



# PICES XV

## Yokohama October 2006

### **CCCC Topic Session**

**Modeling and historical data analysis of pelagic fish,  
with special focus on sardine and anchovy**

# S6



# PICES XV

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### **CCCC Topic Session**

## **Modeling and historical data analysis of pelagic fish, with special focus on sardine and anchovy**

Eastern North Pacific sardine spawning through climate,  
latitudinal, and inshore-offshore gradients

**Salvador E. Lluch-Cota, Daniel Lluch-Belda and Daniel Lluch-Cota**

# The Regime Problem topic is now at least 23 years old (since Kawasaki 1983)

1980s

FAO efforts, Vigo conference, Sendai conference, the Regime group,  
...many more

1990s

SCOR WG98, SPACC  
...many more

2000s

Noumea Workshop (scientists recruitment), Honolulu meeting  
...many more

...many ongoing

# Several hypotheses, big progress

(especially disseminating the concept and recruiting efforts)

## ...but still far from understanding

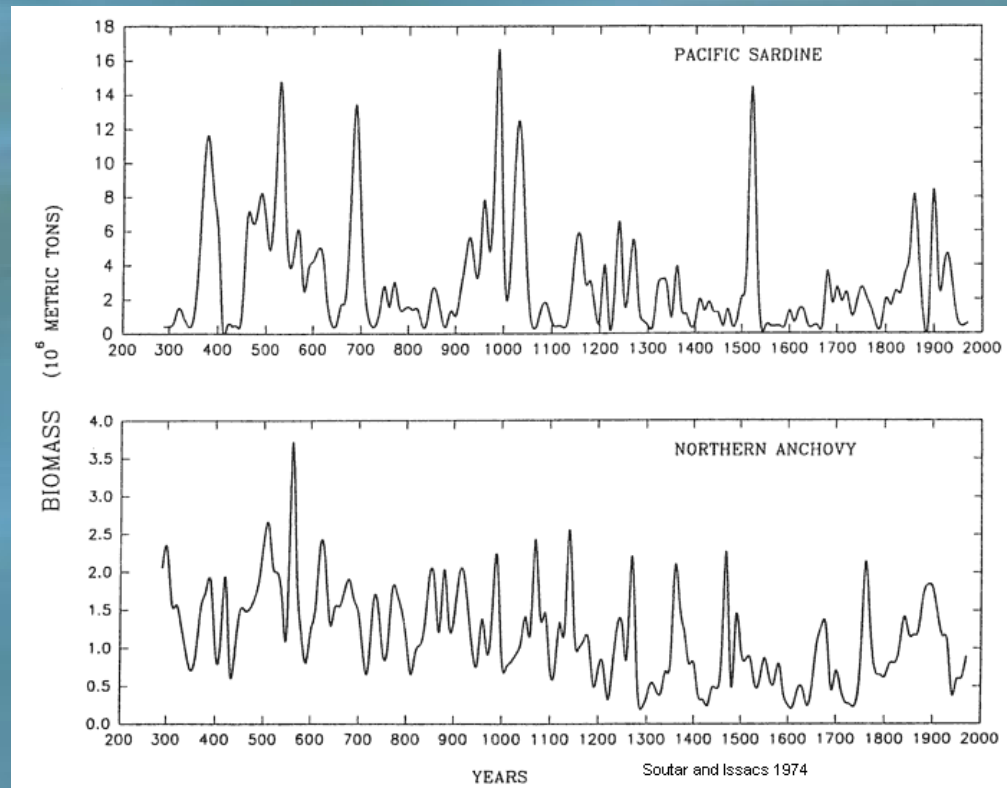
- We have been thinking mostly on single mechanisms
- We have proposed many hypotheses, but performed almost no testing
- We have insufficient data (?) and tools (models, models coupling)

Three components:

the low frequency abundance **fluctuations**,  
the **synchrony** between systems, and the  
abundance **alternation** between species of  
the same system.

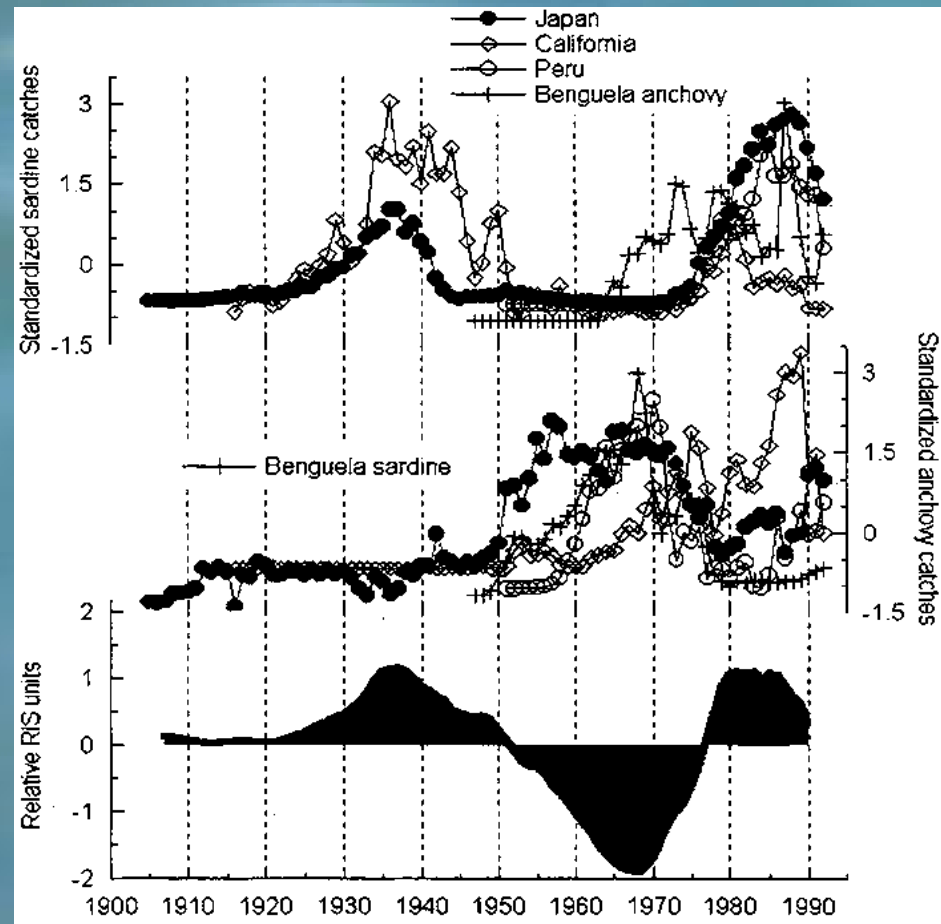
# Fluctuations

- no quantitative system-wide abundance proxies



# Fluctuations

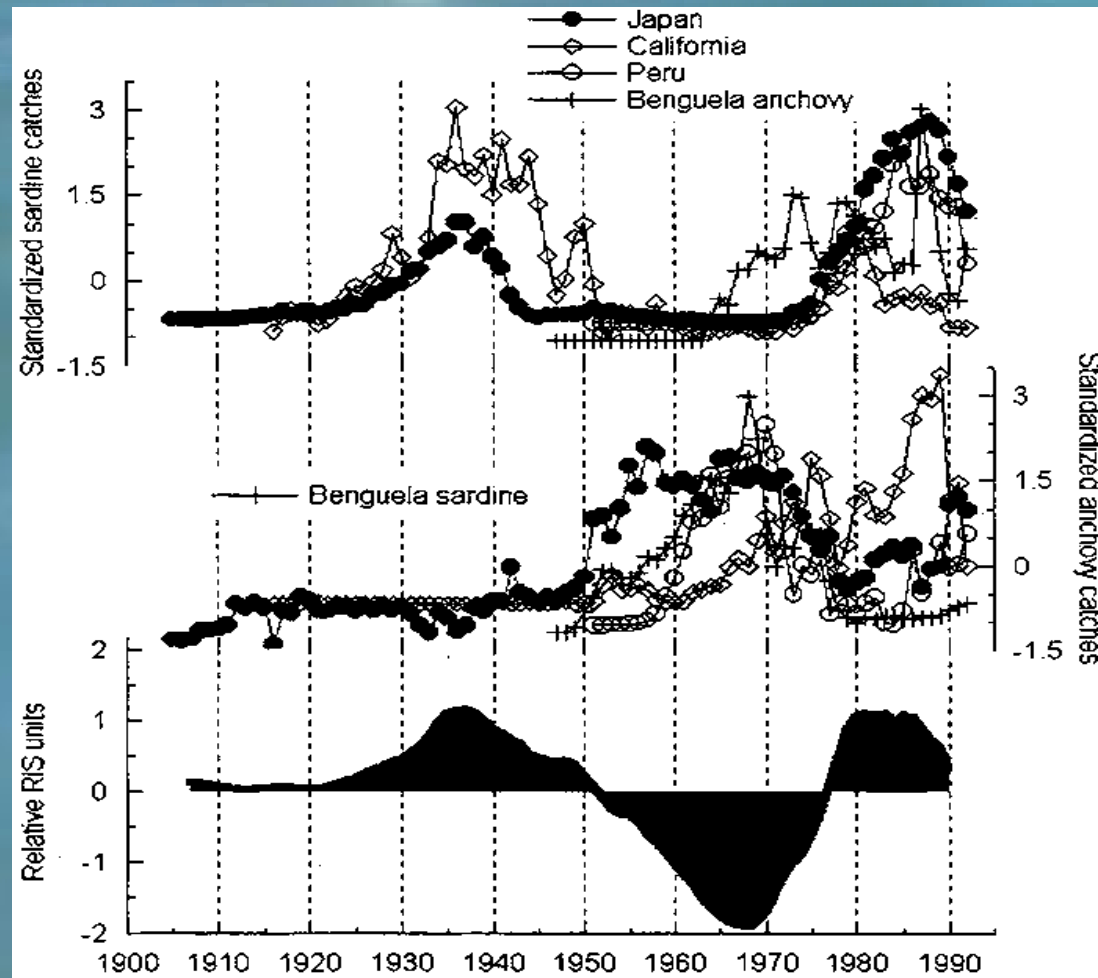
- no quantitative system wide abundance proxies
- the best record (catch) is contaminated with fishing signal (unknown)





# Synchrony

- needing update, last full dataset is 10 yrs old (from Schwartzlose et al., 1999)



