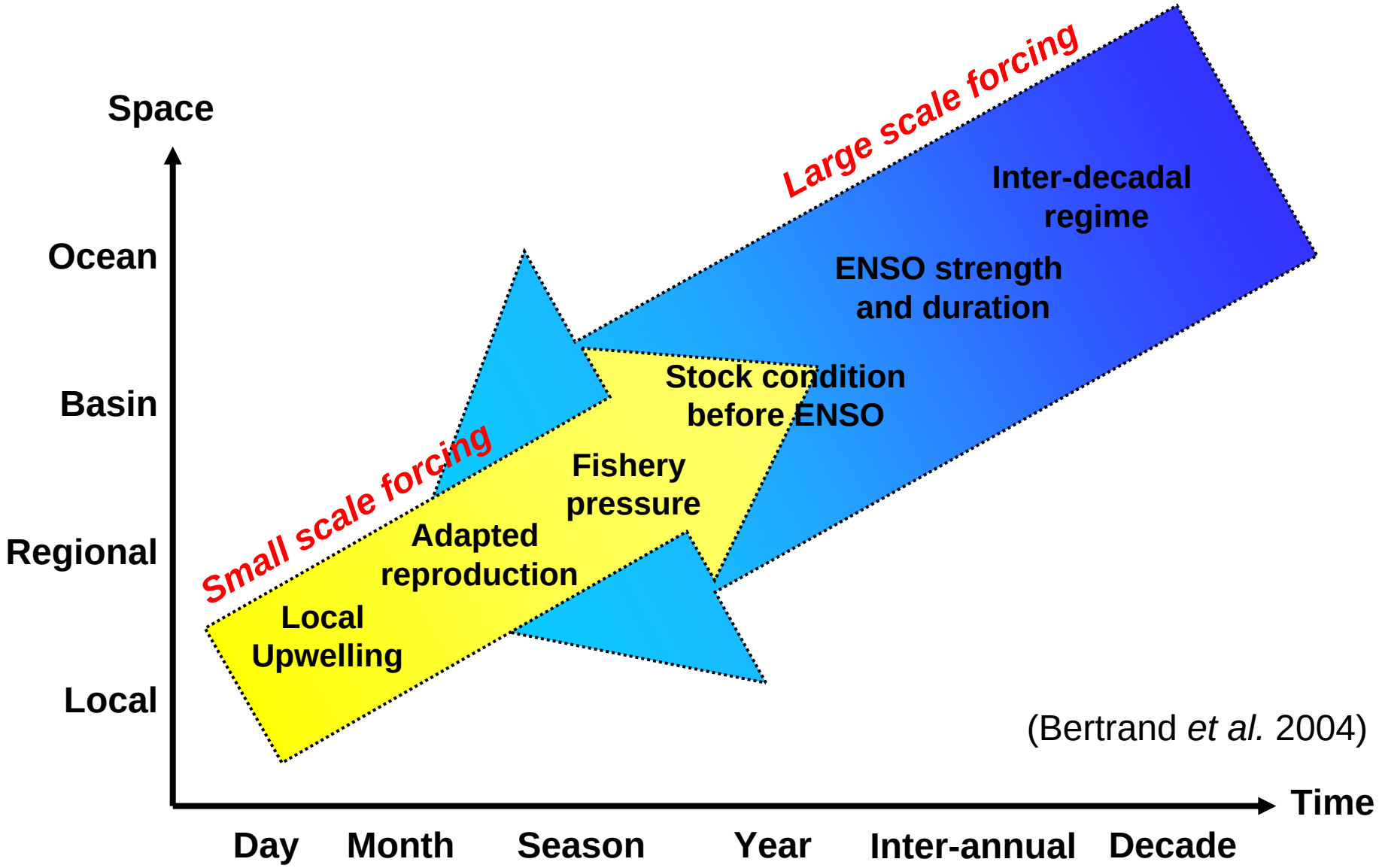
Statistical Models

- Depend on past behavior of system
- Short term prediction of variables (*e.g.*, CPUE)

