- 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, BeatrizGuijarro and EnricMassutí

SPANISH INSTITUTE OF OCENOGRAPHY

IDEADOS final workshop
16 November 2012, Palma

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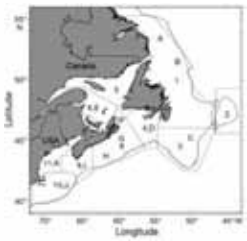
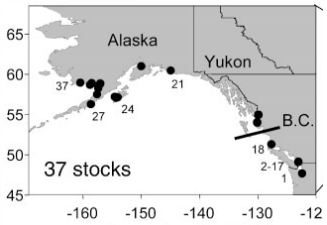
NON-STATIONARY **SYNCHRONY** AND ASYNCHRONY IN A DEEP-SEA POPULATION

Kelly et al. 2009, MEPS



Mueter et al. 2002, Fish Ocenog.



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

Asynchrony in population dynamics of sockeye salmon in southwest Alaska

Lauren A. Rogers and Daniel E. Schindler

Oikos 117: 1578–1586, 2008
doi: 10.1111/j.2008.0030-1299.16758.x.

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

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

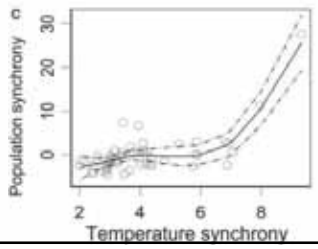
1. Environmental variability

Climate

LINK

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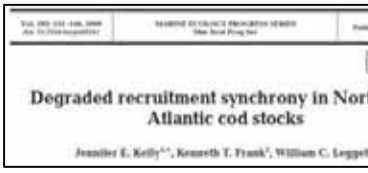
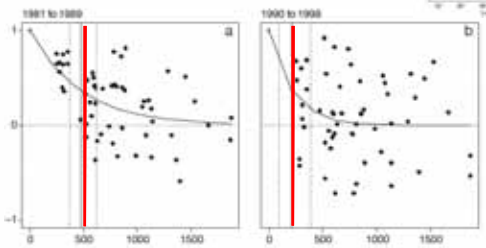
NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

2. Fishing



Degraded recruitment synchrony in Northwest Atlantic cod stocks

Recruitment correlation



Distance (km)

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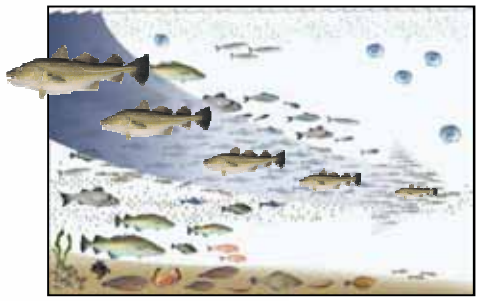
NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

2. Fishing

↓ Strength of synchrony → ↓ Connectivity



↑ Strength of synchrony

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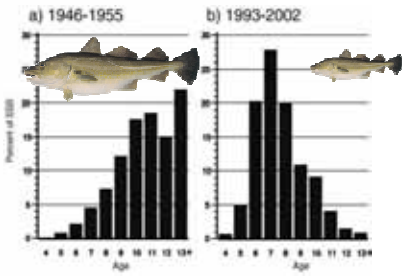
NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

2. Fishing

↓ Strength of synchrony → ↓ Connectivity



Ottersen et 2006, Fish. Oceanog.