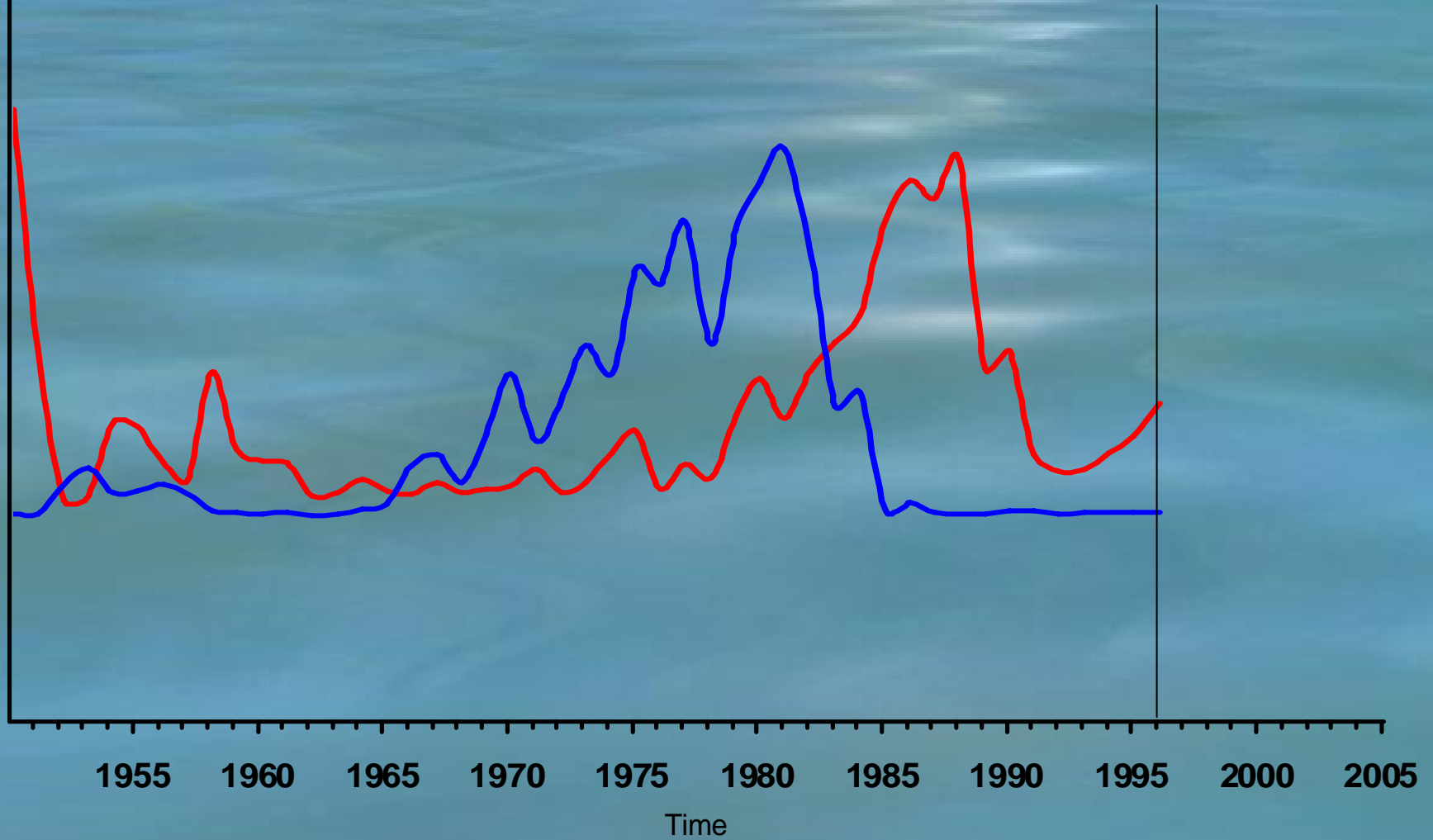


# Synchrony

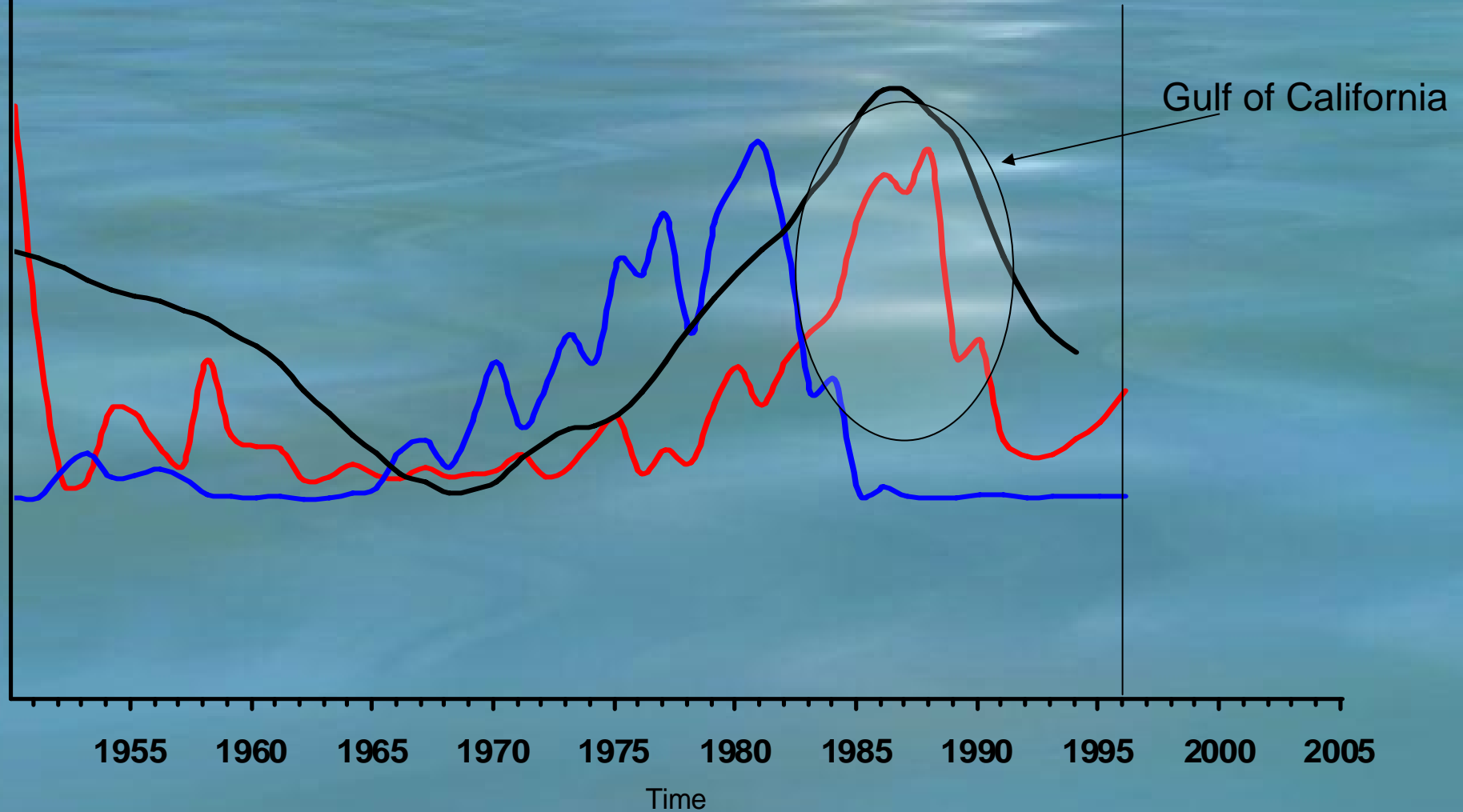
- needing update, last full dataset is 10 yrs old (from Schwartzlose et al., 1999)
- define which systems, and define systems

# North East Pacific **sardine** and **anchovy** catches *(includes GC)*

*Schwartzlose et al. (1999)*



North East Pacific **sardine** and **anchovy** catches (includes GC)  
*Regime indicator series (from FAO circular 934; 1997)*



# Synchrony

- needing update, last full dataset is 10 yrs old (from Schwartzlose et al., 1999)
- define which systems, and define the systems
- unknown mechanisms
- same large scale forcing (physical)

*Kondo (1980 and many others) flow patterns as a mechanism off Japan, Parrish et al (2000) wind stress north Pacific, MacCall (2002) extended to all systems: coherent with warm temp off California, Humboldt, and Benguela, and cold off Japan.*

# Alternation

## Sardine and anchovy only?

- Regime changes = ecosystem change
- Succession instead of alternation  
(*sequence of species; Matsuda et al 1992, MacCall 1996*)

## Real?

- Not many cases, some exceptions

# Alternation

## Mechanisms?

Different habitat preferences

- Temperature
- Diet (total productivity requirements, food type)

Competition

- Early stages (as larvae for food, predation on the other's eggs)
- Same resources, dif abilities (swimming, filtering, reprod)

Capacity to use ocean features

- Sardine (only) able to use offshore habitat
- Abundance depending on mesoscale eddies  
(*not clear: is eddy formation enhanced during weak current flow?*)

Top down

- Reallocation of predators (such as squid)
- Fishing impact

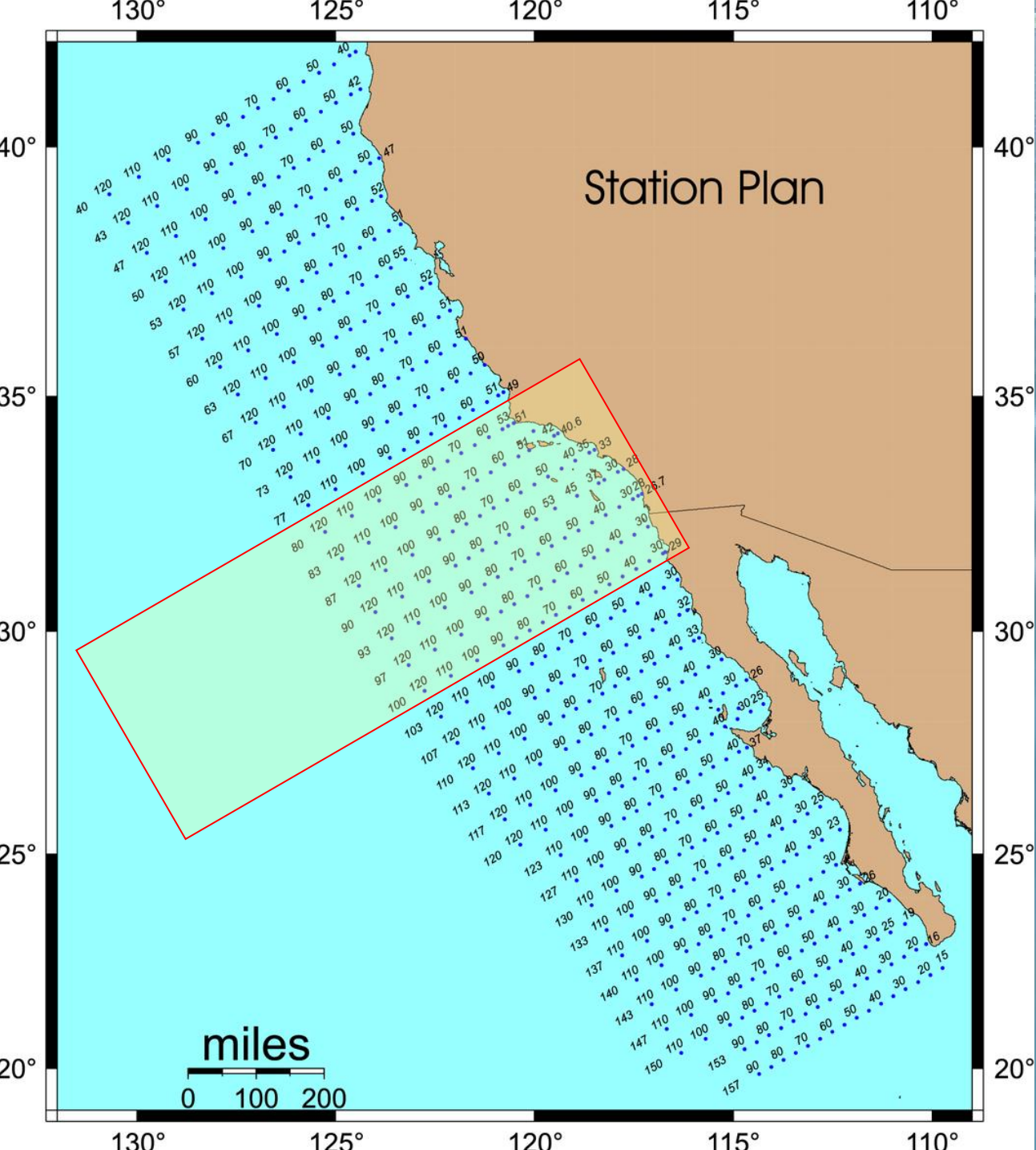
We will not get better historical data...we need strong sampling, experiments, **and modeling**

Models such as NEMURO.FISH might prove useful to explore mechanisms

What can we explore at single small systems with models such as NEMURO.FISH?

The best sampled area within the California Current (CalCOFI data) is probably the best chance to evaluate potential results of modeling efforts





