# *Sandy beach ecosystems and climate variability*

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PEW FELLOWS PROGRAM IN MARINE CONSERVATION

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# Sandy beaches

- World's coastlines total almost $10^6$ km

- Sandy beaches dominate open coastlines

- Accreting beaches are the exception (<10%)

- > 80 % are experiencing some erosion

# Sandy beaches: main physical factors

tides

waves

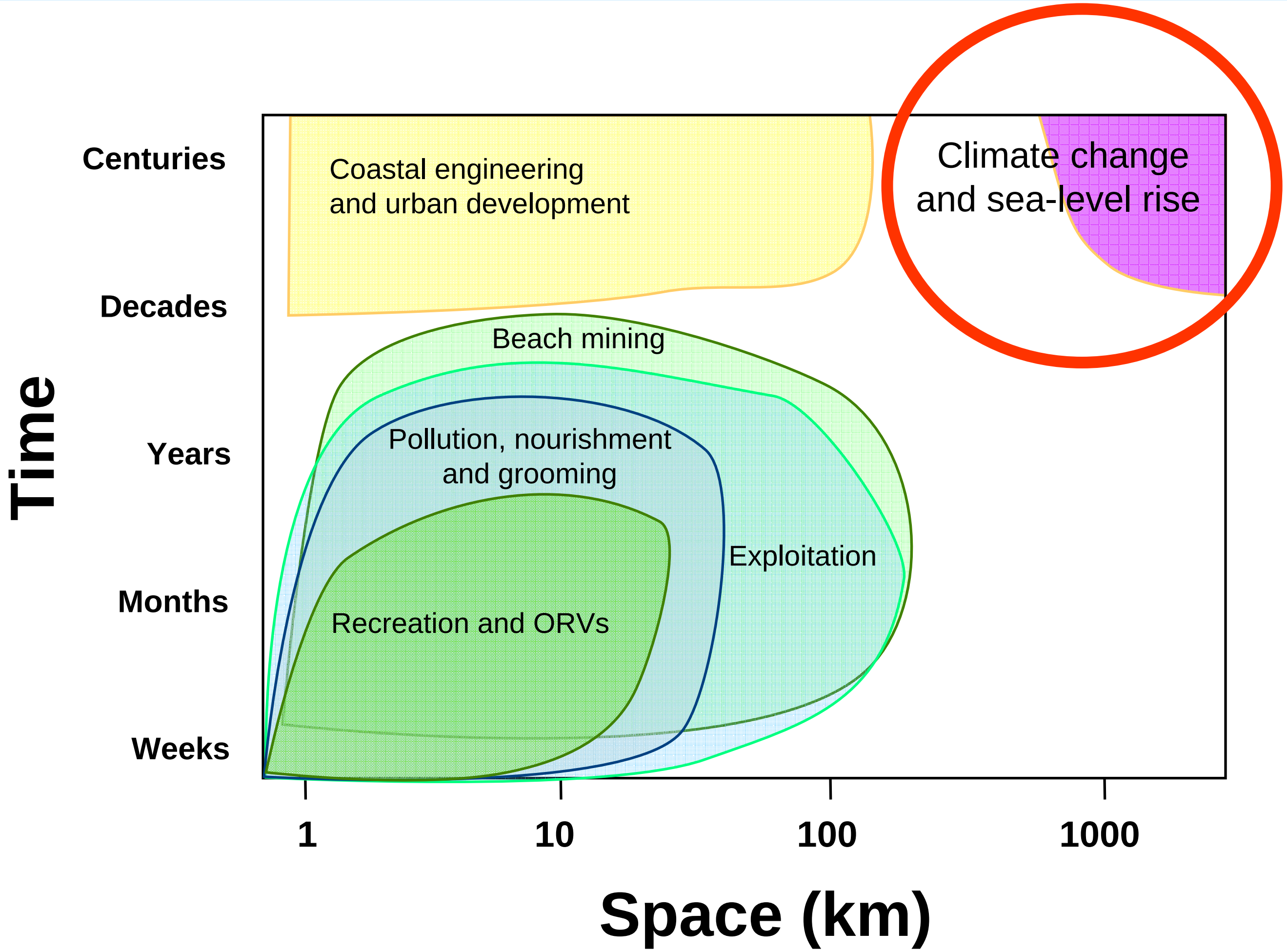
sand

# Sandy beach threats

Sandy beaches provide irreplaceable ecosystem services to society

Environment and biota are being threatened by several drivers acting at multiple temporal and spatial scales

Severely under-represented in climate change ecology

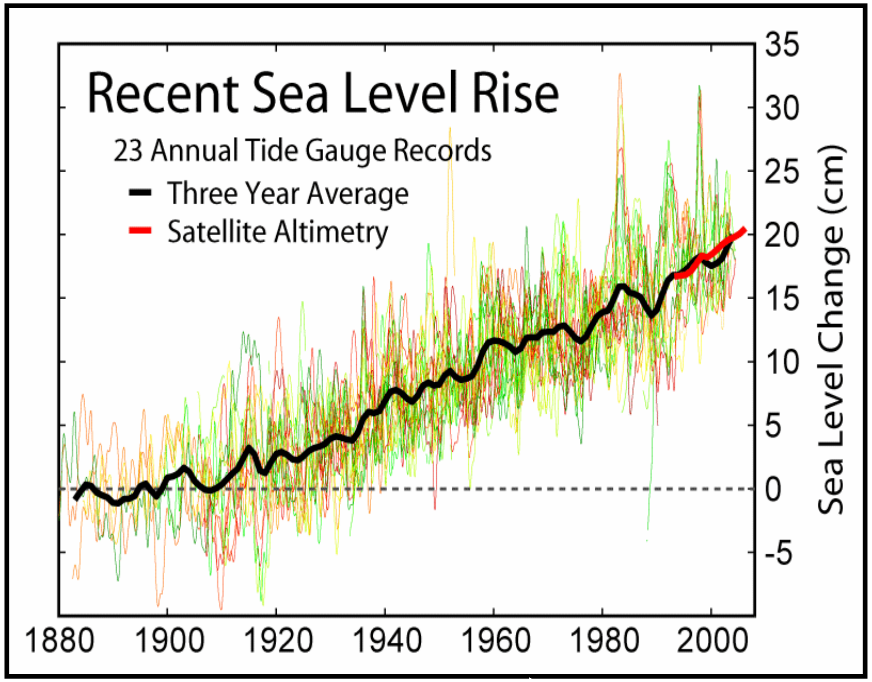



Do sandy beaches respond to climate change in ways that are consistent with expectations of hypotheses from general climate-change ecology?

