

- IDEADOS project (CTM2008-04489-C03-01)

- BALEARES project (CTM2009-07944 MAR)

## NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

Climate, fishing and population-dependent drivers

Manuel Hidalgo, Lucia Rueda, Juan Carlos Molinero, Beatriz Guijarro and Enric Massutí



SPANISH INSTITUTE OF OCEANOGRAPHY



IDEADOS final workshop

16 November 2012, Palma

Outline

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&  
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### NON-STATIONARY **SYNCHRONY** AND ASYNCHRONY IN A DEEP-SEA POPULATION

**Mechanisms** leading to intra-specific synchrony:

- 1. Exogenous environmental conditions** (i.e. Moran effect).
- 2. Dispersal and connectivity** processes among populations or population subunits.
- 3. Trophic interactions** with populations of other species.

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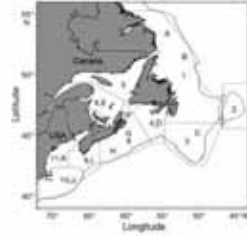
Synthesis




## NON-STATIONARY **SYNCHRONY** AND ASYNCHRONY IN A DEEP-SEA POPULATION

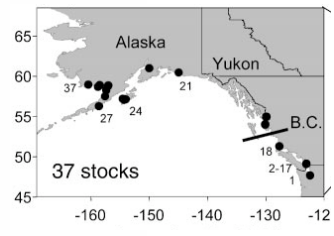


Kelly et al. 2009, MEPS





Mueter et al. 2002, Fish Ocenog.



37 stocks

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## NON-STATIONARY SYNCHRONY AND **ASYNCHRONY** IN A DEEP-SEA POPULATION





Asynchrony in population dynamics of sockeye salmon in southwest Alaska

Oikos 117: 1578–1586, 2008

Lauren A. Rogers and Daniel E. Schindler doi: 10.1111/i.2008.0030-1299.16758.x.

**“Response diversity** may reflect important variation among **local population dynamics** driven by population-specific responses to **regional environmental change**”

**Ore**


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**NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION**

## Non-stationarity

Temporal changes in the **strength of synchrony**

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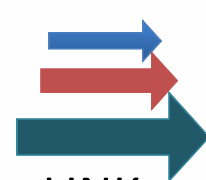
Synthesis




**NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION**

### 1. Environmental variability






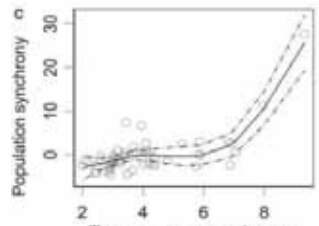
**LINK**



Climate

Regional / local







Post & Forchhammer 2004, PNAS

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## NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

### 2. Fishing


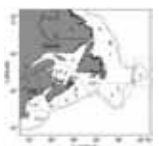



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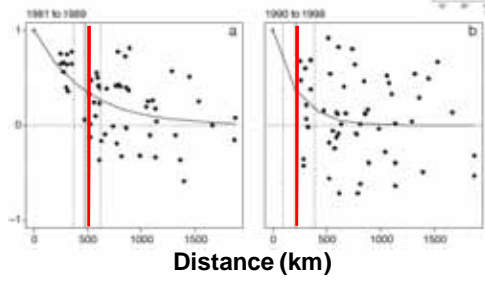
## NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

### 2. Fishing



Journal E. Kelly<sup>1</sup>\*, Kenneth T. Frank<sup>2</sup>, William C. Leggett<sup>3</sup>

Recruitment correlation



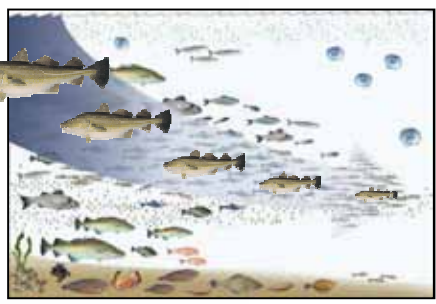
Distance (km)

**NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION**


**2. Fishing**

↓ Strength of synchrony → ↓ Connectivity

↑ Strength of synchrony



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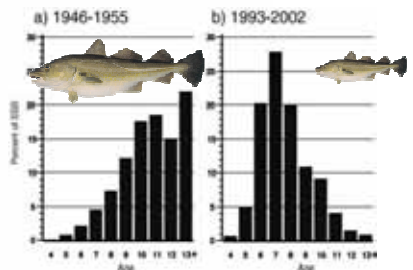


**NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION**

**2. Fishing**

↓ Strength of synchrony → ↓ Connectivity

↑ Strength of synchrony



a) 1946-1955      b) 1993-2002


Percent of 1000

Age

Age

Ottersen et 2006, Fish. Oceanog.