↑ Strength of synchrony

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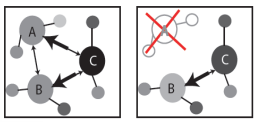
NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

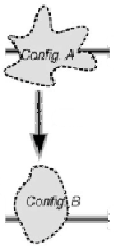
2. Fishing =>F (Spatial structure)

↓ Strength of synchrony → ↓ Connectivity



Ciannelli et al. In press, MEPS

↑ Strength of synchrony → ↑ Recruitment-dependence → Climate



Perry et 2010, J. Mar. Syst

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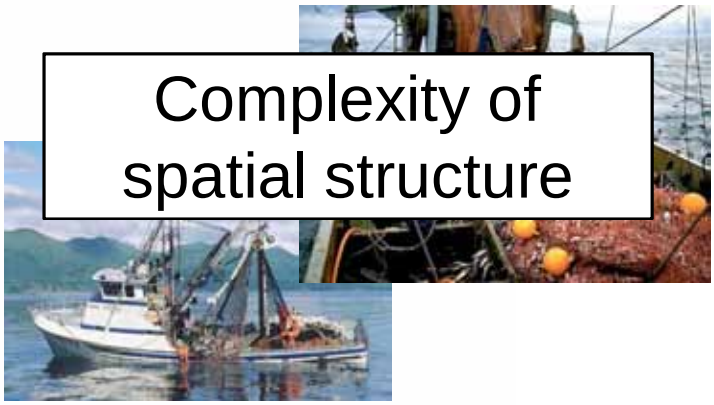
NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

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
Aristeusantennatus

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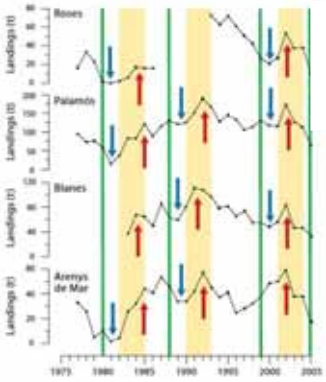
NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN **A DEEP-SEA POPULATION**

Evidences of synchrony:

1. Cascading events



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

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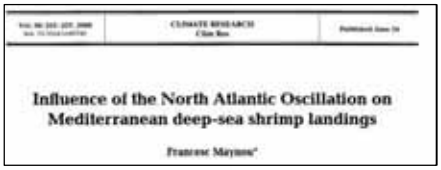
NON-STATIONARY SYNCHRONY AND ASYNCHRONY IN A DEEP-SEA POPULATION

Evidences of synchrony:

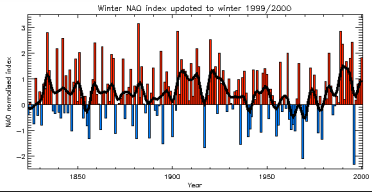
1. Cascading events
2. Climate:

North Atlantic Oscillation



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

Francesc Maynou*



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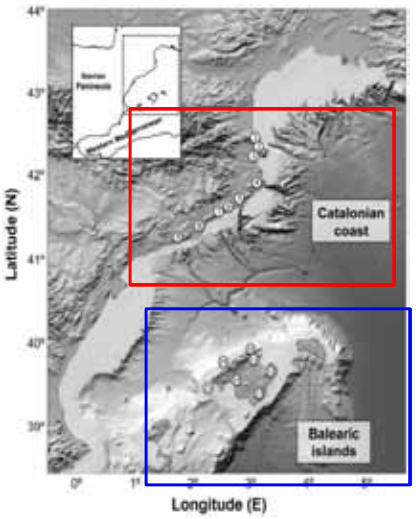

Catalan coast

Mallorca Island

Monthly Catches per Unit of Effort (CPUE)

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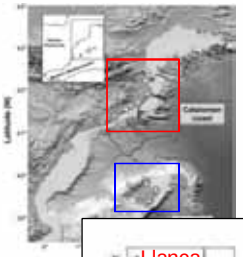
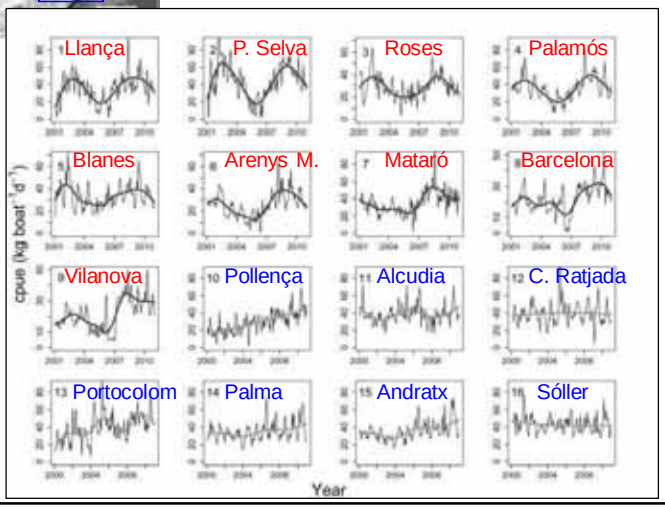