Defeo et al 2009, 2013, Schoeman et al 2014

# The physical environment: coastal squeeze

- Beaches are caught between rising sea and expanding human activity
- Retreat is not possible in most cases because of urban development
- Beach and dunes reduced/lost




**COAST**

**Expanding population**

Coastal squeeze

**Sea level rise**

# Coastal squeeze + erosion: negative socio-economic effects

# Coastal squeeze: negative socio-economic effects

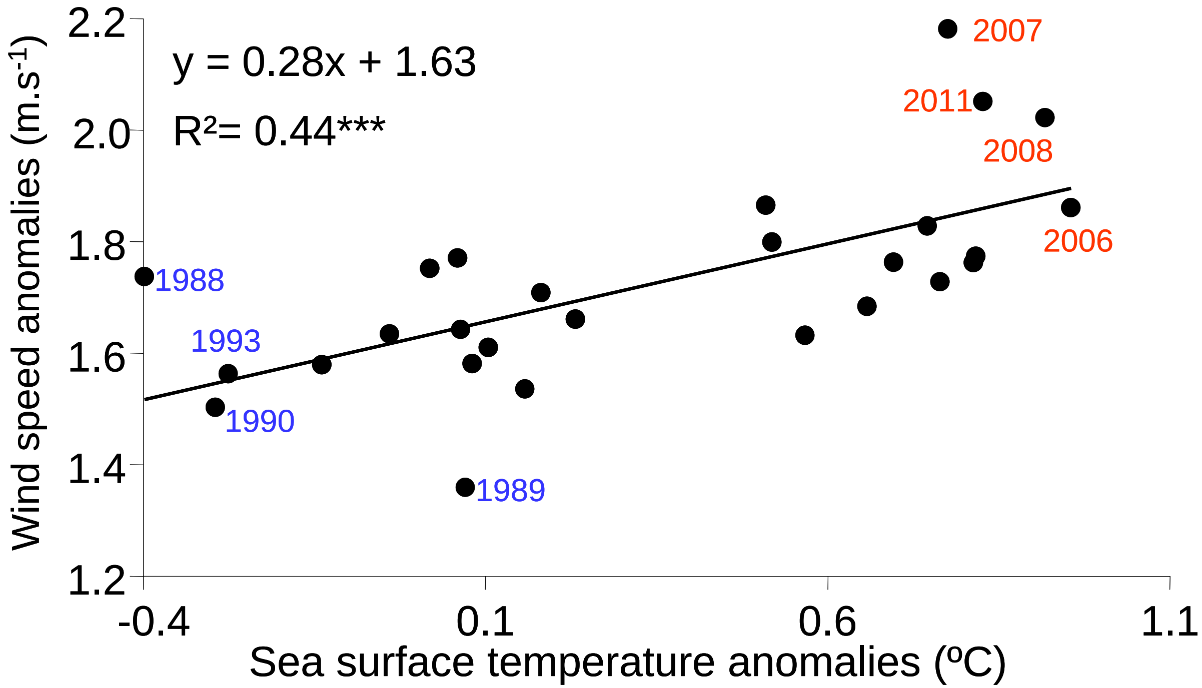
# Increase in temperature, onshore winds and extreme events