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## NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

### 2. Fishing =>F (Spatial structure)

↓ Strength of synchrony

→

↓ Connectivity

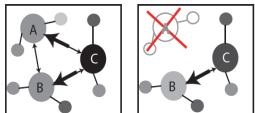
↑ Strength of synchrony

→

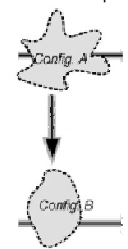
↑ Recruitment-dependence

↓

Climate



Ciannelli et al. In press, MEPS



Perry et 2010, J. Mar. Syst

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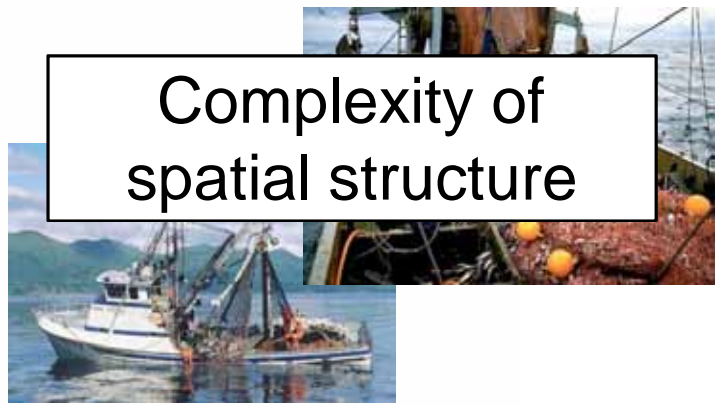
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## NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

### 2. Fishing



# Complexity of spatial structure

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## NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

Deep-sea species:

- Lack of knowledge on **spatiotemporal dynamics**.
- Lack of knowledge on **recruitment dynamics**.
- Increasing **impact of fishing**.

Mediterranean Sea:

**Red shrimp**  
*Aristeus antennatus*



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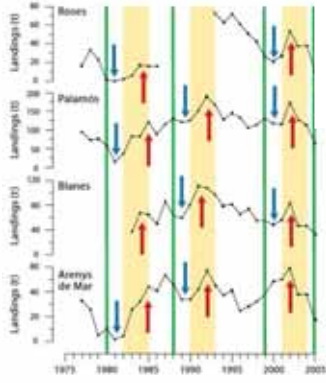


## NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

Evidences of synchrony:


1. Cascading events





Company et 2008, PLoS ONE; Canals et al. 2009 Oceanography


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## NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

Evidences of synchrony:


1. Cascading events
2. Climate:



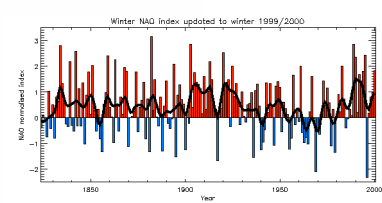
CLIMATE RESEARCH  
Climate Res

### Influence of the North Atlantic Oscillation on Mediterranean deep-sea shrimp landings

Francisc Maynou\*



North Atlantic Oscillation




Winter NAO index updated to winter 1999/2000

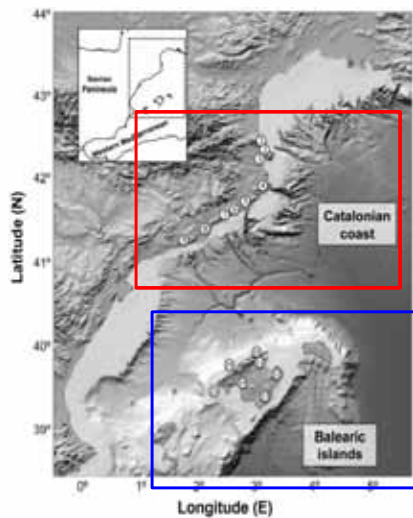
NAO normalized index

Year

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Latitude (N)