Catalan coast (9 ports)

Mallorca Island (7 ports)



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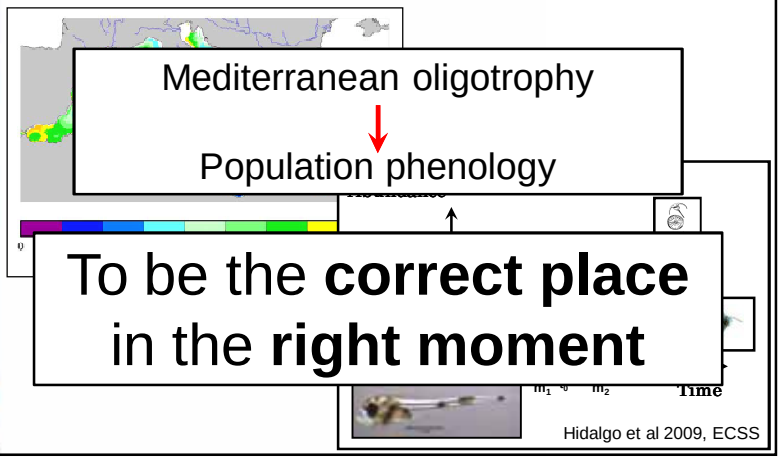
Non-stationary pattern of **seasonal** synchrony and asynchrony



Mediterranean oligotrophy

↓

Population phenology

To be the **correct place** in the **right moment**

Hidalgo et al 2009, ECSS

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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 cyclicity.

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 cyclicity.

Method: Clustering analyses of wavelet spectra

2. Non-stationary synchrony within each population.

Method: Time-varying spatial correlograms.

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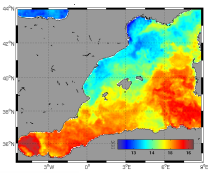
2. Non-stationary synchrony within each populations.

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

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

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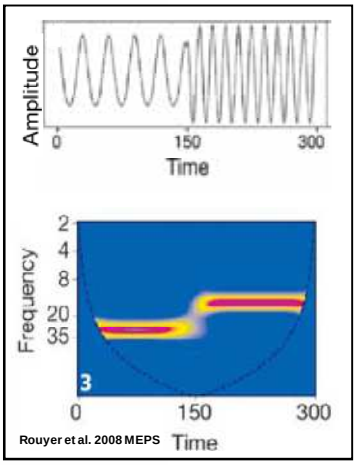
Methods and results

1. Clustering analyses of wavelet spectra

Wavelet analyses



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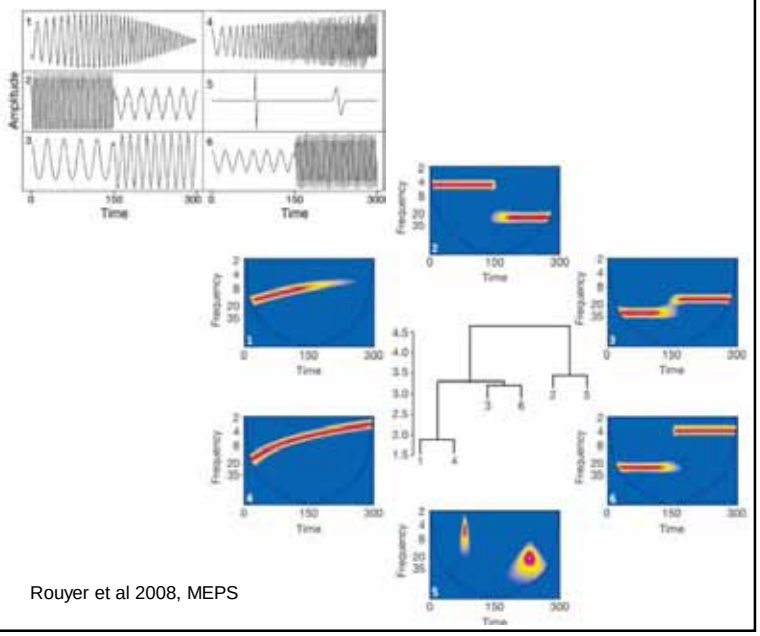
1. Clustering analyses of wavelet spectra