**Subset of CalCOFI**

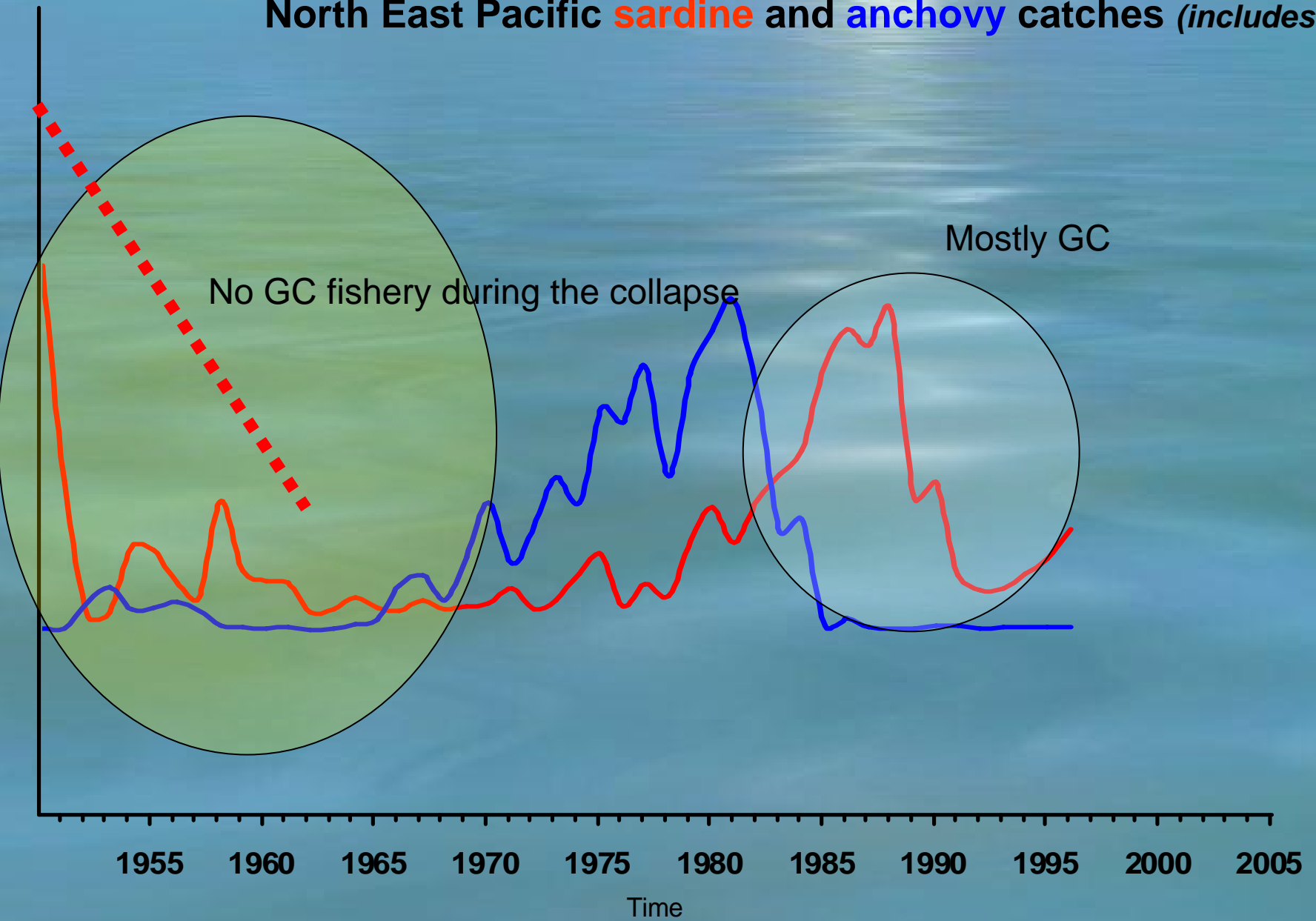
**Period: 1954-2005**

**Spatial: 80-100 lines**

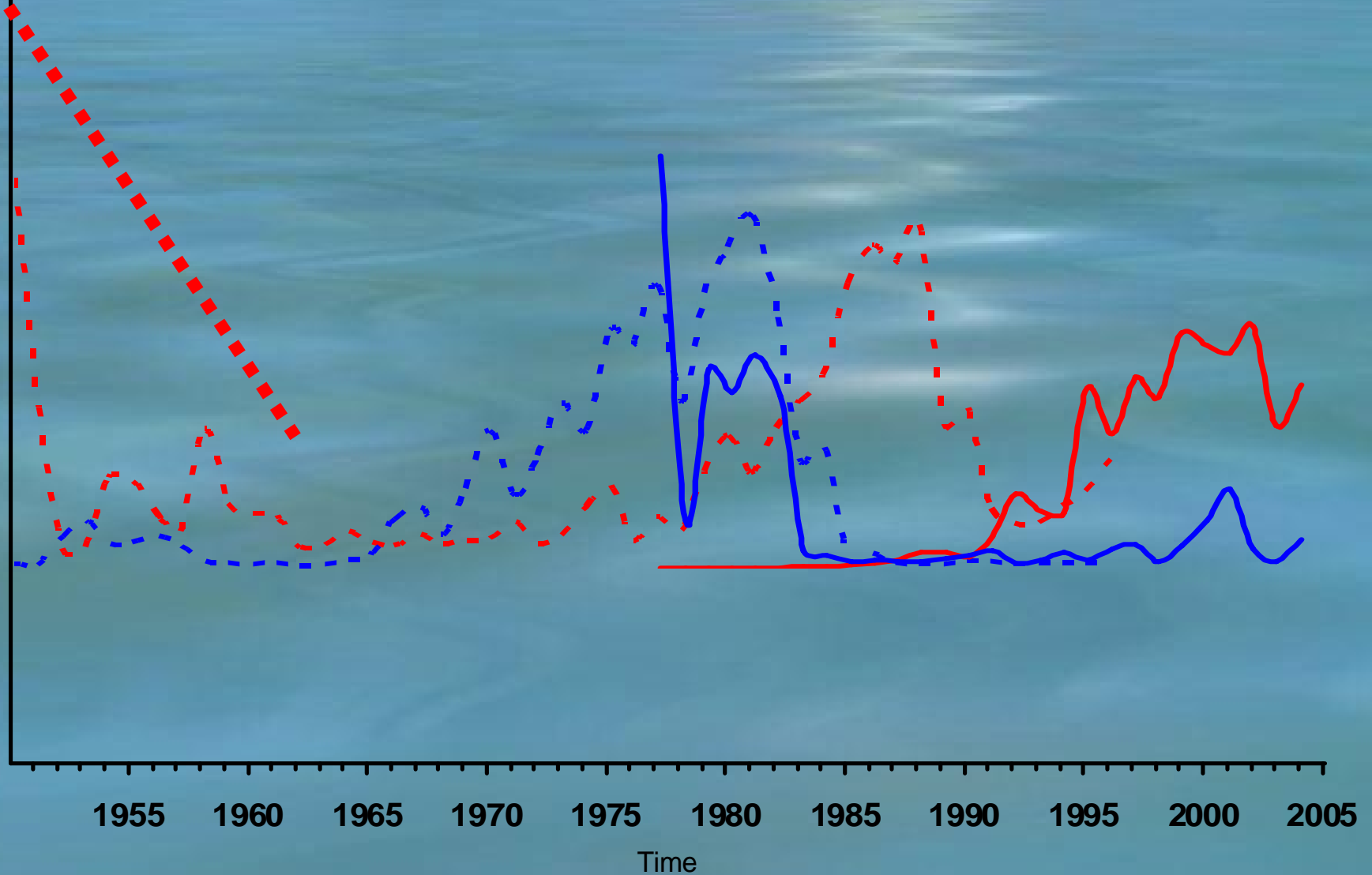
**Samp: Sar and anch**

**Distance to coast**

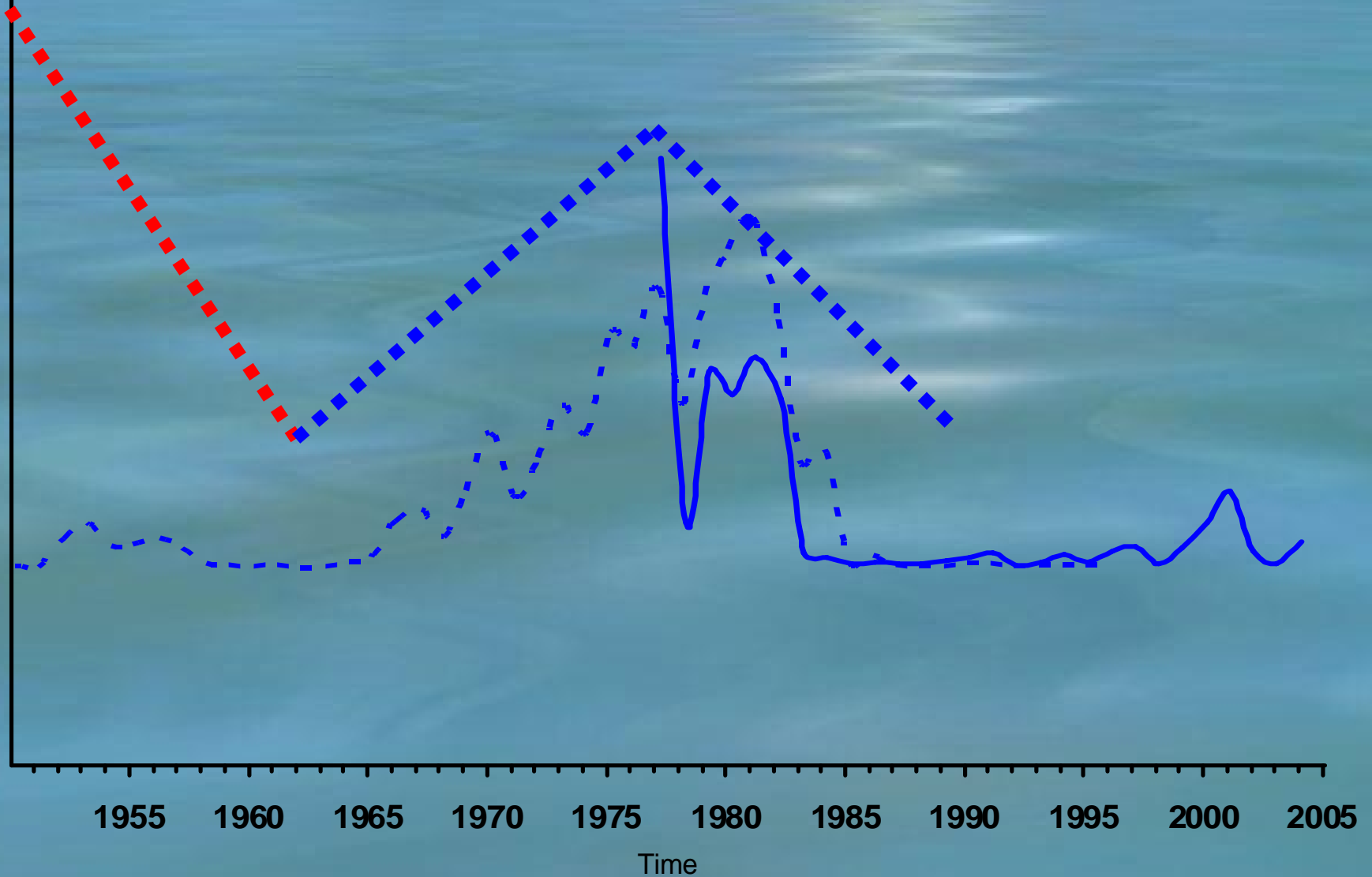
# North East Pacific **sardine** and **anchovy** catches *(includes GC)*



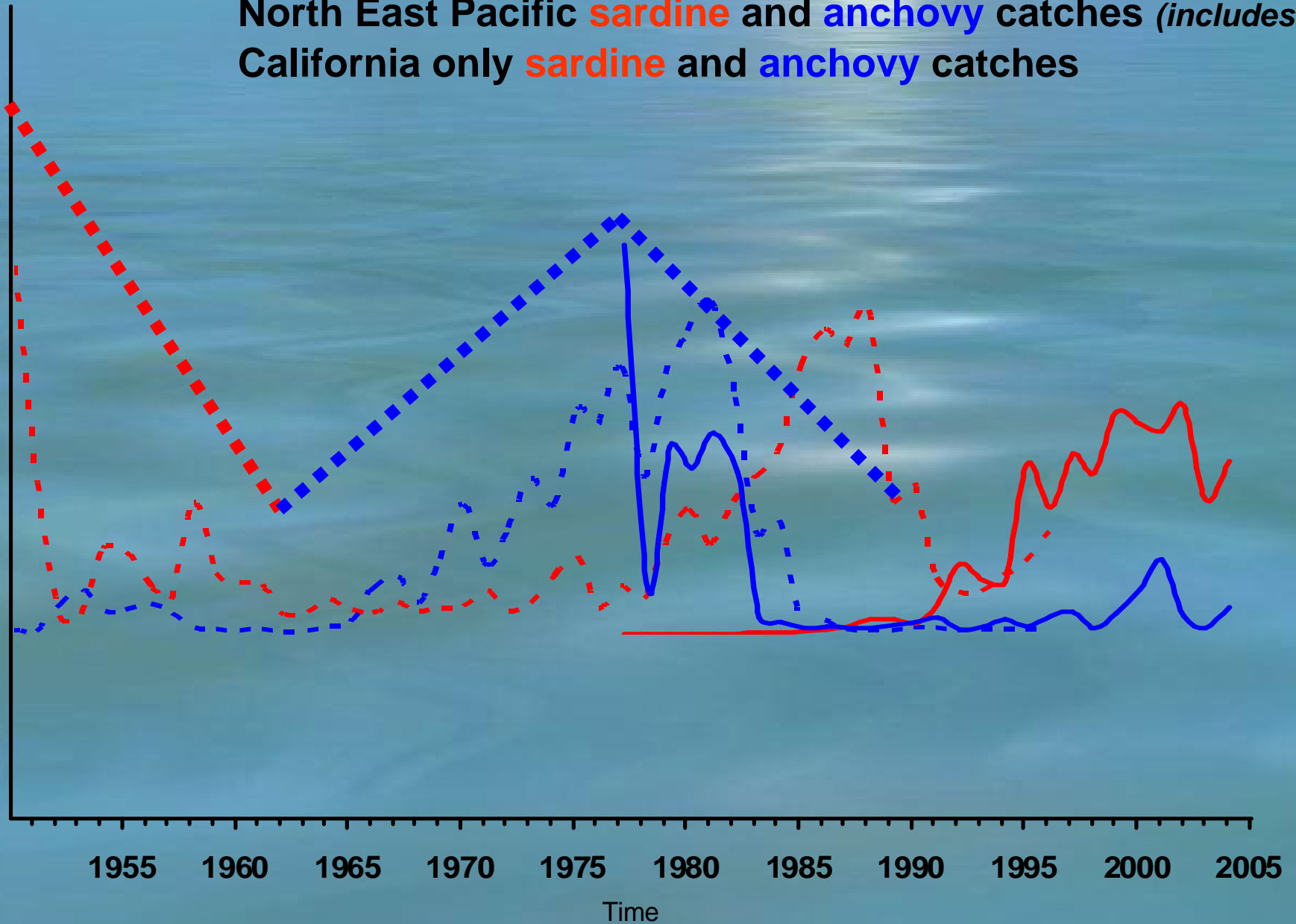
North East Pacific **sardine** and **anchovy** catches (*includes GC*)  
California only **sardine** and **anchovy** catches



North East Pacific **anchovy** catches (*includes GC*)  
California only **anchovy** catches