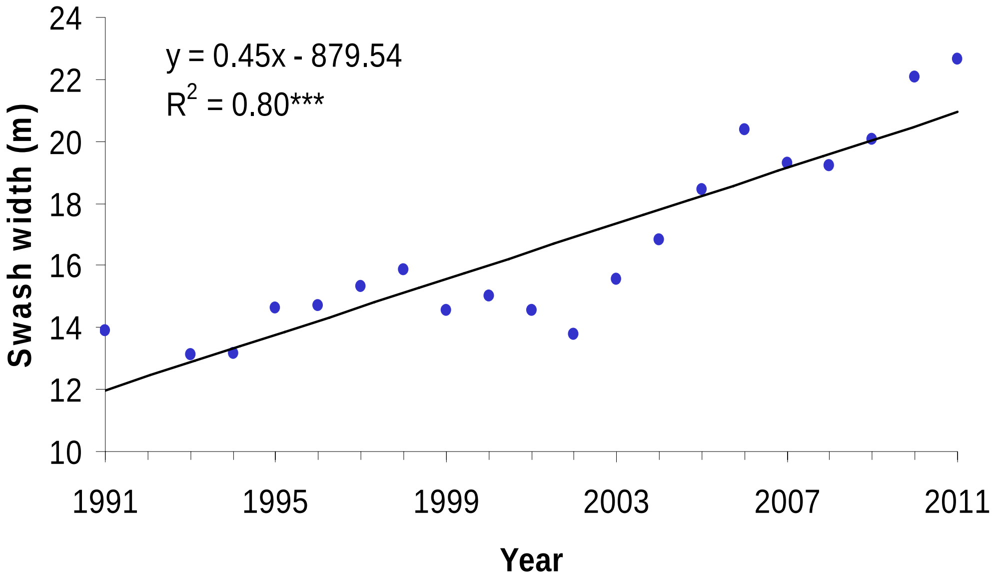
Ortega et al. 2013, Defeo et al. 2013

**Uruguayan coast:**

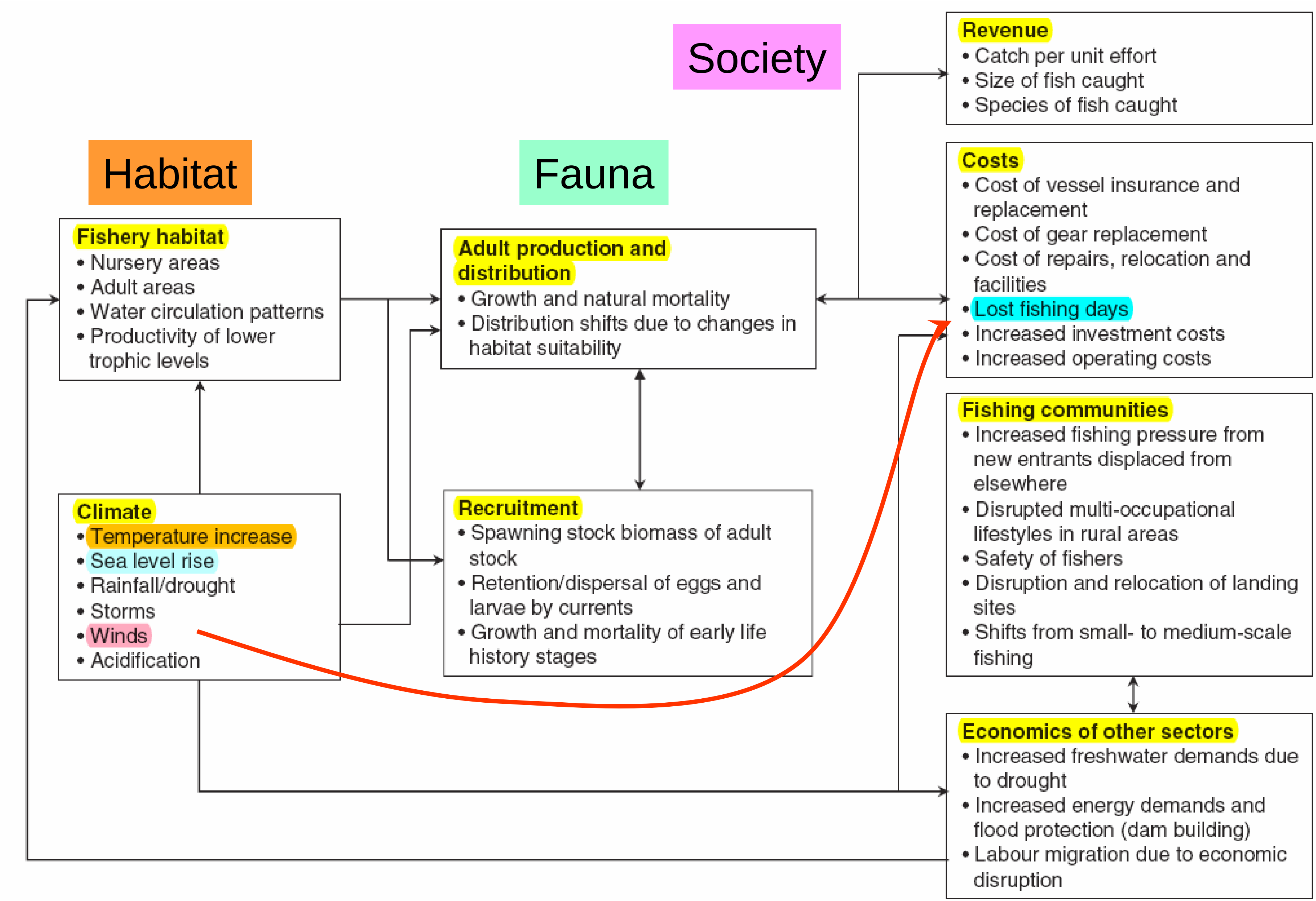
Increase in temperature, and in the frequency, intensity and speed of onshore winds

Long-term increase in wave height, swash width, and decrease in beach slope ➔ EROSION