Rouyer et al 2008, MEPS

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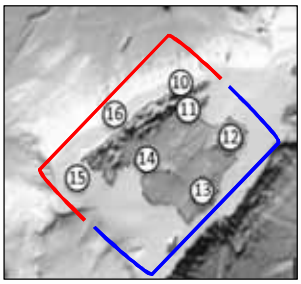
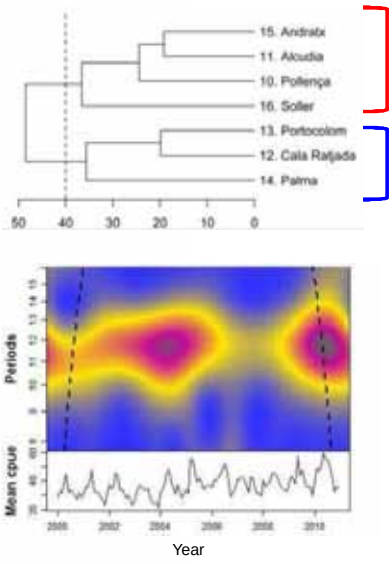
1. Clustering analyses of wavelet spectra

Mallorca Island





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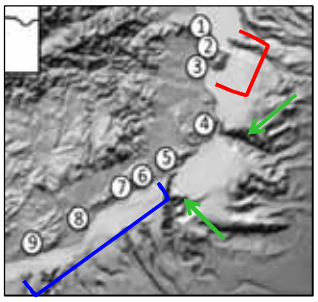
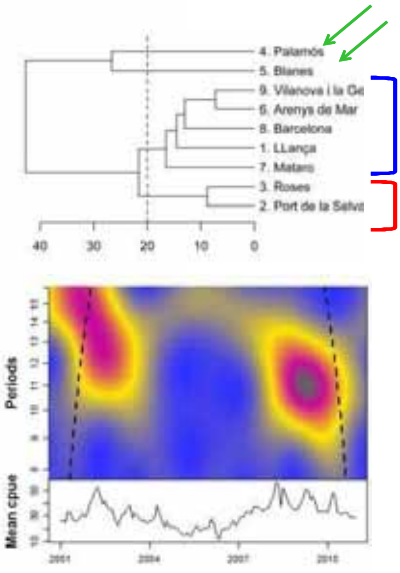
1. Clustering analyses of wavelet spectra

Catalan coast



Submarine Canyons



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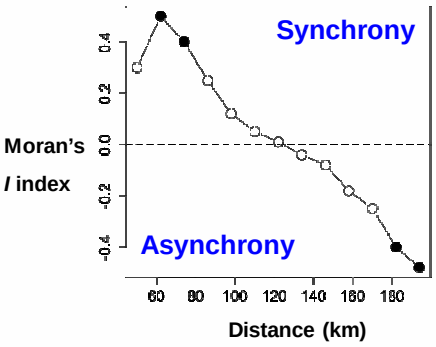
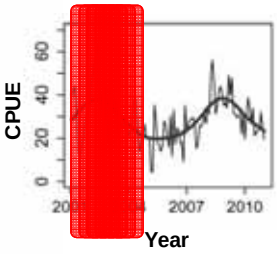
2. Time-varying spatial correlograms.