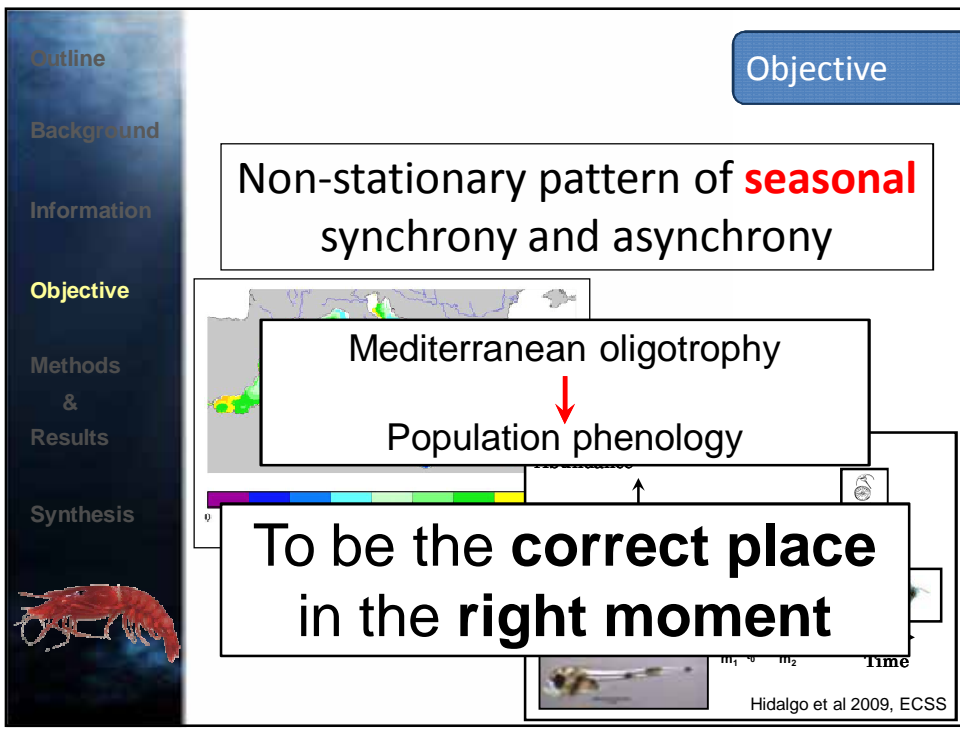
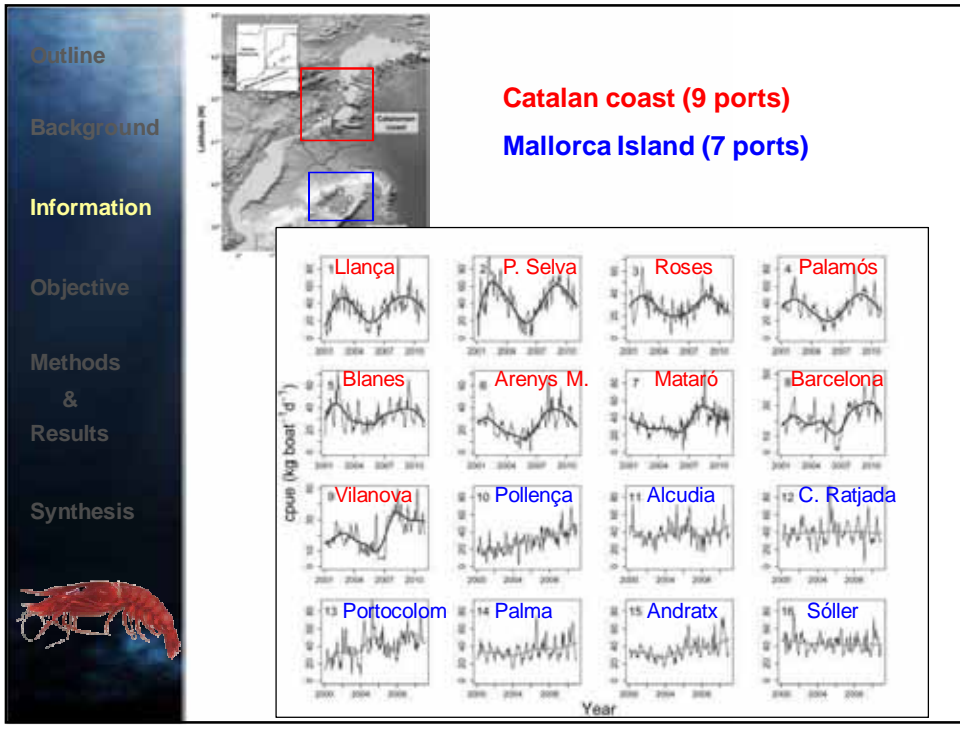
Longitude (E)