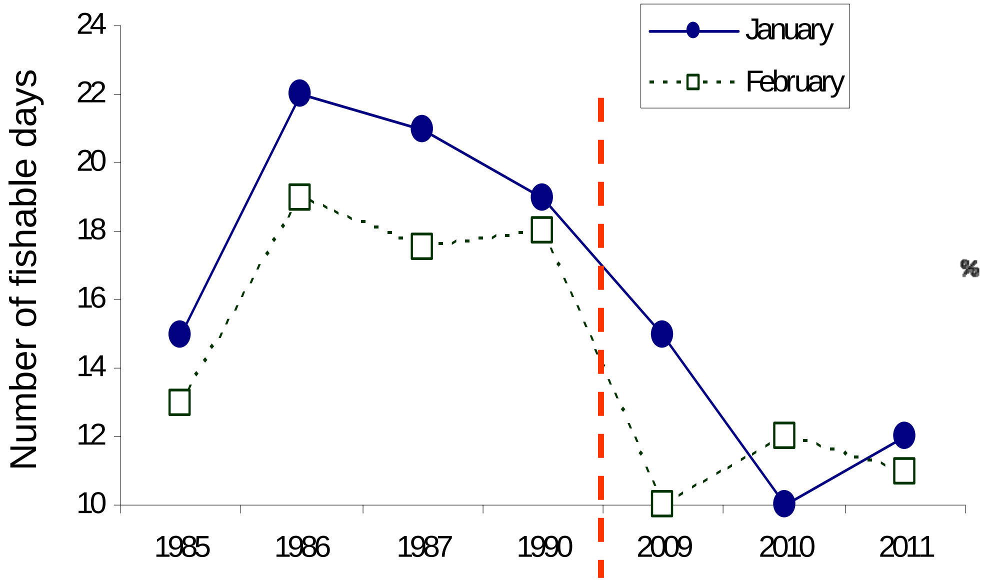



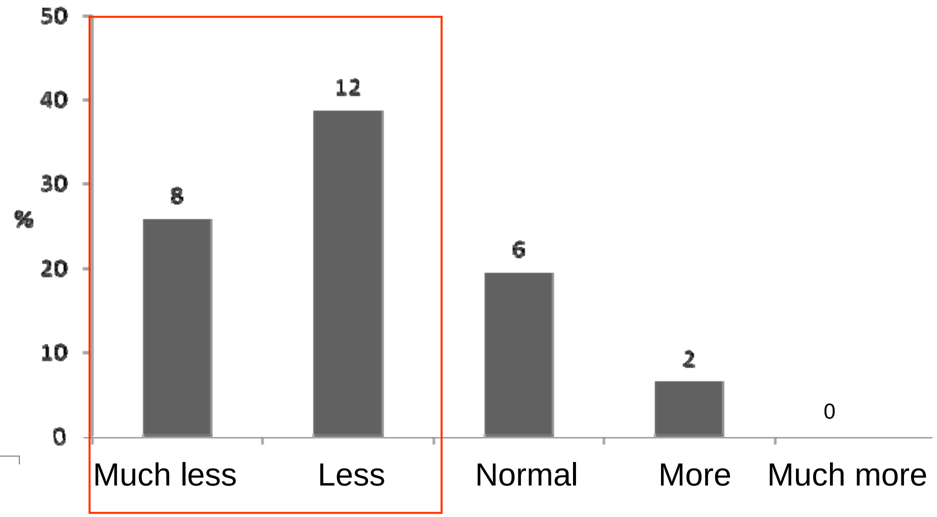

# Climate fluctuations affect the social-ecological system




Hall 2011, Defeo & Castilla 2012, Defeo et al. 2013

# Loss of intertidal habitat, catchability, fishing days and $$$




# Sandy beach macrofauna

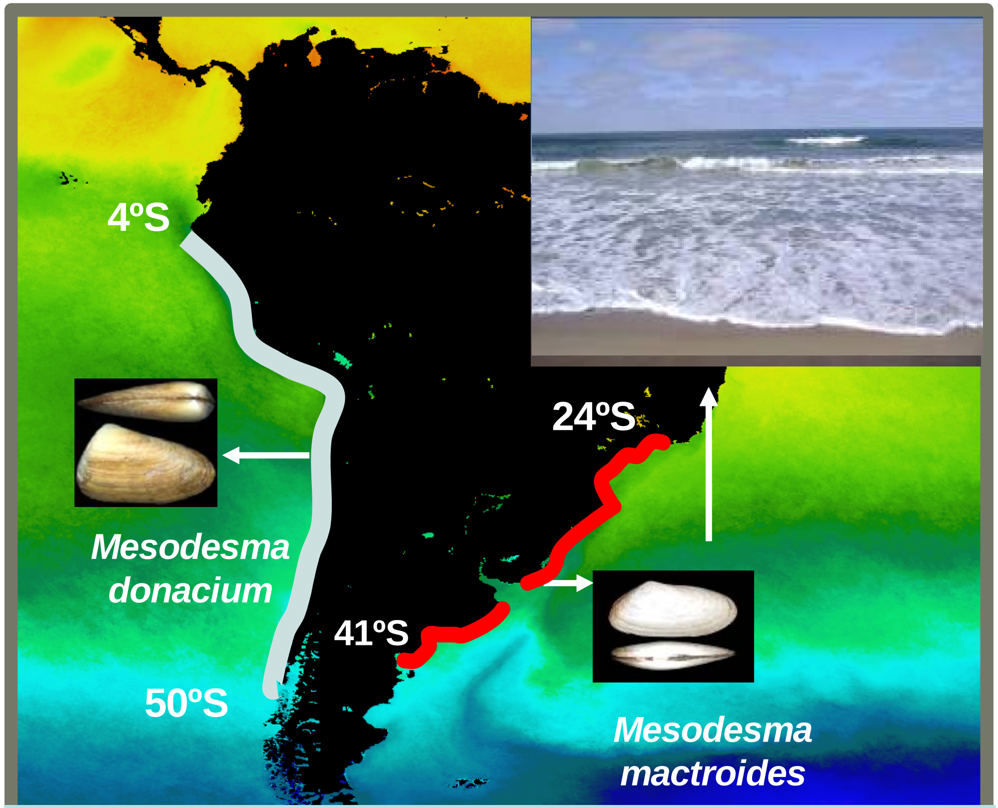
> 95% of species, abundance and biomass made up by three taxa:

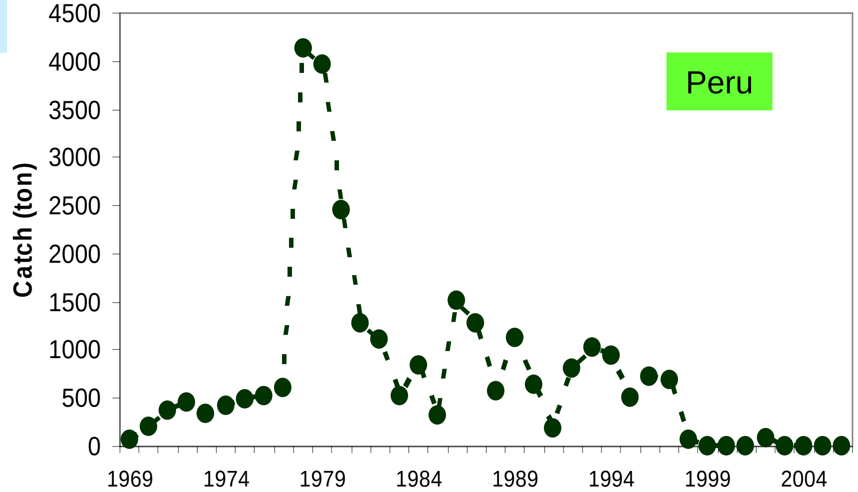
- Crustaceans (isopods, amphipods, hippids, mysids, decapods)
- Molluscs (bivalves and gastropods)
- Polychaete worms

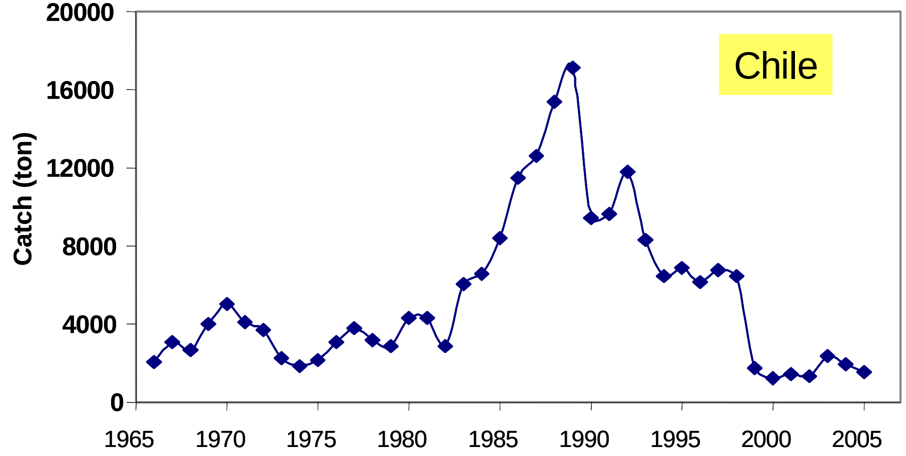
How do they respond to the beach environment and climate variability?