Moran's *I* index





Time window = 24 months

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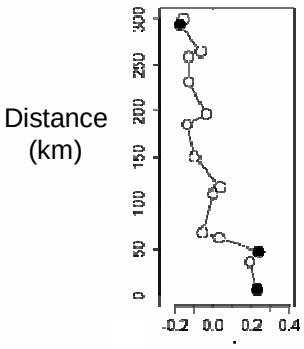
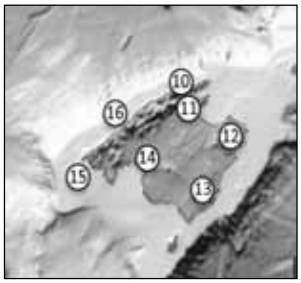
2. Time-varying spatial correlograms.

Mallorca Island





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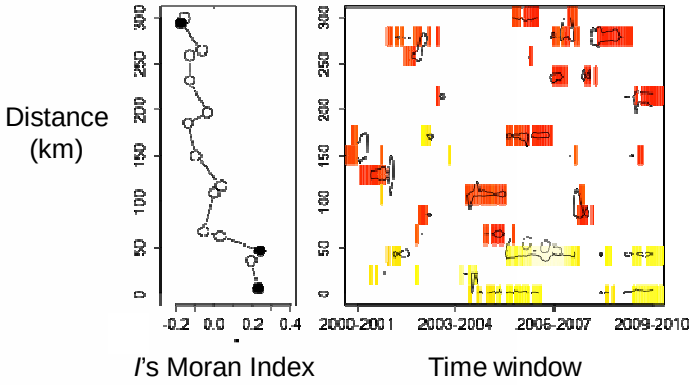
2. Time-varying spatial correlograms.

Mallorca Island

I's Moran Index > 0
I's Moran Index < 0



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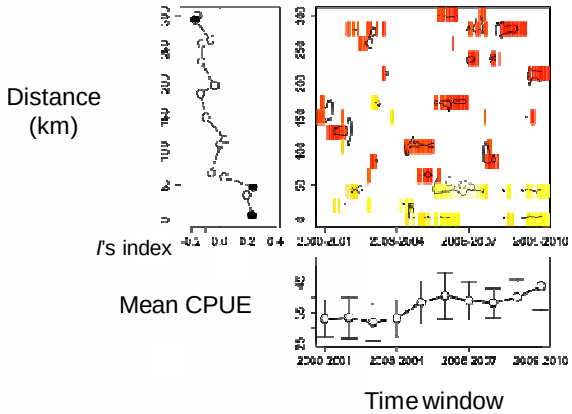
2. Time-varying spatial correlograms.

Mallorca Island



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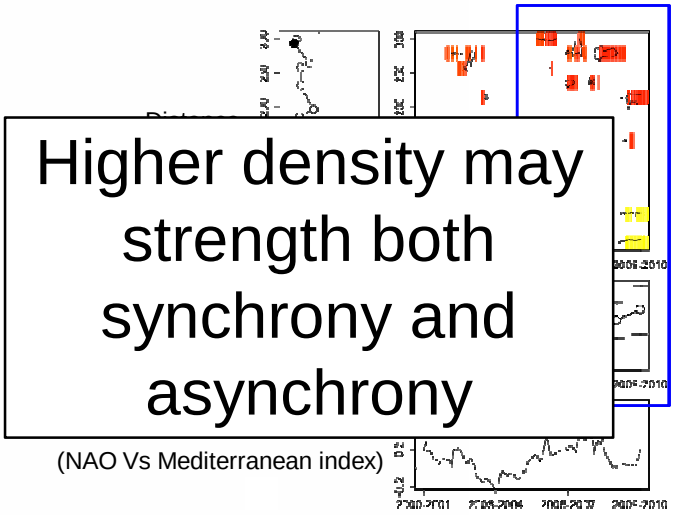
2. Time-varying spatial correlograms.