Mechanistic Models

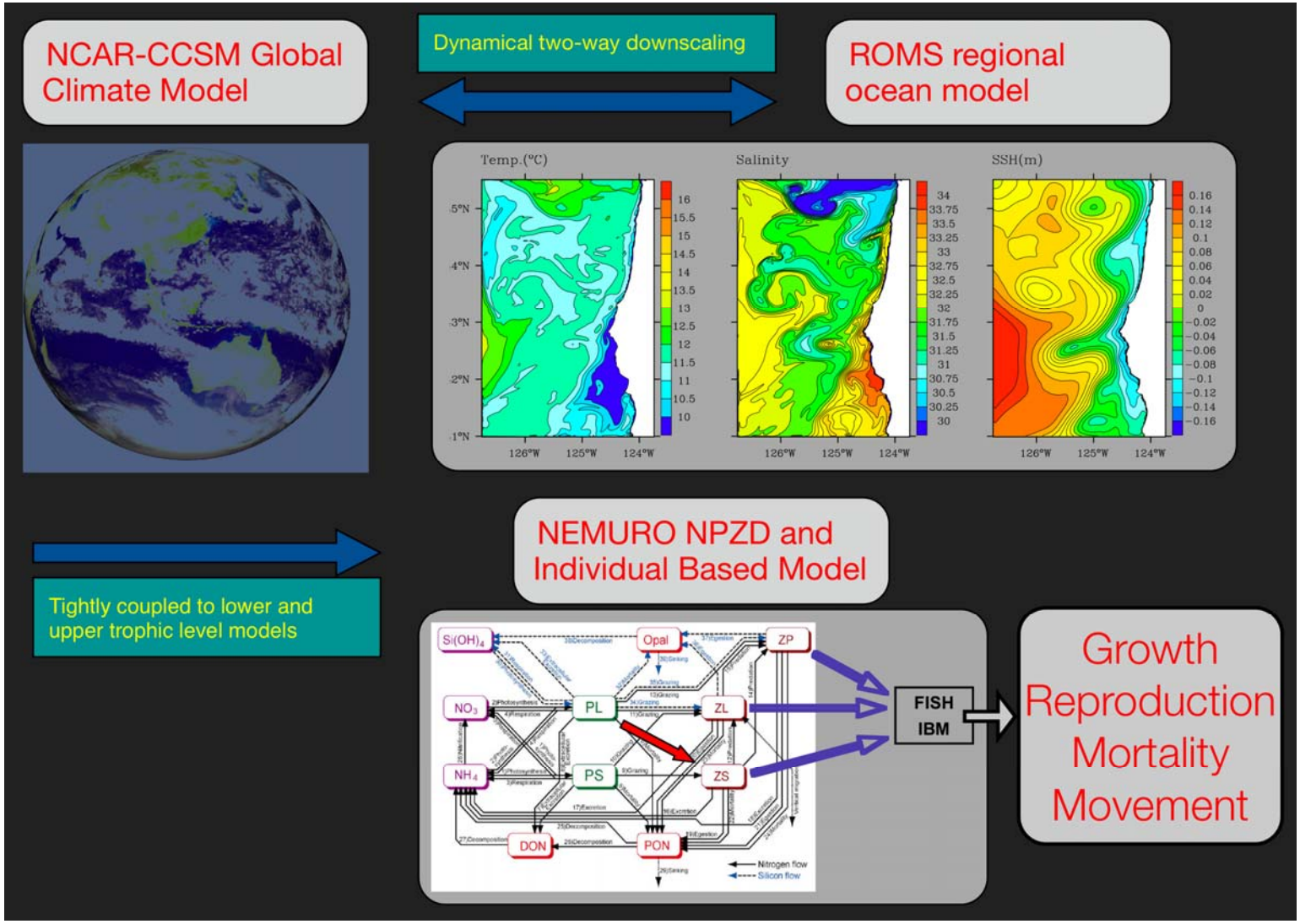
- Complex, uncertain
- Short- to long-term prediction of system properties

Interactions between time scales



(Bertrand *et al.* 2004)

Deterministic Model W Coast Sardine



(Rose **P1-D1-6106 this session 15:45**) (Curchitser pers. comm.)

Recommendations

1 – SPACC II

2 – “We recommend the periodic, international assessment of climate effects on small pelagic fish.”