**Catalan coast**

**Mallorca Island**

## Monthly Catches per Unit of Effort (CPUE)





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Objective

Non-stationary pattern of **seasonal**  
synchrony and asynchrony

**SPATIOTEMPORAL DYNAMICS**

**1.** Geographical grouping of CPUE attending to changes in the seasonal cyclicality.

**Method:** Clustering analyses of wavelet spectra

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Non-stationary pattern of **seasonal**  
synchrony and asynchrony

**SPATIOTEMPORAL DYNAMICS**

**1.** Geographical grouping of CPUE attending to changes in the seasonal cyclicality.

**Method:** Clustering analyses of wavelet spectra

**2.** Non-stationary synchrony within each population.

**Method:** Time-varying spatial correlograms.

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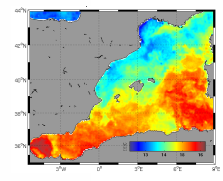
**2. Non-stationary synchrony within each populations.**

**MECHANISMS:**

a) Climate Vs regional hydroclimatology



→



**North Atlantic Oscillation**

**Mediterranean index**

(PCA of surface variables)

Molinero et al 2006, GCB  
Hidalgo et al 2011, MEPS

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Objective


**2. Non-stationary synchrony within each populations.**

**MECHANISMS:**

a) Climate Vs regional hydroclimatology

b) Variation in demography.

FISHING



Two commercial categories:

- Large
- Small

Small category contribution =  $\frac{\text{CPUE (Small)}}{\text{CPUE (Total)}}$

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Methods and results

# 1. Clustering analyses of wavelet spectra

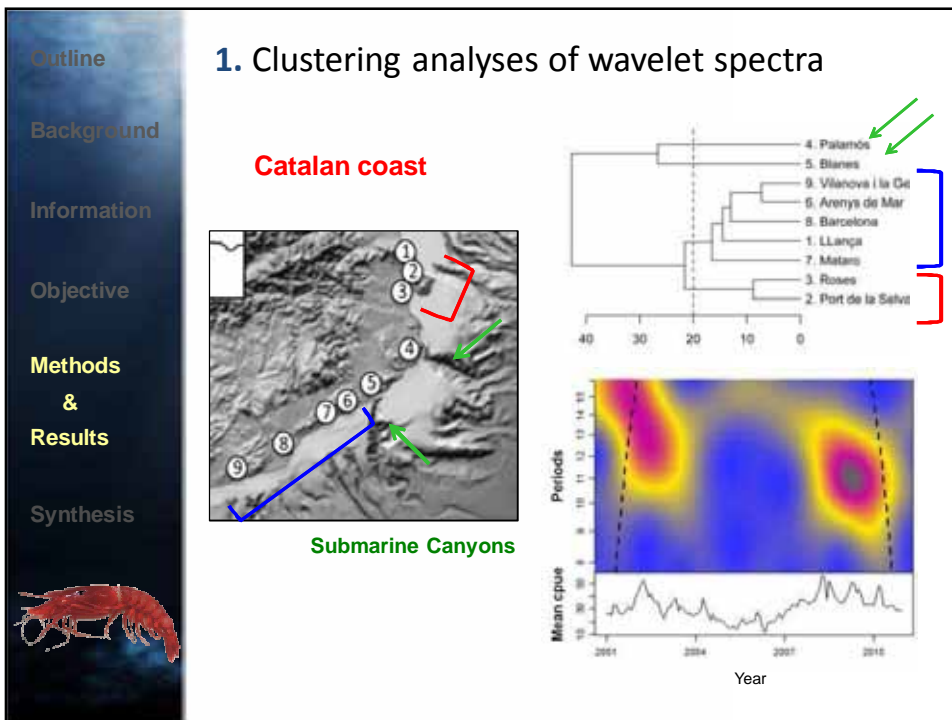
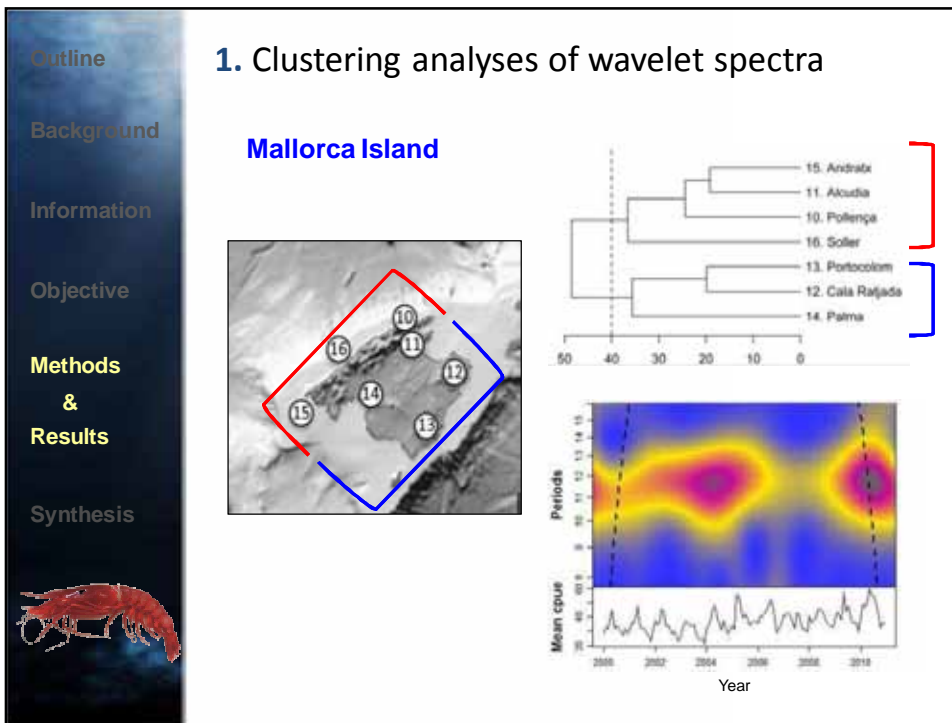
## Wavelet analyses