Mallorca Island



Higher density may strength both synchrony and asynchrony

(NAO Vs Mediterranean index)

Time window

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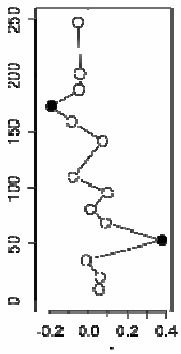
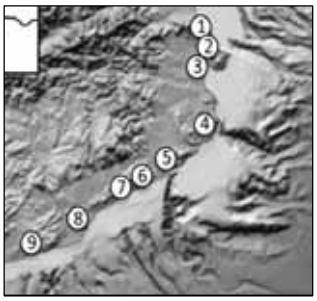
2. Time-varying spatial correlograms.

Catalan coast

Distance (km)



I's Moran Index



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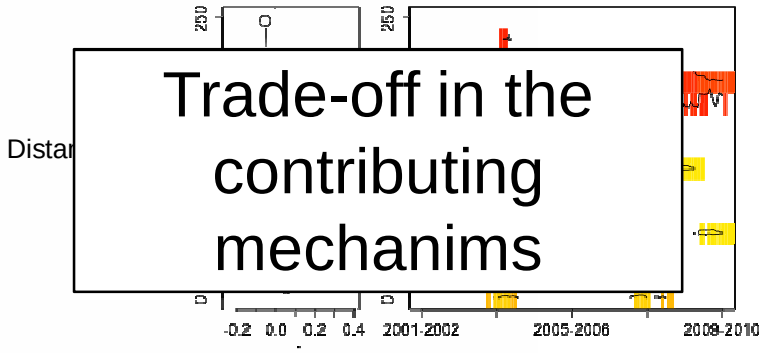
2. Time-varying spatial correlograms.

Catalan coast

I's Moran Index > 0
I's Moran Index < 0



Trade-off in the contributing mechanims

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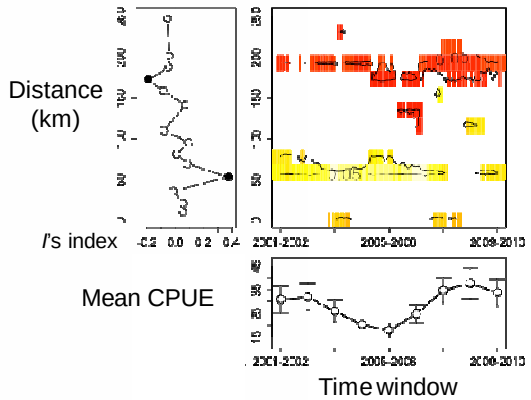
2. Time-varying spatial correlograms.

Catalan coast



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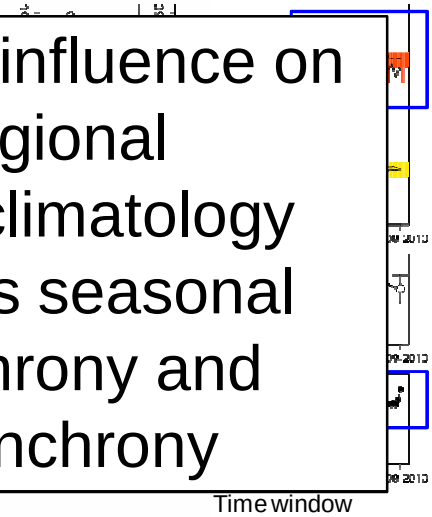
2. Time-varying spatial correlograms.

Catalan coast

Climate influence on regional hydroclimatology shapes seasonal synchrony and asynchrony



Time window

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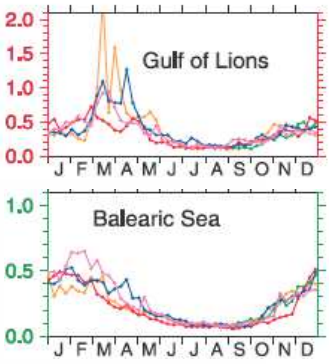
2. Time-varying spatial correlograms.