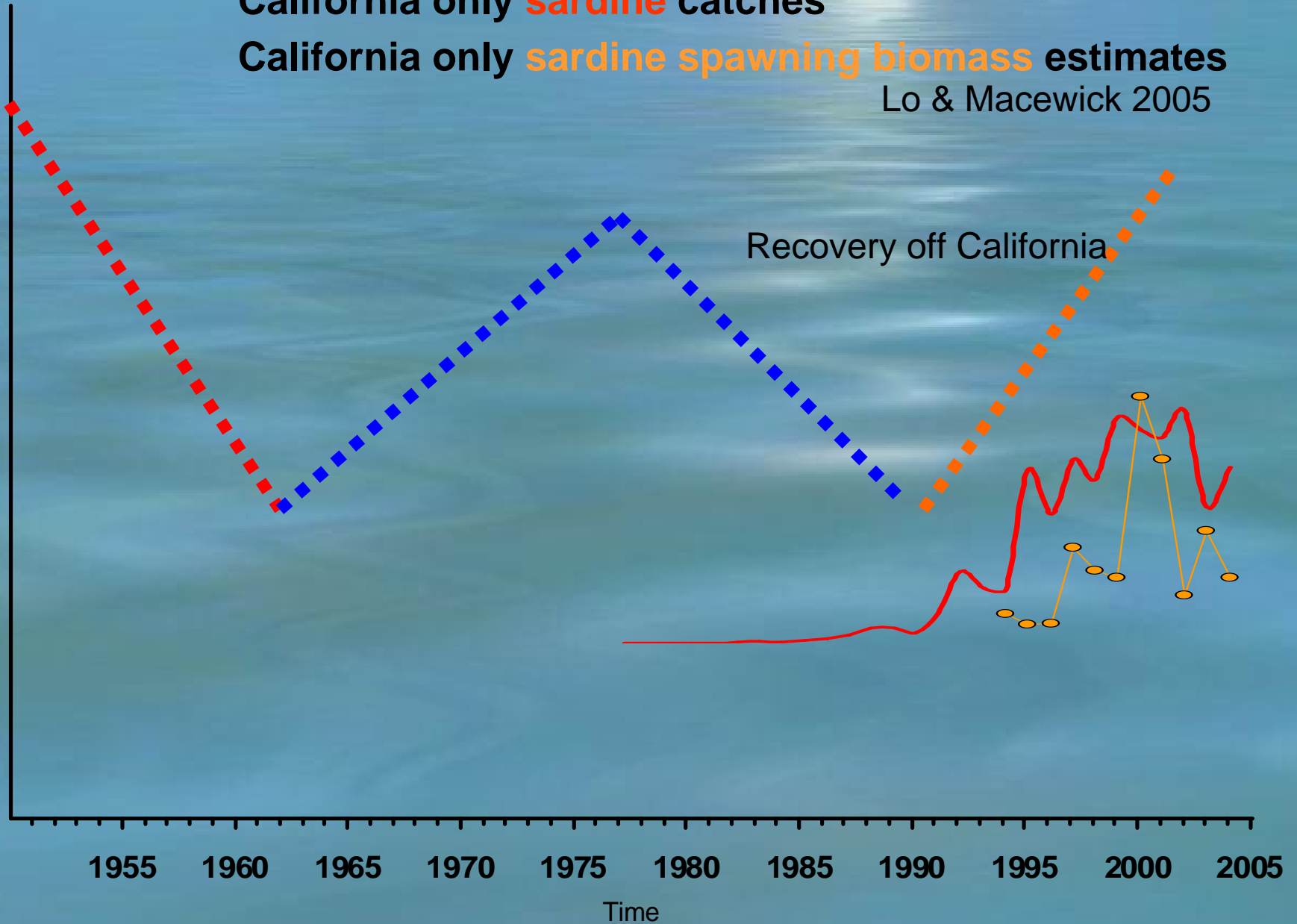
North East Pacific **sardine** and **anchovy** catches (*includes GC*)  
California only **sardine** and **anchovy** catches