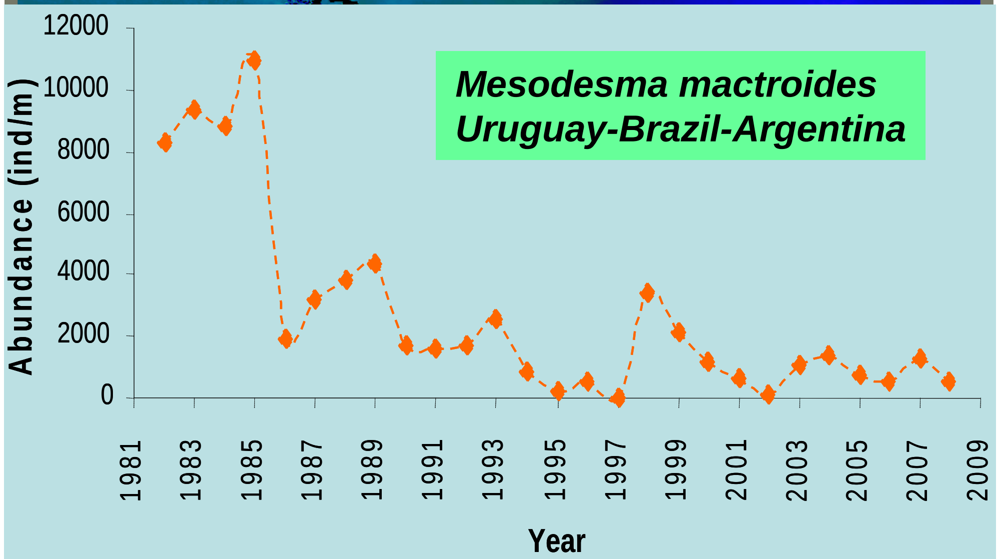


# Sandy beach clams – Pacific – Atlantic South America



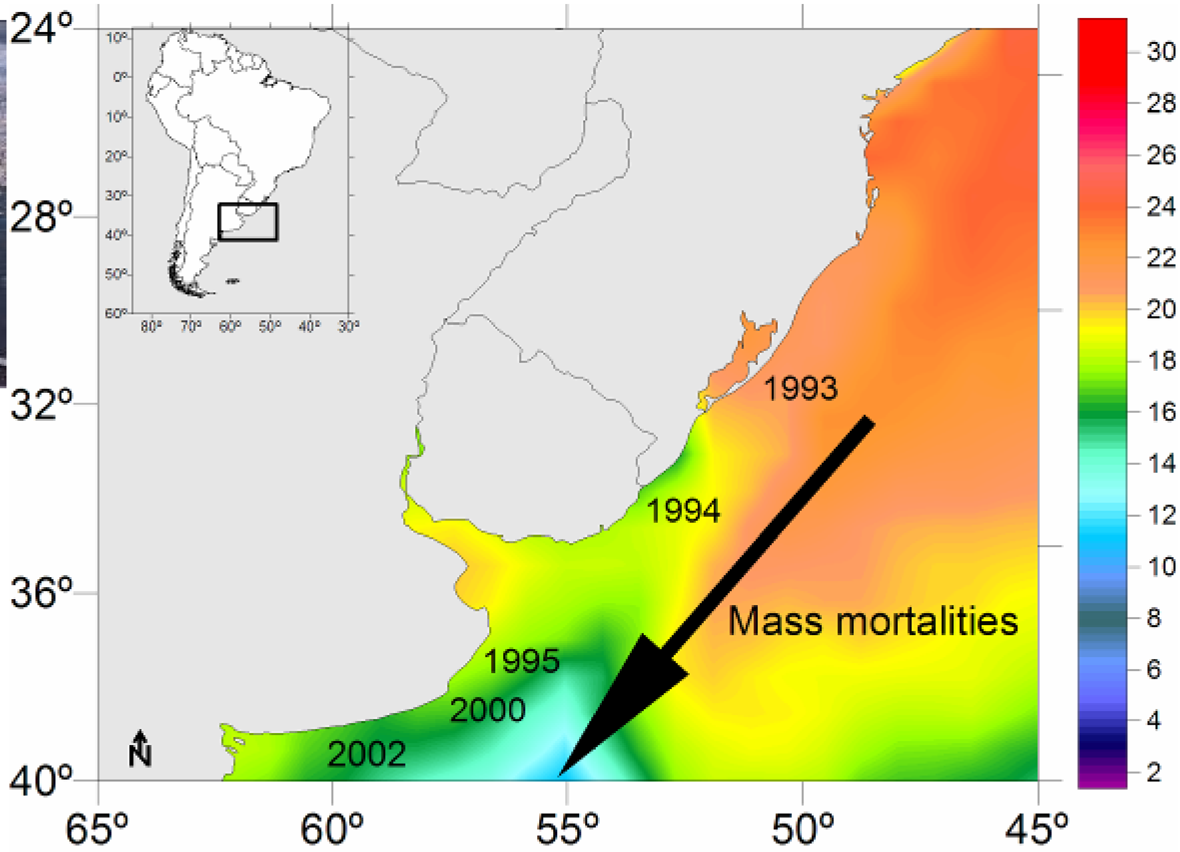

Almost collapsed fishery stocks, despite management strategies (area-based + co-management) that succeeded in other benthic fisheries (Chile, Uruguay)

# Sandy beach clams: mass mortalities

**Mass mortalities** of this cold-water clams during the last 2 decades decimated populations throughout entire distribution ranges in the Atlantic and Pacific:

1. Important SOCIAL-ECOLOGICAL SYSTEMS: fisheries and human livelihoods affected
2. Community structures and ecosystems drastically changed
3. Possible causes: fishing PLUS **temperature increase**, algal blooms, diseases