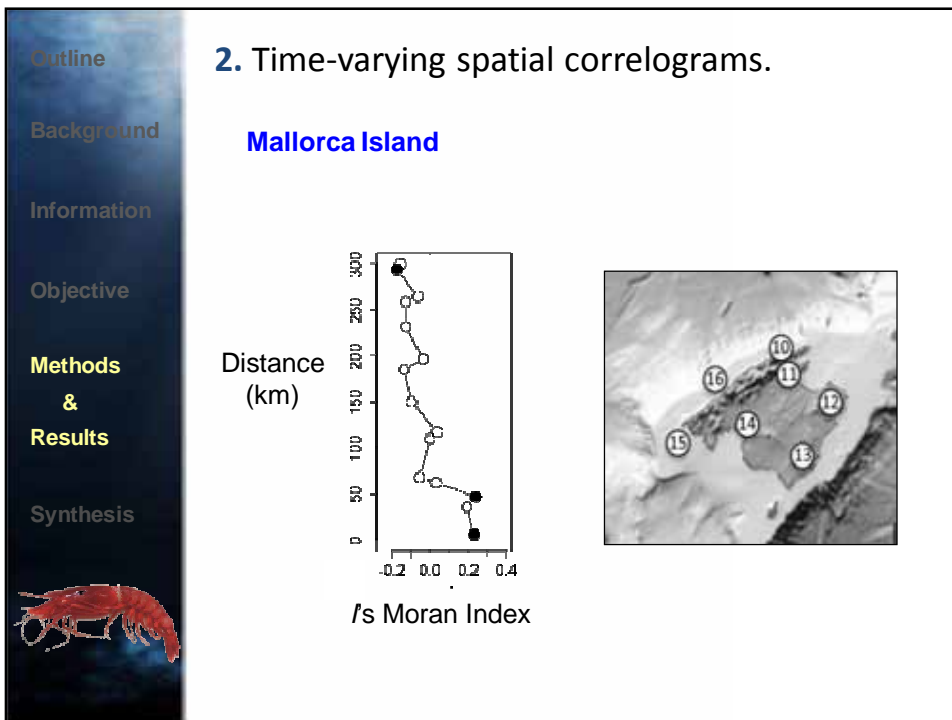
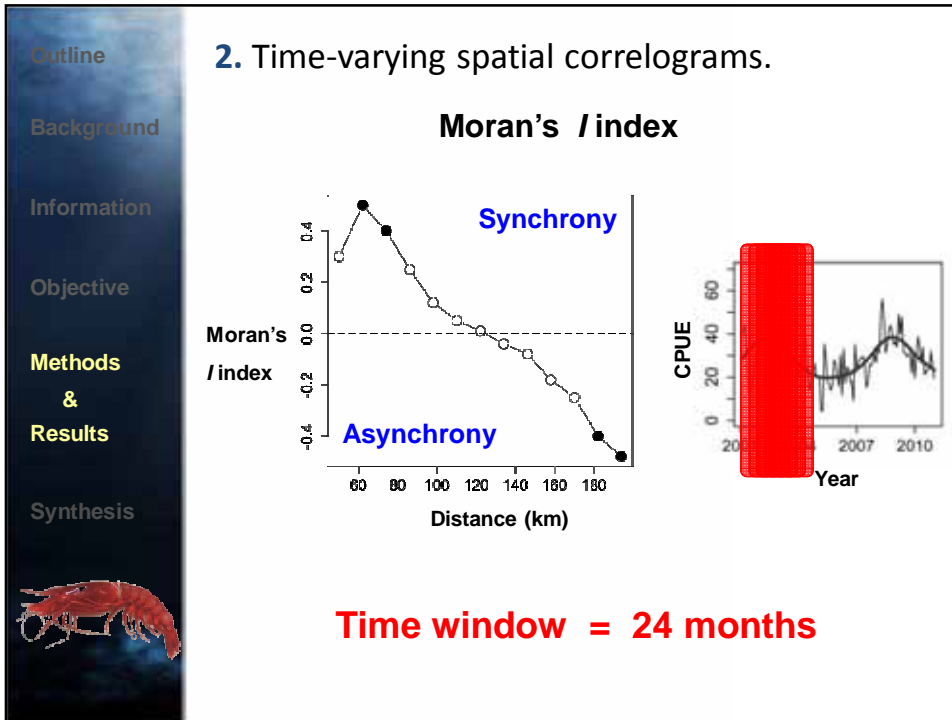
Rouyer et al. 2008 MEPS