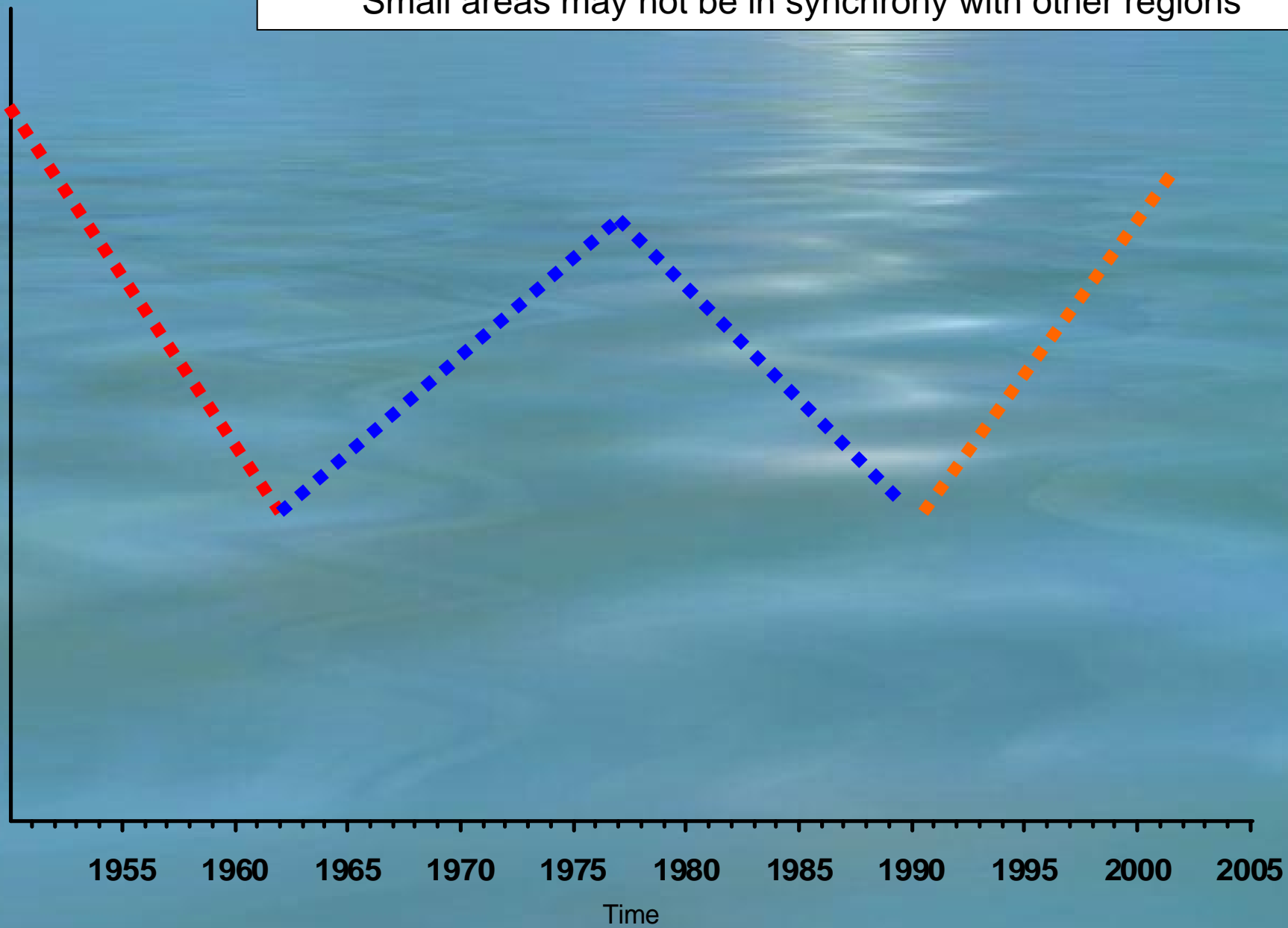
California only **sardine** catches

California only **sardine spawning biomass** estimates

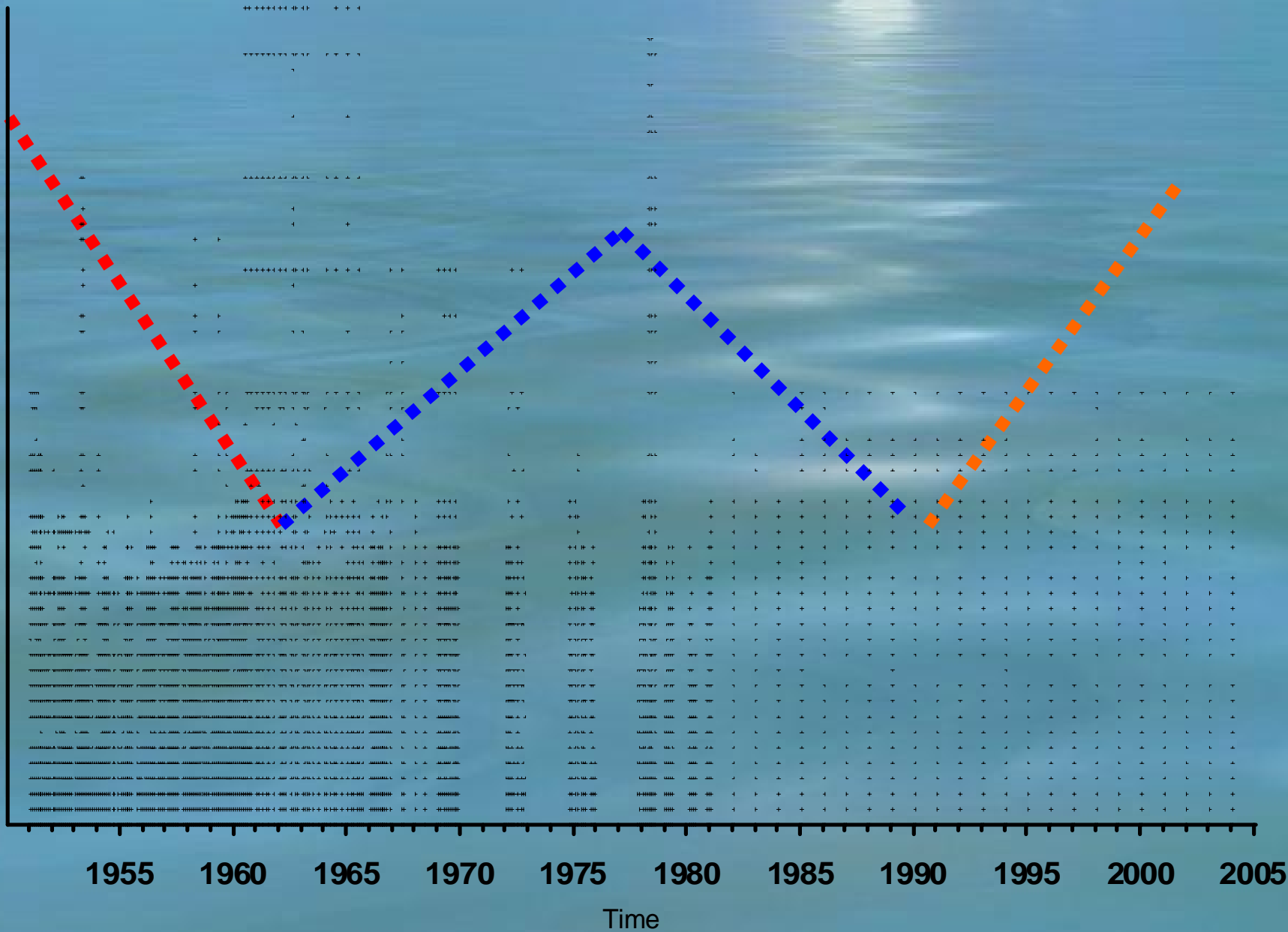
Lo & Macewick 2005

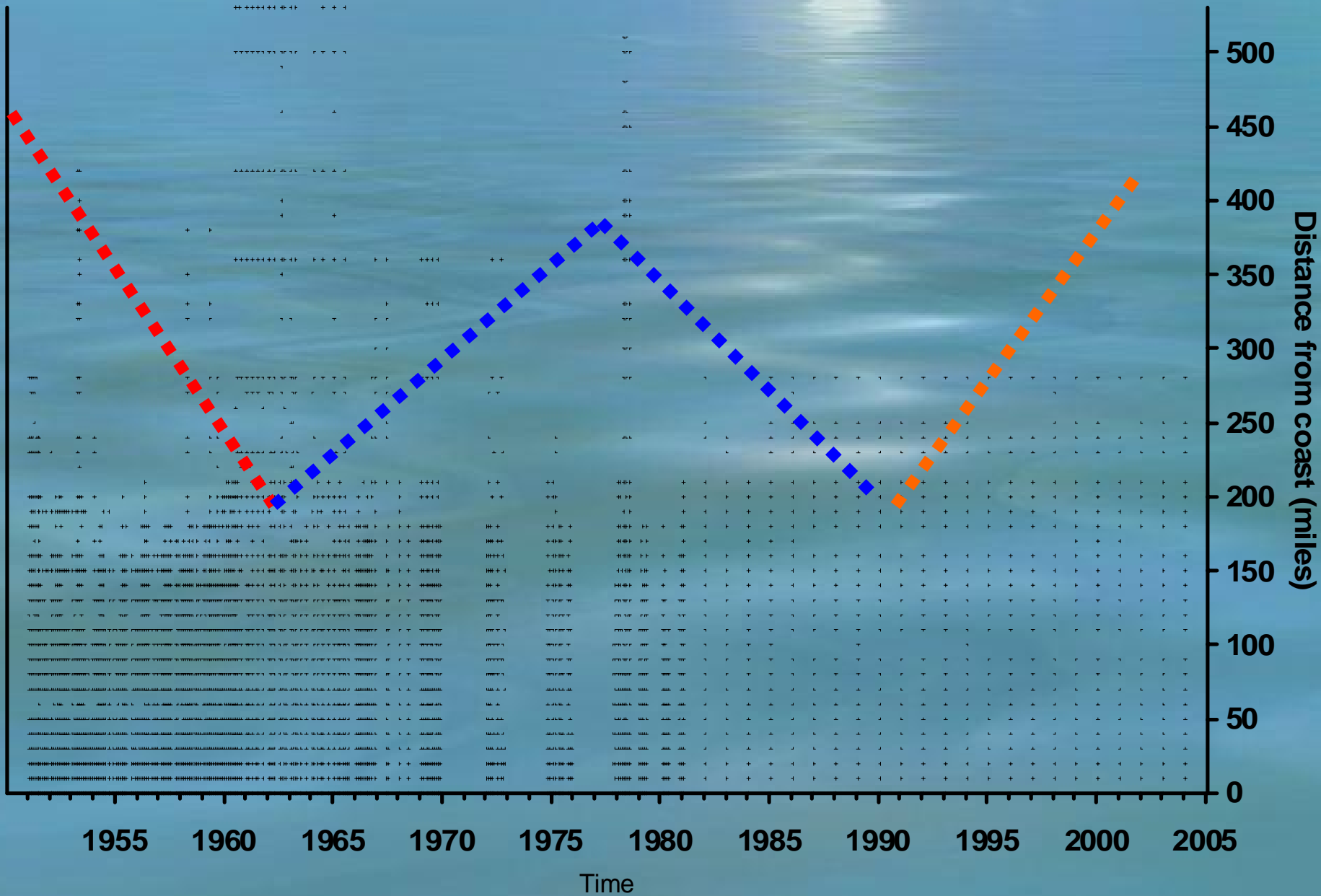


Small areas may not be in synchrony with other regions

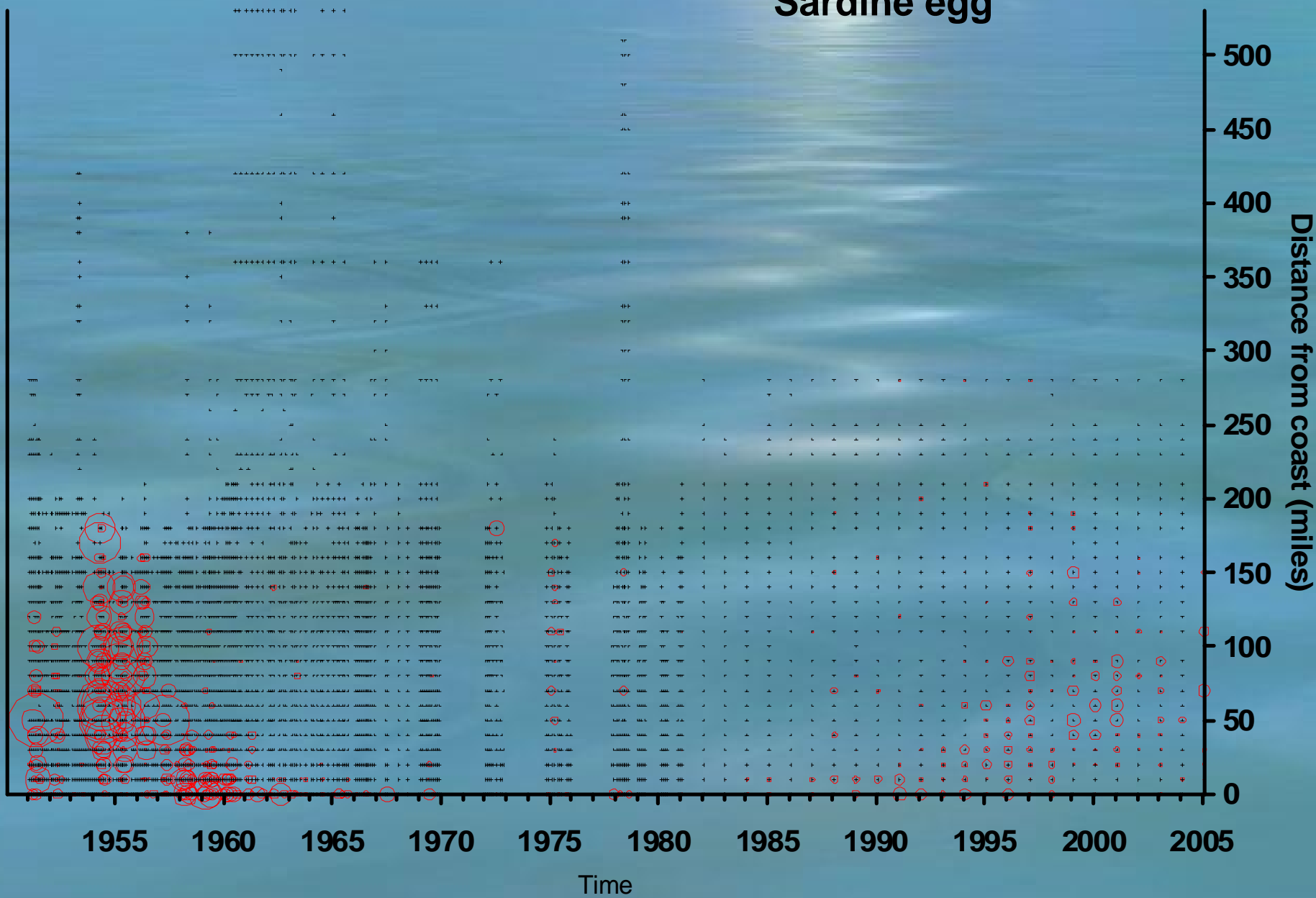




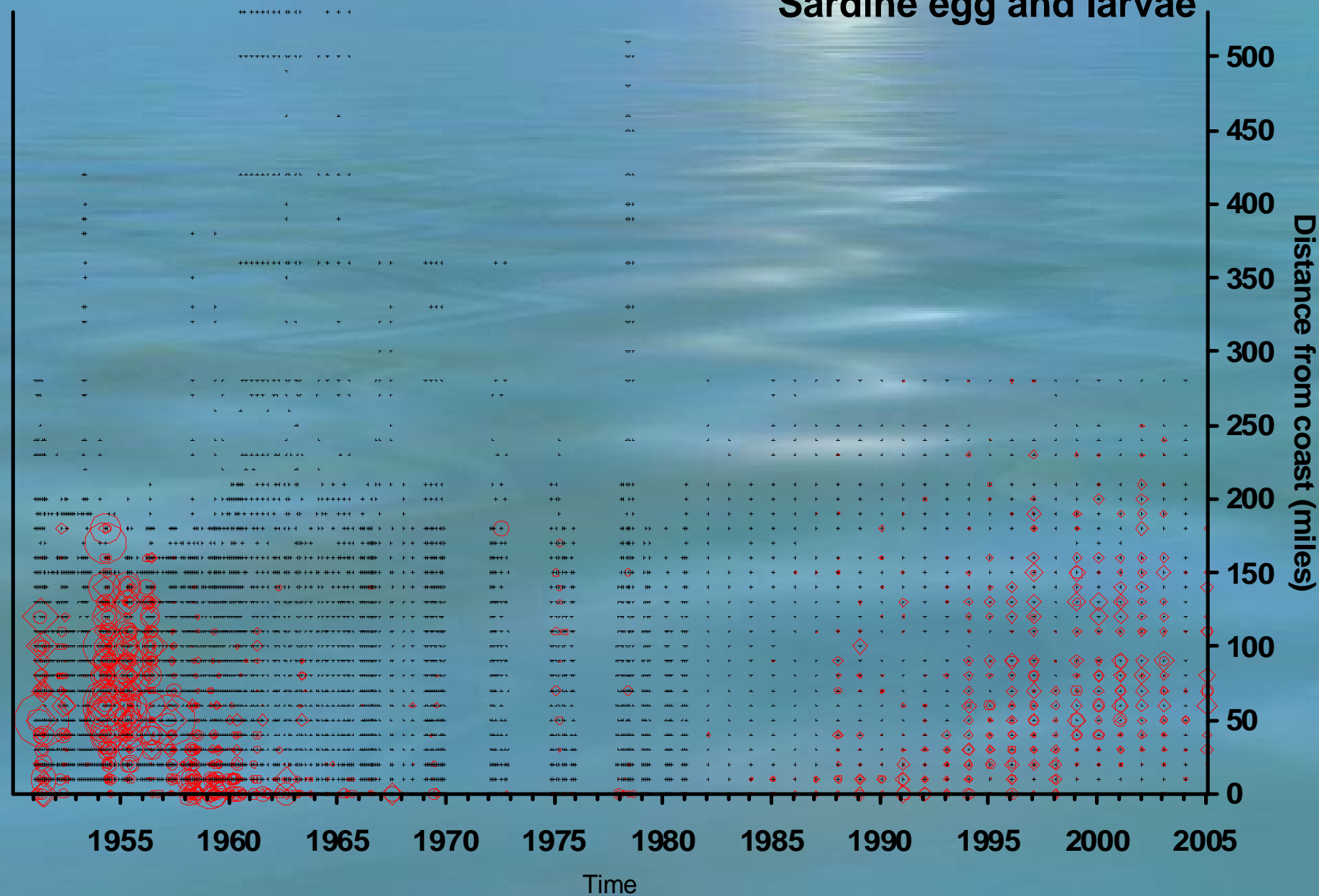




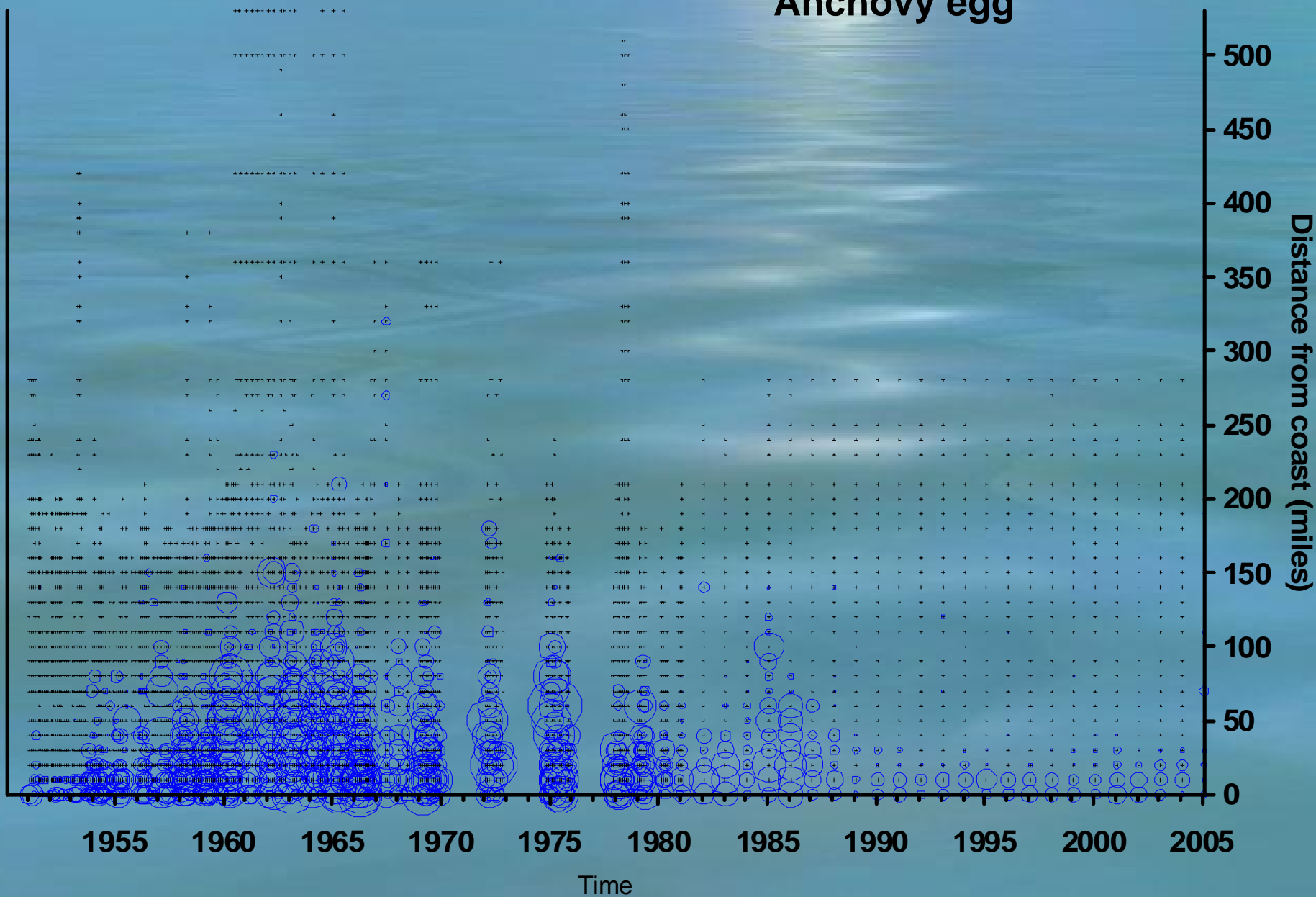