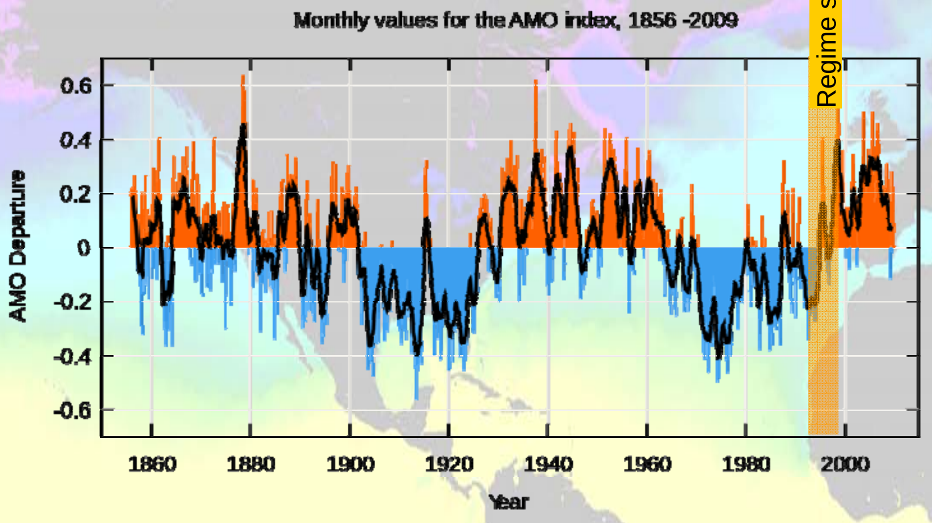




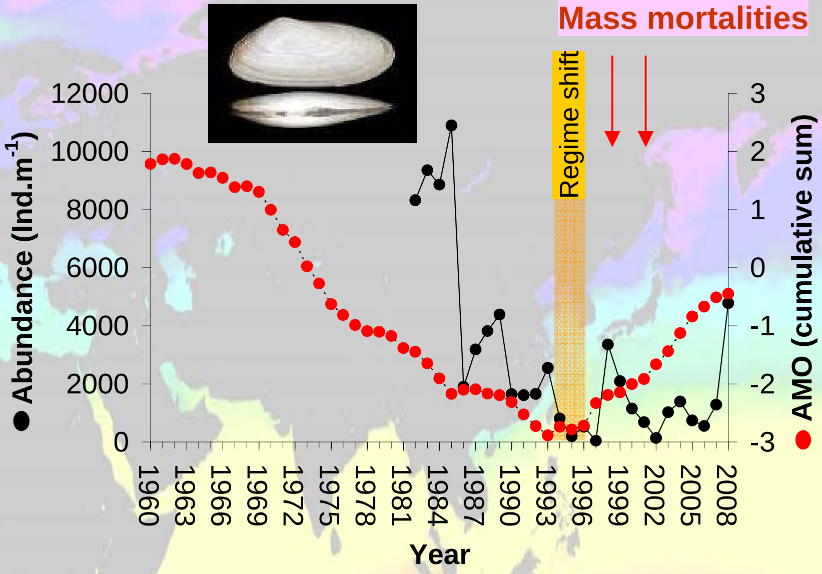

Fiori et al. 2004, Fiori & Defeo 2006, Oderbrecht et al 2009

# Atlantic yellow clam: mass mortalities and increasing temperature

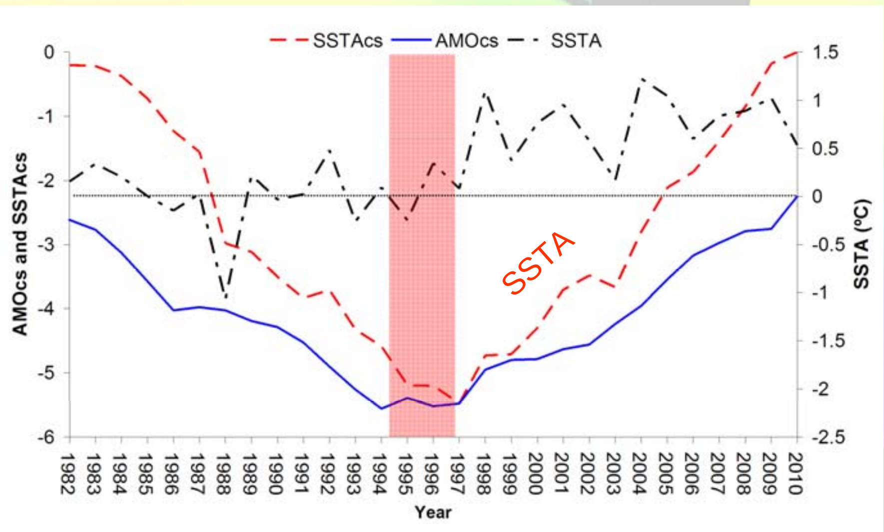
## Atlantic Multidecadal Oscillation




## Mass mortalities




## Increase in temperature

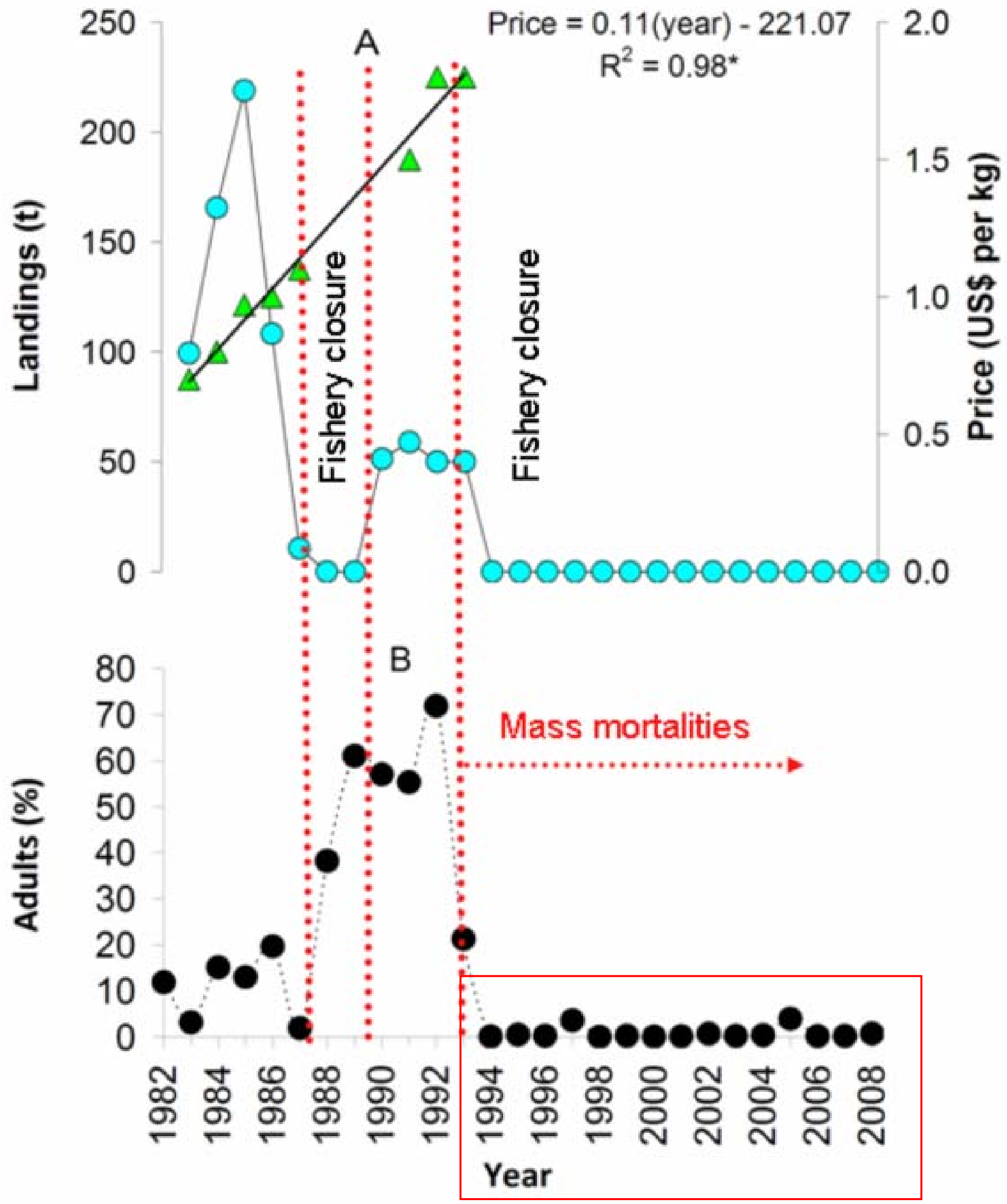



Defeo & Castilla 2012, Ortega et al. 2012, 2013, Schloeman et al. 2014

## Mass mortalities: negative socio-economic effects

Mass mortalities that began in late 1993

Closed fishery until 2008, without showing evidence of stock recovery, particularly in the adult (harvestable) stock