Part IV

SPACC II

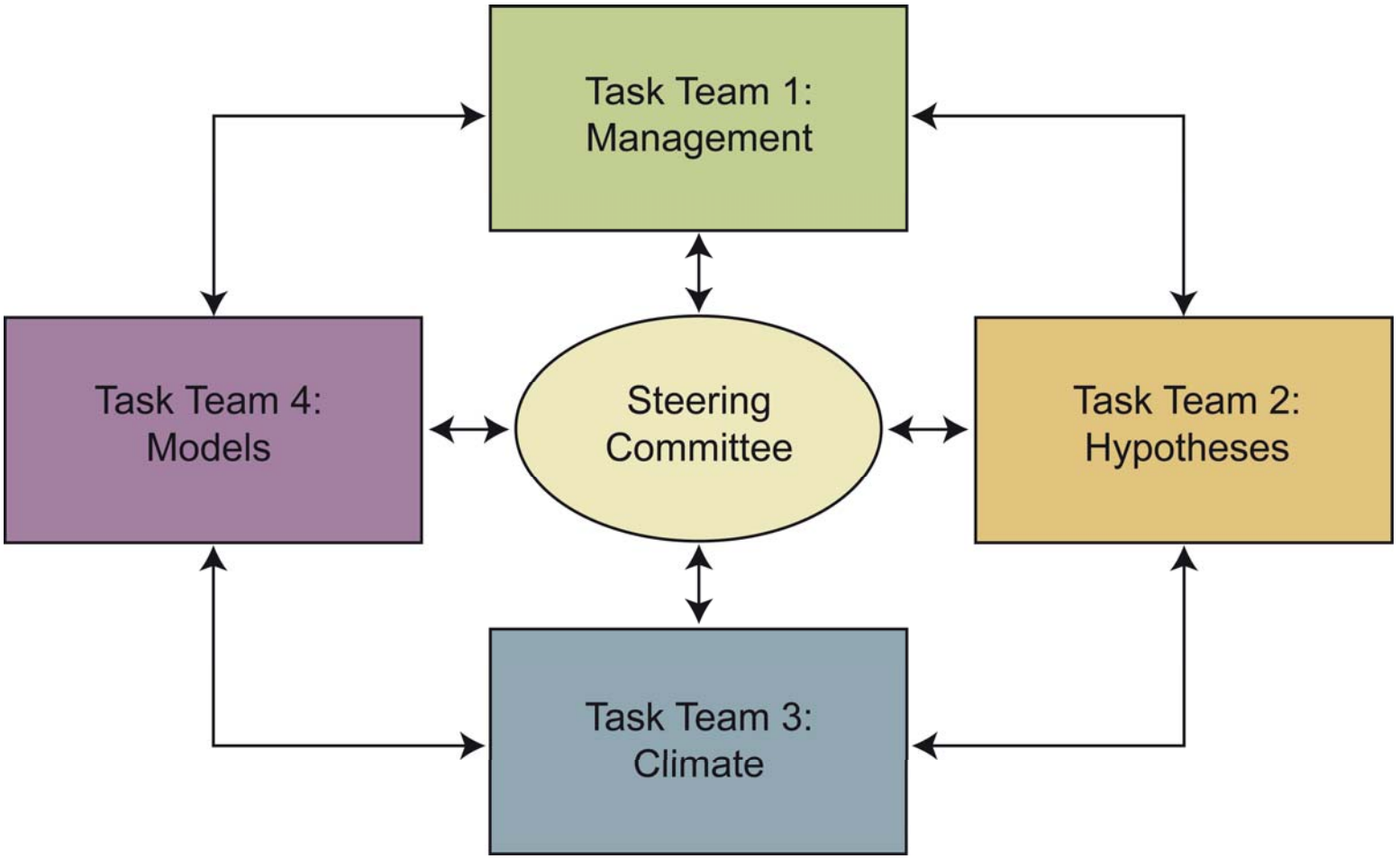
Planning Meeting, 24-26 February 2010, La Paz, Mexico

Carl van der Lingen, Salvador Lluch-Cota, Miguel Bernal, Dave Checkley, Sharon Herzka, Akinori Takasuka

SPACC II Mission Statement

The goal of SPACC II is to develop, synthesize and make available information to scientists, management authorities and other stakeholders on the **mechanisms** underlying low-frequency fluctuations of small pelagic fish populations in the context of variable and changing climate, and to develop and evaluate the capability for **forecasting** such fluctuations.

Proposed Organization of SPACC II



SPACC II Contacts

Carl van der Lingen	vdlingen@deat.gov.za
Salvador Lluch-Cota	slluch@cibnor.mx
Miguel Bernal	mbernal@marine.rutgers.edu
Sharon Herzka	sherzka@cicese.mx
Akinori Takasuka	takasuka@affrc.go.jp
Dave Checkley	dcheckley@ucsd.edu