# Sardine egg



# Sardine egg and larvae

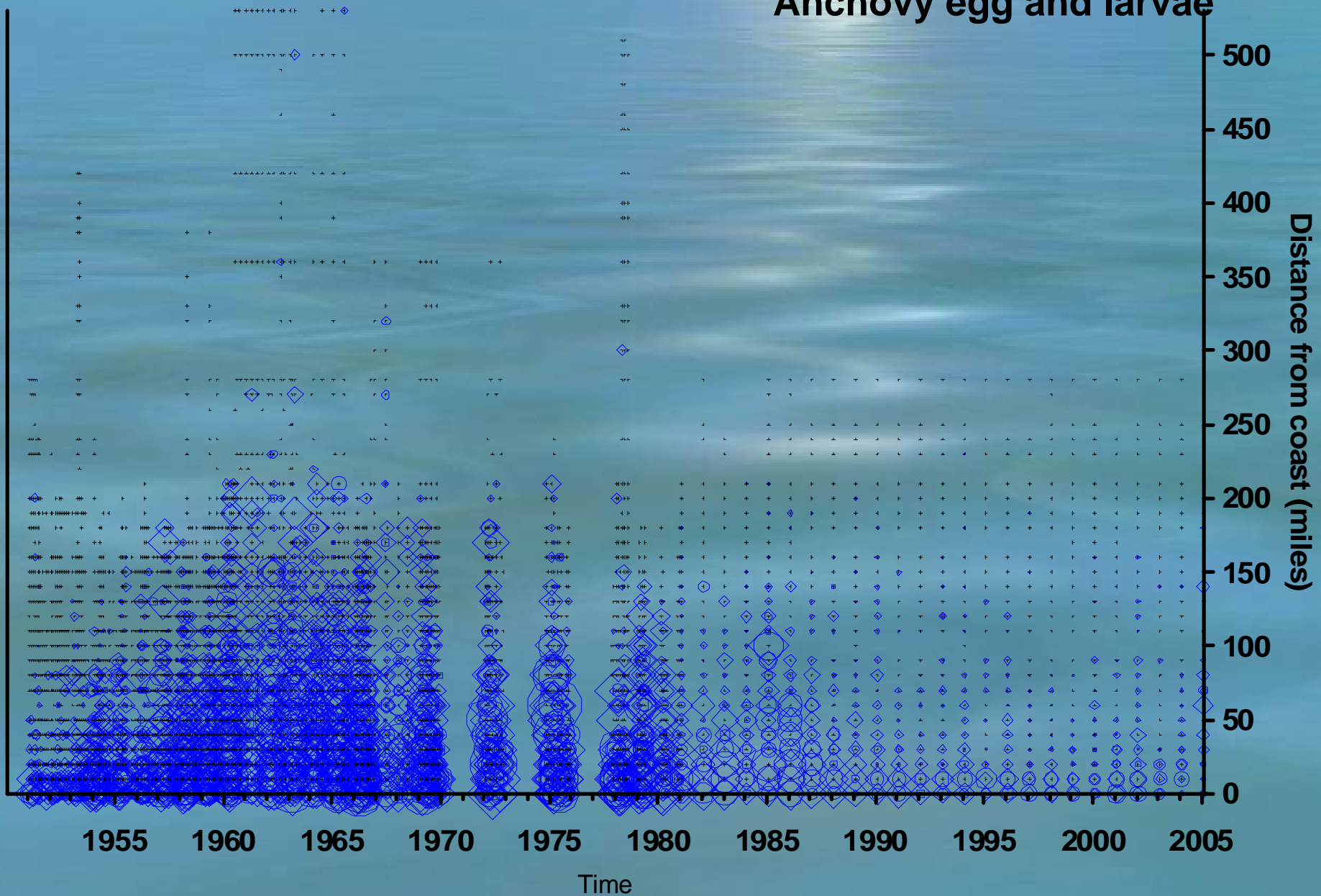


# Anchovy egg

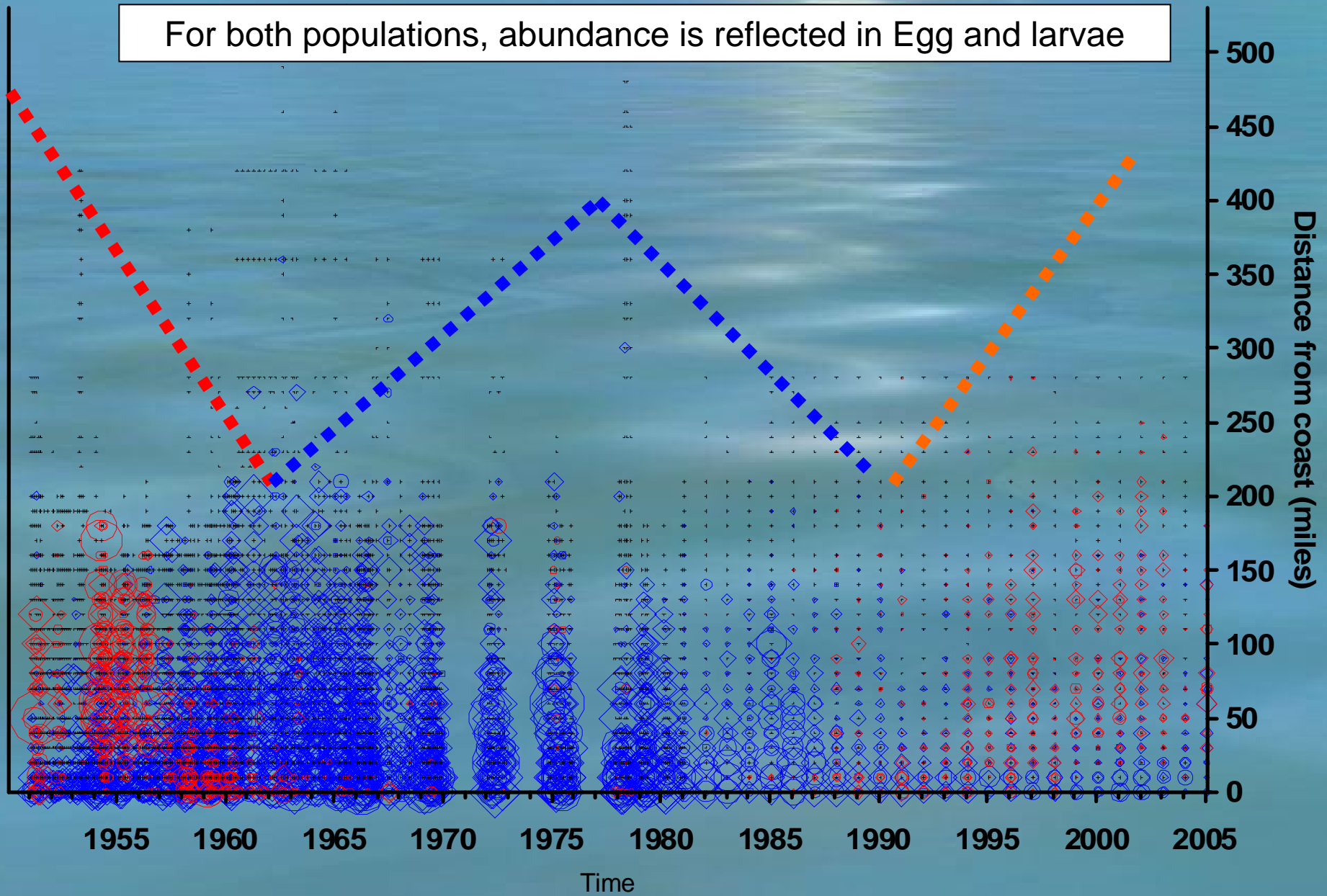




# Anchovy egg and larvae

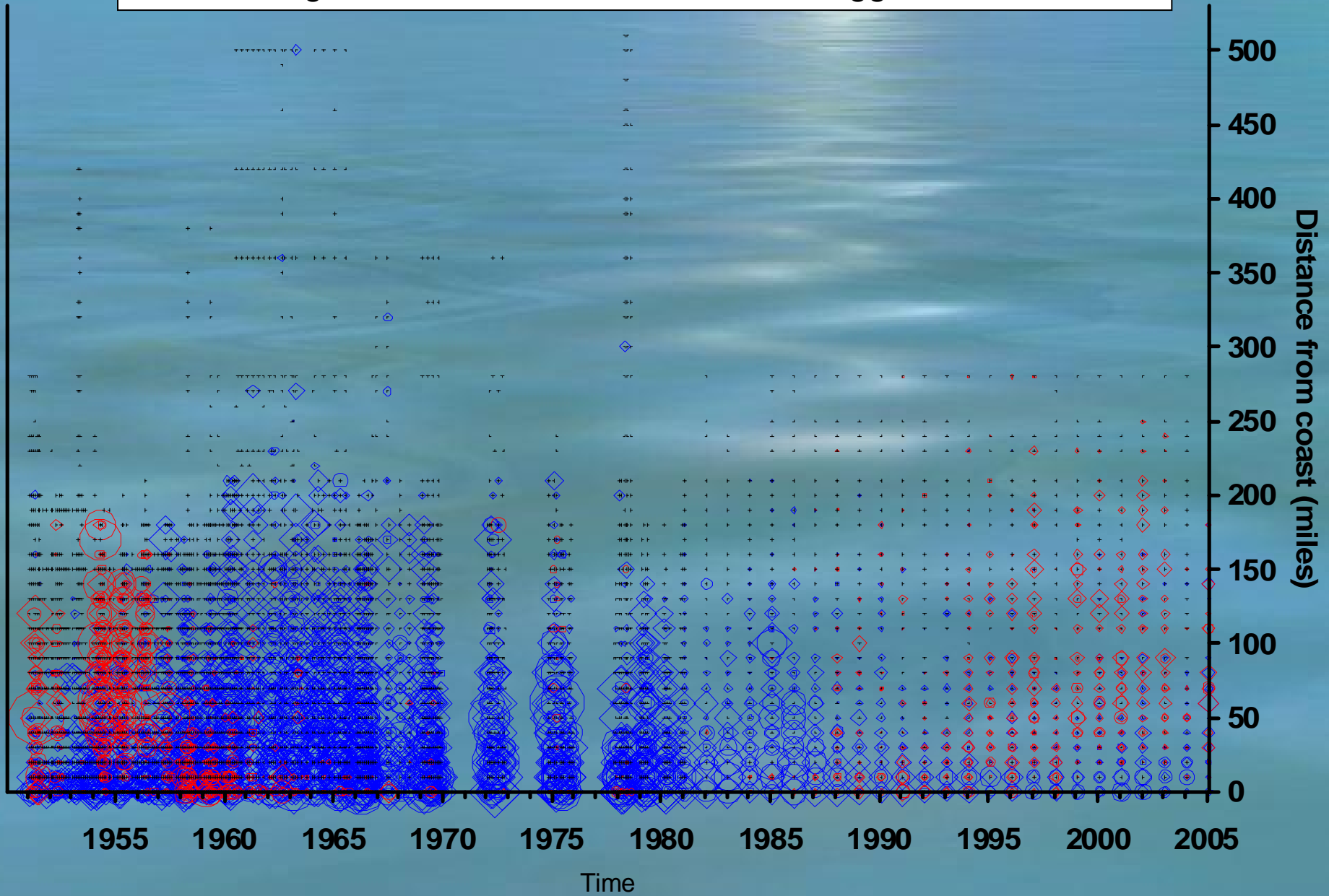


For both populations, abundance is reflected in Egg and larvae

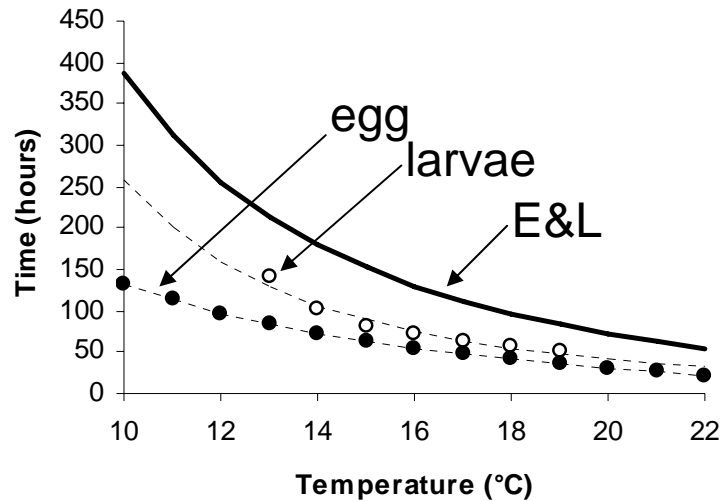




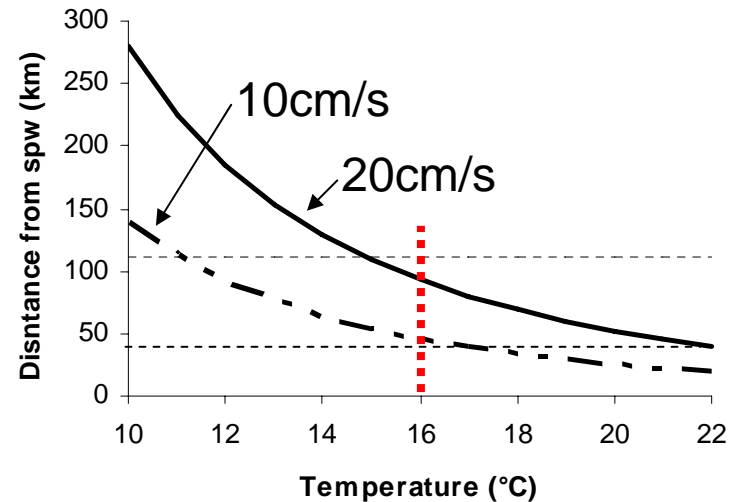
# Not big distribution differences between eggs and larvae