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# 1. Clustering analyses of wavelet spectra

Rouyer et al 2008, MEPS





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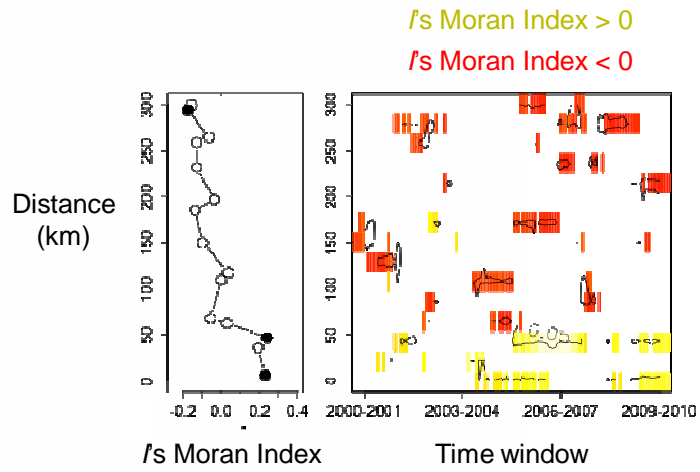
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## 2. Time-varying spatial correlograms.

### Mallorca Island



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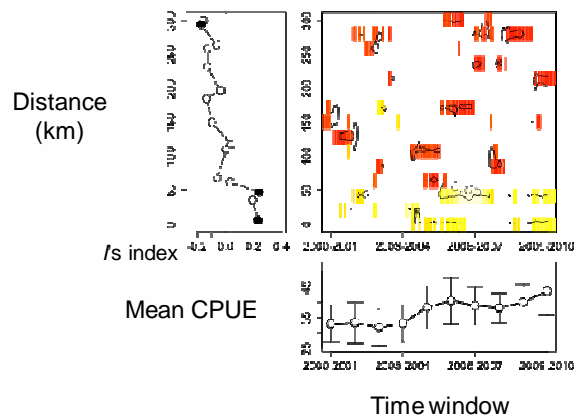
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## 2. Time-varying spatial correlograms.