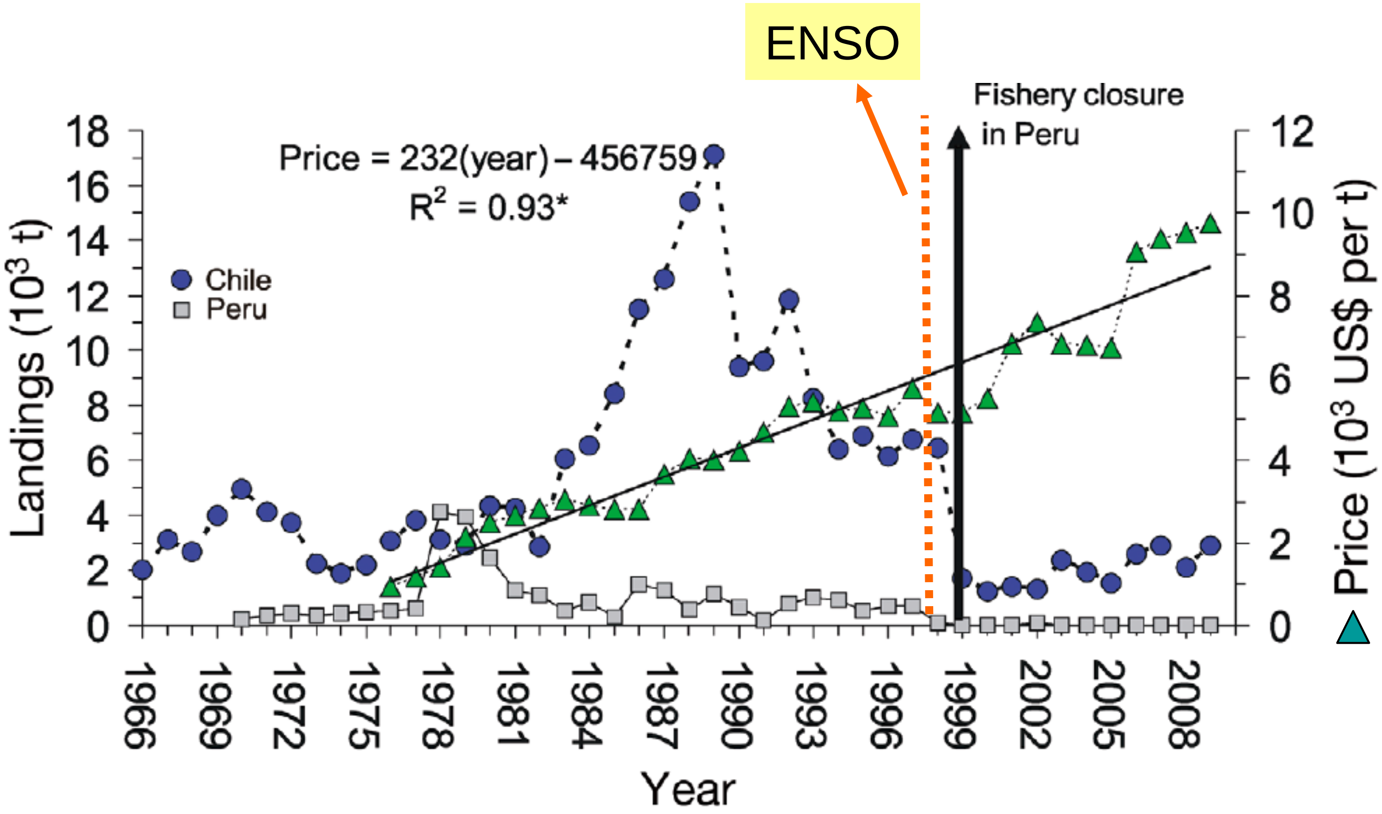



Ortega et al. 2012, 2013, Defeo et al. 2014

# Pacific surf clam: mass mortalities, ENSO and fishery collapse

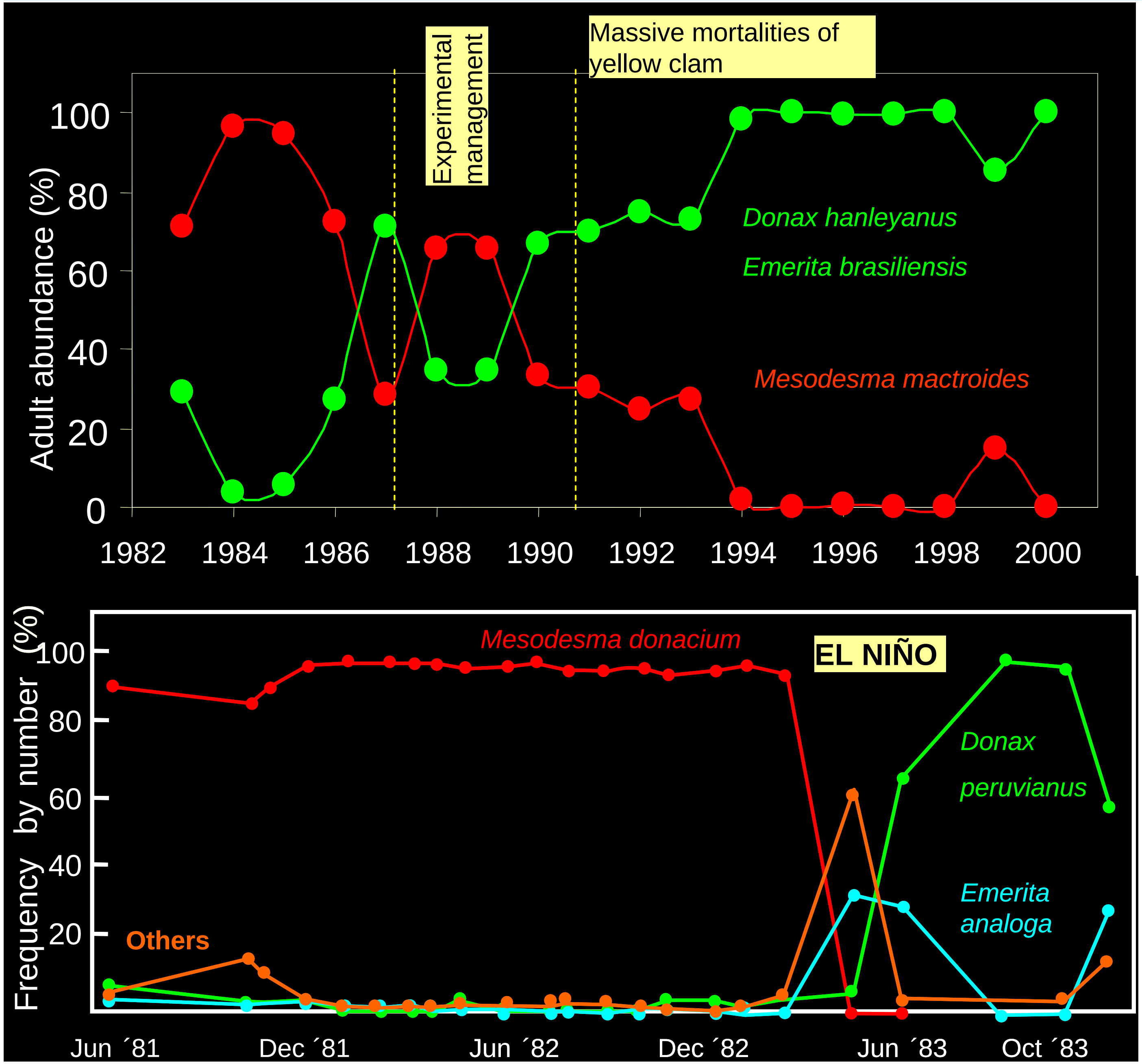
**ENSO affected landings in Peru and Northern Chile: closed season in Peru since 1999…**