Early stage grow rate as a function of temperature



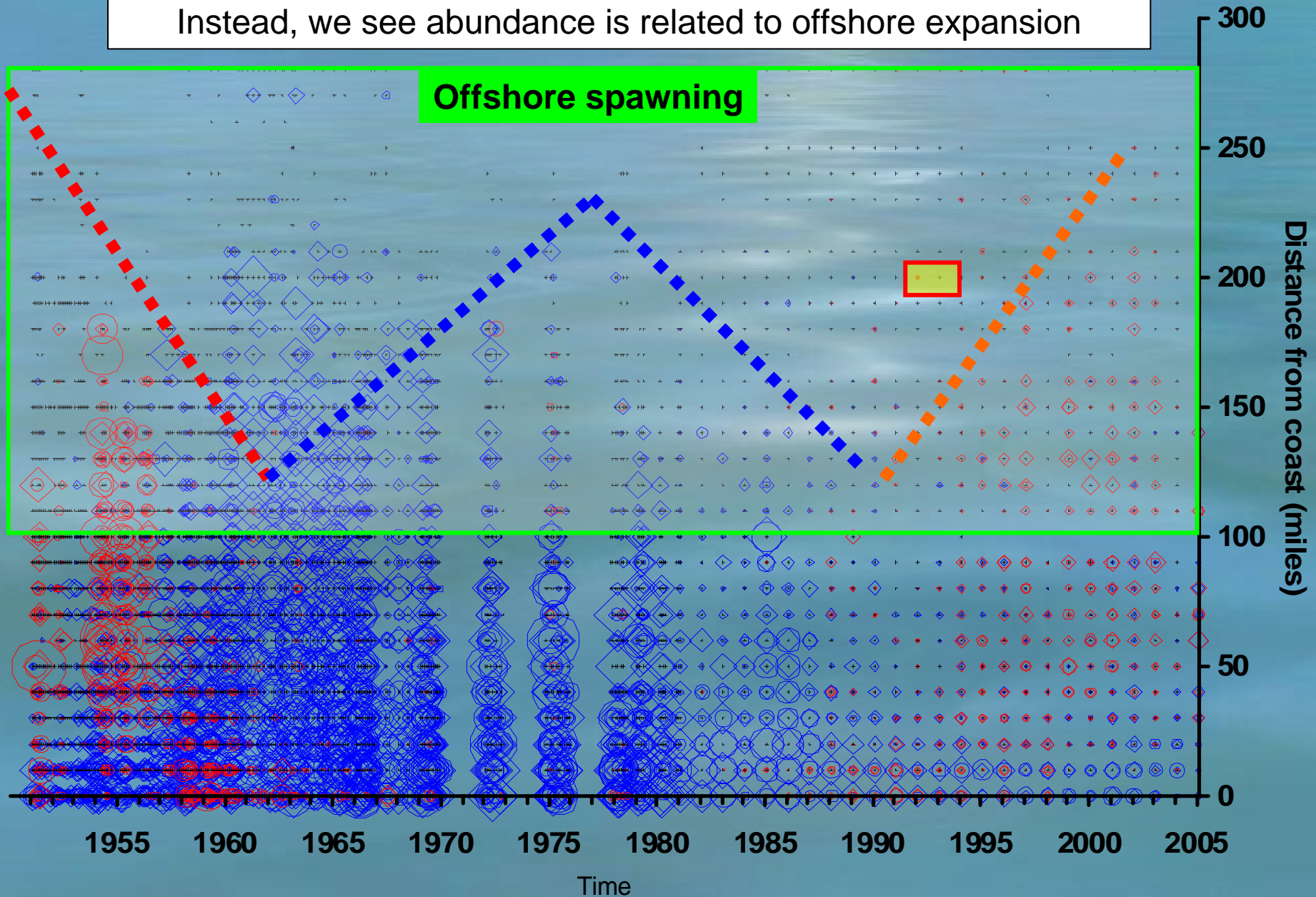
Advection (distance) from where egg was spawn



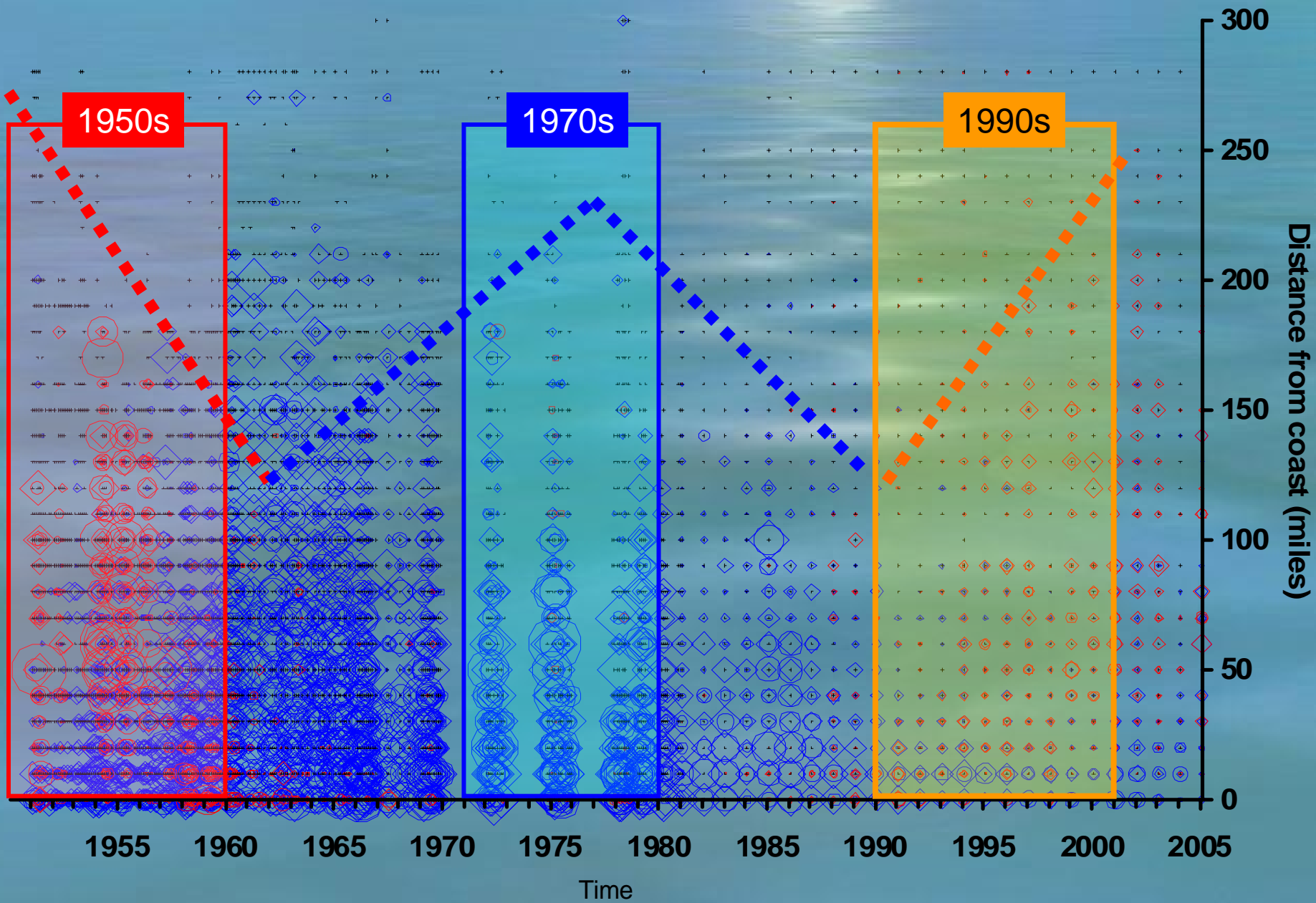
In terms of retention, exploration might not need to include ocean structures (eddies/eddies-only)

We do not see clear offshore sardine habitat and coastal anchovy

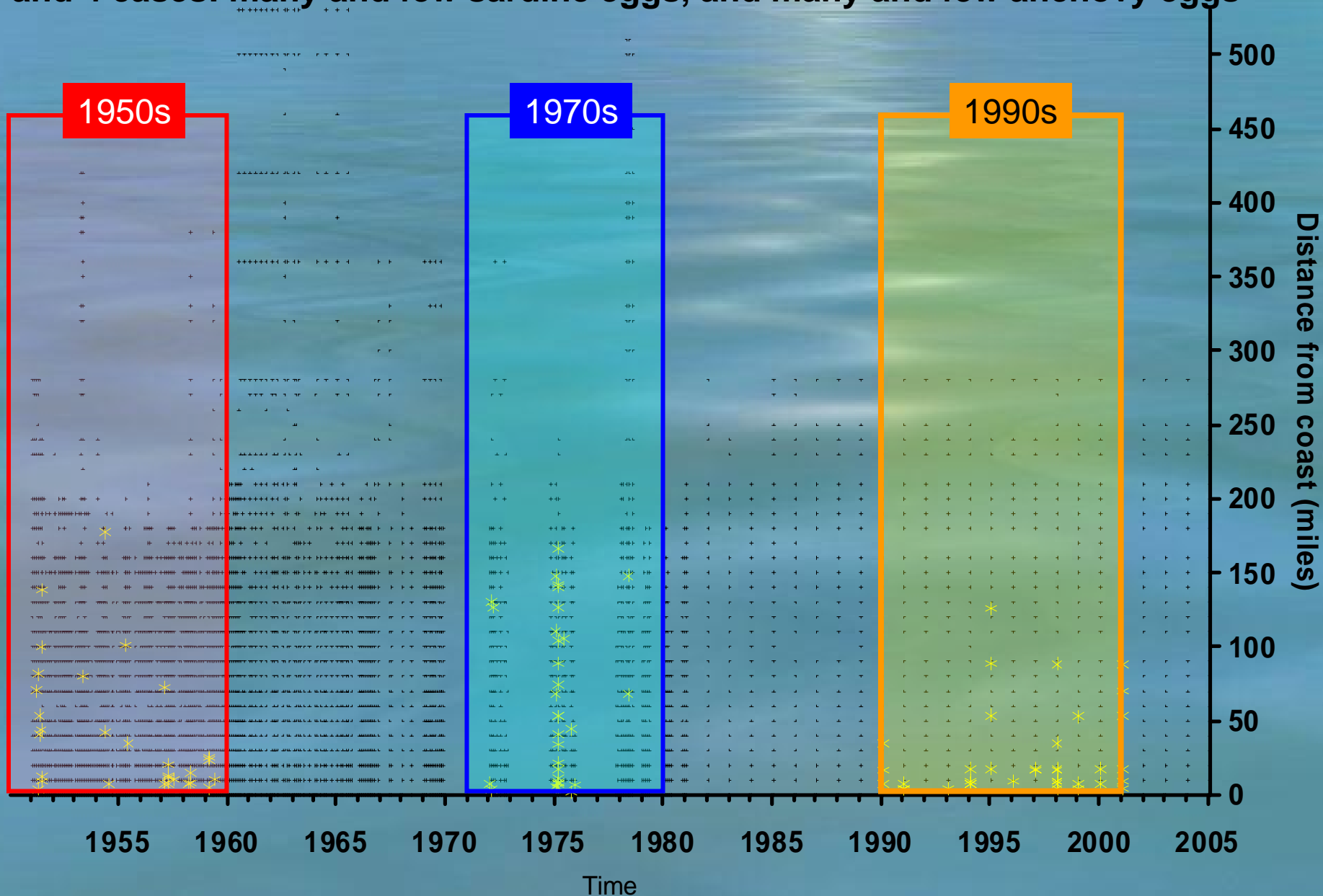
Instead, we see abundance is related to offshore expansion



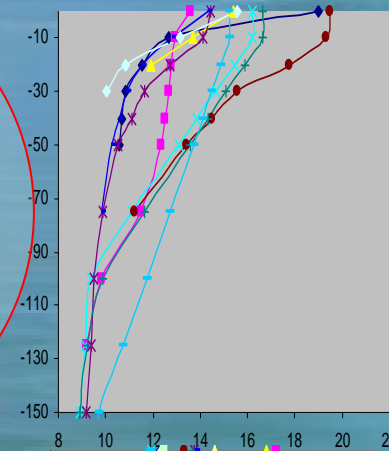
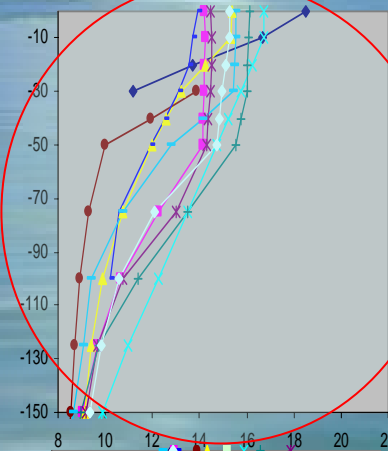
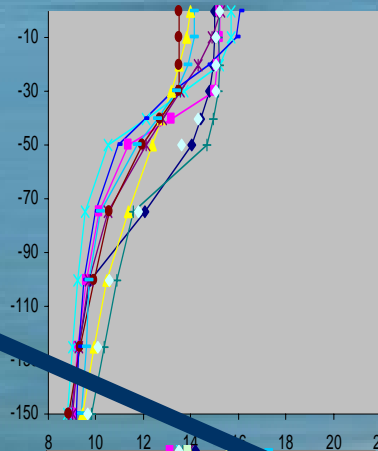
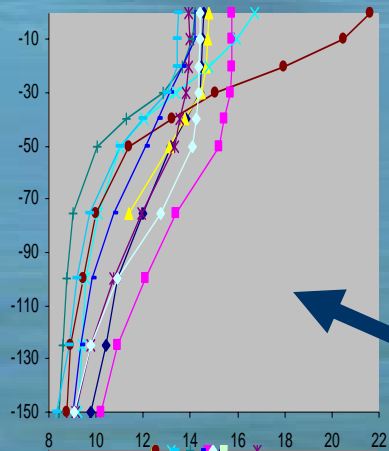




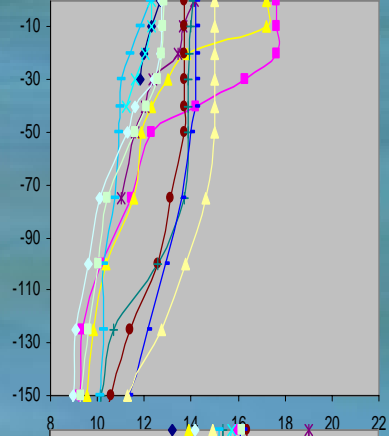
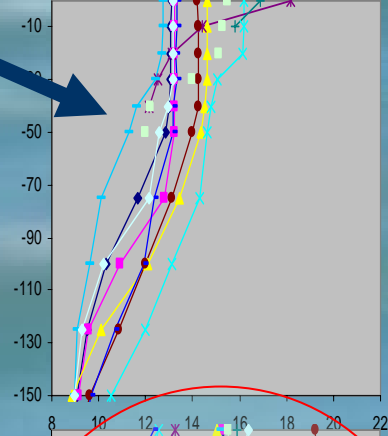
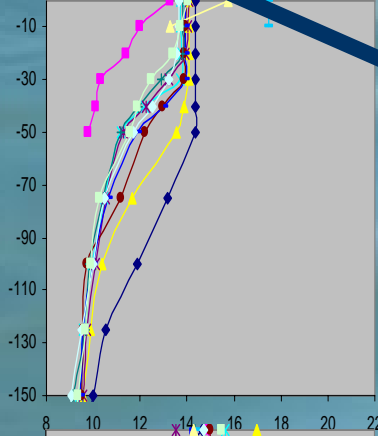
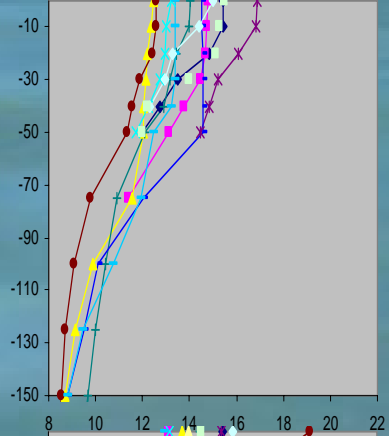
# Sampled temperature profiles (positive stations only) for the three periods, and 4 cases: many and few sardine eggs, and many and few anchovy eggs