### Mallorca Island

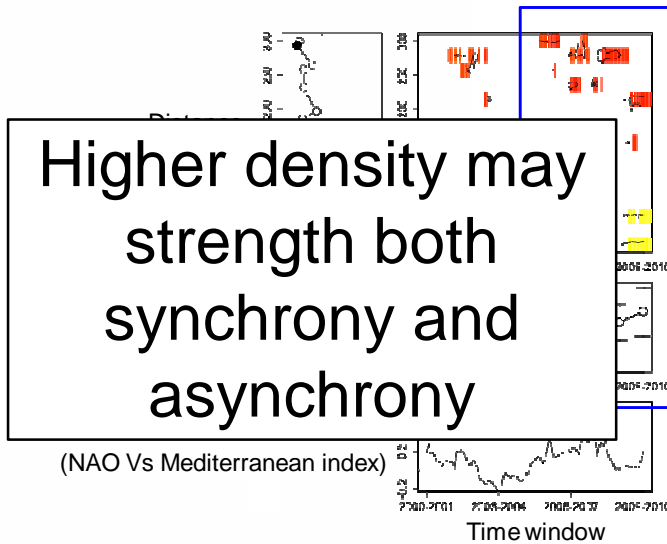


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2. Time-varying spatial correlograms.

Mallorca Island

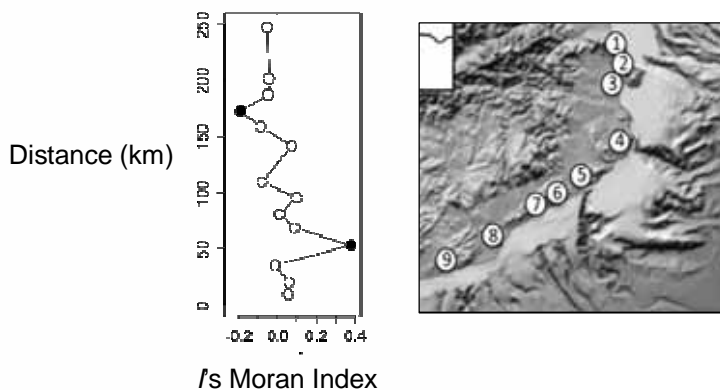


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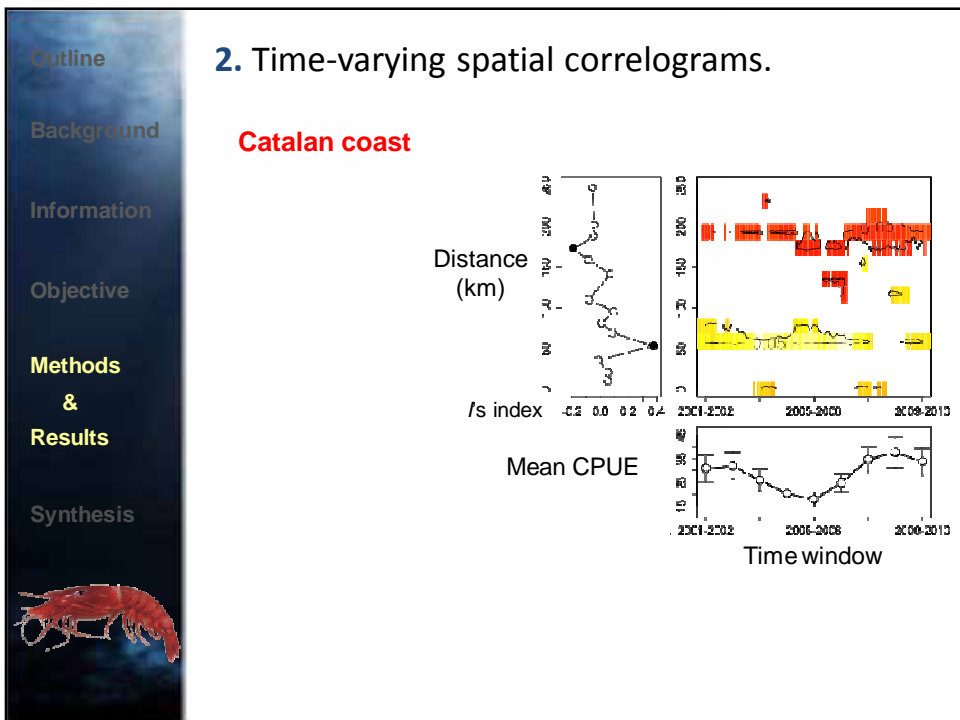
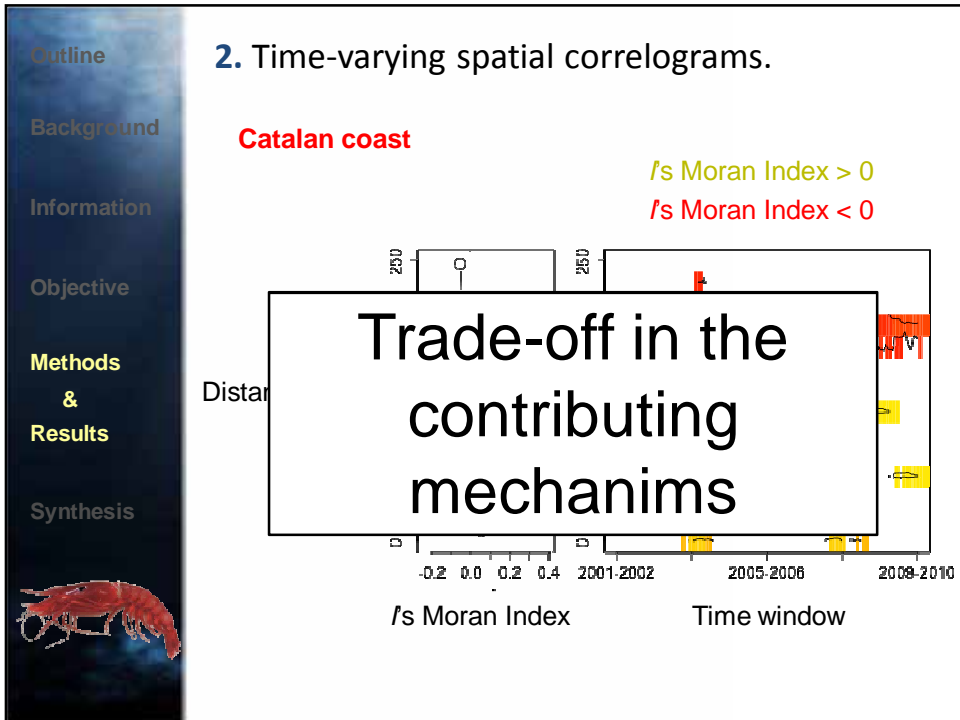