Unit price: another significant predictor of long-term trends




Ortega et al. 2012

# Ecological effects of climate variability: tropicalization




**Changes being assessed:**

1. Increasing SST
2. Phytoplankton biomass, composition and intensity of blooms
3. Benthic community structure
4. Population abundance
5. Persistence of invasive species
6. Range shifts

# Climate change and transitional waters

Changes in:

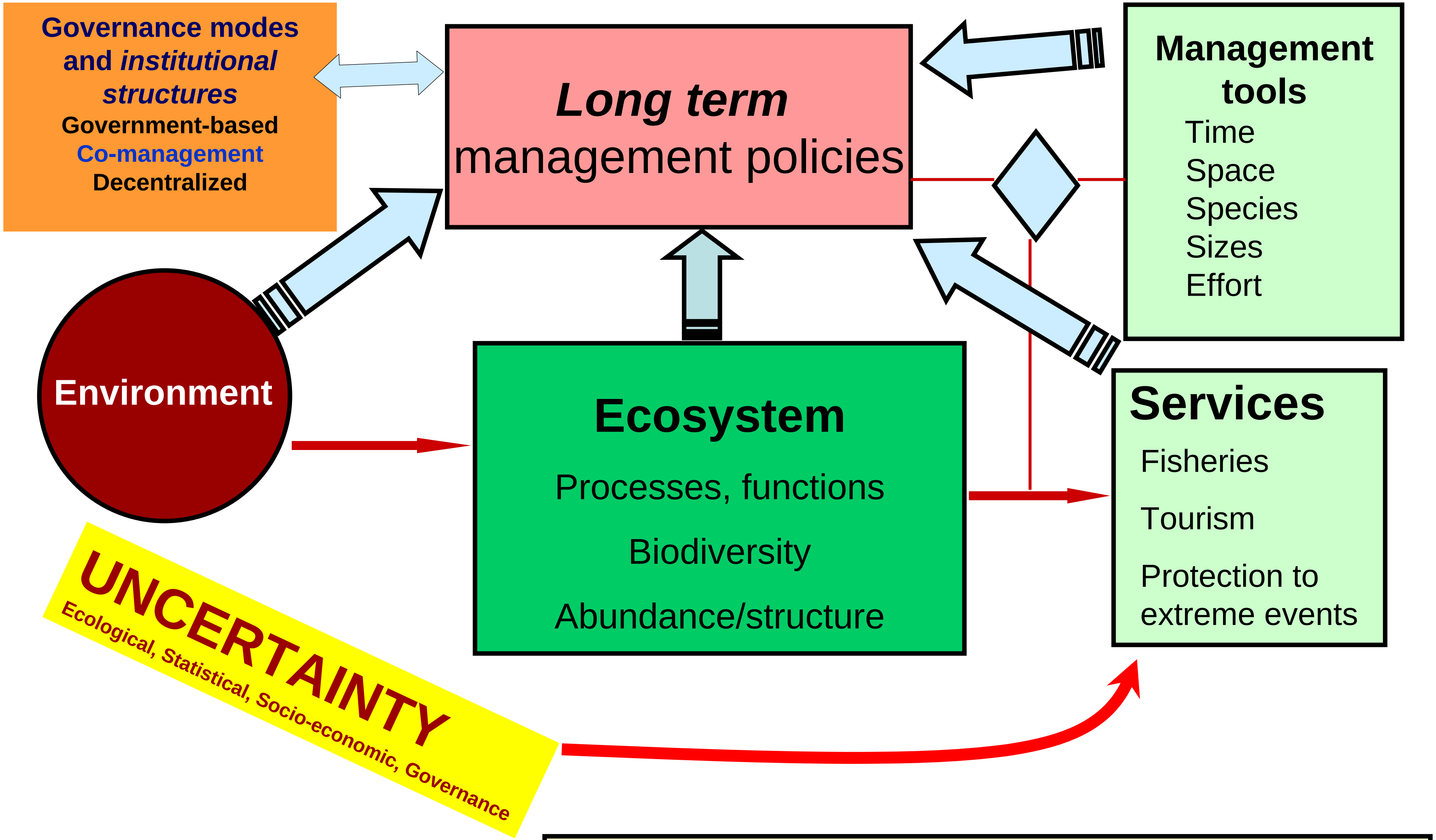
- Temperature
- Precipitations
- Sea level
- Water runoff


Hypotheses to be tested:

- Spp composition shifts
- Expansion of exotic species (*Corbicula*)?
- Increase in mortality of marine species

Basset et al. 2013, Schoeman et al. 2014

# Sandy beaches as social-ecological systems




Sandy beach management requires the integration of ecology with socio-economic and institutional factors

# Conclusions: sandy beaches & climate variability

1. Different lines of evidence support a climate change interpretation as a primary causal agent in sandy beaches

2. Effects on the environment:

   a. Coastal squeeze (sea level rise and urbanization)

   b. Changes in beach morphodynamics: erosion

   c. Increase in swash width

3. Effects on macrofauna:

   a. Biodiversity loss: a major driver of ecosystem change (regime shifts)

   b. Across taxa: similar effects in parallel communities (Atlantic and Pacific)

# Conclusions: sandy beaches & climate variability

1. Biophysical changes affected socio-economic issues: *sandy beaches as social-ecological systems*

2. Effects of climate variability swamped management measures

3. Long-term policies, early warning systems (e.g. red tides) and co-governance of SES are needed

4. Institutional adaptive capacity to cope with climatic and human drivers of change

Gutierrez et al. 2011 - Nature