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

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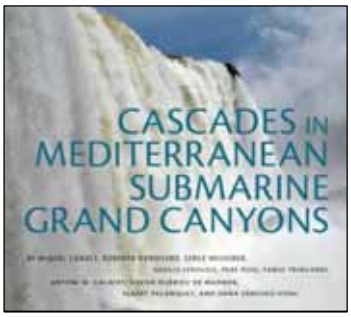
2. Time-varying spatial correlograms.

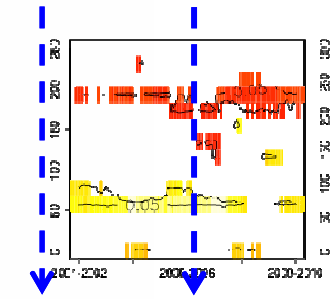
Catalan coast

WHY?

Phenology of primary production

Cascading events?





1999 **2005**

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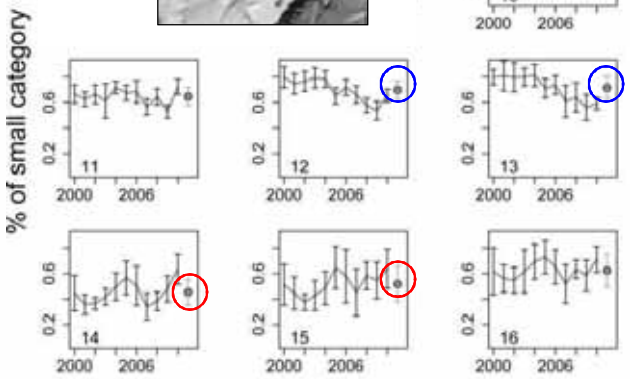
Variation in demography

Mallorca Island



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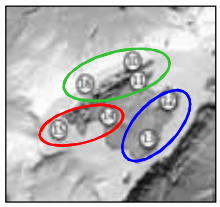

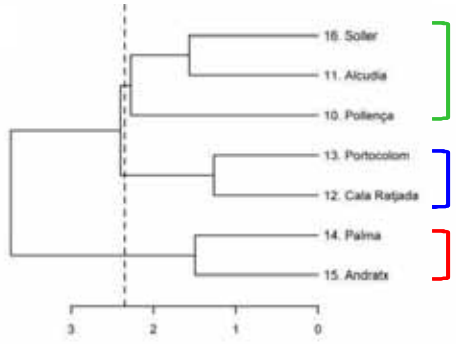

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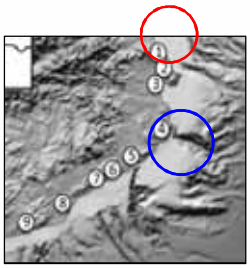
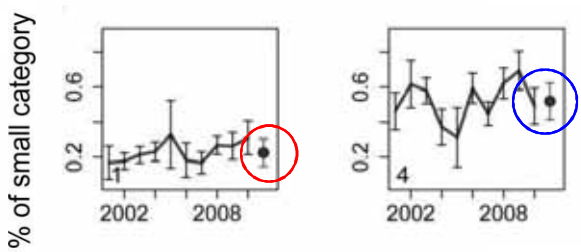
Catalan coast





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Take-home messages

1. Seasonal **synchrony at short** spatial scale while seasonal **asynchrony** was observed **at broad** spatial scale.

2. The spatial pattern of seasonal (a)synchrony was not static, **changing with time** according to the variable contribution of **externa**l (climate) and **internal drivers** (demography and life history).

3. Relative **contribution of different drivers** depends on the **complexity of the spatial structure** of the population.

- **a.** Mallorca: **Local dynamics**.
- **b.** Catalan coast: **Climate influence** on the regional hydroclimatology.

4. No evidence of **fishing influence.**

5. Management implications.

The broad range of population responses of deep-sea populations to climatic variability **encompasses both local and regional scales**, and the maintenance of such **diversity** is a **conservation** added **value.**