2. Time-varying spatial correlograms.

Catalan coast







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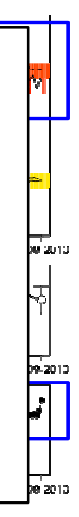
Synthesis



## 2. Time-varying spatial correlograms.

**Catalan coast**

# Climate influence on regional hydroclimatology shapes seasonal synchrony and asynchrony



Time window

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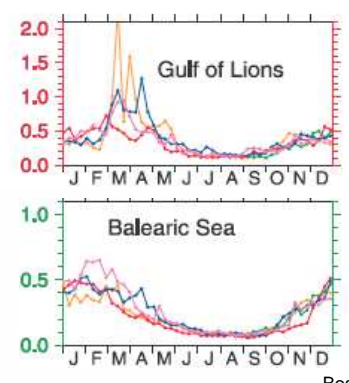
## 2. Time-varying spatial correlograms.

**Catalan coast**

### WHY?

#### Phenology of primary production

Chlorophyll concentration



Bosc et al 2004, GBC

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## 2. Time-varying spatial correlograms.

**Catalan coast** **WHY?**

### Phenology of primary production




→

**Temporal dispersion of primary production phenology**

→

**Asynchrony at large scale**



→

**Strengthening of local dynamics**

→

**Synchrony at short scale**

Outline

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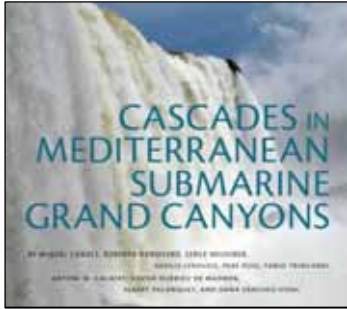
Synthesis

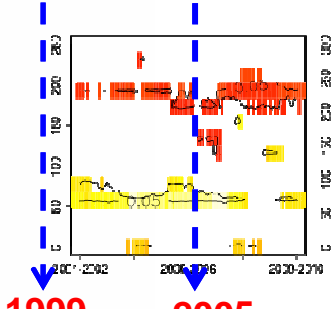
## 2. Time-varying spatial correlograms.

**Catalan coast** **WHY?**

### Phenology of primary production

### Cascading events?





1999
2005