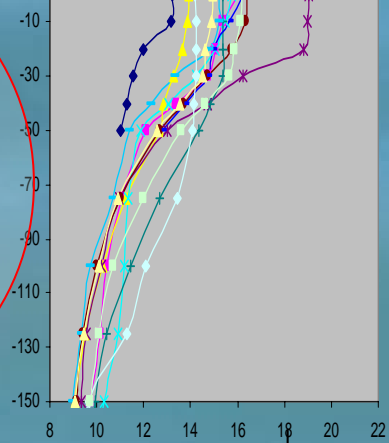
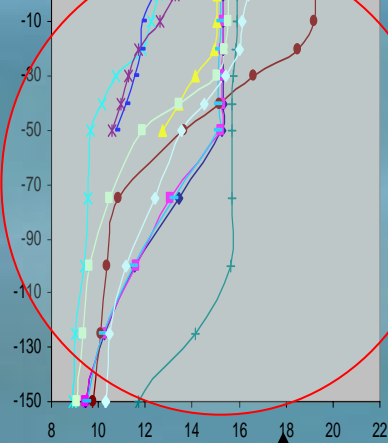
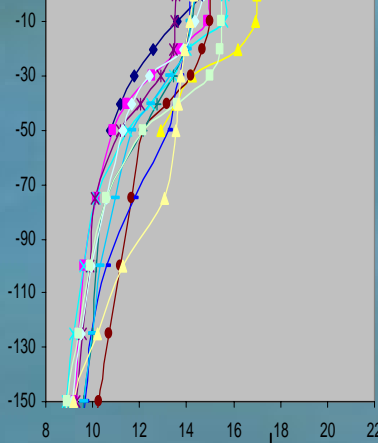
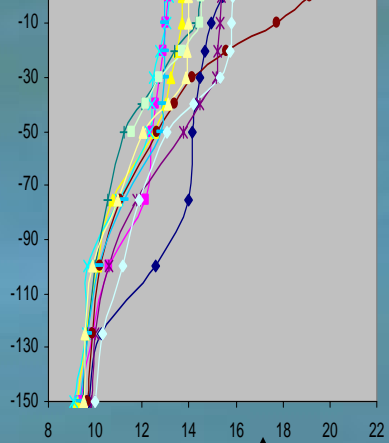
**1950s**



**1970s**



**1990s**



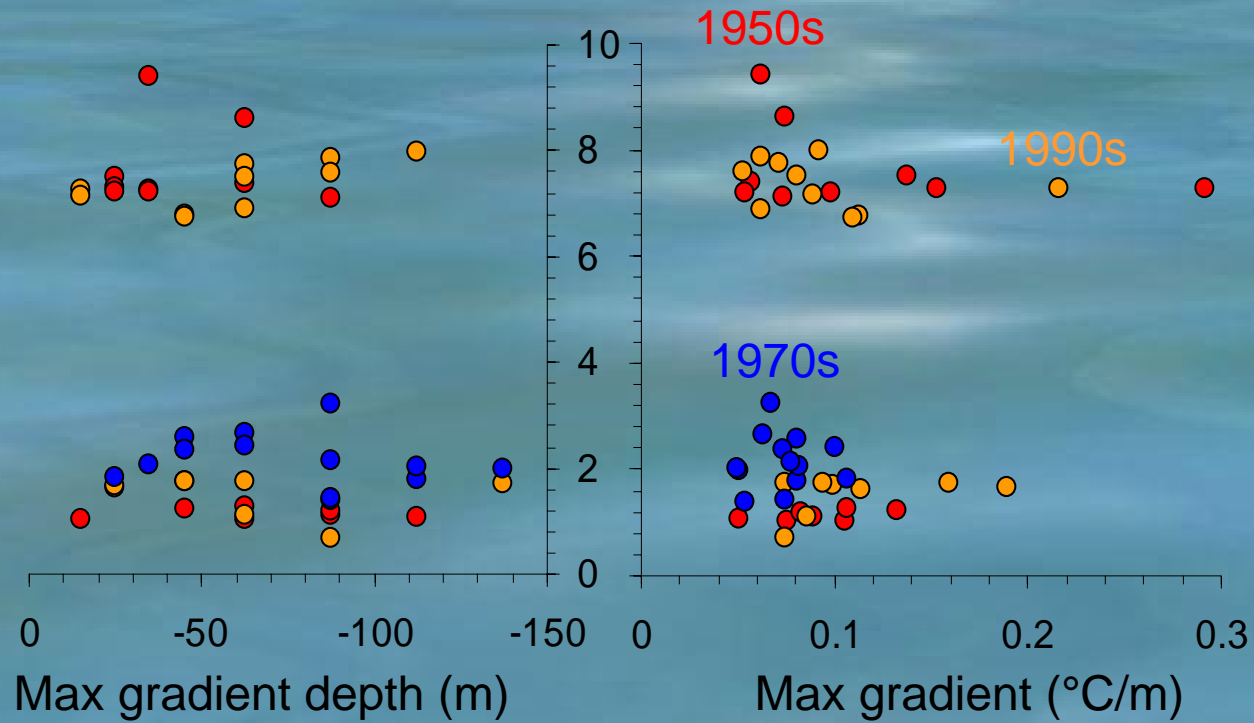
Sardine ↑

Sardine ↓

Anchovy ↑

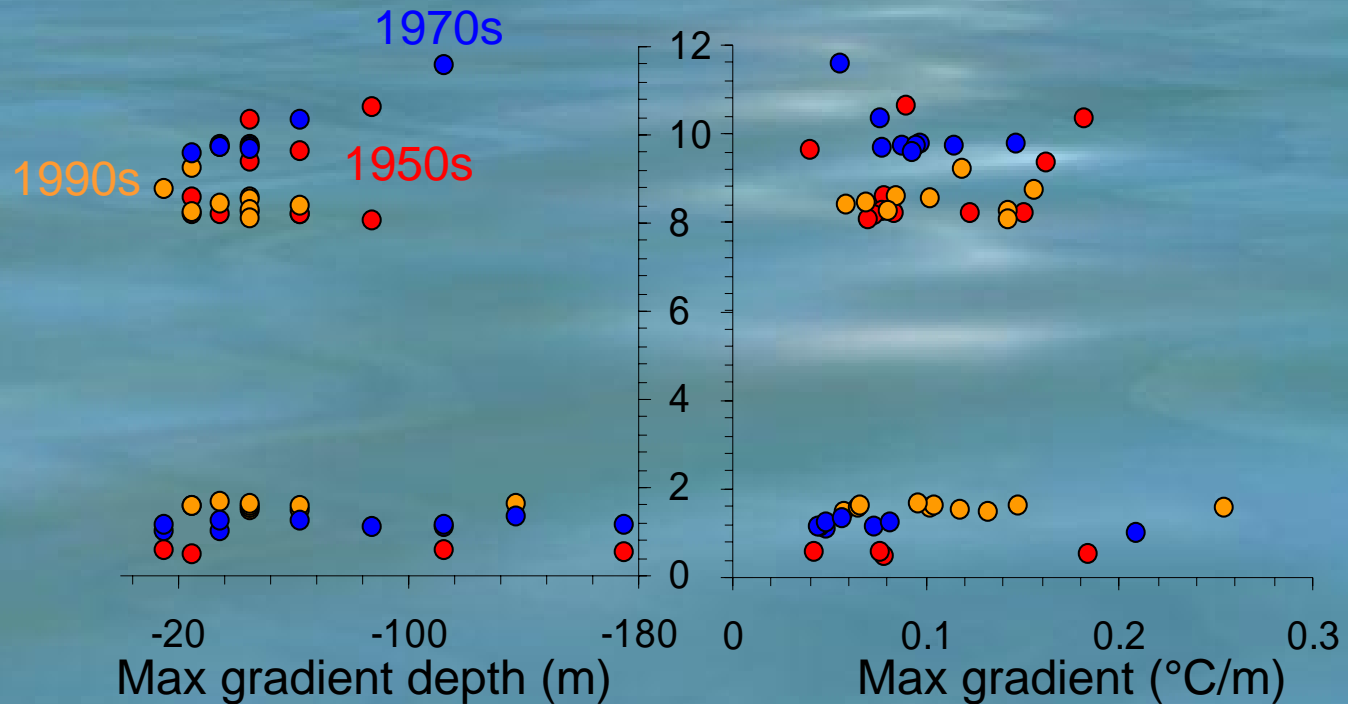
Anchovy ↓

## High and low sardine egg number ( $\ln x+1$ )





## High and low anchovy egg number (ln x+1)



At least for these two indicators, and considering few profiles, no signal is evident in vertical structure to explain alternancy

From references:

Sardine and anchovies show strong overlap in food habits (Blaxter and Hunter, 1982), but different ability to use energy (ecophysiology)

### **SOME IDEAS AND FRUSTRATIONS ABOUT FISHERY SCIENCE**

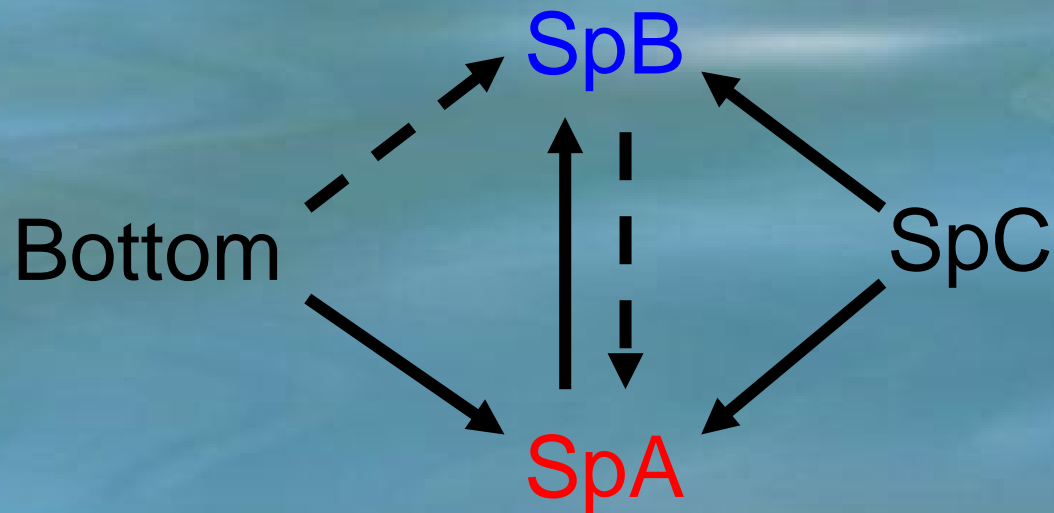
JOHN D. ISAACS  
Scripps Institution of Oceanography  
La Jolla, California 92093

#### *6. The only substantial aspect of gamete production is reproduction.*

There is undoubtedly a substantial or even dominate flow of material (and a larger flow of energy) downward in the food web through this mechanism, which must be a powerful part of the homogenizing process that I spoke of earlier. This mechanism is an aspect that we have the data to evaluate—Reuben Lasker's and other work—but we have not looked at it broadly in the ocean. Everything is sitting or swimming around throwing reproductive products freely into the ocean in such great quantities as to constitute a very powerful flux that is a predacious trophic step on the adult populations by primitive forms!

We might need to reconsider predation, and different ways of competition.

Reconsider ecophysiological, reproductive and behavior differences,  
and different (co-acting) was of control



<b>Small areas may not be in synchrony with other regions</b>
<b>For both populations, abundance is reflected in egg and larvae</b>
<b>Not big distribution differences between eggs and larvae</b>
<b>In terms of retention, exploration might not need to include ocean structures (eddies/eddies-only)</b>
<b>We do not see clear offshore sardine habitat and coastal anchovy</b>
<b>Offshore expansion proportional to abundance</b>
<b>At least for these two indicators, and considering few profiles,</b>
<b>no signal is evident in vertical structure to explain alternancy</b>
<b>Sardine and anchovies show strong overlap in food habits, but different ability to use energy (ecophysiology)</b>
<b>Predation and competition</b>
<b>Different interacting control ways</b>



# Final comments

1. Limited answers, especially for synchrony
2. We still need retrospective analysis (particularly renewed review)
3. Big potential to explore alternancy
4. Best strategy might be not linking physics to biology through lagrangian approaches (strong tendency)
5. Two dimensions might prove useful enough
6. We must design and include interactions between species and both bottom-up and top-down controls to really explore different hypotheses



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### CCCC Topic Session

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with special focus on sardine and anchovy**

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